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* Chet Welle
  * Rochester WRP
Innovation As a Catalyst for Sustainable Utilities

Presenter: Sudhir Murthy, PhD, PE, BCEE
WEF Fellow, IWA Fellow
Innovations Chief
DC Water
Blue Plains AWTP

- 370 mgd (AA) + 21 mgd of CS
- TN < 4 mg/l & TP < 0.18 mg/l
Several Major Capital Programs Currently in Planning

- New Wet Weather Pump Station & High Rate Enhanced Clarification Facility
- New Side Stream Centrate Treatment Process
- Upgrade & expansion of the Nit/Denit system
- Expansion & Upgrade of the Secondary High Rate System & Clarifiers
- New Biosolids Management Program
Enhanced Nitrogen Removal (ENR)

ENR is a program providing new facilities and upgrades to existing facilities at Blue Plains to meet the new total nitrogen discharge limit included in DC Water’s permit that goes into effect in 2015.
Thermal Hydrolysis & Anaerobic Digestion

MPT Complex

Screening Building (not shown)

• Pre-dewatering building

• Cambi trains

• Digester building (between digesters)

• Digesters
Final Dewatering Facility

Final Dewatering Building

• Belt Filter Presses will be used
Filtrate is a low-flow; highly concentrated nitrogen rich recycle stream

- Sidestream Deammonification
- One-Third energy demand compared to mainstream treatment
- No internal or external carbon
- Increases reliability to meet NPDES nitrogen requirement
Sustainability and Innovation

Source: Annual Energy Review 2006, Energy Information Administration

Imported Costs

Source: Matthew Higgins, Sydney Isaacs and Lara Murray, Bucknell University
The Fly and The Elephant

- House fly - 17 days
- Starling - 17 months
- Carp - 19 years
- Shark - 25 years
- Cat - 36 years
- Lobster - 50 years
- Elephant - 70 years
Innovation Disruption

Cook S et al. Eur Heart J 2006;27:2387-2393
The Fly and The Elephant

Increasing Maximum Life
Innovation and Risk

Managing Risk

Taking Risk

http://www.uniondocs.org
http://addictinginfo.org DCWATER.COM
Rocket Science
DC Water Decommissioned Digesters after about 65 years service
Diffusion of Innovation

Adapted from Rogers, 1962
Water Technology

Cambi

- Cumulative 37 projects
- Cumulative capacity tds/year

Davyhulme Plant, Manchester, United Kingdom

Effect of thermal pretreatment on digestibility and dewaterability of organic sludges,

*J. Water Poll. Control Fed.*, 50, 73.

Source: Cambi
Side-stream applications: DEMON

DEMON-features –

• pH-based process control
• cyclone for anammox enrichment
Side-stream applications: Paques

Granular Sludge Anammox Features
- Granular Sludge Based
- Continuous Aeration – Load controlled

Cumulative Capacity

80000
60000
40000
20000
0
“In study after study, of composers, basketball players, fiction writers, ice-skaters, concert pianists, chess players, master criminals,” writes the neurologist Daniel Levitin, “this number comes up again and again. Ten thousand hours is equivalent to roughly three hours a day, or 20 hours a week, of practice over 10 years... No one has yet found a case in which true world-class expertise was accomplished in less time. It seems that it takes the brain this long to assimilate all that it needs to know to achieve true mastery.” – Malcolm Gladwell, Outliers
“If you want to bring a fundamental change in people's belief and behavior...you need to create a community around them, where those new beliefs can be practiced and expressed and nurtured.”
— Malcolm Gladwell, *The Tipping Point: How Little Things Can Make a Big Difference*

New beliefs need to be practiced and expressed and nurtured
“Giants are not what we think they are. The same qualities that appear to give them strength are often the sources of great weakness.”
— Malcolm Gladwell, *David and Goliath: Underdogs, Misfits, and the Art of Battling Giants*

Gladwell’s perspective is that our “weaknesses” and “shortcomings” may actually be our greatest *strength.*
What Is LIFT?

A WEF/WERF Program
Accelerating Innovation Into Practice

- Scholarship
- Exploration
- Collaboration
Diffusion of Innovation

Adapted from Rogers, 1995
LIFT Program Components

1. Technology Evaluation Program
2. People and Policy
3. Communication
4. Informal Forum for R&D Managers
LIFT Participants

**Working Group:**
- Initially about 25 facility owner members, currently about 250+ members

**VEP (Volunteer Experts Pool):**
- Established for non-facility owners including consultants, academics, equipment manufacturers, etc.
Utility Technology Survey

Purpose:

• **Scholarship**: Focus groups can study these technologies in detail
• **Exploration**: Identify new technologies currently being evaluated at facilities
• **Collaboration**: Provide a networking and collaboration tool for facility owners

To participate in survey:
E-mail Ravi George: rgeorge@werf.org
Technology Push and...

...Technology Pull
LIFT Focus Areas

1. Shortcut Nitrogen Removal
2. P-Recovery
3. Digestion Enhancements
4. Biosolids to Energy
5. Energy from Wastewater

To sign up:
E-mail Ravi George: rgeorge@werf.org
P-Recovery Focus Group

Available:
P-Recovery Technology Fact Sheet (about 40 technologies)
Biosolids to Energy Focus Group: Technologies

1. Gasification
2. Hydrothermal Gasification / Liquification
3. Pyrolysis
4. SuperCritical Water Oxidation
5. Chemical Extraction
6. Other
Energy from Wastewater Focus Group: Technologies

- Effluent Heat Extraction
- Microbial Fuel Cell / Electrolysis Cell
- Mainstream Anaerobic Treatment
- Hydrokinetic Energy Recovery
- Algae Production
- Osmotic Power
- Enhanced Primary Solids Removal
- Raw Wastewater Heat Extraction
- Centrate Heat Recovery
- Ammonia for Fuel
LIFT Focus Areas
Technology Development, Testing, & Implementation
(Accelerating High-Priority Research)

- Digester Enhancements
- Bio solids to Energy
- Energy from Wastewater
- Nutrient Removal
- Phosphorus Recovery

WERF Research Knowledge Areas
Research, Learning, & Understanding

- Stormwater
- Decentralized Systems
- Integrated Water Management
- Security & Disaster Response
- Climate Change
- Use Attainability Analysis
- Strategic Asset Management
- Operations Optimization
- Pathogens
- Sensors
- Trace Organics
- Water Reuse
- Conveyance Systems

LIFT Integration with WERF Research
LIFT Technology Scans

• Identify and evaluate innovative technologies
• Provide platform for vendors to introduce technologies
• Facilitate collaboration on tech testing & demos
• Pilot launched Nov. 2013
• Opportunities:
  • Technology Provider Forums
  • Participate in Pilots/Demos
  • Access New Technologies:

www.werf.org/lift
LIFT Website: werf.org/lift
LIFT Contacts at WEF and WERF

WERF

Jeff Moeller – jmoeller@werf.org 571-384-2104
Ravi George – rgeorge@werf.org 571-384-2105
- Technology Evaluation Program (TEP)
- Technology Focus Groups

WEF

Matt Ries – mries@wef.org 703-684-2406
Claudio Ternieden – cternieden@wef.org 703-684-2416
- People and Policy
- Communication and Education
How does our Program work?

• Collaboration (Teams)
  – Within DC Water (Program Management)
  – Other Utilities (Alex Renew, WSSC, Fairfax County, HRSD, PWD, NYCDEP, Thames Water, Strass, Salzburg)
  – Universities (GWU, HU, UMd, VMI, VT, BU, PSU, U. Waterloo, U. Inns, Ghent)

Approximately 200 publications and presentations
Approximately 40 MS and PhDs in past 8 years
Moving Research into Practice

Resulted in 25 publications and 1 patent

Students

- David Inman, MS 2004;
- Sangeetha Subramanian, MS 2005
- Jared Webb, MS 2006
- Nitin Kumar, MS 2006

- Christopher Wilson, MS 2006
- Sarita Banjade, MS 2008
- Charan Tanneru, MS, 2009
- Christopher Wilson, PhD, 2009
VS Destruction

- Tested over 50 Digestion options at lab-scale (VT)
  - Feedstock for all tests was Blue Plains solids (primary and WAS)
DC Water Decommissioned Digesters after about 65 years service

Startup in June 2014
Contact: Sudhir N. Murthy, PhD, PE, BCEE
DC Water
Towards Energy Neutrality at WRRFs-Results and Findings of Recent WERF Research (WERF ENER1C12)

Steve Tarallo, Black & Veatch

19th Annual Central States Education Seminar
April 8, 2014
Project Overview
Energy – Production and Efficiency

Objective:
Provide research to develop new approaches that will allow wastewater treatment plants to be energy neutral, and thus able to operate solely on the energy embedded in the water and wastes they treat.

(from WERF Energy Management Challenge Exploratory Team Report, January 2011)
Definition of Energy Neutrality

- A water resource recovery facility that generates 100% or more of the energy it needs for its operation solely from the energy embedded in the water and wastes it treats.

- On the road to energy neutrality, metric can be any of the following:
  - Site Electrical energy
  - Site Total Energy (electricity + fuels; chemicals embedded energy)
  - Primary Energy

- At 100% energy neutrality, the metrics are equivalent; on the road to neutrality, they are not
WERF ENER1C12 – Project Overview
Phased Tasks

- Task 2 – Energy Neutral Case Studies
- Task 3 – Triple Bottom Line Evaluation of Biosolids Management Alternatives
- Task 4 – Deliverables and Communication
Task 1 Results and Discussion
Task 1 Energy Modeling - Approach

- 50 Baseline energy models
  - Common WRRF configurations
    - 25 “typical”
    - 25 “best practices”
- Software: GPS-X; e!Sankey
- 9 Variations on common unit processes
- 18 “pioneering” process modules
  - Potential for significant step towards energy neutrality
  - Innovative or Established (not Embryonic)
BOD removal only w/CHP

- 26% of influent chemical energy remains in dewatered biosolids
- 36% of influent chemical energy converted to digester gas
- 631 kWh/MG generated by CHP
- 31% of influent chemical energy remains in dewatered biosolids
- 33% of influent chemical energy converted to digester gas
- Acetic acid for BNR requires significant natural gas to produce (2.3 times energy in per COD energy out)
### Baseline Configurations – Results

**Typical vs. Best Practice**

<table>
<thead>
<tr>
<th>Configuration</th>
<th>Typical</th>
<th>Best-Practice</th>
<th>Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>BOD-removal only</td>
<td>870</td>
<td>1,334</td>
<td>35%</td>
</tr>
<tr>
<td>Nitrification</td>
<td>1,075</td>
<td>1,697</td>
<td>37%</td>
</tr>
<tr>
<td>BNR</td>
<td>1,133</td>
<td>1,876</td>
<td>40%</td>
</tr>
<tr>
<td>ENR</td>
<td>1,198</td>
<td>1,947</td>
<td>38%</td>
</tr>
<tr>
<td>MBR</td>
<td>2,815</td>
<td>5,676</td>
<td>50%</td>
</tr>
</tbody>
</table>

- 40% average reduction from typical (TYP) to best practices (BP)
- BOD removal only w/CHP 45% (TYP) to 85% (BP) electrical energy neutral
- BNR w/CHP: 26% (TYP) to 50% (BP) electrical energy neutral
CEPT (applied to BOD removal w/CHP - best practice)

