Phosphorus Removal within the SuAsCo River Watershed

Thomas E. Parece, P.E.
AECOM

Maureen D. Neville, P.E.
CDM Smith

AECOM CDM Smith

PLANT OPERATIONS
Perspectives on Phosphorus Removal in the Sudbury-Assabet-Concord River Watershed

2019 SPECIALTY CONFERENCE & WORKSHOP SERIES

Acknowledgments

- Billerica, MA
  - Woodard & Curran
  - Evoqua Water (CoMag®)
- Concord, MA
  - CDM Smith
  - Evoqua Water (CoMag®)
- Hudson, MA
  - Wright Pierce
  - Infilco Degremont, Inc. (AquaDAF®)
- Maynard, MA
  - Brown and Caldwell
  - Evoqua Water (CoMag®)
- Marlborough, MA (Easterly)
  - CDM Smith
  - Evoqua Water (BioMag®)
- Marlborough, MA (Westerly)
  - CDM Smith
  - Nexom (Blue PRO®)
- Westborough, MA
  - AECOM
  - Kruger, Inc. (Actiflo®)

Can 0.1 mg/L TP be achieved? Yes, but…..

- Depends on the Permit Language
  - Push for Seasonal Average or Median Load or Concentration
  - Consider Regulating Ortho-P vs. TP (to mitigate non-reactive P)
  - Delete Maximum Day Limits – Nutrients are Not Toxic and are a Chronic Not Acute Concern
- Pushing Detection Limits
- It is Costly to Construct
- It is Costly to Operate
  - Power including Intermediate Pumping
  - Cost of Chemicals - Coagulation and Alkalinity
  - Increase in Sludge Production

Is it Worth It?
Environmental Benefits/Impacts

- Upgraded Facilities are Now More Reliable
- Phosphorous Processes also Improve Solids and Metals Removal
- In-stream Phosphorus Concentrations Trending Downward
- Non-point Sources Now the Most Prominent Source of Phosphorus in the Watershed
- Chemical Use and Sludge Production have Increased
- Power and Thus Greenhouse Gas Emissions have Increased

How Can You Use This Information? Knowledge is Power!

- Communities
  - Visit Facilities
  - Understand Costs
  - Understand Receiving Waters
  - Think About Re-use
- Vendors
  - Reduce Power
  - Reduce Chemicals
- Regulators
  - Understand the Receiving Waters
  - Understand the Indirect Environmental Impacts of Permit Limits
  - Consider Seasonal Limits
  - Be Reasonable
  - Think Holistically
- Consultants
  - All of the Above

Assabet River Consortium

Hudson, MA
Marlborough, MA (Westerly)
Maynard, MA
Westborough, MA

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Perspectives on Phosphorus Removal in the Sudbury-Assabet-Concord River Watershed

2019 SPECIALTY CONFERENCE & WORKSHOP SERIES

Assabet River Consortium
Background – Summary and Goals

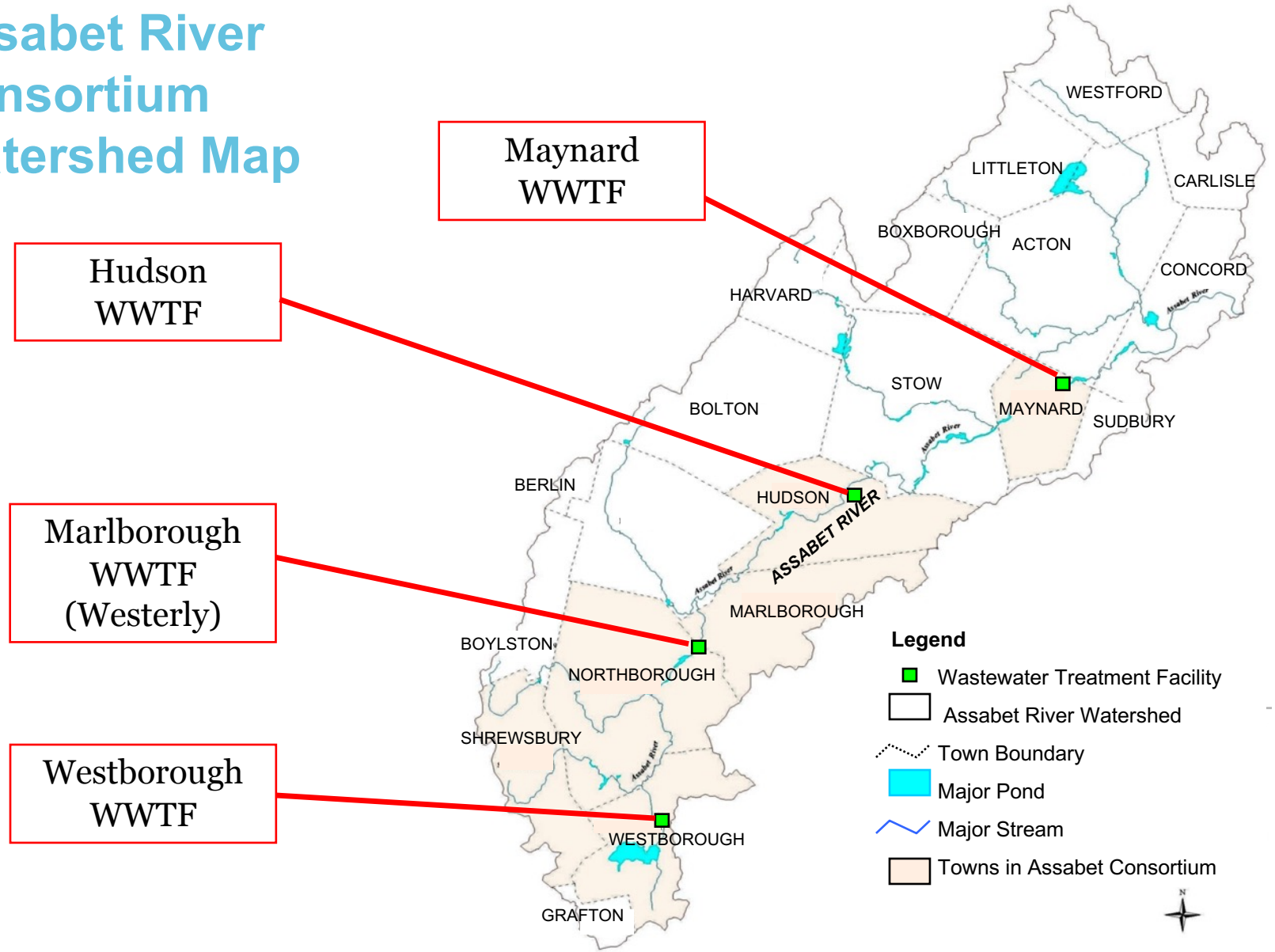
Summary

- Hudson, Marlborough, Maynard, Shrewsbury, Westborough and Westborough Treatment Plant Board
- Joint CWMP/EIR Ran Concurrently with the MassDEP's TMDL Study
- Watershed Based Management Approach to Wastewater Regulation
- Cooperative Effort to Balance Environmental Protection, Smart-growth, and Local Fiscal Stability

