Wastewater Nitrogen & Phosphorus Removal without Plant Upgrades: Optimizing the Operation of Existing Facilities

Grant Weaver, PE & wastewater operator

Webinar
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Grant Weaver, Your Presenter

President
The Water Planet Company

Licensing

- Professional Engineer
- Wastewater Operator

Education

- Kansas State University: BS Biology
- Oklahoma State University: MS Bio-Environmental Engineering
- Massachusetts Institute of Technology: Post-Graduate Studies in Environmental Toxicology

Traditional Approach: Facility Planning

As an analogy, let's assume …

I have a five year old car that squeaks and sputters.
I'm looking for advice.

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Alternative Approach: Use Existing Equipment Differently to Create Habitats to Support N&P Removal

Montana DES

Two Day Classroom Seminar (2012)

	t-N Before (mg/L)	t-N After (mg/L)
Chinook	25	13
Conrad	26	5
Manhattan	11	7

Facilities Not Designed for Nitrogen Removal

	t-N Before	t-N After
Montague, MA	11	5
Upton, MA	20	6
Palmer, MA*	20	8
Plainfield Village, CT	20	8
Plainfield North, CT	15	8
Farmington, CT	12	8
Amherst, MA	25	10

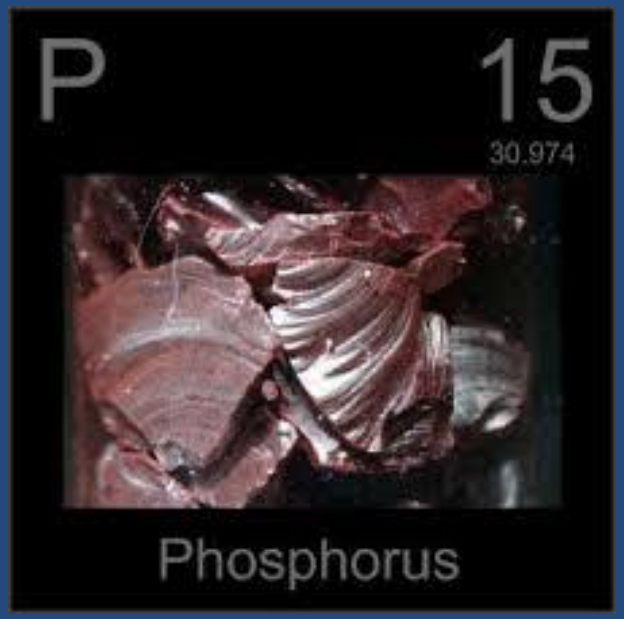
Facilities Operated Differently from O&M Manual

	t-N Before	t-N After
Suffield, CT	6	2
Windsor Locks, CT	7	5
Colchester-East Hampton, CT	11	8

Phosphorus Removal without Facility Upgrades

	t-P Before	t-P After
Keene, NH	3.0	0.2
East Haddam, CT	3.5	0.4
Montague, MA	5.5	0.6
Suffield, CT	3.0	0.7
Plainfield Village, CT	3.0	0.8

Nutrient Removal



Biological Nitrogen Removal:
Soluble organic-N is converted to Nitrogen Gas

Oxygen Rich Habitat

Ammonia-Nitrogen (NH_4) converts to Nitrate-Nitrogen (NO_3)

Oxygen Poor Habitat

Nitrate-Nitrogen (NO_3) converts to Nitrogen Gas (N_2)