- Reduced biological reactor electricity use by 15%
- Increased digester gas production by 15%
- 101% electrical energy neutral (up from 85%)
Increased digester gas production by 11%
27% reduction in dewatered biosolids energy
55% electrical energy neutral (up from 50%)
Co-digestion (applied to BNR w/CHP-best practice)

- Increased digester gas production by 18%
- 5% increase in dewatered biosolids energy
- 58% electrical energy neutral (up from 50%)
- 21% electrical energy neutral
- On-site electricity production offsets 33% of natural gas energy import
- 13% total site energy (electricity + natural gas)
Task 2 Results and Discussion
Task 2 Energy Neutral Case Studies - Approach

- 33 utility partner surveys completed; 44 treatment facilities
- 9 “real world” energy neutral leading facilities selected for case studies
  - Interviews with key staff
- 10 model facilities
  - start with best practice configurations
  - combine with select pioneering process modules
# Utility Partner Survey Results

<table>
<thead>
<tr>
<th>Facility Name</th>
<th>Electric Energy</th>
<th>Total Energy</th>
<th>Elec. Intensity kWh/MG</th>
<th>Flow MGD</th>
</tr>
</thead>
<tbody>
<tr>
<td>East Bay Municipal Utility District, CA (no survey)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>L.A. County JWPCP, CA</td>
<td>94%</td>
<td>94%</td>
<td>1418</td>
<td>273</td>
</tr>
<tr>
<td>Thousand Oaks Hill Canyon WWTF, CA</td>
<td>81%</td>
<td>76%</td>
<td>2102</td>
<td>9</td>
</tr>
<tr>
<td>Gloversville-Johnstown Joint WWTF, NY</td>
<td>90%</td>
<td>72%</td>
<td>2660</td>
<td>6</td>
</tr>
<tr>
<td>Sheboygan Regional WWTP, WI</td>
<td>75%</td>
<td>70%</td>
<td>1630</td>
<td>10</td>
</tr>
<tr>
<td>PWD Northeast WPCP, PA - forecast</td>
<td>74%</td>
<td>70%</td>
<td>1016</td>
<td>164</td>
</tr>
<tr>
<td>Melbourne Western Treatment Plant, AU</td>
<td>46%</td>
<td>46%</td>
<td>3021</td>
<td>130</td>
</tr>
<tr>
<td>JCW Douglas L. Smith Middle Basin WWTP, KS</td>
<td>47%</td>
<td>26%</td>
<td>4234</td>
<td>11</td>
</tr>
<tr>
<td>Ithaca Wastewater Treatment Plant, NY</td>
<td>38%</td>
<td>44%</td>
<td>1788</td>
<td>6</td>
</tr>
<tr>
<td>South Columbus Water Resource Facility, GA</td>
<td>38%</td>
<td>38%</td>
<td>1596</td>
<td>30</td>
</tr>
<tr>
<td>Encina Water WPCF, CA</td>
<td>79%</td>
<td>30%</td>
<td>1954</td>
<td>22</td>
</tr>
<tr>
<td>Des Moines WRF, IA</td>
<td>41%</td>
<td>28%</td>
<td>1872</td>
<td>48</td>
</tr>
<tr>
<td>Denver Metro WWRP</td>
<td>31%</td>
<td>27%</td>
<td>2285</td>
<td>123</td>
</tr>
<tr>
<td>Melbourne Eastern Treatment Plant, AU</td>
<td>28%</td>
<td>24%</td>
<td>3310</td>
<td>112</td>
</tr>
<tr>
<td>Madison Nine Sprints WWTF, WI</td>
<td>27%</td>
<td>23%</td>
<td>1985</td>
<td>40</td>
</tr>
<tr>
<td>Kent County Regional WWTF, DE</td>
<td>20%</td>
<td>18%</td>
<td>2491</td>
<td>11</td>
</tr>
<tr>
<td>NYCDEP Owls Head WWTP, NY</td>
<td>30%</td>
<td>17%</td>
<td>1087</td>
<td>92</td>
</tr>
<tr>
<td>Derry Twp. Clearwater Roads WWTP, PA</td>
<td>14%</td>
<td>13%</td>
<td>3356</td>
<td>4</td>
</tr>
<tr>
<td><strong>27 Facilities</strong></td>
<td><strong>&lt; 10%</strong></td>
<td><strong>&lt;5%</strong></td>
<td><strong>--</strong></td>
<td><strong>--</strong></td>
</tr>
</tbody>
</table>
Utility Partner Case Study Key Findings

- Successful programs have “champions” and institutional framework
- Long-term commitment
- Eager to innovate; to lead
- Co-digestion as near-term key to energy neutrality
- Dynamic market for co-digestion feedstocks
Model Facilities – Processes Applied to Best Practice Baseline Configurations

**Main liquid stream treatment**
- CEPT (all configs.)
- Pre-anoxic zone (Nitrification)
- Fermenter (BNR and ENR)

**Solids Treatment**
- FOG and food waste co-digestion
- Thermal hydrolysis
- Sidestream deammonification

**Energy Recovery**
- Steam turbine (FBI)
- IC Engine CHP (Anaerobic Dig.)
- Water source heat pumps
- Adsorption chillers (CHP)
Primary Energy

Grid Electricity:
3.34 units primary energy per unit site energy

Pipeline nat. gas:
1.05 units primary energy per unit site energy
## Model Facilities and Results

<table>
<thead>
<tr>
<th>10 Modeled Facilities</th>
<th>Electric Energy</th>
<th>Primary Energy</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 BOD removal only <em>(CEPT)</em>; Anaerobic Dig. <em>(THP, FOG and FW co-digestion)</em>; CHP; Dewatering</td>
<td>139%</td>
<td>139%</td>
</tr>
<tr>
<td>2 BOD removal only <em>(CEPT)</em>; Dewatering (satellite to #9 or #10)</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>3 Nitrification <em>(CEPT, pre-anoxic)</em>; Anaerobic Dig. <em>(THP, FOG and FW co-digestion, sidestream deammonification)</em>; CHP; Dewatering</td>
<td>110%</td>
<td>110%</td>
</tr>
<tr>
<td>4 BNR <em>(CEPT, fermenter)</em>; Anaerobic Dig. <em>(THP, FOG and FW co-digestion)</em>; CHP; Dewatering</td>
<td>61%</td>
<td>61%</td>
</tr>
<tr>
<td>5 BNR <em>(CEPT, fermenter)</em>; Fluidized Bed Incineration <em>(steam turbine energy recovery)</em></td>
<td>13%</td>
<td>11%</td>
</tr>
<tr>
<td>6 ENR <em>(CEPT, fermenter)</em>; Anaerobic Dig. <em>(THP, FOG and FW co-digestion)</em>; CHP; Dewatering</td>
<td>49%</td>
<td>39%</td>
</tr>
<tr>
<td>7 Reuse-MBR <em>(CEPT, simultaneous N/DN)</em>; Anaerobic Dig. <em>(THP, FOG and FW co-digestion, sidestream deammonification)</em>; CHP; Dewatering</td>
<td>80%</td>
<td>80%</td>
</tr>
<tr>
<td>8 BNR <em>(CEPT, fermenter)</em>; Anaerobic Dig. <em>(THP, FOG and FW co-digestion)</em>; CHP; Dewatering; Fluidized Bed Incineration <em>(energy recovery)</em></td>
<td>69%</td>
<td>59%</td>
</tr>
<tr>
<td>9 Regional – Anaerobic Dig. <em>(Imported solids, THP, FOG and FW co-digestion)</em>; CHP, Dewatering – System includes #2</td>
<td>103%</td>
<td>99%</td>
</tr>
<tr>
<td>10 Regional – Fluidized Bed Incinerator <em>(imported solids, steam turbine energy recovery)</em> System includes #2</td>
<td>52%</td>
<td>41%</td>
</tr>
</tbody>
</table>
BOD removal only w/ CHP - Key Findings (Relative to Best Practice configuration w/ CHP)

<table>
<thead>
<tr>
<th>Electric Energy</th>
<th>Primary Energy</th>
</tr>
</thead>
<tbody>
<tr>
<td>139%</td>
<td>139%</td>
</tr>
</tbody>
</table>

- 21% reduction in biological reactor electricity use
- Only 2% reduction in total electricity use
- Digester gas 62% of plant influent energy (vs. 39% for best practice configuration)
- 60% increase in CHP electricity generation (442 kWh/MG electricity export)
Nitrification w/ CHP - Key Findings (Relative to Best Practice configuration w/o CHP)

- 19% reduction in biological reactor electricity use
- Only 2% reduction in total electricity use
- Digester gas 59% of plant influent energy (vs. 37% for best practice configuration)
- 171 kWh/MG electricity export
BNR w/ CHP and FBI energy recovery - Key Findings (Relative to Best Practice configuration w/ CHP)

<table>
<thead>
<tr>
<th>Electric Energy</th>
<th>Primary Energy</th>
</tr>
</thead>
<tbody>
<tr>
<td>BNR (CEPT, fermenter); Anaerobic Dig. (THP, FOG and FW co-digestion); CHP; Dewatering; Fluidized Bed Incineration (energy recovery)</td>
<td>69%</td>
</tr>
</tbody>
</table>

- 9% reduction in total electricity use
- Fermenter eliminates 9,625 MJ/MG of natural gas for production of acetic acid
- 2,550 MJ/MG of natural gas use for FBI
- FBI/steam turbine produces 12% of total electricity generated
Model Facilities – General Findings to Date

- CEPT, co-digestion, and THP combine to achieve energy positive BOD-removal only facility
- CEPT, co-digestion, THP, and sidestream deammonification combine to achieve energy positive nitrification facility
- For BNR and ENR, fermentation reduces pioneering modules’ benefit for energy production; but energy for external C-source is reduced
- Sidestream deammonification electrical consumption benefit is marginal for BNR
- Future Shortcut Nitrogen Removal (mainstream) will be key to energy neutral BNR and ENR facilities
Conclusions and Next Steps
WERF ENER1C12 – Conclusions and Next Steps

- Energy efficiency best practices contribute significantly to energy neutrality goal
- Mainstream Short-cut Nitrogen Removal for BNR and ENR plants to achieve energy neutrality
- Innovation is Key – LIFT program helps utilities move innovation into practice (www.werf.org/lift)
- Final report – late Spring 2014
  - Navigation tool
    - Baseline configurations, energy neutral model facilities, energy neutral case studies
  - TBL tool for biosolids mgmt. options
Acknowledgments

- Lauren Fillmore - Sr. Program Mgr., WERF
- Kathleen O’Connor – Sr. Project Mgr., NYSERDA
- All of our utility partners
- The Issue Area Team (IAT)
- Andy Shaw – GPTL, Black & Veatch
- Ralph Eschborn – AECOM
- The entire project team
Thank you!

Questions?

19th Annual Central States Education Seminar
April 8, 2014
Moving Toward Sustainability

Michael Mucha
Madison Metropolitan Sewerage District

Presentation available at www.cswea.org
Good KRMA?
An Energy-Conscious Utility
Moves Toward Net Zero

A Case Study of the Kankakee River Metropolitan Agency (KRMA)

Central States Water Environment Federation
19th Annual Education Seminar – Sustainability

April 8, 2014

Richard G. Simms, P.E. – Executive Director
Scott W. Stearns, P.E., BCEE – Project Director
Presentation Outline

- WWTP background information
- Historical alternative energy sources used at the plant
- New construction allows focus on comprehensive energy management:
  - Optimize existing alternative energy sources.
  - Minimize energy consumption.
  - Consider additional alternative energy sources.
- Wrap-Up
Serves the City of Kankakee, Villages of Bradley and Bourbonnais, and Aroma Park.