Goals

- Upgrade Aging Facilities
- Address Need Areas
- Meet New Seasonal Phosphorous Limit (0.1 mg/L)
- Future Lower Limits (< 0.1 mg/L)

Assabet River Consortium Watershed Map



Hudson, Massachusetts
IDI AquaDAF® Technology

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Perspectives on Phosphorus Removal in the Sudbury-Assabet-Concord River Watershed

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Hudson, Massachusetts
History of the Facility

- Originally Constructed in 1960 Using Trickling Filters
- Renovated and Upgraded in 1979
- Operation
  - Trickling Filter Process During the Winter Months
  - Trickling Filter Process with Conventional Activated Sludge Process During the Summer Months

Hudson, Massachusetts Evaluation

- Ballasted Flocculation
  - Actiflo® Process
  - CoMag® Process
- Solids Contact Clarification
  - Densadeg® Process
- Direct Filtration
  - Deep Bed
  - Cloth Media
- Dissolved Air Flotation
  - AquaDAF®
- Membranes
  - Membrane Biological Reactor
  - Tertiary Membrane Filtration

Hudson, Massachusetts
Short List, Pilot Testing and Selection

Short List and Pilot Testing

- Ability to Meet TP of 0.1 mg/l and Future, More Stringent TP Limits
- Capital and O & M Costs
- Site Specific Effluent Quality (silica from industrial user)
- Stress Testing (Hydraulic / Solids
- Capability to Pilot (Pilot Testing Required to be Selected)
  - Kruger, Inc. - Actiflo®
  - IDI AquaDAF®
  - CoMag® (Pilot Not Available)

Selection

- Dissolved Air Flotation (IDI AquaDAF®) System Selected
- Lowest Capital Construction Cost
- Produces a “Thick” Sludge
  - Reduced Solids Handling Costs
  - Smaller Holding Tanks Required
- Site Visits to Existing DAF Facilities to Confirm Selection
- Ease of Operation (preferred by Town)

Hudson, Massachusetts
Chemical Pumping, Recycle Rate/Saturator Pressure
Vassal and IDI AquaDAF® Floating Sludge

Hudson, Massachusetts
Plant Performance

Description	Design Values	2011 – 2012 Values
Flow (MGD)		
Average Daily Flow	3.00	1.95
Peak Day	9.20	10.00
Influent (mg/L)		
BOD_5	300	160
TSS	240	180
Phosphorous	6.0	5.5
Effluent (mg/L) (Summer / Winter)		
BOD_5	15 and 30	6.8 and 7.6
TSS	15 and 30	3.1 and 4.5
Phosphorus	0.10 and 1.00	0.1 and 0.15

Hudson, Massachusetts
Plant Performance (continued)

Description	2011 – 2012 Values
Chemical Dosage (Summer / Winter)	
Ferric Chloride (mg/l)	141 and 116
Ferric Chloride (gpd)	455 and 406
Ferric Chloride (gal)	95,500 and 61,000
Power Usage (kWH per day)	765
Sludge Dewatered (gpd)	50,000
Labor (hours per day)	2 to 4
Operating Cost (Summer)	$360,000
Phosphorous Pounds Removed	15,000
Cost per Pound of Phosphorus Removed	$24.00

Hudson, Massachusetts
Operational Requirements and Summary

Operational Requirements

- Plugged Nozzles – Recycle now 215 gpm at 98 psi
- Reduced Scraping Frequency and Speed
- Better Access for Tank Cleaning
- $FeCl_3$ Usage
  - Primary Clarifier Effluent at 140 gpd
  - Trickling Filter Clarifier Effluent at 140 gpd
  - DAF System Influent at 100 gpd

Summary

- Upgrades Completed within Budget ($14.98M) and on Schedule (SRF Loan Funded)
- DAF System Operating within NPDES Permit Limit
- DAF System Easy to Operate and Maintain
- DAF System assists with Cu Removal
- Actual DAF O&M Costs within Anticipated O&M Cost

Marlborough, Massachusetts (Westerly)
Bluewater Blue PRO® Technology

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Perspectives on Phosphorus Removal in the Sudbury-Assabet-Concord River Watershed

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Marlborough, Massachusetts (Westerly)
History of the Facility

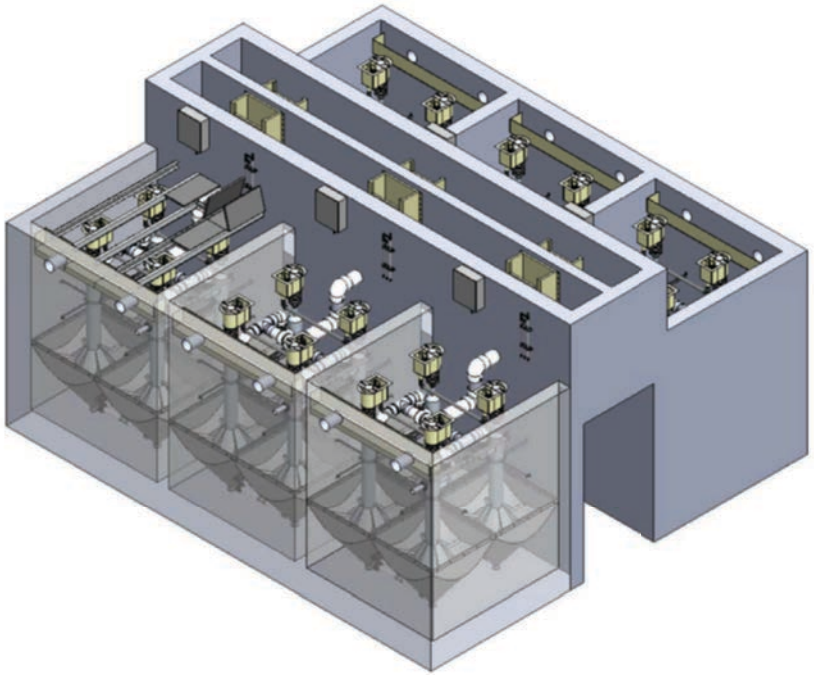
- Constructed 1973
  - 2.0 mgd
  - Secondary Treatment Facility
- Upgraded and Expanded 1988 to 2.89 mgd
  - Single-stage Seasonal Nitrification
- Upgraded and Expanded 2012 to 4.15 mgd
  - Single-stage Year-round Nitrification w/add-on TP Removal Process to Achieve 0.1 mg/L

Marlborough, Massachusetts (Westerly) Evaluation and Selection

- Screening of Available Alternatives
- 2-week Trailer Mounted Pilot Study
  - CoMag®
  - Actiflo®
  - Blue PRO®
- RFP for Phosphorus Removal System
- Selection Based on Cost and Non-cost Factors

Marlborough, Massachusetts (Westerly) Evaluation and Selection (cont.)