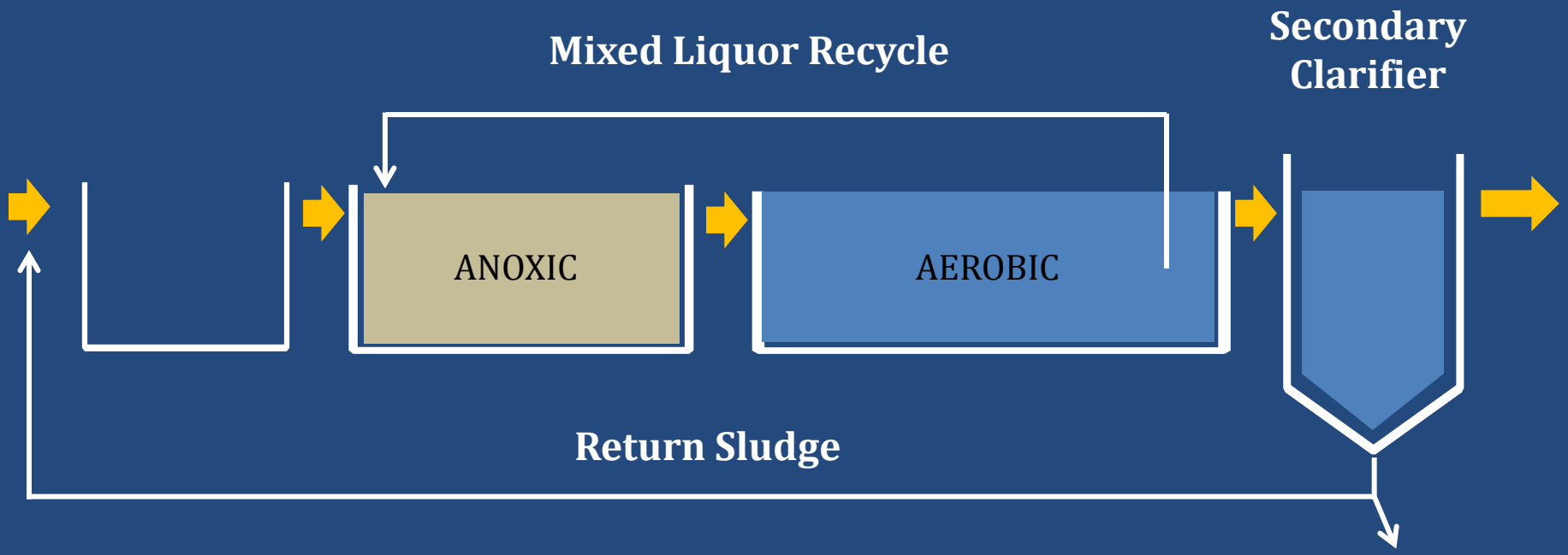
Biological Phosphorus Removal:
Soluble ortho-P is removed as sludge (dead bacteria)

Zero Oxygen Habitat

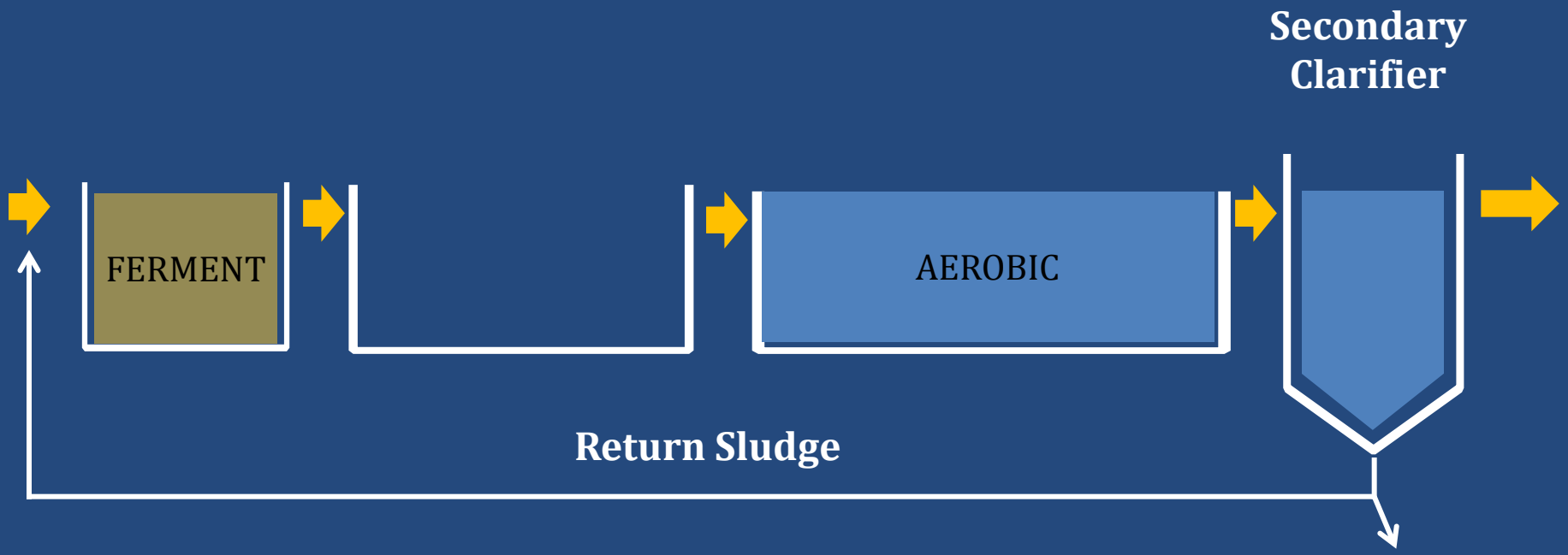
Bacteria take in energy (VFAs) and temporarily expel P