- **25 mgd** average daily flow, **45 mgd** peak wet weather, **100 mgd** peak instantaneous.
- **28,200 lbs BOD/day** design average; **39,200 lbs BOD/day** peak month.
- 40 percent of load is industrial.
Historical Alternative Energy Sources

- Three Kaplan Turbines (Siphon Turbine).
- Each Induction Generator is rated at 400 kWh.
- “Run-of-the-River” installation.

City of Kankakee Hydro Electric

- Utility must maintain a **minimum** flow over the dam while turbines are in operation.
- Production is minimized during times of drought, ice packing the inlets, and high water.
Biogas Combined Heat and Power

**Historical Energy Sources**

- **Engine Generators**
- **DAF and Blended Sludge Storage**
- **Primary Anaerobic Digesters**
- **Secondary Anaerobic Digesters**

**Alternative Energy Sources**

- 2-240 kW generators with antiquated synchronizing equipment.
- Engine and exhaust heat recovery used for sludge and building heating.
## Energy Production and Usage

<table>
<thead>
<tr>
<th>Description</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Plant Demand</td>
<td>1,200 kWh</td>
</tr>
<tr>
<td>Range of Hydro Production</td>
<td>0 – 1,000 kWh</td>
</tr>
<tr>
<td>Range of Biogas Production</td>
<td>90 – 400 kWh</td>
</tr>
<tr>
<td>Range of Power Purchased</td>
<td>(200) – 1,100 kWh</td>
</tr>
</tbody>
</table>

- Very little natural gas used when engine is operating.
Several Projects Allowed to Focus on Comprehensive Energy Management

Recent Total Projects Construction Cost of
~$55 million
~$3 million grant or principal forgiveness
Energy Goals Sought During Design

- Optimize existing alternative energy sources.
- Minimize energy consumption.
- Consider additional alternative energy sources.
Electrical Improvements Allows for Seamless Transition to Hydro

- Service Entrance Gear modified to allow Hydro to operate on both of the primary feeds.
- Cannot run hydro as a standby source because of the type of generator.
- Standby generator and synchronizing gear added to provide power to all processes – selection via SCADA system.
CHP Upgrade Optimizes Biogas Utilization

- Biological H₂S Removal
- Moisture Removal
- Compression
- Generation/Heat Recovery

Optimize existing alternative energy
Direct Feed of Hauled Wastes to Digesters Increases Biogas Production

- Improved Anaerobic Digester Mixing
- Example Hauled Waste Accepting Facility to Digester

Optimize existing alternative energy
Benefits of Accepting High-Strength Hauled Wastes

- Reduce energy compared to routing through forward flow train.
- Higher biogas production = more energy production.
- Tipping Fees ~ $0.043 - $0.105/gal
I/I Reduction Reduces Pumping and Treatment Costs in the Collection System and at the WWTP

August 20, 2011 M01 KRMA

- Minimize energy consumption

- I/I Reduction Reduces Pumping and Treatment Costs in the Collection System and at the WWTP

- Rainfall
- Wet Weather Flow
- Dry Weather Flow
High Speed Turbo Blowers and Controls Provide Energy Savings

- Estimated $100,000 savings per year
- Received $130,000 grant from DCEO

Minimize energy consumption
Heat from Blowers Used for Building Heat When Needed

Reject Heat to Exterior

Reject Heat to Room

Radiator
Aeration Tank Modifications Allow for Nitrification/Denitrification

- Flow distribution
- Anoxic basins and mixers
- Nitrate recycle - NO₃ used as energy source

Minimize energy consumption
High Efficiency Lighting Provides Energy Savings

- $13,700 savings per year
- Received a $19,000 grant from DCEO

Minimize energy consumption
Solar Evaluation Performed at

Consider Alternative Energy Sources

Solar Radiation (Watts per Meter^2)

Potential Wattage

Solar Radiation Photovoltaic Output 20% Efficiency

24 Hours from Midnight to Midnight

Solar Radiation
Photovoltaic Output 20% Efficiency
Wind Evaluation Performed at

Wind Speed and Wind Gusts

24 Hours from Midnight to Midnight

Sampled Wind Speed
Maximum Wind Gusts

Wind Direction

24 Hours from Midnight to Midnight

(0-90) North - East
(90-180) East - South
(180 - 270) South - West
(270 - 359) West - North

Consider Alternative Energy Sources
Photovoltaic Project Designed and Bid, but Not Implemented

- Approximately 120’ x 275’
- 100 kWh
- Construction cost of $447,000
- Simple payback of ~18 years
KRMA Continues to Implement Energy Projects with Significant Payback

- Solar
- Wind
- HVAC/Lighting
- Biogas
- Codigestion
- Cogeneration
- Hydro-Electric
- Aeration Equipment/Controls/BNR
Overcoming the Barriers for Energy Recovery:
Developing WLSSD’s Energy Vision

CSWEA Education Seminar
April 8, 2014
Introductions

Caroline F. Clement, PE - WLSSD
Nate Hartman, PE - WLSSD
Leon Downing, PhD, PE – Donohue
Mike Gerbitz, PE - Donohue
what is the WLSSD
1971 – Created by Minnesota Legislature
  - St. Louis River horribly polluted
  - Existing facilities inadequate
  - 18 separate river discharges
1974 - Legislature added full responsibility for solid waste management
1978 - Plant began operations
1980 - River dramatically improved
Today - River is active walleye fishery and resource for recreation, commerce and quality of life
WLSSD Board of Directors

- 9-member citizen board; 7 votes required for action
  - 4 appointed by Duluth Mayor
  - 3 appointed by Cloquet City Council
  - 1 elected by other Carlton County communities
  - 1 elected by other St. Louis County communities
Sludge Disposal Background

- Designed during the 1970s oil embargo
- Originally designed to incinerate sludge with #2 fuel oil
- Design modified from fuel oil to Refuse Derived Fuel “RDF” (Municipal Solid Waste)
  - Resulted in “Free Energy”; no facility heating costs

Operational until late 1990s
After 20 Years of Incineration

- Aging facilities
- Uncertainty about future MSW “flow”
- Changing technologies
- Great Lakes Initiative
- Need to develop 20-year Plan of Operation
- 1995 – Start of Master Planning
Background – After 20 years

- **Solid Waste**
  - Stopped processing MSW in 1996
  - Began phased process to decommission incinerator

- **Solids Treatment**
  - Considered multiple solids treatment technologies
  - Concluded: Temperature Phased Anaerobic Digestion (TPAD) and Land Application of Biosolids
  - Low Pressure Steam Boilers replace facility heat source (using existing steam/heating hot water distribution)
Service Area

- 530 square miles
- 2 counties, 8 cities, 9 townships, 4 industries
- Population: 130,000
Collection System

- 75 miles of interceptor sewer
- 17 pump stations
  - Cloquet
    - 36 mgd capacity
    - 30’ forcemain
  - Scanlon
    - 46 mgd capacity
    - 42” forcemain
  - Knowlton
    - 49 mgd capacity
    - 54” forcemain
- 7 metering stations
About WWTP

- 48 mgd design
  - 36 mgd average 2013
- 50% industrial
  - Kraft Paper Mill
- No primary treatment
- Pure oxygen
- TPAD, land application
Biosolids Production and Land Application

- $33 million production facility opened in 2001
- Biosolids are applied to local agricultural lands or used in mineland reclamation
- Average 35 tons land applied/day
- 2,000 acres/year
Solid Waste Overview

- Solid waste used as fuel to incinerate wastewater solids through the 1990s
- Solid Waste Transfer Station opened in 1999
- Other SW programs include:
  - Organics Composting
  - Household Hazardous Waste and Clean Shop
  - Materials Recovery Center
The WLSSD is More Than a WWTP

- Clean water
- Biosolids
- Biogas
- Compost
- Low grade heat
- Electricity
the champions
District Energy Team

- 7-member multi-discipline core team
  - Executive Director
  - O&M Manager
  - Engineering
  - Finance
  - IT

- Energy policies must be adopted by entire staff
the vision
Offset rate increases with energy reduction improvements

Dedicate resources to identify energy reduction opportunities

Establish energy management program

Evaluate energy conservation beyond district consumption (manufacturing, transport)

Goal of utilizing 100% of waste energy

Establish standing capital item for energy reduction improvements

Incorporate energy efficiency, conservation, and technology in all new installations, modifications and replacements to existing process designs
the barriers
Barriers to Energy Independence

- Biogas Utilization Study 2008
- Complex Problem
  - Energy systems are interconnected
  - Overwhelming
  - Funding
- Which technology is the right fit for District?
the roadmap
Vision: Stairway to Energy Independence

- Biogas Boilers
- Enhance Biogas Utilization
- Advanced Primary Treatment
- Import of HSW or Food Waste
- HPO System Improvements
- Emerging Opportunities
- Operations and Equipment Upgrades
- Effluent Heat Recovery
- Heating system improvements
- Near Term Action Plan
- Long Term Vision
what **forms** of energy are used
Energy Use

- Renewable: 26% of Energy Use

Energy Use (MkWh)

- Biogas
- Gasoline
- Diesel
- Fuel oil
- Natural Gas
- Electricity - Collection
- Electricity - Treatment
Energy Use

Electricity: 57% of Energy Use

- Biogas
- Gasoline
- Diesel
- Fuel oil
- Natural Gas
- Electricity
what are the costs for the various forms
Energy Purchased

Annual Energy Cost ($M)

- Gasoline
- Diesel
- Fuel oil
- Natural Gas
- Electricity
Energy Purchased

- Annual Energy Cost ($M)
- Electricity: 86% of Energy Cost
- Gasoline
- Diesel
- Fuel oil
- Natural Gas
- Electricity

(Chart showing energy cost distribution with a focus on electricity.)
Electricity is an Expensive Form of Energy

86% of Energy Cost

Electricity: 57% of Energy Use

- Gasoline
- Diesel
- Fuel oil
- Natural Gas
- Electricity - Collection
- Electricity - Treatment

Annual Energy Cost ($M)
Electricity Rates Projected to Increase

Annual Electricity Cost ($M)

where is the energy used
Where Energy is Used

- Electricity - Collection: 26%
- Electricity - Treatment: 60%
- Fleet: 7%
- Heating: 7%
Resource Recovery Facility Uses Majority of Electricity

![Graph showing annual electricity cost for collection and treatment. Collection costs are significantly lower than treatment costs.](image-url)
where should the District focus its near-term energy efforts
Focus Energy Evaluation on Resource Recovery Facility
Benchmarking: Process-by-Process Perspective

Average Electricity Use (kWh/MG)

- WLSSD Average
- Industry Benchmark

- Overall
- Solids Dewatering
- Solids Thickening
- Anaerobic Digestion
- Solids (Activated Sludge)
- Filtration
- Secondary Clarification
- HPO/Activated Sludge
- RWW Pumping
- Preliminary Treatment

Electricity Use (kWh/MG)
District Pursuing Largest Opportunity to Improve Efficiency

District Successfully Addressing

Average Electricity Use (kWh/MG)