Blue PRO® System



- Lowest Capital and Operation and Maintenance Costs
- Reactive Filtration Observed Potential for Some Level of Non-reactive P Removal
- Willing to Agree to Guarantees, Warrantees and Bonds
- Financial Backing of Shaw Group

Marlborough, Massachusetts (Westerly) Plant Performance

Description	Design Values	2012 - 2014
Flow (mgd)		
Average Daily Flow	4.15	1.93
Maximum Daily Flow	7.5	4.5
Influent (mg/L)		
CBOD	184	200
TSS	269	312
Phosphorus	6.1	7.2
Effluent (mg/L)		
CBOD	15 to 25	0.88
TSS	15 to 30	2.70
Phosphorus – in season	0.1	0.089
Phosphorus – off season	1.0	0.21

Marlborough, Massachusetts (Westerly) Plant Performance (continued)

Description	2012 - 2014
Chemical Dosage	
Ferric Chloride (mg/L)	
- To Primaries	47
- To Filters	21
Magnesium Hydroxide (lbs/day) (2012 only)	1,050
Blue PRO Power Usage (kWh per day) (not incl. PS)	210
Sludge Production (dry tons/day)	2.37
Labor (hours per day)	2

Marlborough, Massachusetts (Westerly) Summary

- $27.5M Project Completed ($4.5M Under Planning Estimate); TP Removal Approx. 22% of Total ($6 million)
- 30 Month Construction Duration
- Utilized SRF Funding
- 2012-2014 Operational Data Shows Exceptional Removal Efficiencies
- Award Winning Construction Project Met Administrative Ordered Construction Schedule

Maynard, Massachusetts
CoMag® Technology

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PLANT OPERATIONS
Perspectives on Phosphorus Removal in the Sudbury-Assabet-Concord River Watershed

2019 SPECIALTY CONFERENCE & WORKSHOP SERIES

Maynard, Massachusetts
History of the Facility

- Conventional Secondary Plant, Dates to 1930s
- Converted from activated sludge to RBC's in 1986
- Discharges to Assabet River at ~1.0 MGD (Average) and 5.0 MGD (Peak)
- 10,000 residents with 95% Sewered

Maynard, Massachusetts
Evaluation and Limitations

Evaluation

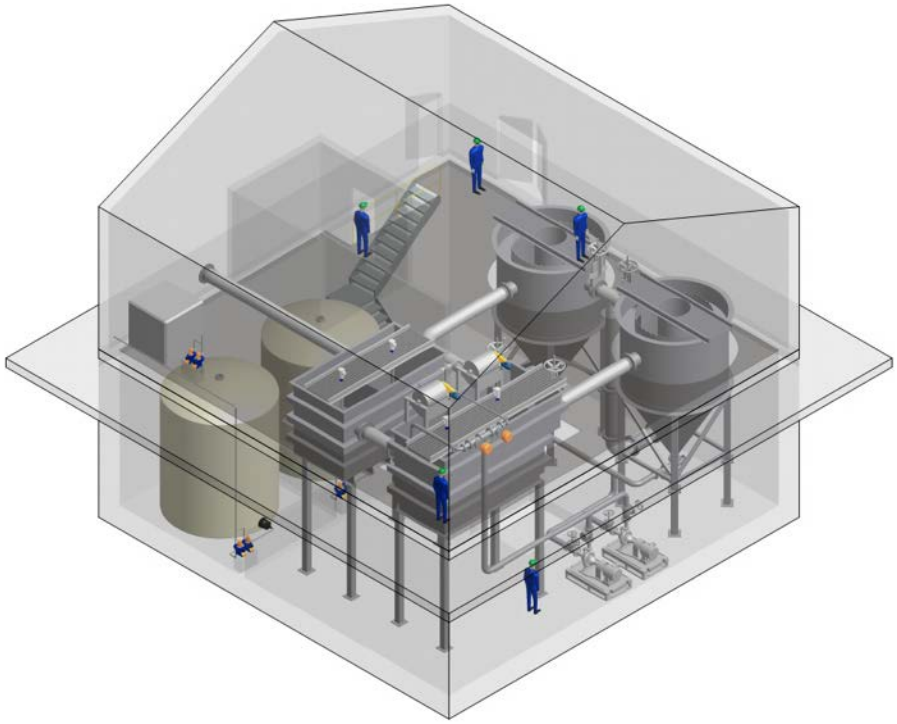
- Review of Technologies Capable of Achieving
  - Ability to Achieve Concentrations Less Than 0.1 mg/l
  - Operational Simplicity
  - Capital and Operational Cost
  - Impacts to Sludge Handling and Production

Limitations

- Constrained Existing Site
- Significant Budget Limitations
- Considerations for Other Upgrades

Maynard, Massachusetts Selection

- Selection in Part Based on “Polishing Filter” to Help Achieve Potential 0.05 mg/l Limits
- Significant Input Regarding O&M Considerations
- Conceptual Design of CoMag® Mimicked Concord WWTP
- Partial Re-use of Existing Aeration Basins



Maynard, Massachusetts
Design Optimization

Review

Review and Observation of Concord WWTP Performance

Identify

Identification of Key Areas for Improvement

- *Flow Transition / Distribution*
- *Floc Stability*

Adapt

Adaptation to Optimize Cost and Fit within Existing Structure

- *Eliminate Round Peg in Square Hole*
- *Considerations for Seasonal Operational Flexibility (lower winter limits)*

Maynard, Massachusetts
Plant Performance

Description	Design Values	Current Values
Flow (MGD)		
Average Daily Flow	1.45	1.06
Peak Hourly Flow	5.0	1.97
Influent (mg/L)		
BOD_5	225	190
TSS	225	189
Phosphorous	10	3.51
Effluent (mg/L)		
BOD_5	30	1.2
TSS	30	2.1
Phosphorous – Winter	1	<1
Phosphorous – Summer	0.1	0.17