Oxygen Rich Habitat

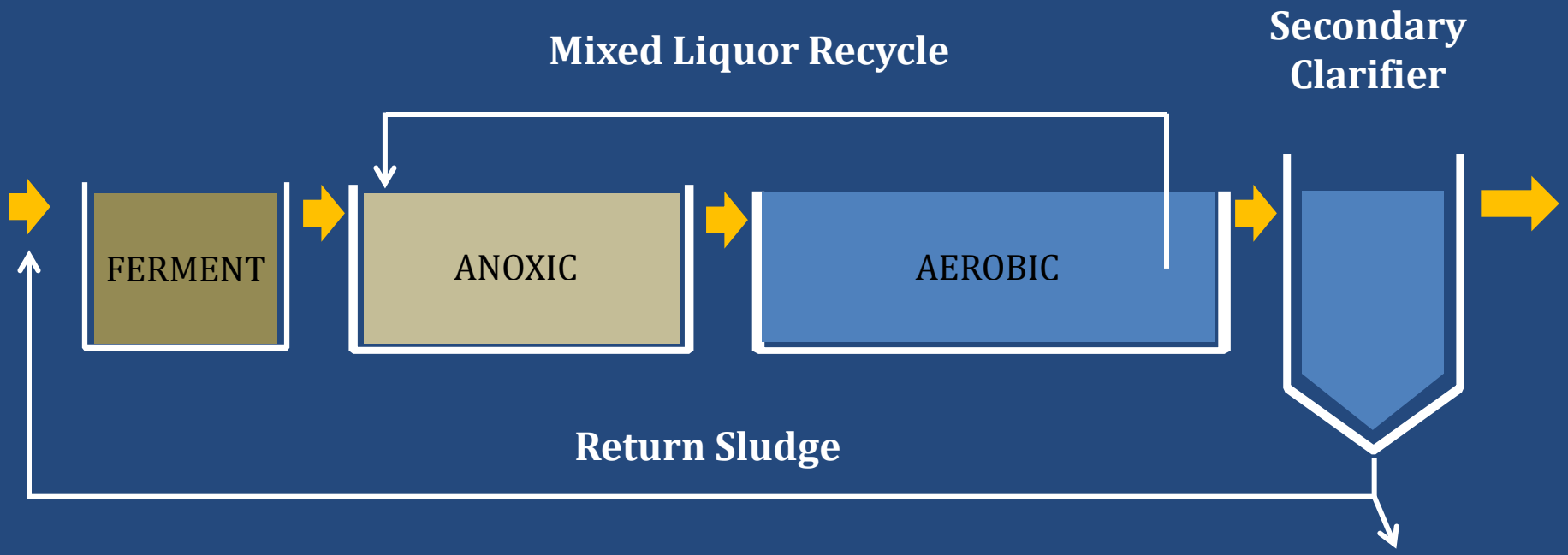
Bacteria use energy to "bulk up" on ortho-P



