SESSION 11: UPGRADING WASTEWATER TREATMENT FACILITIES WITHOUT MULTI-MILLION DOLLAR UPGRADES

UTILITY MANAGEMENT CONFERENCE: MAKING PROGRESS MORE APPARENT
SAVANNAH, GEORGIA
FEBRUARY 26, 2014
Upgrading Wastewater Treatment Facilities without Multi-Million Dollar Upgrades

Paul LaVigne – State of Montana
Jay Young - Plainfield, Connecticut
Bob Trombley - Montague, Massachusetts
Grant Weaver - The Water Planet Company

Utility Management Conference: Making Progress More Apparent
Savannah, Georgia
February 26, 2014
Our Story: Operations First

Nutrient Limits are Coming!

Approaches to Meeting New Permit Limits

1. Traditional: Facility Upgrade
2. Experiment with Operational Changes (Model A)

Empowered Operators can oftentimes make Existing Equipment meet new Permit Limits at Incredible Financial Savings

$10s Millions on Upgrades
$100s Thousands in O&M Costs

Case Studies
Q&A
National effort to upgrade Wastewater Treatment Plants to Remove Nitrogen & Phosphorus

Why the interest in Nutrient Removal?

Montana's regulatory approach to N&P Removal

Permittee approach to compliance

- Conventional Facility Planning by Design Engineers
- New Model A: Operational Strategies

A few words about Wastewater Operators

Paul LaVigne
State of Montana
EMPOWERING OPERATORS to IMPROVE NUTRIENT REMOVAL at WASTEWATER TREATMENT PLANTS

CHANGING THE FOCUS FROM CAPITAL IMPROVEMENT PROJECTS TO OPTIMIZING OPERATIONS USING EXISTING INFRASTRUCTURE
First of all, Why Nutrients?
Nuisance algal growth, rivers & streams
Attached algae growth commonly quantified as chlorophyll *a* per square meter of stream bottom.

- 40 mg Chla/m²
- 120 mg Chla/m²
- 300 mg Chla/m²
Nutrient Reduction

• Nitrogen and/or Phosphorous
  – Enhance eutrophication of streams and lakes
  – Municipal discharges are a concern
  – — there are other sources
  – Evolving numeric nutrient stds may affect many WWTPs that discharge to surface water

• Two Basic Options:
  – Eliminate or reduce the discharge — not always practical
  – Provide better treatment
Numeric Nutrient Stds Timing (Montana)

• After 5-years of outreach to stakeholders
• Variance process currently in law
• General variance is in law
• Stds rule package well underway
• Public hearing March 24, 2014
• Expected to be implemented this year as permits come up for renewal
Proposed Nutrient Limits (Montana)

In-Stream WQ Stds

- Ecoregion-based
- TP – 0.006 – 0.124 mg/l
- TN – 0.209 – 1.358 mg/l

Effluent Limits

- Variance Processes
  - Affordability-based
  - Hyd. Capacity-based
- Phased approach
- Mech. WWTP > 1MGD
  - TP 1 mg/l, TN 10 mg/l
  - TP 0.5 mg/l, TN 8 mg/l
  - ??? (lower) ???
  - Meet Stds in 20 yrs ???
Better Treatment: Changing the Model

• Model for the past 40+ years for Wastewater Treatment Improvement:
  – Identify a deficiency
  – Hire an engineer to prepare Facilities Plan
  – Obtain loans and grants
  – Raise user rates to pay the debt
  – Design and construct a capital project
  – Train operators to manage the facility
    • Directed by design engineer or their predecessor
A New Model

- Model A for Wastewater Treatment
  - Identify a deficiency (lower N and P limits)
  - Look in-house at possible solutions
    - Look at EXISTING infrastructure
    - Look CLOSELY at the operations as a solution
  - Train operators to TAKE CONTROL of the Facility (make it do what we want it to)
  - THEN, if not successful, hire an engineer to begin planning
Put Another Way……

• Using existing infrastructure, can we re-engineer our operations to make the facility do things it was not originally designed to do?