Maynard, Massachusetts
Plant Performance (continued)

Description	Design Values	Current Values
Chemical Dosage		
PAC (Winter / Summer)	60 to 90 ppmv / 80 to 150 ppmv	
Polymer	0.8 to 1.2 ppmv	
Sodium Hydroxide	As Necessary	
Soda Ash	100 lbs/day	
Magnetite	10 lbs/day	
Power Usage (kWH per day)	1,841	
Sludge Production (dry tons/day)	0.88	
Labor (hours per day)	2 to 4	

Maynard, Massachusetts
Operations and Conclusions

Operations

- Stability
  - Good Operational Consistency
  - Some Sensitivity Related to Peripheral Equipment
- Performance
  - Lower Chemical Usage (400 gpd to About 125 gpd)
  - Reduced Sludge Production
  - Stable Magnetite Usage (About 10 lbs/day)

Conclusions

- Successfully Implemented New Design Features
- Demonstrated Ability to Achieve Performance Approaching 0.05 mg/l Without Additional Filtration
- Created Increased O&M Flexibility
- Maintained Overall O&M costs
- Met Construction Budget

Westborough, Massachusetts
Kruger ActiFlo® Technology

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Perspectives on Phosphorus Removal in the Sudbury-Assabet-Concord River Watershed

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Westborough, Massachusetts
History of the Facility

- Original in 1899
- Upgraded Early 1970s
- Upgraded in 1987
- Allocation of Flows
  - Shrewsbury - 4.39 mgd
  - Westborough - 2.89 mgd
  - Hopkinton - 0.40 mgd

Westborough, Massachusetts
Evaluation and Selection

- Technologies
  - Blue Water Technologies, Inc. - Blue PRO®
  - Infilco Degremont, Inc. - AquaDAF®
  - Kruger, Inc. - Actiflo®
  - Evoqua Water – CoMag®
- Protocol
  - Week 1: Set-Up
  - Week 2: Coagulant Optimization
  - Week 3: Flow and Loading Optimization
  - Week 4: Stress Conditions
- Performance
- Cost (Capital and O&M Costs)
- Miscellaneous
  - Environmental Impacts
  - Footprint and Aesthetics
  - Responsiveness of Manufacturer
- Operation & Maintenance
  - Chemical Alternatives
  - Simplicity and Flexibility
  - Effects on Process
- Interview

Westborough, Massachusetts
Evaluation and Selection (cont.)

- Kruger, Inc. - Actiflo®

- Achieved Low Phosphorus Levels
- Utilizes Multiple Chemicals
- Fit within the Existing Hydraulics of the WWTF
- Lowest 20-year Life Cycle Cost
- Track Record and Full-Scale Operations for Phosphorus Removal in United States

Westborough, Massachusetts
Phosphorous Treatment Components

- Anaerobic Selector Tank for Biological Phosphorous Reduction
- Lime Silo for Alkalinity and pH Adjustment
- Kruger, Inc. - Actiflo®
  - 100 Percent Redundancy
  - 2 mg/L to 0.1 mg/L
- Multi Point Chemical Addition
  - Pre and Post Primary Clarifiers
  - Pre and Post Secondary Clarifiers
- Sludge Processing
  - Co-Thickening with Primary Sludge
  - Gravity Belt Thickeners
  - Gravity Thickeners

Westborough, Massachusetts
Plant Performance

Description	Design Values	Current Vaues
Flow (MGD)		
Average Daily Flow	7.68	5.7
Peak Hourly Flow	14.43	11.0
Influent (lbs/day)		
BOD_5 (lbs/day)	250	210
TSS (lbs/day)	250	220
Phosphorous (mg/L)	10	5.67
Effluent (mg/L)		
BOD_5	10	<2
TSS	10	<2
Phosphorus – In Season	0.10	0.06
Phosphorus – Off Season	0.75	0.51

Westborough, Massachusetts
Plant Performance (continued)

Description	Current Values
Chemical Dosage	
Ferric Chloride (mg/L)	30
Polymer (mg/L)	0.4
Lime (lbs/day)	60
Power Usage (kWH per day)	864
Sludge Production (dry tons/day)	6.93
Labor (hours per day)	4
Operating Cost (April – October 2012)	$188,000
Phosphorous Pounds Removed	50,800
Cost per Pound of Phosphorus Removed	$3.70

Westborough, Massachusetts Construction Facts

- $54M Project Completed $1.8M Under Budget
- 30 Month Construction Duration Completed 45 days Ahead of Schedule
- Maintained NPDES Permit Compliance Throughout The Construction Period
- Completed Construction Activities with No Lost Time or OSHA Violations
- Secured 0% SRF Funding Resulting in a Savings of Over $17M
- Received a Federal Stimulus Grant of Over $8.0M and Energy Rebate of $150K
- Receiving Alternative Energy Credit Rebate of $125K Per Year
- Operational Data Shows Cost Effective and Exceptional Removal Efficiencies