Biological N&P Removal
Nitrogen

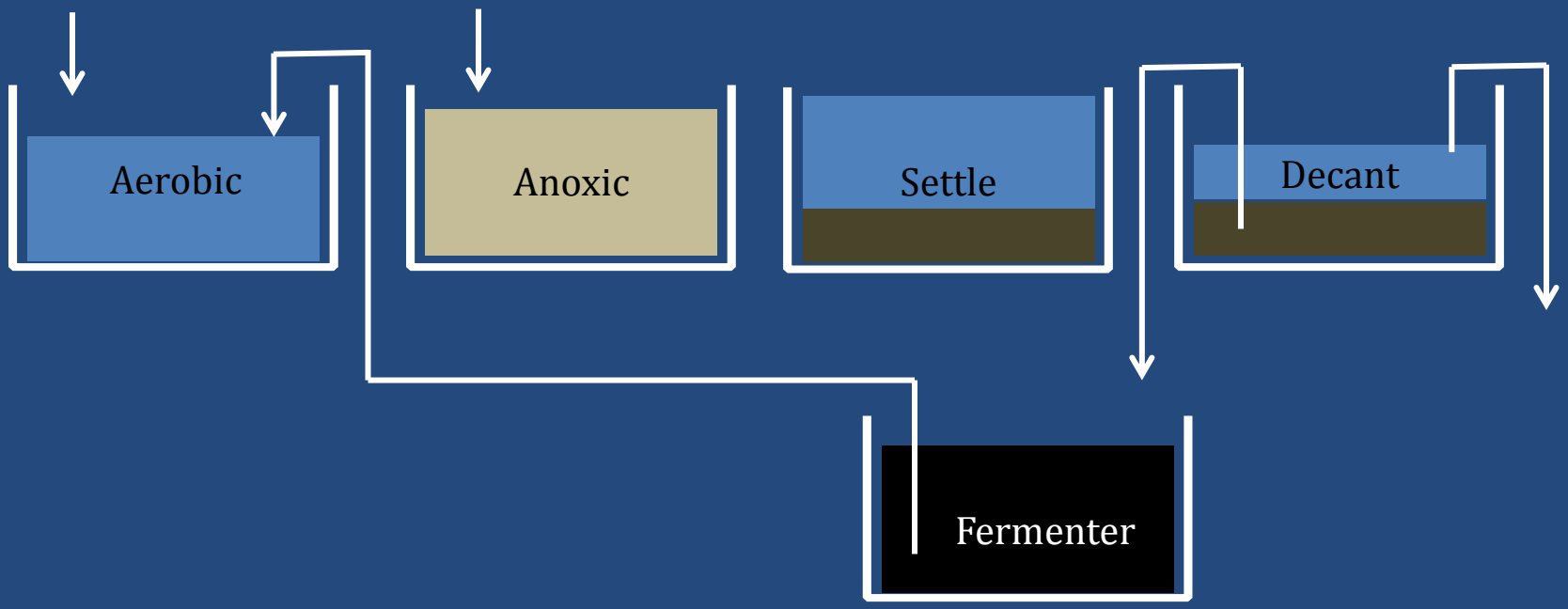


Biological N&P Removal
Phosphorus



Biological N&P Removal

Biological N&P Removal: SBR w/Fermenter



THE SCIENTIFIC METHOD

? PURPOSE ?

WHAT DO I WANT TO LEARN?

Research

Find out as much about your topic as you can.

HYPOTHESIS

Predict what the answer to the problem is.

EXPERIMENT

Design a test to confirm or disprove your hypothesis.

Analysis

Record what happened during the experiment.

Conclusion

Was my hypothesis correct?

NextGen Treatment Requires NextGen Operations: More Wastewater Operator Attention is Required!