<table>
<thead>
<tr>
<th>WLSSD Average</th>
<th>Industry Benchmark</th>
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<tbody>
<tr>
<td>Overall</td>
<td>2,500</td>
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<tr>
<td>Solids Dewatering</td>
<td>2,000</td>
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<tr>
<td>Solids Thickening</td>
<td>1,500</td>
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<tr>
<td>Anaerobic Digestion</td>
<td>1,000</td>
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<tr>
<td>Filtration</td>
<td>750</td>
</tr>
<tr>
<td>Secondary Clarification</td>
<td>500</td>
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<tr>
<td>HPO/Activated Sludge</td>
<td>250</td>
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<tr>
<td>Preliminary Treatment</td>
<td>100</td>
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<tr>
<td>RWW Pumping</td>
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</tbody>
</table>
District Pursuing Largest Opportunity to Improve Efficiency

Limited Other Opportunities to Significantly Move the Energy Needle

Average Electricity Use (kWh/MG)
District Pursuing Largest Opportunity to Improve Efficiency

- Limited Other Opportunities to Significantly Move the Energy Needle
- Large Capital Costs, Small Efficiency Gains

Average Electricity Use (kWh/MG)

- District Successfully Addressing

Bar chart showing different processes and their electricity use compared to WLSSD and Industry Benchmarks.
Capital Projects

Replacement

- Age
- Safety
- Reliability

Efficiency

- Energy Efficiency
- Energy Production

Condition: Energy Nexus
Capital Projects

Continuous Improvement

Condition: Energy Nexus

Replacement

- Age
- Safety
- Reliability

Efficiency

- Energy Efficiency
- Energy Production
Condition: Energy Nexus

- Continuous Improvement
- Long View to Achieving Energy Vision
- Capital Projects
- Replacement
  - Age
  - Safety
  - Reliability
  - Energy Efficiency
  - Energy Production
- Efficiency
biogas opportunity to reduce energy purchases (costs)
Some Biogas Unused

% Biogas Used for Heat

Jan-09 Apr-09 Jul-09 Oct-09 Jan-10 Apr-10 Jul-10 Oct-10 Jan-11 Apr-11 Jul-11 Oct-11 Jan-12 Apr-12 Jul-12 Oct-12

0% 25% 50% 75% 100%
Biogas Offers Tremendous Potential to Reduce Purchased Electricity

Electrical Potential of Biogas

Equivalent to 35% Reduction

Annual Energy Reduction (MkWh)

% Energy Reduction
Near Term Focus

Biogas Use + More Economical Biogas Use

Purchased Electricity
Near Term Focus

- Biogas Use
- Purchased Electricity

More Economical Biogas Use

- Electricity + Heat
biogas utilization evaluation
<table>
<thead>
<tr>
<th>Technology</th>
<th>Engines</th>
<th>Microturbines</th>
<th>Fuel Cells</th>
<th>CNG</th>
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</thead>
<tbody>
<tr>
<td>Cost, $M</td>
<td>7.7</td>
<td>9.5</td>
<td>16.2</td>
<td>7.9</td>
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<tr>
<td>Payback, Yrs</td>
<td>12</td>
<td>19</td>
<td>22</td>
<td>23</td>
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<tr>
<td>Availability, %</td>
<td>90+</td>
<td>95 (30-kW)</td>
<td>Low</td>
<td>N/A</td>
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<tr>
<td></td>
<td></td>
<td>50 (200-kW)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Biogas Experience</td>
<td>Mature</td>
<td>Established</td>
<td>Emerging</td>
<td>Emerging</td>
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<tr>
<td>Testimonials</td>
<td>Good</td>
<td>Mixed</td>
<td>Poor</td>
<td>Good</td>
</tr>
</tbody>
</table>

600,000 GGE/yr
Engine Generators

 Digester Gas Storage

 Biofilter
 - Hydrogen Sulfide Removal

 Compressor ≈2-5 psig

 Chilling
 - Moisture Removal

 Media
 - Siloxane Removal

 Engine

 Generation

 Losses ≈15-25%

 Electricity ≈32-42%

 Maximum Total Energy Use ≈ 75-85%

 Heat ≈ 40-47%
Right Sizing to Overcome the Economic Barrier

Daily Digester Gas Generation (SCFM)

2x825 kW
the near term capital plan
## Near Term Capital Plan

<table>
<thead>
<tr>
<th>Near Term Action Item</th>
<th>Description</th>
<th>Replacement Capital ($M)</th>
<th>Efficiency Capital ($M)</th>
<th>Average Annual Savings ($M)</th>
<th>Payback (yrs)</th>
<th>20-Year PW Savings ($M)</th>
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<tbody>
<tr>
<td>1</td>
<td>Hot-Water Plant</td>
<td>3.70</td>
<td></td>
<td>0.04</td>
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<tr>
<td>2</td>
<td>H2S Control</td>
<td>1.23</td>
<td>0.22</td>
<td>5</td>
<td></td>
<td>2.11</td>
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<tr>
<td>3</td>
<td>BG Utilization</td>
<td>7.72</td>
<td>0.66</td>
<td>12</td>
<td></td>
<td>1.62</td>
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<tr>
<td>4</td>
<td>DAF</td>
<td>1.10</td>
<td>0.50</td>
<td>0.06</td>
<td>8</td>
<td>0.42</td>
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<tr>
<td>5</td>
<td>Heat Conservation</td>
<td>1.85</td>
<td>0.26</td>
<td>7</td>
<td></td>
<td>1.94</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>4.80</strong></td>
<td><strong>11.3</strong></td>
<td><strong>1.21</strong></td>
<td>9</td>
<td><strong>6.09</strong></td>
</tr>
</tbody>
</table>

16.10
the long term focus
Capital Projects

Replacement

Efficiency

Age
Safety
Reliability
Energy Efficiency
Energy Production

Condition: Energy Nexus
overcoming the barriers to energy recovery and efficiency
Overcoming the Barriers to Energy Recovery and Efficiency

- Vision: Mission
- Champions
- Perspective
- Focus
- Commitment
  - Near Term
  - Long Term
The Greatest Barrier: $
Energy Purchased

Annual Energy Cost ($M)

- Gasoline
- Diesel
- Fuel oil
- Natural Gas
- Electricity

Electricity: 3.5
Fuel oil: 0.5
Natural Gas: 0.2
Diesel: 0.1
Gasoline: 0.1
Electricity Rates Projected to Increase

![Graph showing projected increase in annual electricity cost from 2012 to 2019.](image-url)
the right Energy Recovery and Efficiency projects can be good business
New Approaches to Succession Planning
- Who is going to do all this after I leave?

Gregory F. Ford Vice President
GovHR USA
Local Government Staffing Solutions
Discussion Points

- What is Succession Planning?
- Why is it important?
- Who should complete the plan?
- What are the elements of a good plan?
- How does Succession Planning impact Wastewater Professionals?
- What are some new and innovative approaches to Succession Planning?
Succession Planning Definition

Succession Planning:

A process for identifying and developing internal people with the potential to fill key leadership positions in the organization. Succession planning increases the availability of experienced and capable employees that are prepared to assume these roles as they become available.
Succession Planning Components

- **Review** present workforce and organizational objectives
- **Identify** Future workforce needs
- **Analyze** present and future needs to identify gaps or surplus
- **Develop and Implement** Human Resources strategies and plans
- **Evaluate**, monitor and adjust plan
Importance of Succession Planning

- Allows for the Transfer of Institutional Knowledge
- Ensures the Continuity of Operations
- Reduces Exposure and Liability
- Assists in Preserving the Bond Rating – Moody’s
- Positions organization to become an “Employer of Choice”
- Recognizes and Respects the Expertise and Longevity of the Incumbent
Succession Planning Team

- Incumbents
- Key Management Staff – Managers and Department Heads
- Human Resources
- Supervisors and Employees
- Other Stakeholders
  - Committee Members
  - Community Groups
  - Peers
Succession Planning Key Elements

- Clear expectations of outcomes to be achieved
- Aligning Succession Plan goals with organizational goals
- Understanding of external environment – demographics and the availability of talent
- Inclusion of innovative alternatives for staffing
- Commitment to Employee Development
- Commitment to Employee Retention
Succession Planning & Wastewater Professionals

Demographics:

- **80** million Baby Boomers were born between 1946 and 1964
- **46** million Generation X-ers were born between 1965 and 1981
- **76** million Millennials were born between 1982 and 2000
Succession Planning & Wastewater Professionals

Retirement:

According to an Associated Press April 2011 poll:

- 44% of those surveyed have little or no faith they will have enough money to retire when their career “ends”
- 25% believe they will “never retire”
New Approaches to Succession Planning

- Mentoring Talent
- Job Sharing with Colleagues or Communities
- Phasing Retirement
- Outsourcing Part-time or Seasonal Jobs or Projects
- Interim or Project Work
- Temp-to-Hire
Mentoring Talent

- Consider promoting or bringing on staff that may not be fully trained to complete an assignment.
- Use existing staff to develop internal talent by sharing experiences and conducting training.
- Locate and in-source a retired professional to work with a staff member on developing skill sets in areas that may be underdeveloped and on creating a professional network of peers for future support.
Job Sharing – Colleagues/Communities

- Discuss with colleagues in surrounding communities long term staffing needs.
- Retain or engage a professional to complete the identified functions in a job share arrangement.
- Job shares can be used for general oversight, or for very specialized skills.
Phasing Retirement

- Rather than pick a firm retirement date on the calendar, slowly phase out an employee.
- Outsource the employee to a third party provider and then hire the person back on an interim, part-time or as-needed basis.
- Benefits include helping the transition of a new staff member who will be filling the vacated position and easing the transition to retirement for the employee, especially if he or she is long-tenured.
Outsourcing Seasonal/Part-time/Projects

- Consider filling jobs in a non-traditional way based on the actual needs of the organization.
- Look at work cycles and peak staffing times, such as billing cycles, and year-end reports.
- Bring on additional staff through a third party to address the fluctuations in staffing needs.
- Consider permanently outsourcing functions or projects that can be done professional seeking part-time or project oriented work – such as studies or data preparation.
Interim or Project Work

- Consider using interim or project workers to staff in the following instances:
  - During critical times when the primary worker is out – such as medical leave or other long-term leave is necessary but not permanent.
  - When an unplanned departure is made from the organization and there is an opportunity to analyze staffing needs before a permanent appointment is made.
  - When a project needs to be completed on a one-time basis.
Temp-to-Hire

- Temp-to-Hire is an excellent option in the following instances:
  - During a promotional opportunity;
  - When determining if previously laid off workers can be restored to prior positions;
  - When a candidate for a position is suited for a “trial run” before a commitment to permanent employment is offered.
New Approaches to Succession Planning

- Interim: 55%
- Temp-to-Hire: 8%
- Project: 8%
- Seasonal: 8%
- Outsourced: 8%

18
New Approaches to Succession Planning

Implementation - Third Party Employers:

- Jurisdiction enjoys the ability to staff “as needed”;
- Liability and benefit costs are avoided;
- Administrative costs are avoided;
- Expertise is made available at a reduced cost;
- Contracted employees are able to move in and out of the workforce on their terms;
- Ability to tap into a pool of expertise that does not conform to traditional work schedules.
Questions?