Assabet River Consortium

Hudson, MA
Marlborough, MA (Westerly)
Maynard, MA
Westborough, MA

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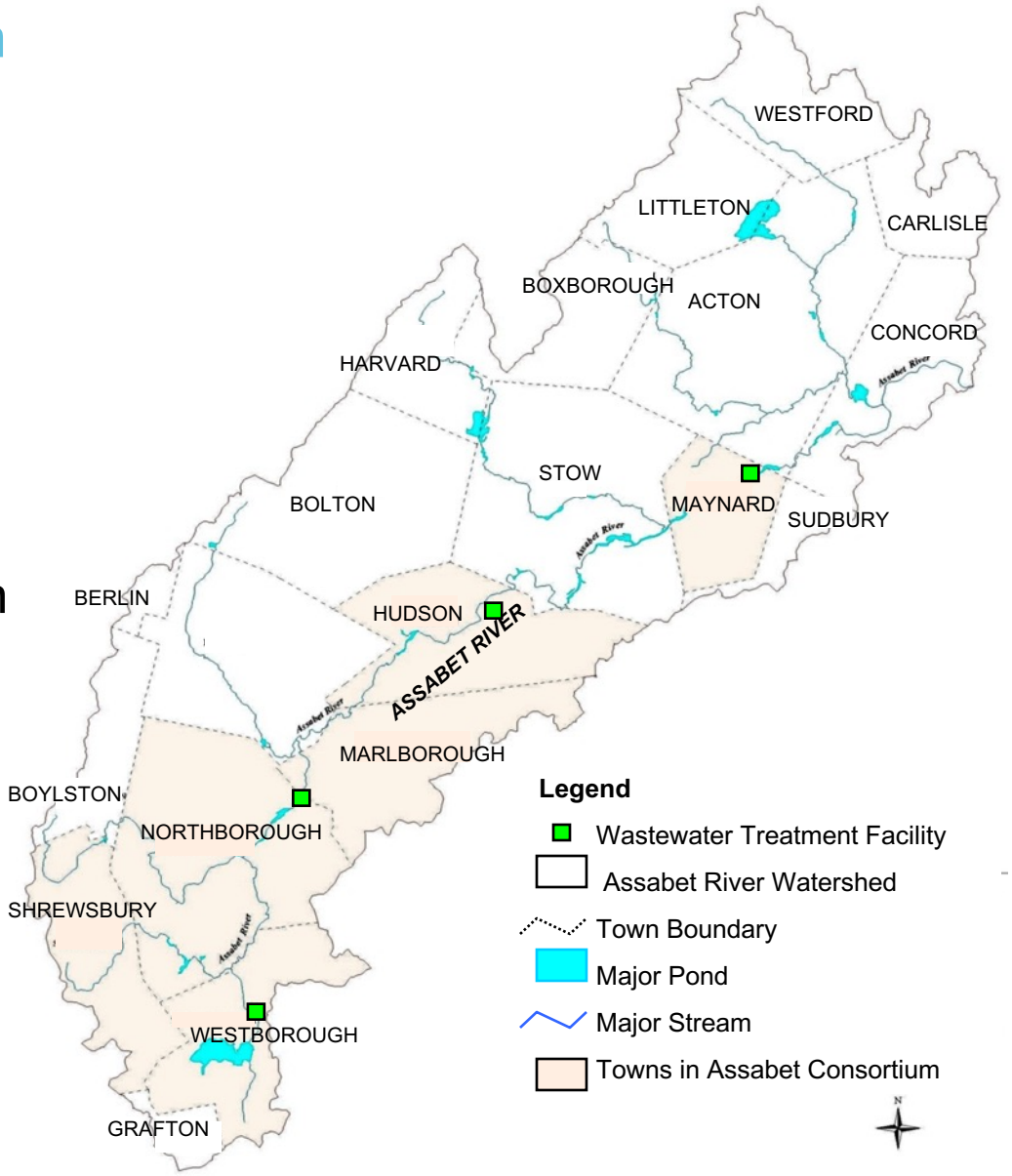
Perspectives on Phosphorus Removal in the Sudbury-Assabet-Concord River Watershed

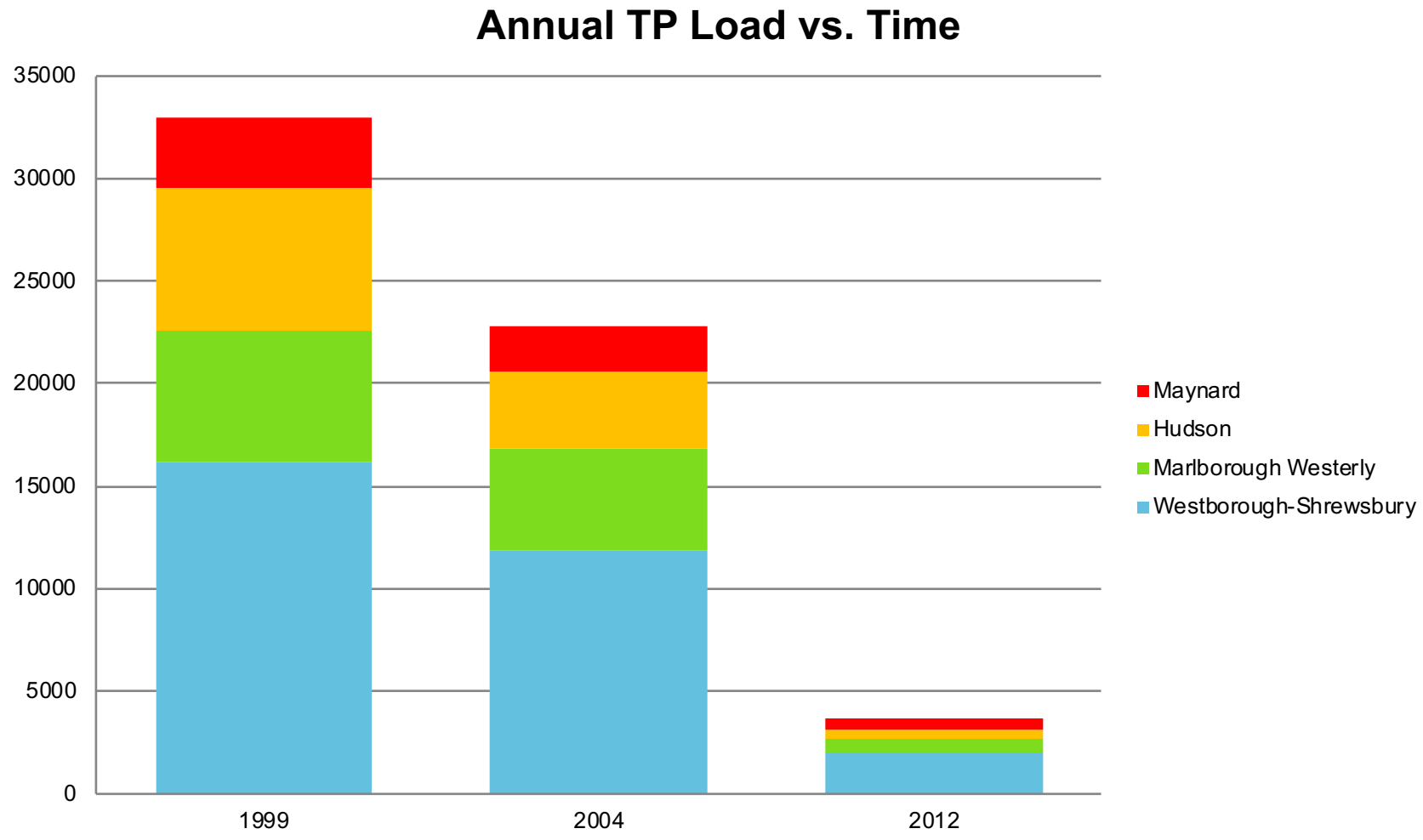
2019 SPECIALTY CONFERENCE & WORKSHOP SERIES