Knowledge

- Nitrogen biochemistry
- Phosphorus biochemistry

Information (*in-line instrumentation & SCADA*)

- Monitor conditions daily
- Interpret data daily

Action

- Daily adjustments
- Preemptive changes
- Reactive changes

Case Study: $100 Million Savings @ 3 Communities

60% Nitrogen Reduction

80% Phosphorus Reduction

Existing equipment: No New Tanks

O&M cost SAVINGS

- Fewer Chemicals
- Less Electricity
- Less Sludge

Carbon Footprint: REDUCED

Case Studies: $100 million savings

Combined Population: 76,000

Total Design Capacity: 14.7 MGD

	total-N (mg/L)	total-P (mg/L)
Amherst, MA	25 to 10	
Plainfield (CT) North	15 to 8	
Plainfield (CT) Village	20 to 8	3.0 to 0.8
Keene, NH		3.0 to 0.2

Plainfield, Connecticut

Population: 15,000

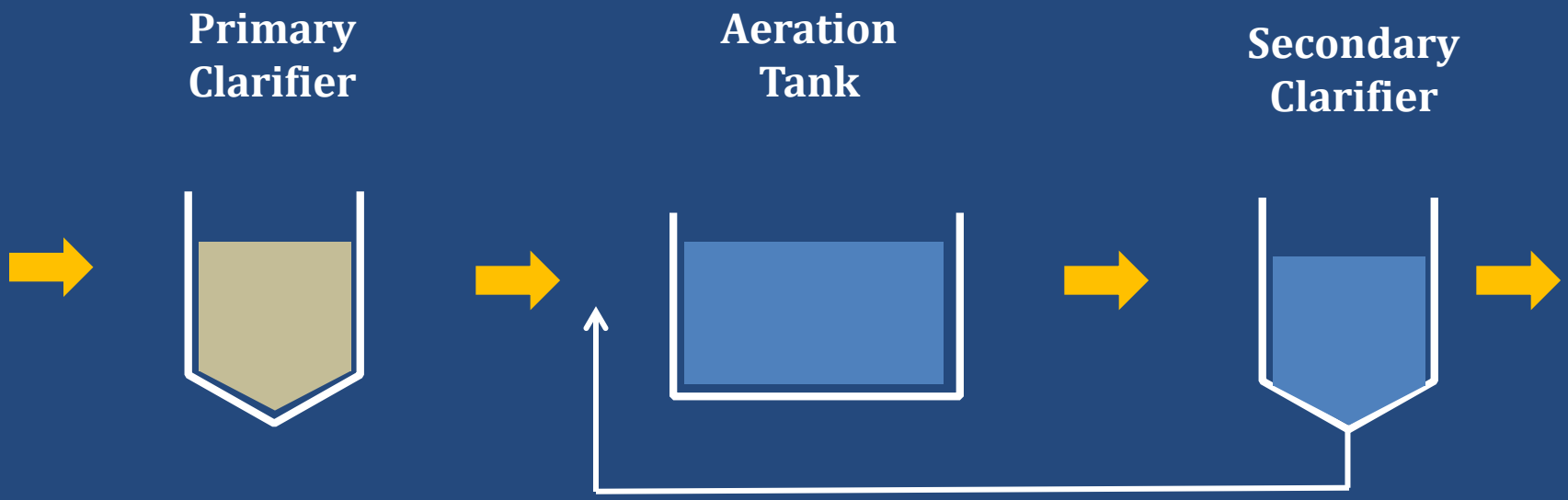
Two Plants
North Design Flow: 1.0 MGD
Village Design Flow: 0.5 MGD