  OR

• Can we get better performance from our existing infrastructure by operating the facility differently?
Comparison of Models

**Old Model**
- Engineer-intensive
- Capital-intensive
- Rate increases
- May be based on models
- Still relies on operator knowledge – nutrients
- Results in lower effluent N & P

**Model A**
- Operator-intensive
- Training and follow up
- Non-Capital-intensive
- May not need rate increases
- Based on actual bio and chemical data
- Results in lower effluent N & P
- Sustainability
The Problem with Operators

- UNDERPAID
- UNDER-APPRECIATED
- UNDER-UTILIZED
- UNDER-TRAINED
Training

• The trainer’s qualifications and intent are critical to the success of this approach.
  – No substitute for operational experience
  – Operators relate to other operators
  – Typically a microbiologist or biochemist
  – Engineer?????
  – A motivational person –
    • May live in a van down by the river

• There aren’t many qualified trainers left
Your Facility

• What is important to success?
  – Existing Infrastructure – what do you have?
  – Loading - industrial sources?
  – Capacity – growth?
  – Public works/City council buy-in
  – Regulator cooperation/understanding
    • Training EPA
  – Operations staff attitude – most important
## With Classroom Training Alone

<table>
<thead>
<tr>
<th>Location</th>
<th>Process Type</th>
<th>Initial TN (mg/l)</th>
<th>Final TN (mg/l)</th>
<th>Improvement</th>
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<tbody>
<tr>
<td>Manhattan, MT</td>
<td>Biowheel</td>
<td>10.7</td>
<td>7.4</td>
<td>31%</td>
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<tr>
<td>Manhattan, MT</td>
<td>Oxidation ditch</td>
<td>25.3</td>
<td>13.1</td>
<td>48%</td>
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<tr>
<td>Conrad, MT</td>
<td>Biolac</td>
<td>26.3</td>
<td>4.7</td>
<td>82%</td>
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</table>
What Happens After the Trainer Leaves??

- Operators have a much better understanding of wastewater treatment.
- Operators are typically more engaged in the performance of the facility.
  - Collect meaningful data
  - Understand why the data is important
  - Understand how to use data to improve performance
- You’ve empowered your operators.
Summary

• Major retrofits or upgrades for nutrient removal can be avoided in many cases through well thought-out operational strategies – enormous cost savings

• The trainer/consultant is critical to success
  – Choose him or her carefully

• We’re shifting the focus from engineers to operators – choose them wisely.

• Operators are cool.
Operators Are Sexy
Two 40-year old wastewater treatment facilities – both well “beyond their design life” – were to be replaced with one new 1.5 MGD treatment facility at a cost of $45 million.

Facility planning had been completed, approved by the state, and recently updated.

Changes in USDA funding rules changed Plainfield’s grant eligibility.
Meanwhile, stimulated by Connecticut’s nitrogen trading program to reduce effluent nitrogen, Plainfield experimented with operations and found both plants capable of removing nitrogen.

The ten year strategy to build new was scrapped in favor of renovating the two existing facilities at a cost of $5 million.
Plainfield, Connecticut (population 15,000)
1.5 MGD (two plants)

Traditional Facility Plan Solution:
- Demolish two existing treatment facilities
- Build one new wastewater treatment plant
- Construct new pumping station and force main

Cost: $45,000,000
ReEngineer Operations

Instead ...
- $10,000 investment in monitoring equipment
- Two years of technical support

Resulted in ...
- Improved conventional treatment (TSS & BOD) - permit compliance
- 50% nitrogen reduction
- 75% phosphorus reduction (Village Plant)
- Without increasing O&M expenses

And ...
- Decision to forgo upgrade and instead replace existing equipment at cost of $5,000,000
Primary Clarifier

Aeration Tank

Secondary Clarifier

North Plant (1.0 MGD)
Plainfield, Connecticut
North Plant (1.0 MGD)  
Plainfield, Connecticut
Plainfield North Connecticut

Raise bacterial population (mixed liquor)
Cycle air ON for Ammonia removal / air OFF for Nitrate removal
Monitor with in plant ORP probe
Daily test strip testing for:
  - Ammonia
  - Nitrate
  - Nitrite
  - Alkalinity

Weekly site visits to adjust air ON and air OFF cycles
Plainfield Village (0.5 MGD)
Plainfield, Connecticut

Conventional Operations

Aeration → Secondary Clarifier → Gravity Thickener
Plainfield Village (0.5 MGD)  
Plainfield, Connecticut

Modified Operations
Plainfield Village
Connecticut

Raise bacterial population (mixed liquor)
Keep fixed speed mechanical aerator operating 24/7
Route a percentage of the RAS through the Gravity Thickener
Daily test strip testing for:
   Ammonia
   Nitrate
   Nitrite
   Alkalinity

Weekly data review
Plainfield, Connecticut

New Facility Upgrade: $5,000,000
Renovate both treatment plants

Original Facility Upgrade: $45,000,000
Replace Village Plant with Pumping Station
Build all new plant at site of existing North Plant

$40 million savings
Staff commitment to reducing operating costs...
Capital investment of $75,000...
Five years of ongoing adjustments...
Two years of technical support...