Assabet River Consortium Summary of the Four Facilities

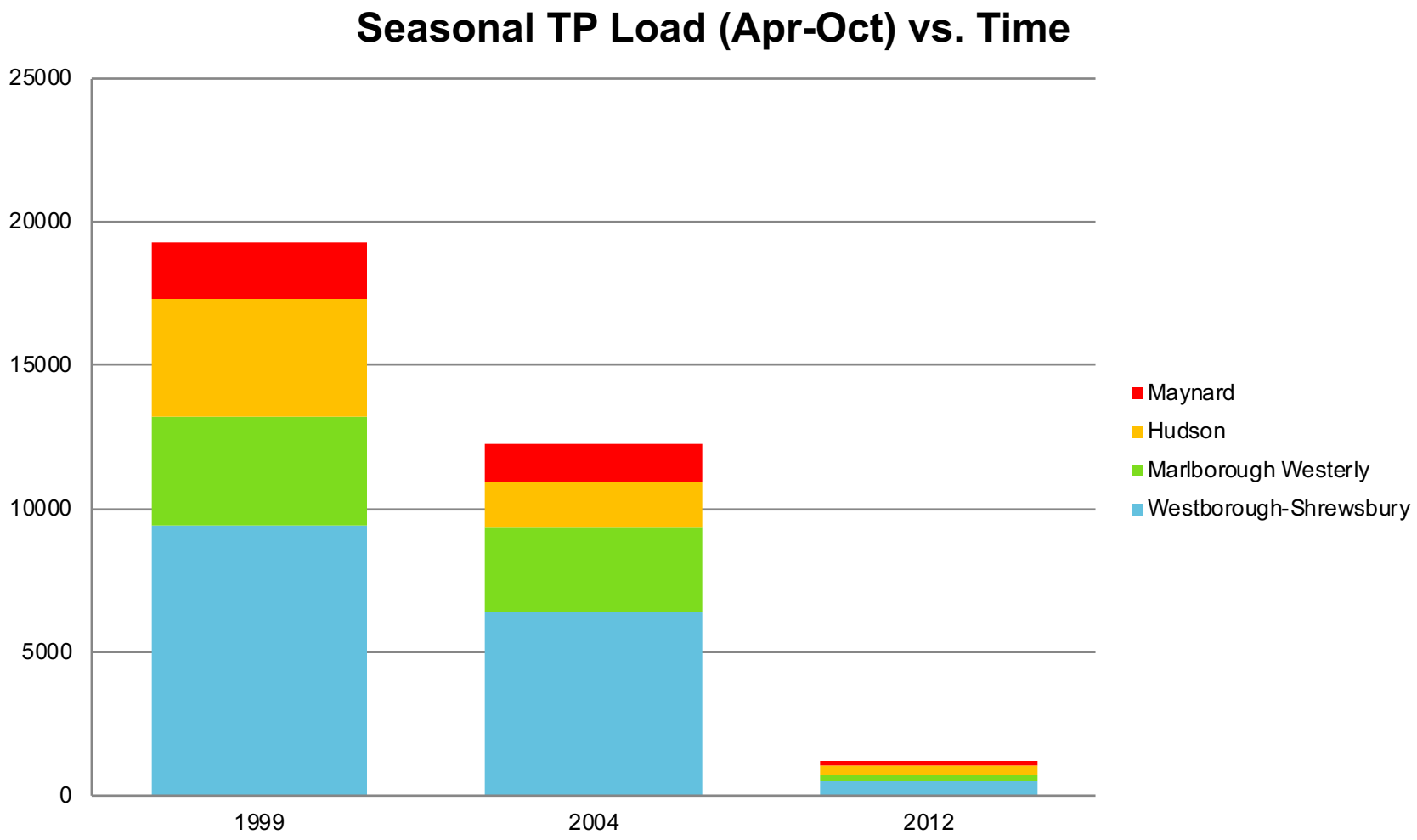
- Phosphorus Reduction
- Increase of Indirect Environmental Impacts
  - Greenhouse Gas Emission
  - Chemical Use
  - Sludge Production



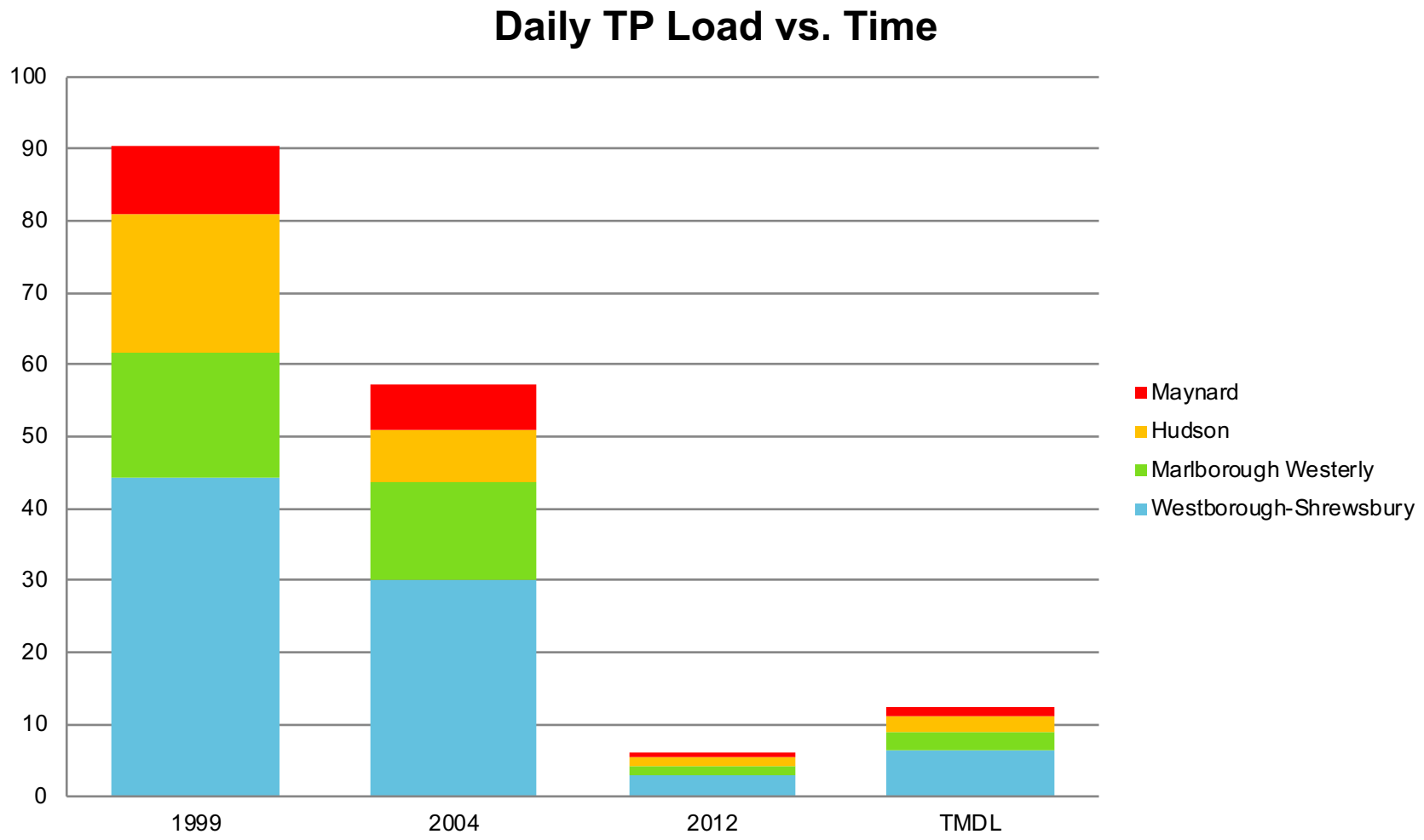
Annual Phosphorus Load to the Assabet River from POTWs - 89% Reduction From 1999 to 2012