Plainfield, Connecticut
North Plant

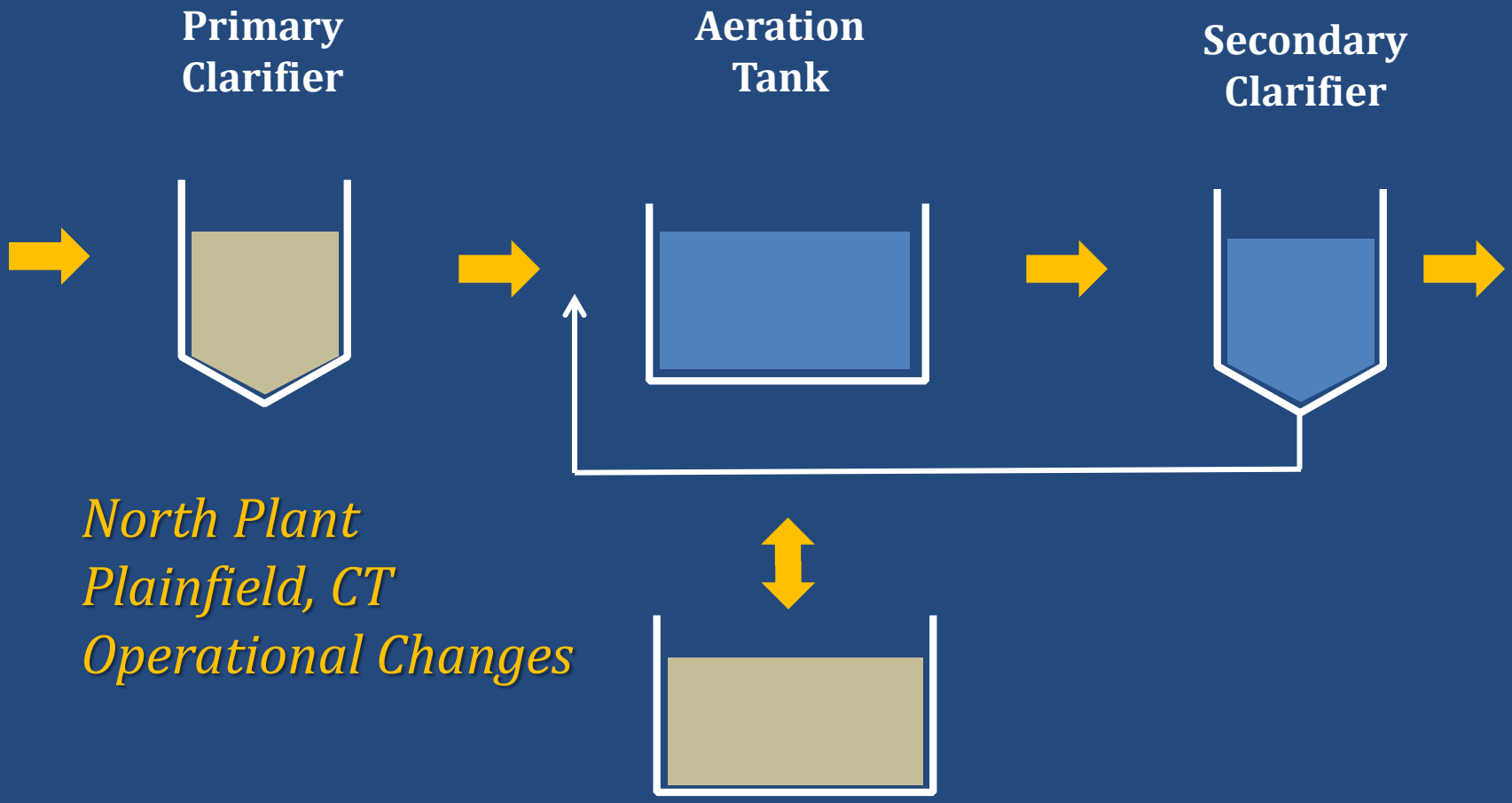
Design Flow: 1.0 MGD
Actual: 0.4 MGD

Effluent total-N
- Before Changes: 15 mg/L
- After Operational Changes: 8 mg/L
- After Plant Renovation: 5 mg/L (anticipated)