Gford@govhrusa.com  847 320-3240  info@govhrusa.com
Integration of Deammonification into the DCWater WRRF

Presenter: Sudhir Murthy, PhD, PE, BCEE
Innovations Chief, DC Water
The People

Olawale Akintayo
Heather Battiste-Alleyne
Charles Bott
Ryder Bunce
Kartik Chandran
Michael Desta
Haydee De Clippeleir
Norman Dockett
Yixuan Fang
Dana Fredericks
M. Gomez Brandon
Mofei Han
Martin Hell
Becky Holgate
Jose Jimenez
Hansa Keswani
David Kinnear
Yi Wei Ma
Matthew Michaelis

Mark Miller
Sudhir Murthy
Geert Nyhuis
Sylvia Okogi
Ahmed Omari
Maureen O’Shaughnessy
Hong Keun Park
Sabine Podmirseg
Pusker Regmi
Rumana Riffat
Andrew Shaw
Heather Stewart
Beverley Stinson
Imre Takacs
Tanush Wadhawan
Claire Welling
Bernhard Wett
Qi Zhang
Blue Plains AWTP

- 370 mgd (AA) + 21 mgd captured CS
- TN < 4 mg/l & TP < 0.18 mg/l
- 12°C winter monthly average
Several Major Capital Programs Currently in Design

- New Biosolids Management Program
- New Side Stream Centrate Treatment Process
- Upgrade & expansion of the Nit/ Denit system
C:N Ratio is an important factor determining pathway

- **Higher C:N ratio**
  - 6 - 10 :1 range?
  - Heterotrophs Dominate

- **Medium C:N**
  - 3 - 5 :1 range?

- **Lower C:N ratio**
  - 1 - 3 :1 range?
  - Mostly Anammox

**Process Types**
- Conventional Nitrification / Denitrification
- Nitrite Shunt
- Deammonification

Blue Plains
C:N ratio will drive combination of nitritation/denitritation and mainstream deammonification

- **High Rate, CEPT or A-Stage:** 50-80 % COD removal
- **Typical C:N Ratios:**
  - CEPT Effluent – 3:1 to 6:1 (add Fe)
  - A- Stage Effluent – 3:1 to 10:1 (SRT of 0.25d to 0.5 d)
  - High Rate or A-Stage/Fe – 1:1 to 2:1
Simulated COD Balance of the AIZ Strass WWTP

How mature is deammonification technology?

Main-stream Deammonification
Emerging technology

Side-stream Deammonification
Established State of the Art

Conventional N-removal technologies
Nitrogen Removal 2.0
Conventional Nitrification-Denitrification

Autotrophic Bacteria
Aerobic Environment

Heterotrophic Bacteria
Anoxic Environment

Nitrification

Denitrification

1 mole Nitrite
(NO₂⁻)

1 mole Nitrite
(NO₂⁻)

1 mole Nitrite
(NO₂⁻)

½ mol Nitrogen Gas
(N₂)

Ammonia Oxidizing Bacteria (AOB)

75% O₂ (energy)
~100% Alkalinity

1 mole Ammonia
(NH₃ / NH₄⁺)
Nitrification

60% Carbon (BOD)

DCWATER.COM
Nitrogen Removal 3.0

Partial Nitritation-Anammox = “Deammonification”

**Advantages:**
- 63% reduction in oxygen demand (energy)
- Nearly 100% reduction in carbon demand
- 80% reduction in biomass production
NOB out-selection

• Sidestream NOB out-selection
  - AOB growth rate > NOB growth at high temperatures
  - Free NH3 inhibition of NOB
  - AOB DO affinity > NOB DO affinity at high temperatures
  - Nitrous acid inhibition of NOB

☐ NOB out-selection Strategies in Sidestream
  - Temperature control
  - Free ammonia control (Feed, temp and pH)
  - SRT control (1-2 days)
  - DO control (0.3-0.9 mg/L, intermittent aeration depending on the suspended growth, granular sludge and attached growth systems)
Filtrate is a low-flow; highly concentrated nitrogen rich recycle stream

- Deammonification process identified as sidestream treatment option
- No chemical addition, 50% lower energy demand than mainstream treatment compared with conventional treatment and lowest GHG emissions.
- Proven full-scale performance in Europe and the US
- Scheduled to be on line after new digester facility is operational
- Increases reliability to meet NPDES nitrogen requirement and reduced external carbon requirements
Plants with Anaerobic Digestion

- Incentive for C-redirection
- Opportunity to bioaugment AOB and AMX from sidestream

Key Features:
- Direct AMX and AOB in the cyclone overflow (or screens) to the mainstream
- Cyclone/screen for AMX retention in mainstream

Being piloted at by DC Water at Blue Plains WWTP
Plants without anaerobic digestion

Key Features:
- Bioaugmentation of AMX and AOB to the mainstream is not possible
- Anammox process (attached growth) as final polishing step
- Goal to obtain maximum TIN removal during Nitrite shunt and feed optimal Nox/NH4 ratio to anammox MBBR
Our Recipe

• Anammox
  – Anammox Bioaugmentation
  – Anammox Retention (Growth?)

• AOB
  – AOB Bioaugmentation

• NOB
  – Maintain ammonia residual through most of the process
  – High DO (~1.5 mg/L)
  – Aggressive Aerobic SRT Management
  – Intermittent Aeration and Rapid Transitions to Anoxia
- Ammonia levels and temperature are too low for free NH3 inhibition
- Residual ammonia allows AOB to grow closer to their maximum growth rate

Monod Curves for AOB and NOB

Strategy # 1 Maintain Residual NH$_4$-N > 1.5 mg/L
High DO (>1.5 mg/L) allows AOB to grow close to their maximum rate and out select NOB (k-strategist).

Strategy #2: Operate at DO > 1.5 mg/L

Ko AOB ~ 0.5 mg/L
Ko NOB ~ 0.1 mg/L
Transient Anoxia

- Limit nitrite availability for NOB by rapid transient anoxia
- COD availability could decrease transition times

Strategy #3 rapid transient anoxia
Maintain SRT such that AOB removal rates are close to nitrogen loading rate => close to AOB washout

Washout NOB

Strategy # 4 Aggressive SRT
HIGH DO INTERMITTENT AERATION
(1 MONTH)

Concentration (mg/L)
NH4-N; NO2-N; NO3-N

Time (hr)

0 1 2 3 4

-8 mgN/L
~ +0.7 mgN/L
HIGH DO INTERMITTENT AERATION (1 MONTH)

Concentration (mg/L)
NH₄-N; NO₂-N; NO₃-N

- ~ - 4.2 mgN/L
- ~ - 5 mgN/L

Time (hr)

NH₃  NO₂  NO₃
High Ammonia Residual

-5 mgN/L

+1.5 mgN/L

Time (hr)

Concentration (mg/L)

NH₄-N, NO₂-N, NO₃-N

sCOD Concentration (mg/L)

NH3
NO2
NO3
SCOD
HIGH DO
Intermittent Air – “N Profiles”

Medium Ammonia Residual

Concentration (mg/L)

NH₄-N; NO₂-N; NO₃-N

~8 mg/N/L

~+1 mg/N/L

Time (hr)

0.0 1.0 2.0 3.0 4.0

0 2 4 6 8 10

SCOD Concentration (mg/L)

0 10 20 30 40 50 60 70

DCWATER.COM

-25-
HIGH DO
Intermittent Air – “N Profiles”

Low Ammonia Residual

- Concentration (mg/L)
  - NH4-N, NO2-N, NO3-N

- Time (hr)

- SCOD Concentration (mg/L)

-26-

DCWATER.COM
MODEL PARAMETER CALIBRATION

Simulation Results

DO Profiles
- Low/Constant DO
- Low/Intermittent aeration
- High/Intermittent aeration

N Profiles
- NH₃ (Model), NO₂ (Model), NO₃ (Model), NH₃ (Data), NO₂ (Data), NO₃ (Data)

AMX Activity
- NH₃ (Data), NO₂ (Data), NO₃ (Data)
Mainstream pilot (DC Water)

- Mixer
- Aerobic (Diffusers)
- Anoxic (Mixer)
- Swing (Mixer & Diffusers)

Sequential Oxic/Anoxic Operation
Anammox Retention Approaches

Granulation:
1) Settlers (internal or external)
2) Cyclones
3) Sieves

Biofilm:
4) Plastic Media
Selective SRT

cyclone under-flow (recycled) and overflow (wasted)
Retention on Screens

![Image of a sieve with retained waste]

**Microbial activity rate (mg N/L/h)**

- **Mixed liquor**
  - AnAOB: 25 ± 2 mg N/L/h
  - AerAOB: 23 ± 2 mg N/L/h
  - NOB: 3 ± 1 mg N/L/h

- **Retained**
  - AnAOB: 18 ± 2 mg N/L/h
  - AerAOB: 15 ± 1 mg N/L/h
  - NOB: 2 ± 0.5 mg N/L/h

- **Waste**
  - AnAOB: 1 ± 0.3 mg N/L/h
  - AerAOB: 0.8 ± 0.2 mg N/L/h
  - NOB: 0.5 ± 0.2 mg N/L/h

[DCWATER.COM]
Full-scale experiments at WWTP Glarnerland

Plant loading profiles (PE) and MLSS (TSS).

SVI-profiles (ml/g) and temperature (°C)
Comparison of this year’s and last year’s operational data of the full-scale pilot Strass indicating advanced NOB-repression (typically high nitrate level at Christmas peak-load; similar temperature conditions of ca. 10°C, load conditions and ammonia effluent concentrations of ca. 2-5 mgN/L for both years)
The last samples show ammonia removal during anaerobic activity test (anammox activity)

Only 25% of NOx produced from ammonia oxidation is converted to nitrate during aerobic activity test of the last sample
Rethink Conventional Wisdom for Short Cut in Nitrogen in Activated Sludge Systems

- Longer SRTs  Shorter SRTs
- Lower dissolved Oxygen  Higher Dissolved O2
- Continuous Low DO  Transient Anoxia
## Overall proposed strategy

<table>
<thead>
<tr>
<th></th>
<th>Nitrite shunt</th>
<th>Mainstream deammonification</th>
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<tbody>
<tr>
<td><strong>NOB out selection</strong></td>
<td></td>
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<tr>
<td>High DO</td>
<td>+</td>
<td>=</td>
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<tr>
<td>Ammonium residual</td>
<td>+</td>
<td>=</td>
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<tr>
<td>Transient anoxia</td>
<td>+</td>
<td>=</td>
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<tr>
<td>Aggressive aerobic SRT</td>
<td>+</td>
<td>=</td>
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<tr>
<td>AerAOB seed</td>
<td>+/-</td>
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<tr>
<td>COD needed for nitrite removal</td>
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<td>≠</td>
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<table>
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<th></th>
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<th>Selective AnAOB retention</th>
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<td>High AnAOB SRT (cyclone/screen)</td>
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<td>+</td>
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<tr>
<td>Shear to avoid NOB in AnAOB fraction</td>
<td>-</td>
<td>≠</td>
<td>+</td>
</tr>
<tr>
<td>AnAOB seed</td>
<td>-</td>
<td>†</td>
<td>+</td>
</tr>
</tbody>
</table>
Contact: sudhir.murthy@dcwater.com
Utilizing Integrated Planning to Cost-Effectively Address Municipal Wet Weather Challenges

Presented by:

John Lyons, P.E.