Seasonal Phosphorus Load to the Assabet River from POTWs - 94% Reduction From 1999 to 2012



Total Daily Phosphorus Load from POTWs to the Assabet River ½ of TMDL Requirements in 2012



Billerica, Massachusetts
CoMag® Technology

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Perspectives on Phosphorus Removal in the Sudbury-Assabet-Concord River Watershed

2019 SPECIALTY CONFERENCE & WORKSHOP SERIES

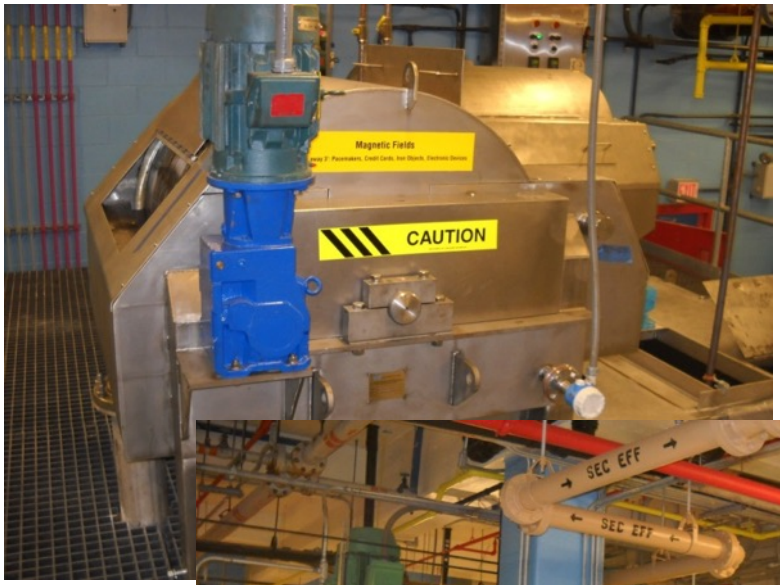
Billerica, Massachusetts
History of the Facility

- Conventional Activated Sludge Facility
- Originally Constructed in 1966, Upgraded Multiple Times
- 2005 NPDES Permit Renewal required 0.2 mg/L Total Phosphorus and 357 µg/L Total Aluminum
- Mandated Facility Upgrades within a 4 Year Timeframe
- Comprehensive Planning Recommended Installation of Tertiary Treatment and Solids Handling System Modifications

Billerica, Massachusetts
Evaluation and Selection

- CoMag® System by Evoqua Water
  - Coagulants Pilot Tested - Aluminum Salts and Ferric
  - Aluminum Sulfate Selected as Most Cost Effective Coagulant
- Eliminated Sludge Batching and Installed Gravity Thickeners for Sludge Co-Thickening
- Small Available Area Required Re-use of Existing Buildings and Tanks

Billerica, Massachusetts
Pumping, Magnetic Drum Separator and CoMag® Floc



Billerica, Massachusetts
Plant Performance

Description	Design Values	Current Values
Flow (MGD)		
Average Daily Flow	5.4	3.8
Peak Hourly Flow	16.5	12.8
Influent (lbs/day)		
BOD_5 (lbs/day)	12,600	4,202
TSS (lbs/day)	10,100	7,933
Phosphorous (mg/L)	0.20	
Effluent (mg/L)		
BOD_5	30	<2
TSS	30	<2
Phosphorus – In Season	0.20	0.06
Phosphorus – Off Season	1.00	0.51

Billerica, Massachusetts
Plant Performance (continued)

Description	Current Values
Chemical Dosage (mg/L)	
Alum	50 ppmv
Polymer	3 gal/day
Power Usage (kWH per day)	Unknown
Sludge Dewatered (gpd)	50,000
Labor (hours per day)	4 to 6

Billerica, Massachusetts
Performance and Construction Facts

Performance

- Overall the System Works Well
  - Results
  - Benefits
  - Location of CoMag® Ability to Experiment
- Keys
  - Understanding of Flow Pattern
  - Conditioning
  - Chemical Addition
  - Settling
  - Wasting/Return
- Pro-active not Reactive!

Construction Facts

- $12.3 M Construction
- Maintained NPDES Permit Compliance Throughout The Construction Period
- Completed Construction Activities with No Lost Time or OSHA Violations
- Utilized SRF Funding

Concord, Massachusetts
CoMag® Technology

CDM Smith

PLANT OPERATIONS

Perspectives on Phosphorus Removal in the Sudbury-Assabet-Concord River Watershed