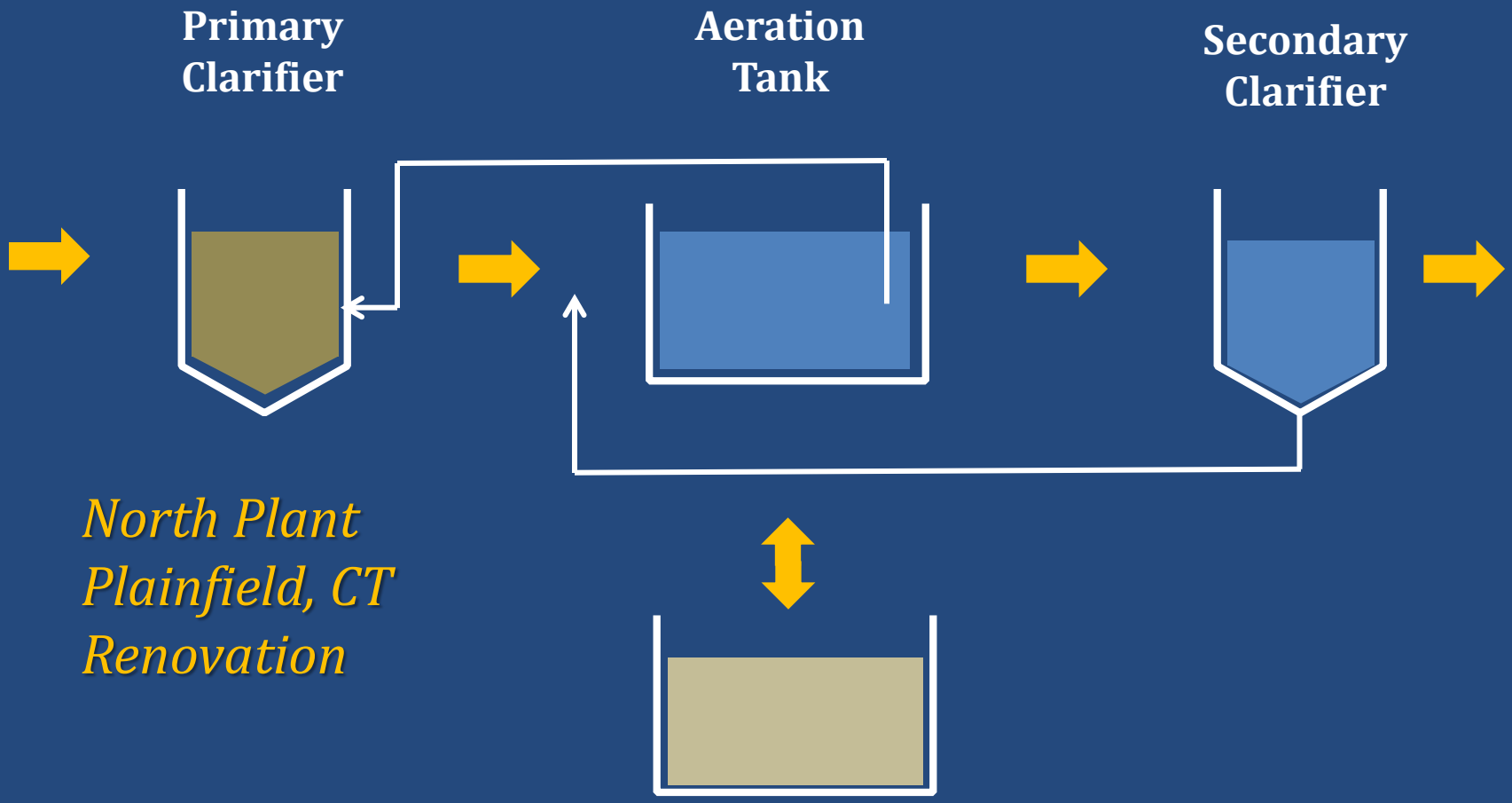
Effluent total-P
- Before Changes: 2.0 mg/L
- After Operational Changes: 2.0 mg/L
- After Plant Renovation: 0.5 mg/L (anticipated)