- resulted in -

Nutrient Removal
Huge Monetary Savings
Montague, Massachusetts (population 8,500)

1.8 MGD design / 1.0 MGD average day

**1962 upgrade**  
Primary Treatment

**1982 upgrade**  
Secondary Treatment

**2009 upgrade**  
Combined Sewer Overflow

**2012 upgrade**  
Sludge Press

**2012-2014 projects**  
Sequenced Aeration  
Sludge Composting
Monetary Savings

Capital Savings
  Projected cost of Facility Upgrade for Nitrogen Removal: $4.5 million
  Actual cost: $75,000

Annual O&M Savings*
  $400,000 Increased Revenues from Trucked-In Wastes
  $250,000 Reduced Expenses
    Sludge disposal
    Chemicals

*50% improvement to Montague’s annual budget of $1.25 million
Nutrient Removal

5 mg/L total-Nitrogen
0.75 mg/L total-Phosphorus

18 mg/L BOD
22 mg/L TSS
Current Mode of Operation: Sequenced Aeration
**Sequenced Aeration**

Every 1-1½ hours, valves open and close to switch conditions in the aeration tanks, much like a Sequencing Batch Reactor

Air ON cycle
- Influent valve closes
- Aeration valve opens
- RAS valve closes

Air OFF cycle
- Influent valve opens
- Aeration valve closes
- RAS valve opens
Sequenced Aeration

Primary Clarifiers

Aeration Tanks

Air OFF

Air ON

Secondary Clarifiers

Sequenced Aeration
Secondary Clarifiers

Aeration Tanks

Air ON

Air OFF

Primary Clarifiers

Secondary Clarifiers

Sequenced Aeration
Sequenced Aeration

Raise bacterial population (MLSS) for ...
   Ammonia-Nitrogen removal
   Reduce the amount of waste sludge

Cycle air ON and OFF to create habitats for ...
   Ammonia removal (air ON)
   Nitrate removal (air OFF)

Open and Close inlet and RAS valves to ...
   Optimize treatment time in air ON and air OFF zones
   Reduce solids loading on secondary clarifiers

Return sludge and create zero oxygen zones in Primary Clarifiers to ...
   Remove Phosphorus
   Biodegrade sludge by recycling RAS to headworks (25% volatile suspended solids)
### Montague, Massachusetts Operating Data

<table>
<thead>
<tr>
<th>Jun-Dec '13</th>
<th>Flow (MGD)</th>
<th>Influent (mg/L)</th>
<th>Final Effluent (mg/L)</th>
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<tbody>
<tr>
<td></td>
<td>Total N</td>
<td>BOD</td>
<td>TSS</td>
</tr>
<tr>
<td>0.916</td>
<td>69</td>
<td>747</td>
<td>921</td>
</tr>
</tbody>
</table>
Montague Wastewater Solids (lbs/day)
Influent Solids - White
Sludge Removed - Red
<table>
<thead>
<tr>
<th></th>
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<th></th>
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<th></th>
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</thead>
<tbody>
<tr>
<td>Sewer Customers</td>
<td>$1,348,541</td>
<td>$1,312,016</td>
<td>$1,384,937</td>
<td>$1,457,858</td>
<td>$1,356,392</td>
<td>$1,225,822</td>
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<tr>
<td></td>
<td>96%</td>
<td>97%</td>
<td>94%</td>
<td>92%</td>
<td>86%</td>
<td>73%</td>
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<tr>
<td>Trucked-In Waste</td>
<td>$53,301</td>
<td>$40,865</td>
<td>$81,757</td>
<td>$122,649</td>
<td>$224,267</td>
<td>$457,937</td>
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<tr>
<td></td>
<td>4%</td>
<td>3%</td>
<td>6%</td>
<td>8%</td>
<td>14%</td>
<td>27%</td>
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</table>
Montague, Massachusetts

“We as Operators run the Plant. The Plant doesn’t run us.”

Operator John Little
Grant Weaver

Summation

Two Approaches for Permit Compliance

New Equipment – Traditional Facility Planning
Existing Equipment – the “Model A” approach

A small Investment in Wastewater Operations can provide BIG Paybacks

Improved Water Quality
Financial Savings
Capital
O&M

More Case Studies

Discussion / Q&A
Traditional Approach: Facility Planning
As an analogy, let’s assume ...

I have a six year old car that squeaks and sputters.
I’m looking for advice.
As an analogy, let’s assume ...