2019 SPECIALTY CONFERENCE & WORKSHOP SERIES

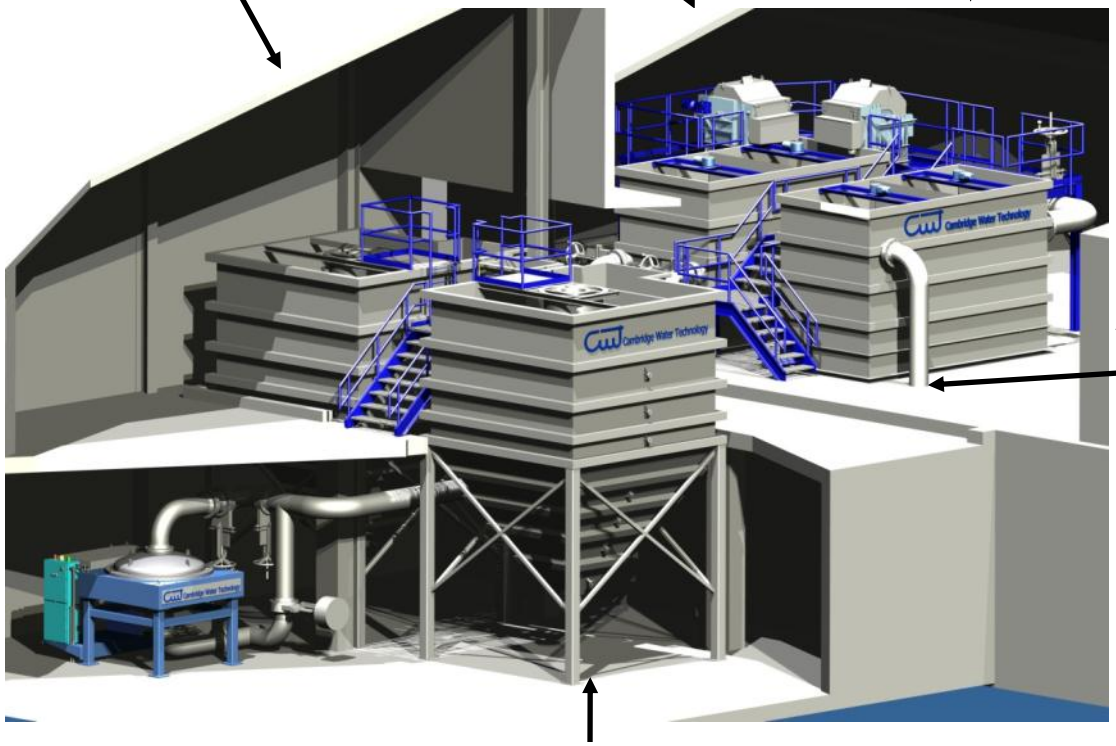
Concord, Massachusetts
History of the Facility

- Originally Constructed in mid 1980s
  - 1.2 mgd
  - Trickling Filters
- Upgraded 2008 to Meet New Permit Limit
  - 0.2 mg/L
  - First CoMag® Installation

Concord, Massachusetts
Evaluation and Selection

- Evaluation Completed by the Town
  - CoMag® Commercial Demonstration Plant Operated for Several Years
  - Conducted Alternatives Evaluation which included Actiflo®, CoMag®, DensaDeg®, Cloth Filters, Membranes
  - CoMag® Had the Highest Overall Score
- Town Issued a Competitive Request for Bids since Other Viable Alternatives
- Bids Resulted in Pre-Purchase of CoMag® for $3M and Incorporated into Larger Plant Upgrade

Concord, Massachusetts
Process Schematic



Concord, Massachusetts
Plant Performance

Description	Design Values	Current Values
Flow (MGD)		
Average Daily Flow	1.2	1.16
Peak Hourly Flow	2.4	4
Influent (mg/L)		
BOD_5	250	255
TSS	275	282
Phosphorous	5	-
Effluent (mg/L)		
BOD_5	30	4
TSS	30	3
Phosphorus – Winter	1	0.87
Phosphorus – Summer	0.2	0.183

Concord, Massachusetts
Plant Performance (continued)

Description	Current Values
Chemical Dosage - Alum (ppmv)	
Winter	70 to 80
Summer	88 to 100
Magnetite (lbs/day)	30
Power Usage (kWh per day)	1,380
Sludge Production (dry tons/day)	0.62
Labor (hours per day)	
Weekday	16 to 24
Weekend	4
Operating Cost (April – October 2018)	$408,000
Phosphorus Pounds Removed	8,820
Cost per Pound of Phosphorus Removed	$46.20

Concord, Massachusetts Summary

- $13M Project Completed Including Installation of CoMag® Equipment
- 18 month Construction Schedule
- Utilized SRF Funding
- Achieving Permit Without Use of the Polishing Magnet

Marlborough, Massachusetts (Easterly) BioMag® Technology

CDM Smith

PLANT OPERATIONS

Perspectives on Phosphorus Removal in the Sudbury-Assabet-Concord River Watershed

2019 SPECIALTY CONFERENCE & WORKSHOP SERIES

Marlborough, Massachusetts (Easterly)
History of the Facility

- Originally Constructed early 1970s
  - 5.5 mgd
  - Two-stage/Two-sludge Process
- Upgraded 2015 to Meet 0.1 mg/L TP Limit
  - Two-stage Process with A/O in First-stage and BioMag® in Second-stage

Marlborough, Massachusetts (Easterly) Evaluation and Selection

- Evaluated BioMag®, Actiflo® and Blue PRO® in Combination with Biological P Removal in First-stage
- BioMag® was selected for the following reasons:
  - Lowest Present Worth Cost
  - No Additional Tankage Required on a Site with Constraints
  - No Intermediate Pumping Station Required
- BioMag® was a Viable Option Due to Low Overflow Rates in Second-stage Clarifiers (similar to CoMag® rates)

Marlborough, Massachusetts (Easterly)
BioMag Equipment

CDM Smith

Marlborough, Massachusetts (Easterly)
Plant Performance

Description	Design Values	Current Values
Flow (mgd)		
Average Daily Flow	5.50	3.75
Peak Daily Flow	8.83	4.5 to 8.5
Influent (mg/L)		
BOD_5	250	190 to 350
TSS	250	150 to 250
Phosphorus	---	3 to 12
Effluent (mg/L)		
BOD_5	7 / 10 / 15	<=2
TSS	15 / 20 / 30	1 to 4
Phosphorus – In Season	0.10	0.05
Phosphorus – Off Season	0.75	0.05

Marlborough, Massachusetts (Easterly) Plant Performance (continued)

Description	Current Values
Chemicals Dosage	
Alum (GPD)	---
Ferric Chloride (GPD)	120 to 225
Polymer mg/L	0.75 to 1.0
Lime	pH Control
BioMag Power Usage (kWh per day)	960
Sludge Production (dry tons/day)	5 to 10
Labor (hours per day)	7

Marlborough, Massachusetts (Easterly) Summary

- 1st Major Upgrade since 1972
- $45M Project Completed 90 days Ahead of Schedule TP Removal Approx. 25% of Total ($11M)
- Activities with 2 Lost Time or OSHA Violations
- Utilized SRF funding
- Received Energy Rebate of $50K

- Maintained Permit Compliance Since System was Started (60 Day Rolling Average)

Questions