April 8, 2014
Communities across the country are struggling with issues of deteriorating infrastructure, unemployment, decreasing populations, regulatory compliance, and limited funds. This presentation will include case studies of regional integrated planning efforts for CSO communities and how a holistic approach that considers Clean Water Act compliance in the context of other community needs can be implemented cost effectively.
INTEGRATED SOLUTIONS FOR CSO CONTROL
Challenges Facing Today’s Communities

Urban Blight  Flooding  Public Services  Employment
Integrated Planning Leads to Community Specific Solutions

- **Natural Systems**: Topography, Hydrologic Network, Tree Canopy, Soils & Geology
- **Built Systems**: Transportation Infrastructure, Sewer Infrastructure, Utilities, Property Boundaries/Ownership

**Integrated Planning Solution**

- **Community**: Demographics, Local Economy, Cultural Resources, Building Stock
- **Planning Tools**: Historical Maps, Neighborhood Plans, Comprehensive Plans, Site Reconnaissance

**INTEGRATED SOLUTIONS FOR CSO CONTROL**
“Business Case” Criteria Solutions

• **Cost-Benefit Evaluations**
  - Cost per Gallon (CSO)
  - Cost per Gallon (Stormwater)

• **Triple Bottom Line Evaluations**
  - Social
  - Environmental
  - Economical

• **Life Cycle Cost Evaluations**
  - Program Duration
  - Annual O&M
A Holistic, *Watershed-Based* Approach to CSO Control Provides Sustainable, Cost-effective Solutions

Combined Sewer Overflows (CSOs)

- **14.3 billion** gallons annually
- **212 CSO** locations

Sanitary Sewer Overflows (SSOs)

- **76 SSO** locations
Lick Run Watershed
Lick Run Watershed – Existing Conditions

Annual Stormwater Runoff Volume
3.02 BG

Annual CSO Volume
1.50 BG
Lick Run Watershed – Progression of Land Use
Lick Run Watershed
What is the Best Way to Achieve CWA Compliance?

Existing 19.5’ Sewer

Proposed Deep Tunnel
Lick Run Watershed – Community Challenges

• CSOs
• Localized flooding
• High crime
• High vacancy/foreclosure
• Low MHI
• High unemployment
• Transportation network
Existing Conditions
Community Issues Within the Watershed

Per Capita Income (2008)
- South Fairmount: $14,500
- Cincinnati: $26,000

Median Household Income (2008)
- South Fairmount: $27,197
- Cincinnati: $37,209
Lick Run Watershed – Priority and Non Priority Basins

Tier 1 Area = approximately 1,850 acres
Tier 2 Area = approximately 850 acres
Proposed Solution Lick Run Solution

712 MG of CSO Reduction
$164M = $0.23/gallon

Includes Construction, Property Acquisition, Design, Contingency
How could MSD’s investment support future public/private investments?

Neighborhood District Concept
Hybrid Conveyance System and Functions
Proposed Lick Run Solution
Proposed Lick Run Solution
Proposed Outfall from Lick Run to the Mill Creek
### Deep Tunnel vs. Sustainable Alternative

<table>
<thead>
<tr>
<th></th>
<th>Deep Tunnel</th>
<th>Sustainable Alternative</th>
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<tbody>
<tr>
<td>Reduce CSOs</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>Maximize Water Quality Benefits, Convey Runoff to Mill Creek</td>
<td>✗</td>
<td>✔</td>
</tr>
<tr>
<td>Maximize Community Benefits</td>
<td>✗</td>
<td>✔</td>
</tr>
<tr>
<td>Provide Catalyst for Community Investment</td>
<td>✗</td>
<td>✔</td>
</tr>
<tr>
<td>Enhance/Improve Neighborhood Assets</td>
<td>✗</td>
<td>✔</td>
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<tr>
<td>Address Vacancy, Foreclosure and Abandonment Issues</td>
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<td>✔</td>
</tr>
<tr>
<td>Strategic Reuse of Urban Land</td>
<td>✗</td>
<td>✔</td>
</tr>
<tr>
<td>Create Green Space</td>
<td>✗</td>
<td>✔</td>
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</tbody>
</table>
### Lower Mill Creek Sustainable Alternative Cost Comparison

<table>
<thead>
<tr>
<th></th>
<th>Grey Alternative</th>
<th>Sustainable/Hybrid Alternative</th>
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</thead>
<tbody>
<tr>
<td><strong>Capital</strong></td>
<td>$ 414,446,000</td>
<td>$ 244,367,000</td>
</tr>
<tr>
<td><strong>Cost/gallon removed</strong></td>
<td>$ 0.40</td>
<td>$ 0.23</td>
</tr>
</tbody>
</table>

“The Grey Alternative has significantly higher capital, life cycle, and CSO reduction unit costs [compared to] those of the Phase 1 Sustainable/Hybrid Alternative.”

*Lower Mill Creek Partial Remedy: Alternatives Evaluation Preliminary Findings Report, June 25, 2012*
Rapid Run Watershed
Rapid Run Watershed Evaluation

Drainage Area: 949 acres
395 MG annual stormwater runoff volume
465 MG of Annual CSO
Proposed Gray HRT Solution = $26M
The historical hydrologic network included 10.6 miles of creeks and streams. Today only 2.5 miles remain.
There are 16 miles of combined sewers in the Rapid Run study area.
FEMA Hazard Mitigation Grant

Legend

FEMA Properties
- Purple: FEMA Grant Phase 1 Parcels
- Green: FEMA Grant Phase 2 Parcels
- Blue: FEMA Grant Phase 3 Parcels
Rapid Run Watershed Evaluation

DRAINAGE AREA SUMMARY

Detention Opportunities
- Drainage Area: 137 acres
- Annual Runoff: 66 MG

Offloading Opportunities
- Drainage Area: 812 acres
- Annual Runoff: 329 MG
Example Channel Segment

Potential for Expanding Existing Sidewalk between Channels

Proposed Biofeature

Proposed Waterway

8’ Maintenance & Multi-Purpose Path
Conceptual Integrated Solution
### Cost and Benefit Summary

<table>
<thead>
<tr>
<th>Cost and Benefit</th>
<th>HRT Facility</th>
<th>Integrated Solution</th>
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<tbody>
<tr>
<td>Total Cost</td>
<td>$26.6M</td>
<td>$25.6M</td>
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<tr>
<td>Volume of CSO Reduction</td>
<td>213 MG</td>
<td>229 MG</td>
</tr>
<tr>
<td>Cost/Gallon of CSO Removed</td>
<td>$0.12</td>
<td>$0.11</td>
</tr>
</tbody>
</table>
Sanitation District No. 1

Green Infrastructure Program
Supports Adaptive Watershed Management Consent Decree

Combined Sewer Overflows (CSOs)

2 billion gallons annually

Sanitary Sewer Overflows (SSOs)

80 million gallons annually

Stormwater Runoff (NSP+MS4)

70 billion gallons annually

Hydromodification

209 miles of sewer infrastructure adjacent to streams
Regional Green Infrastructure

- Western Gateway
- Conserve Supporting/Exceptional Waters
- Green Urban Core
- Ohio River "Defining Water Resource"
- Eastern Gateway
- Licking River Valley "Regional Green Spine"
- Provide Buffers for Major Streams
- Enhance and Connect Region's Green Framework
- Southern Gateway
- Conserve Supporting Waters
- Restore/Enhance Impaired Waters
Willow Run Watershed
Willow Run Watershed

Existing Conditions:
1,800 acres, 614 MG CSO

Proposed Solutions:
- Basin retrofits
- Stormwater Re-use
- KYTC Partnership
- Regional WQ Treatment

INTEGRATED SOLUTIONS FOR CSO CONTROL
Willow Run Watershed
Willow Run: Terraced Reforestation
Willow Run: Terraced Reforestation

2010

2012
Willow Run: Terraced Reforestation

Existing Conditions
17 Acre drainage area

Modeled Benefits
5.6 MG CSO reduction annually

Actual Cost
$1.29 Million
$0.23/gallon of CSO reduction
Willow Run: Retrofit of Existing Dry Basin

- Multi-staged outlet control structure provided very minimal benefit for smaller design storms
- Detention basin provided excess storage capacity that was under utilized during most storm events
Willow Run: Retrofit of Existing Dry Basin
Willow Run: Retrofit of Existing Dry Basin

Existing Conditions
110 acre drainage area
2 acre existing basin

Monitored Benefits
23.2 MG CSO reduction annually

Actual Costs
$300,000 (retrofit only)
$0.013/gallon of CSO reduction
$1.6 M (complete project)
$0.07/gallon of CSO reduction

Flow monitoring performed 1 year pre-construction and 1-year post-construction at the outfall of the basin to validate the benefit.
Willow Run: 12th Street Green Street

Modeling Results
300,000 gallon CSO reduction/year

Actual Costs
$80,000
$0.27/gallon of CSO reduction
Benefits of Integrated Planning

• Achieves CWA compliance goals cost effectively
• Maximizes the return on investment (ROI) with community specific solutions
• Incorporates current planning and priority issues within the study area
• Identifies opportunities for public and private partnerships
• Identifies programs and policies to ensure future sustainable growth and redevelopment
• Considers community connectivity and revitalization opportunities
QUESTIONS?

John Lyons, P.E.
Strand Associates, Inc.

John.lyons@strand.com
Central States WEA 19TH Annual Education Seminar: SUSTAINABILITY

MMSD’s Regional Green Infrastructure Plan: Visions of 740 Million Gallons

April 8, 2014

Karen Sands, AICP
Manager of Sustainability
Milwaukee Metropolitan Sewerage District
Today’s Talk...

• MMSD Background/Impetus for Going Green
• Pre-Plan Programs
• MMSD Regional GI Plan
• What’s Next?
Milwaukee Metropolitan Sewerage District

We Serve:
• 1.1 Million Customers
• 28 Municipalities
• 411 Square Miles

We Protect the Public & Lake Michigan:
• Convey/Store/Reclaim Wastewater
• Manage Flooding
MMSD’s Grey Backbone...

- Sewers
- Treatment Plants
- Tunnels/Storage Vessels
- Large-scale Flood Management
The MMSD Region’s Sewers

300 Miles
MMSD Sewers

3,000 Miles
Municipally Owned Sewers

3,000 Miles
Private Laterals

3/26/2014
Water Reclamation Facilities

Jones Island

South Shore

3/26/2014
ISS/Deep Tunnels

300 Feet
Below ground

521 Million
Gallons of Storage

28.5 Miles
Long

17- to 32-feet
In Diameter

Designed to minimize basement backups and for 1-2 overflows per year.
Also, Flood Management
Lincoln Creek Example

- Concrete removal to naturalize channel
- Minimized floodplain
- Habitat enhancement
The Deep Tunnel has kept 98+ Billion Gallons of pollution out of Lake Michigan.