I have a six year old car that squeaks and sputters. I’m looking for advice.
Alternative Approach: Operations
## Montana DES

### Two Day Classroom Seminar (2012)

<table>
<thead>
<tr>
<th>Location</th>
<th>t-N Before (mg/L)</th>
<th>t-N After (mg/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chinook</td>
<td>25</td>
<td>13</td>
</tr>
<tr>
<td>Conrad</td>
<td>26</td>
<td>5</td>
</tr>
<tr>
<td>Manhattan</td>
<td>11</td>
<td>7</td>
</tr>
</tbody>
</table>
Case Studies: these are not isolated examples

18 Wastewater Treatment Plants: Personal Experience

Case studies:
Chinook (MT), Conrad (MT), Manhattan (MT), Montague (MA), Plainfield North & Village (CT)

N-Removal Projects:
Amherst (MA), Farmington (MA), Northfield (MA) & Upton (MA)

P-Removal Projects:
Columbia Falls (MT), East Haddam (CT), Keene (NH) & Suffield (CT)

Ongoing N &P Projects:
Easthampton (MA), Greenfield (MA), Palmer (MA) Westfield (MA)

2008 MA DEP Study:
11 of 21 studied can be “operated to remove Nitrogen”

2014 NEIWPCC Study (Preliminary Findings):
24 of 29 plants studied can remove Nitrogen with “minor” upgrade
$110 Million Savings @ 3 Communities

> 50% Nitrogen Reduction

> 75% Phosphorus Reduction

Existing equipment: No New Tanks

O&M cost SAVINGS

Fewer Chemicals

Less Electricity

Less Sludge

Carbon Footprint: REDUCED
Plainfield, Connecticut (population 15,000)
1.5 MGD (two plants)

Nitrogen Targets: ~6 mg/L
Phosphorus Limit for Village Plant: 0.7 mg/L

Facility Plan: Build one new plant and demolish existing facilities.

Instead, a 2-year optimization effort and $10,000 in equipment ... improved TSS & BOD removal, 50% less nitrogen & 75% less phosphorus at Village Plant

Facility Plan Proposal: $45,000,000
New Facility Upgrade: $5,000,000

$40 Million Savings
Amherst, Massachusetts (population 38,000)
7.2 MGD

New Nitrogen Limit: 546.5 pounds/day, approximately 15 mg/L

2008 BioWin modeling results:

“The existing facility has half of the necessary volume at the current flows ... ... there are no operational or minor modifications/retrofits that could be implemented at this facility to consistently achieve nitrogen removal. “

Instead, by cycling air on and off, the facility is meeting its limit.

Facility Upgrade cost estimate: $61,000,000
Cost of compliance ............. $100,000

$60 Million Savings
Keene, New Hampshire (population 23,000) 6.0 MGD

New Phosphorus Limit: 0.2 mg/L

BioWin modeling determined new equipment needed.

Instead, by fermenting wastewater in an existing tank, biological phosphorus removal has cut chemical usage in half while meeting a restrictive effluent limit.

Facility Upgrade budget: $16,000,000
Revised project ............... $4,500,000

$10 Million Savings
$110 million savings

Combined Population: 76,000
Total Design Capacity: 14.7 MGD

<table>
<thead>
<tr>
<th>Location</th>
<th>total-N (mg/L)</th>
<th>total-P (mg/L)</th>
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</thead>
<tbody>
<tr>
<td>Amherst, Massachusetts</td>
<td>25 to 10</td>
<td></td>
</tr>
<tr>
<td>Keene, New Hampshire</td>
<td></td>
<td>3.0 to 0.2</td>
</tr>
<tr>
<td>Plainfield, Connecticut</td>
<td></td>
<td>3.0 to 0.8</td>
</tr>
<tr>
<td>North Plant</td>
<td>15 to 8</td>
<td></td>
</tr>
<tr>
<td>Village Plant</td>
<td>20 to 8</td>
<td></td>
</tr>
</tbody>
</table>

**O&M Costs**

- Amherst, MA: $30,000/yr Savings (sludge disposal)
- Keene, NH: $50,000/yr Savings (chemical usage)
- Plainfield, CT: Small Savings
**Educating & Empowering Operators**

Knowledge
- Nitrogen biochemistry
- Phosphorus biochemistry

Information (*in-tank instrumentation w/computer display*)
- Continuously monitor conditions
- Interpret data daily

Action
- Daily adjustments
- Preemptive changes
- Reactive changes
The Right Equipment?

Educated, Empowered Operations?
Kitchen?

Chef?
Clubs?

Golfer?
Car ...

... and ...

Driver!
Facility Upgrade?

ReEngineer Operations?
Making clean water affordable

g.weaver@cleanwaterops.com
Grant Weaver, Your Moderator
g.weaver@cleanwaterops.com

President
The Water Planet Company

Licensing
Professional Engineer
Wastewater Operator

Education
Massachusetts Institute of Technology (MIT):
Post-Graduate Studies in Environmental Toxicology

Oklahoma State University (OSU):
MS Bio-Environmental Engineering

Kansas State University (KSU):
BS Biology
Thank You!

g.weaver@cleanwaterops.com