3/26/2014
Overflow Reduction Plan

- $1 Billion Spent by 2010
- Reclamation Facility Upgrades
- Deep Tunnels
- Sewer Rehabilitation

3/26/2014
End Result!
Despite An Extensive Grey Backbone, CSOs Still Happen
To Serve Our Region...
MMSD Implements Grey & Green Infrastructure

GREEN + GREY = OVERFLOWS
The Business Case For Going Green

• Green Infrastructure Can Supplement Traditional Grey Infrastructure

• Green Infrastructure Provides Many Other Quantifiable Benefits
  • Economic
  • Social
  • Environmental
Before There Was a Plan…

- “Every Drop Counts” Campaign
- Greenseams Property Acquisitions
- Flood Management Projects
- Increasingly Widespread Green…
  - Rain Barrels & Rain Garden Plant Sales
  - Downspout Disconnections
  - Green/Sustainable Infrastructure Partnerships
  - Studies to Justify the “Business Case”
Many Strategies, Many Pilot Projects, Multiple Scales
Greenseams®

2,600+ Acres Since 2002

3/26/2014
Lake Michigan Rain Garden Initiative

Over 26,000 plants sold since 2006
Rain Barrels

• Over 18,000 Sold
• Triple-bottom Line Story
• Over 1,000,000 Gallons/Event
• Benefits in Milwaukee
  • Widespread Implementation
  • Far-Ranging Outreach has Spill-over Value
  • Unique Approaches
  • Culture Change
  • Volume of Interest
  • Technical Successes
Green Roofs

MMSD

Clock Shadow Building

9+ acres

Mequon

MillerCoors

3/26/2014
We Meet Our Effluent & AQ Permits, So...

- Is That Enough?

- Does Our Public Expect More?

- Are We “Sustainable”? What about “Regenerative”?

- What Does the Future Hold? What’s our Role? How Do We Plan For it?
MMSD’s 2035 Vision and Strategic Objectives

Strategic Objectives For:

1. Integrated Watershed Management

2. Climate Change Mitigation/Adaptation with an Emphasis on Energy Efficiency

3/26/2014
2035 Vision’s Green Infrastructure Goals

- Capture the 1\textsuperscript{st} 0.5” of rainfall
- Capture & reuse the 1\textsuperscript{st} 0.25 gallon per SF
Green Infrastructure In MMSD’s Discharge Permit

4.10 Wet Weather Management-Green Infrastructure

“...The practices/control measures put in place in 2013 must cumulatively have a design retention capacity of at least 1 million gallons, and each following calendar year during the permit term an additional 1 million gallons of green infrastructure retention capacity must be put in place...”
Regional Green Infrastructure Plan: Why Do It?

- Implement the 2035 Vision (740 MG!!)
- Help Prioritize GI Funding Decisions
- Provide Input to Next Facilities Plan
- Logically Implement WPDES GI Goals

Milwaukee Metropolitan Sewerage District
Regional Green Infrastructure Plan / 2035 Vision Capture Goal

Capture 0.5 inch of rainfall = 740 million gallons
Recommendations by Green Infrastructure Strategy

- Bioretention/Rain Gardens: 26%
- Porous Pavement: 21%
- Rain Barrels: 1%
- Cisterns: <1%
- Soil Amendments: 22%
- Native Landscaping: 18%
- Green Roofs: 9%
- Stormwater Trees: 3%

740 MG =
Evaluated Green Infrastructure Triple-Bottom-Line Benefits

• Economic benefits
• Social benefits
• Environmental benefits
Watershed-specific Conditions

Planning Area Total Impervious Square Miles
91.1
Out of 411.2 Square Miles in the Planning Area

Impervious Type Breakdown
- Airport: 21%
- Buildings: 38%
- Parking Lots: 34%
- Streets: 45%

FOX RIVER WATERSHED
- Total Square Miles: 41.8
- Impervious Square Miles: 4.7

LAKE MICHIGAN DIRECT DRAINAGE
- Total Square Miles: 21.3
- Impervious Square Miles: 5.3

OAK CREEK WATERSHED
- Total Square Miles: 24.9
- Impervious Square Miles: 5.3

KINNICKINNIC RIVER WATERSHED
- Total Square Miles: 24.7
- Impervious Square Miles: 10.8

ROOT RIVER WATERSHED
- Total Square Miles: 71.8
- Impervious Square Miles: 11.5

MILWAUKEE RIVER WATERSHED
- Total Square Miles: 95.0
- Impervious Square Miles: 24.8

MENOMONEE RIVER WATERSHED
- Total Square Miles: 131.7
- Impervious Square Miles: 28.7
Plan Investment by Surface Type

- Parking Lots: $247 million
- Buildings: $488 million
- Streets: $489 million
- Turf Grass Areas: $71 million
Recommendations Support Other Initiatives

• MMSD:
  – Private Property Inflow & Infiltration (PPII) Reduction Program
  – TMDLs
  – Flood management

• Partners:
  – Watershed restoration plans
  – Other green infrastructure initiatives
How do GI & PPII Intersect? ...Rain Gardens!

Discharge to mowed grass

Discharge to rain garden
What’s So Groundbreaking?

- Emphasizes Combined & Separate Sewer Service Areas
- Supports Private Property Inflow & Infiltration
- Promotes Turf Grass with Soil Amendments

Milwaukee Metropolitan Sewerage District
What’s Next With GI?

• Existing Partnership Programs Continue/Expand

• New Programs:
  – Schools
  – Economic Development

• Ad-hoc Committee Tackles Policy

• R&D with O&M: Sensors/Meters

3/26/2014
Common Threads

• **Innovation**: Imagination is everything. It is the preview of life’s coming attractions.

• **Collaboration**: Coming together is a beginning; keeping together is progress; working together is success.
Karen Sands, AICP
Milwaukee Metropolitan Sewerage District
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414-225-2123
www.mmsd.com
www.h2ocapture.com
19th Annual Central States Education Seminar

Using Innovative Project Delivery Methods to Deploy Sustainable Alternatives

April 8, 2014
Overview

- Project Delivery Basics
  - Types
  - Risks
- Sustainable Project Case Studies
  - Biogas Project (DBFOO)
  - Struvite Recovery Project (Progressive DB)
- Q & A
Project Delivery Basics
Traditional Design-Bid-Build Project

- Utility
  - Design Professional
  - Utility Operations
  - General Contractor
  - Subcontractors
Construction Manager at Risk Project

- Construction Manager
- Design Professional
- Utility Operations
- Subcontractors
Design/Build Project with County Operations

- Utility
  - Independent Consultant(s)
  - Utility Operations
  - Design-Builder
  - Subcontractors
Design-Build-Operate Project

UTILITY

Independent Consultant(s)

DBO Contractor

Subcontractors

Contract Operations
Design-Build- Maintain Project

UTILITY

Independent Consultant(s)

Utility Operations

Design/Build/Maintain Contractor

Subcontractors
Design-Build-Operate-Finance Project

- Utility
  - Independent Consultant(s)
  - Design/Build/Operate/Finance Contractor
    - Subcontractors
  - Operations
  - Contractors

Diagram Source: GERELEY AND HANSEN
Design-Build-Own-Operate-Finance Project

- Utility
- Independent Consultant(s)
- Design/Build/Own/Operate/Finance Contractor
- Subcontractors
- Contract Operations
Project Delivery Choices

- Traditional (Design-Bid-Build)
- Construction Manager at Risk
- Design/Build (traditional)
- Design/Build Maintain
- Progressive Design/Build
- Design-Build-Operate
- Design Build Finance Own Operate
Project Delivery Selection Considerations

- Optimize Risk Allocation
- Optimize Financial Attractiveness
- Minimize Construction Costs
- Minimize O&M Cost
- Minimize Potential for Cost Overruns
- Viable In the Marketplace
Project Delivery Selection Considerations

- Assure Schedule Compliance
- Level of Utility Control
- Assure Discharge Permit Compliance
- Minimize Permitting Risk
- Utility Experience with Method
- Utility Staffing Considerations During Design/Construction
Project Delivery Selection Considerations

- Utility Staffing Considerations During Operation
- Probable Quality of Project
- Ease of Implementing Changes
- Ease of Complying with Changed Regulations
- Risk Adjusted Net Present Cost
## Selection Matrix

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Ranking</th>
<th>Weight</th>
<th>Weighted Ranking</th>
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<tr>
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<td>DBB</td>
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<tr>
<td>Optimize risk allocation</td>
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<td>Alt. Method #1</td>
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<tr>
<td>Optimize financial attractiveness</td>
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<tr>
<td>Minimize construction costs</td>
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<tr>
<td>Minimize O&amp;M costs</td>
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<tr>
<td>Minimize potential for cost overruns</td>
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<tr>
<td>Viable in the marketplace</td>
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<tr>
<td>Assure schedule compliance</td>
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<tr>
<td>Level of County control</td>
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<td>Assure discharge permit compliance</td>
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<td>Minimize permitting risk</td>
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<td>County experience with method</td>
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<tr>
<td>County staffing considerations during design/construction</td>
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<tr>
<td>County staffing considerations during operation</td>
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<td>Probable quality of project</td>
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<tr>
<td>Ease of implementing changes</td>
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<td>Ease of complying with changed regulations</td>
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<tr>
<td>Risked Adjusted NPC</td>
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Risk Allocation / Transfer
Project Delivery Structures:

- CMAR and DBB
- DB
- DBO
- DBFO
- DBFOO
Incorporation of Risk

- **Risks Identification and Quantification**

<table>
<thead>
<tr>
<th>Risk Area</th>
<th>Allocation</th>
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<tbody>
<tr>
<td>Design</td>
<td>Include in Design Contract</td>
</tr>
<tr>
<td>Construction</td>
<td>Include in Construction Contract</td>
</tr>
<tr>
<td>Operating</td>
<td>Include in Operating Contract(s)</td>
</tr>
<tr>
<td>Financing</td>
<td>Reflected in the margin on debt &amp; equity return</td>
</tr>
</tbody>
</table>
What is Risk Management?

- Process of identifying, analyzing, and addressing risks on an on-going basis
  - Help manage (and potentially avoid) negative outcomes

- Ultimate outcome of Risk Management is an Action Plan
  - Mitigate the likelihood and consequences of risk event
Risks

- Alternative Delivery is all about allocating risk
- Alternative Delivery models can result in significant value (savings) if the risks are allocated appropriately
- Alternative Delivery allocates project risks to the party that can best manage the risk
- Transparency is essential
  - All parties must be aware of the risks
  - Parties must agree on risk allocation and responsibility
Application of Risk Management

- **Risk Management Objectives**
  - Business case
  - Procurement
  - Final Contract Negotiations
  - Mitigation for retained risks over the long term

- **Detailed Tasks**
  - Identify & Describe Risk
  - Analyze Possible Range of Consequences
  - Evaluate Likelihood and Impact
  - Quantify if Possible
  - Build / Manage a Risk Matrix
The Risk Process

- **Risk Identification**
  - Brainstorming; Personal and Professional Experience; Project Breakdown Structure Analysis; Others

- **Risk Assessment**
  - Experience; Statistical Evidence
  - Quantification

- **Risk Mitigation**

- **Risk Allocation**
  - Transfer / Retain / Share between the parties
  - Use in Contracts / Agreement
## Risk Allocation for D-B Project

<table>
<thead>
<tr>
<th>Risk</th>
<th>Design-Build Team</th>
<th>Owner</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design</td>
<td>X</td>
<td>?</td>
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<tr>
<td>Building Permits</td>
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<tr>
<td>Environmental Approvals / Permits</td>
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<td>X</td>
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<tr>
<td>Schedule</td>
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<tr>
<td>Cost</td>
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<td></td>
</tr>
<tr>
<td>Project Performance / Acceptance</td>
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<td></td>
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<tr>
<td>Uncontrollable Circumstances</td>
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<td>X</td>
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<tr>
<td>Material Escalation</td>
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<tr>
<td>Subsurface Conditions</td>
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<td></td>
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<tr>
<td>Site Contamination</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Change in Law and Regulations</td>
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<td></td>
</tr>
<tr>
<td>Land and Easement Acquisition</td>
<td></td>
<td>X</td>
</tr>
</tbody>
</table>
Case Study

Biogas Project Experience
Regional Optimization Master Plan (2007)

Findings / Recommendations:
- Current Biosolids Disposal Cost Effective
- Centralize Biosolids Processing
- Single Outlet for Biosolids Disposal / Utilization
- Beneficially Use Biogas
- Replace or Upgrade Existing Powerhouse
- Requires Further Study / Evaluation
Biosolids Process Diagram

Ina Road WRF

RAW WASTEWATER → LIQUID STREAM TREATMENT → SOLIDS → ANAEROBIC DIGESTERS → DIGESTED BIOSOLIDS

Roger Road WRF

SOLIDS FROM SUBREGIONAL TREATMENT FACILITIES

RAW WASTEWATER → LIQUID STREAM TREATMENT → SOLIDS → ANAEROBIC DIGESTERS

ELECTRICITY HEAT

DIGESTED BIOSOLIDS → BENEFICIAL TO LAND APPLICATION
Findings / Recommendations:
- Existing 13.8 KV Service Is Inadequate
- Existing Powerhouse Online for 35+ Years
- Powerhouse at End of Service Life

Recommendations:
- Install New 46KV Feed Service
- Negotiate Most Favorable Energy Rate with Local Commercial Utility (LLP 14 Tariff – 6.3 cents / kWh)
- Shutdown Existing Powerhouse
- Construct Thermal Energy Plant
- Determine Future Use of Biogas
Powerhouse Facility

NEW FACILITIES

REMODELED FACILITIES
System Wide Biosolids and Biogas Utilization Master Plan (2012)

- Request for Expressions of Interest
- Findings / Recommendations:
  - Continue Current System-Wide Biosolids Disposal / Reuse Practices
  - Develop Options for Future Biosolids Beneficial Reuse
  - Expedite Beneficial Use of Biogas Project
    - Clean Biogas to Natural Gas Pipeline Quality
    - Use Alternative Project Delivery – DBFOO
    - Seek Renewable Energy Market Outlets
Why DBFOO?

- Request for Expression of Interest Results Encouraged DBFOO
- Least Risk to Pima County
- Requires Specialized Technologies
- No Financial Investment
- Project Not a Core Function of Wastewater Operations
- County Unfamiliar with Commodity Markets
Key Project Drivers

- RWRD’s Commitment to Beneficially Utilize Byproducts at the Lowest Cost to Its Ratepayers
- In Times of Rising Energy and Electricity Costs, It Makes Economic Sense to Become Increasingly Energy Conscious
- Recent Studies Conclude that Generating Onsite Electricity from Biogas Is Not Economically Justified
- RWRD Believes Biogas Volume and Energy Value Has Economic Benefit
- New Developments In Renewable Energy Markets Make Biogas a Valuable Commodity
Contracting Methodology

- ARS Title 34 Does Not Applicable
  - Careful Interpretation of Regulatory Statutes Critical
    - This is a Biogas Sale, Not a Procurement
- Project Outside RWRD Core Mission/Expertise
- Based on DBFOO Project Delivery
- Project Documents Advertised
  - Volume I: Draft/Final RFP
  - Volume II: Draft Service Contract / Ground Lease Agreement
Why Two Options

- Studies and Research Conclude Biogas-to-Biomethane and Sale to Marketplace
- Recent Biogas Projects in Southwest Included Options:
  - Biogas-to-Biomethane
  - Combined Heat and Power
    (San Antonio, TX and Phoenix, AZ)
- Pima County Seeks the Optimal Return on Biogas Utilization and Revenue
Biogas Cleaning System

(Greenlane Process)
Current Status

- RWRD Advertised Project as RFP
- RWRD Advertised Project as RFQ
- Ranked Received Offerings (5)
- Negotiating with Top Ranked Company
- Revenue % of Gross Receipts
- 15-year Term with 5-year Renewal
Case Study
Struvite Recovery Project
Business Case

- **Struvite Management – FeCl₃ Addition**
- **Struvite Recovery Benefits**
  - Reduces (Eliminates) Chemical Addition
  - Reduces Biosolids Production
  - Reduces Side Stream Recycles
  - Reduces Plant Power Demands
  - Expands Plant Capacity
  - Produces Saleable Product (Struvite)
  - Economic Analysis -- ROI = 8 years
Project Economics
- Partial Demolition of Existing Powerhouse
- Convert WAS Receiving and Blending Tank to WASSTRIP
- Install Appropriate Yard Piping
Struvite Recovery Facility - Section

- NEW ROOF
- FUTURE REACTOR
- 10'-0" CLEARANCE
- CLASSIFYING SCREEN
- STRUVITE RECOVERY FACILITY
- BUCKET CONVEYOR
- Dewatering Screen
- STORAGE SILOS
- BAGGING CONVEYOR
- ROLL-UP DOOR (TYP)

First Floor
(FL EL 2194.00)

Tunnel
(FL EL 2180.00)

Raised Roof

EL 2228.30
WASSTRIP

115' Diameter

WAS Receiving and Blending Tank

PLAN

SECTION

115' Diameter

GREELEY AND HANSEN
Project Characteristics

- Expedite Project Delivery
- New Facilities in Re-Purposed Existing Structures
- O&M Staff Involvement During Project Development
- Request for Qualifications Stating:
  - Performance Requirements
  - Prescriptive Requirements
- Specific Technology
Ostara Pearl Technology

[Diagram of Ostara Pearl Technology process]

- DEWATERING UNIT
- AIR DRYER
- DEWATERED SLUDGE CENTRATE
- CAUSTIC
- MAGNESIUM CHLORIDE
- STRUVITE RECOVERY REACTOR
- DRY STRUVITE PRODUCT
- Metallic Structure
- FEED PUMP
- RECYCLE PUMP
- WAS FILTRATE
Project Delivery

Alternatives

- Design Build-Build
- Construction Manager at Risk
- Design/Build
- Design Build Operate
DBB Delivery *Key Features*

- Owner Controls Bidding Process
- Allows for Design Input and Discussion
- Owner Retains Ownership / Control of Assets
- Provides for Greater Phasing of Components, Integration of New Technologies
- Owner Retains Potential for Greater Cost, Schedule and Lifecycle Risks
CMAR Key Features

- Allows for Fast Tracking and Early Construction Start with Early Price Predictability
- Owner Maintains Complete Design Control
- Provides for Flexibility in Design with Owner Input and Discussion
- Owner Retains Ownership / Control of Assets
DB  *Key Features*

- Expedited Project Delivery
- Owner Sets Forth Performance Criteria
- Owner May Specify Detailed Design Criteria and Clear Standards for Key Systems / Equipment - Level Ranges Low to High
- Price Certainty Is Provided Upon Contract Signing
- Design and Most Construction Risk Rests with Design-Build Team
- Owner Retains Ownership / Control of Assets
- Quality Issues: Potential for Use of Short Lifecycle Equipment/Systems, Therefore, Potential for Greater Overall Lifecycle Cost
## Multiple Criteria Scoring Table

| Scoring Criteria                        | Weight | DBB  | CMAR | DB   | DBO  | DBFO | DBB  | CMAR | DB   | DBO  | DBFO |
|-----------------------------------------|--------|------|------|------|------|------|------|------|------|------|------|------|
| Optimize Risk Allocation                | 8      | 4    | 5    | 7    | 8    | 10   | 32   | 40   | 56   | 64   | 80   |
| Project Quality and Asset Management   | 10     | 6    | 7    | 6    | 8    | 8    | 60   | 70   | 60   | 80   | 80   |
| Implementation Schedule                 | 10     | 5    | 6    | 9    | 8    | 7    | 50   | 60   | 90   | 80   | 70   |
| Regulatory Compliance                   | 4      | 8    | 8    | 8    | 8    | 8    | 32   | 32   | 32   | 32   | 32   |
| Sustainability                          | 4      | 7    | 7    | 6    | 7    | 7    | 28   | 28   | 24   | 28   | 28   |
| Staffing Considerations                 | 4      | 7    | 7    | 7    | 3    | 3    | 28   | 28   | 28   | 12   | 12   |
| Level of County Control                 | 4      | 10   | 9    | 8    | 5    | 5    | 40   | 36   | 32   | 20   | 20   |
| Market Viability                        | 6      | 10   | 10   | 8    | 5    | 4    | 60   | 60   | 48   | 30   | 24   |
| Flexibility                             | 3      | 10   | 10   | 8    | 6    | 5    | 30   | 30   | 24   | 18   | 18   |
| Cash Flow                               | 9      | 5    | 5    | 5    | 5    | 10   | 45   | 45   | 45   | 45   | 90   |
| Cost - Present Value                    | 10     | 7    | 7    | 8    | 9    | 6    | 70   | 70   | 80   | 90   | 60   |
| Predictability of Costs                 | 6      | 4    | 5    | 6    | 8    | 8    | 24   | 30   | 36   | 48   | 48   |
| Fiscal and Legal Complexity             | 6      | 10   | 10   | 9    | 8    | 6    | 60   | 60   | 54   | 48   | 36   |
| **Weighted Rank Totals**                |        |      |      |      |      |      | 559  | 589  | 609  | 595  | 593  |

Ranking: 1 to 10 with 10 being excellent
Weight: 1 to 10 with 10 being extremely important
Progressive Design-Build

- “Progressive” DB Model Complies with Arizona Law
- Qualifications Based Selection - “Price / Cost-Related” Criteria Are Not Included in Selection Criteria (e.g., rates, conceptual / target construction cost…)
- Offers Owners Flexibility / Opportunity to Collaborate on Design
Progressive DB *Key Features*

- Expedited Project Delivery
- Owner Sets Forth Performance Criteria & Collaborates with DB Team
- Owner May Specify Detailed Design Criteria and Standards for Key Systems / Equipment
- Price Certainty Is Negotiated Once Plans Are Almost Finalized
- Most Design and Most Construction Risks Rest with Design-Build Team
- Owner Retains Ownership / Control of Assets
- Quality Issues: Less Potential than DB for Use of Short Lifecycle Equipment
Current Status

- Project Procurement Documents under Development
  - Performance
  - Prescriptive
- Economic Sensitivity Analysis
- Advertise 3rd Quarter of 2014?
Questions and Answers
Design-Bid-Build Delivery

- Defined, Proven Process
- Distinct Milestones to Ensure Expected Results
- Manages to Known Challenges (Unknowns = Change Orders)
- Traditional “Cast” of Participants
- Greatest Potential for Litigation
- Not Performance Based
- *Does Not Always Meet Owners’ Needs for Collaboration, Innovation, and Accountability*
Construction Manager at Risk

- Design-Bid-Build “Plus”
- Promotes Early Collaboration Between Design Professional and Contractor
- Allows Selection of a Contractor Based on Qualifications and Professional Fee (*open book contracting and self-perform work*)
- Not Performance Based
- *Relies on Separate Contracts, Resulting in a “Forced Marriage”*
Design-Build Delivery

- Single Contract for Design and Construction
- Offer Owners a Variety of Evaluation Options Ranging from Nearly All Qualifications Focused, to “Best Value” with Lump Sum or Guaranteed Maximum Price
- Performance Based Results