North Plant
Plainfield, Connecticut



North Plant
Plainfield, CT
Operational Changes



North Plant
Plainfield, CT
Renovation

Case Study
Plainfield, Connecticut
Village Plant

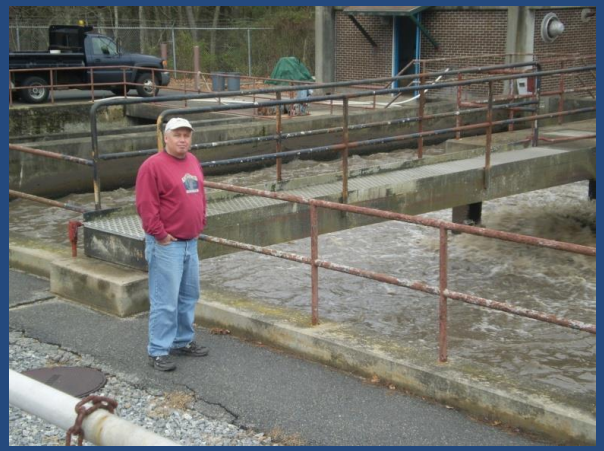
Design Flow: 0.5 MGD
Actual: 0.2 MGD

Effluent total-N

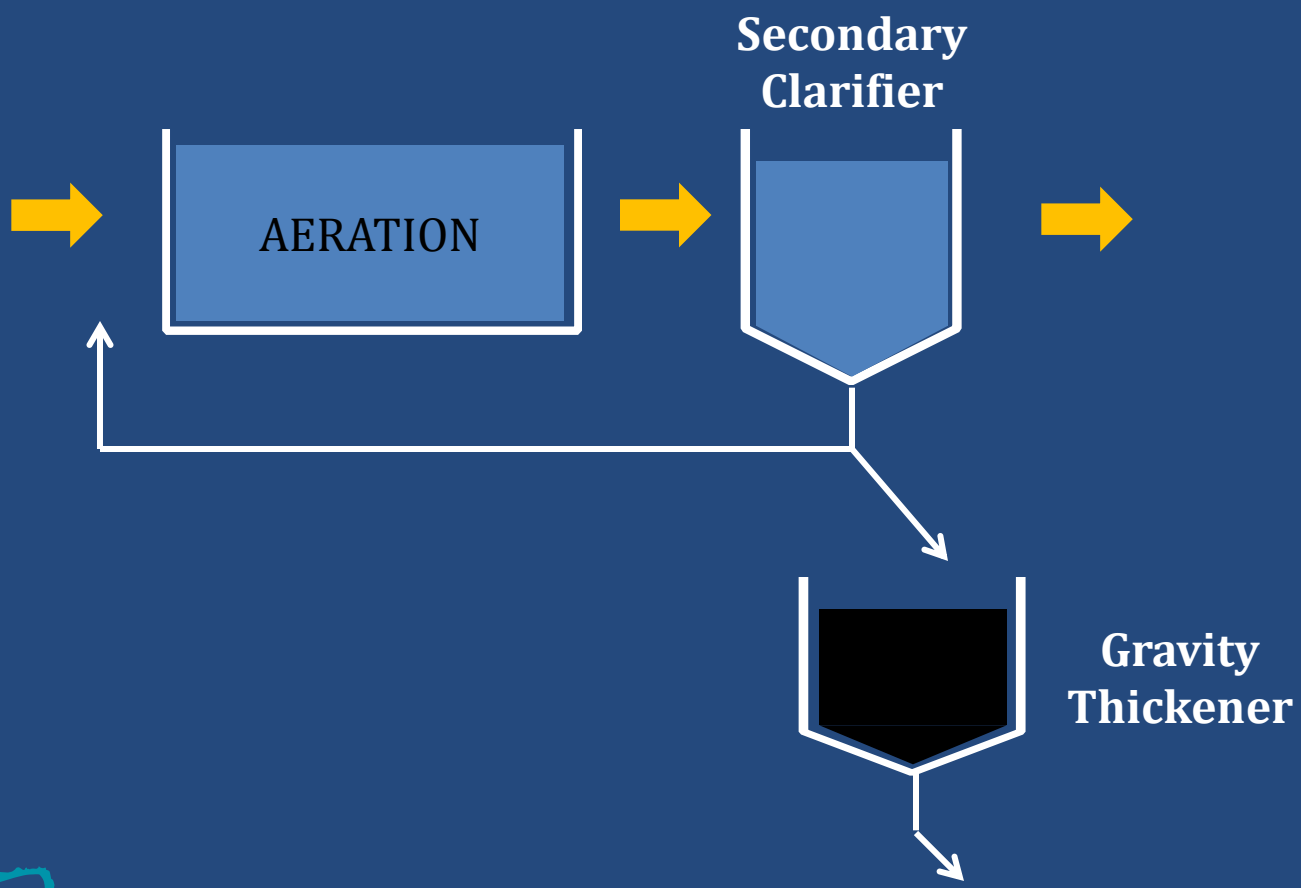
Before Changes:	20 mg/L
After Operational Changes:	8 mg/L
After Renovation (anticipated):	5 mg/L

Effluent total-P

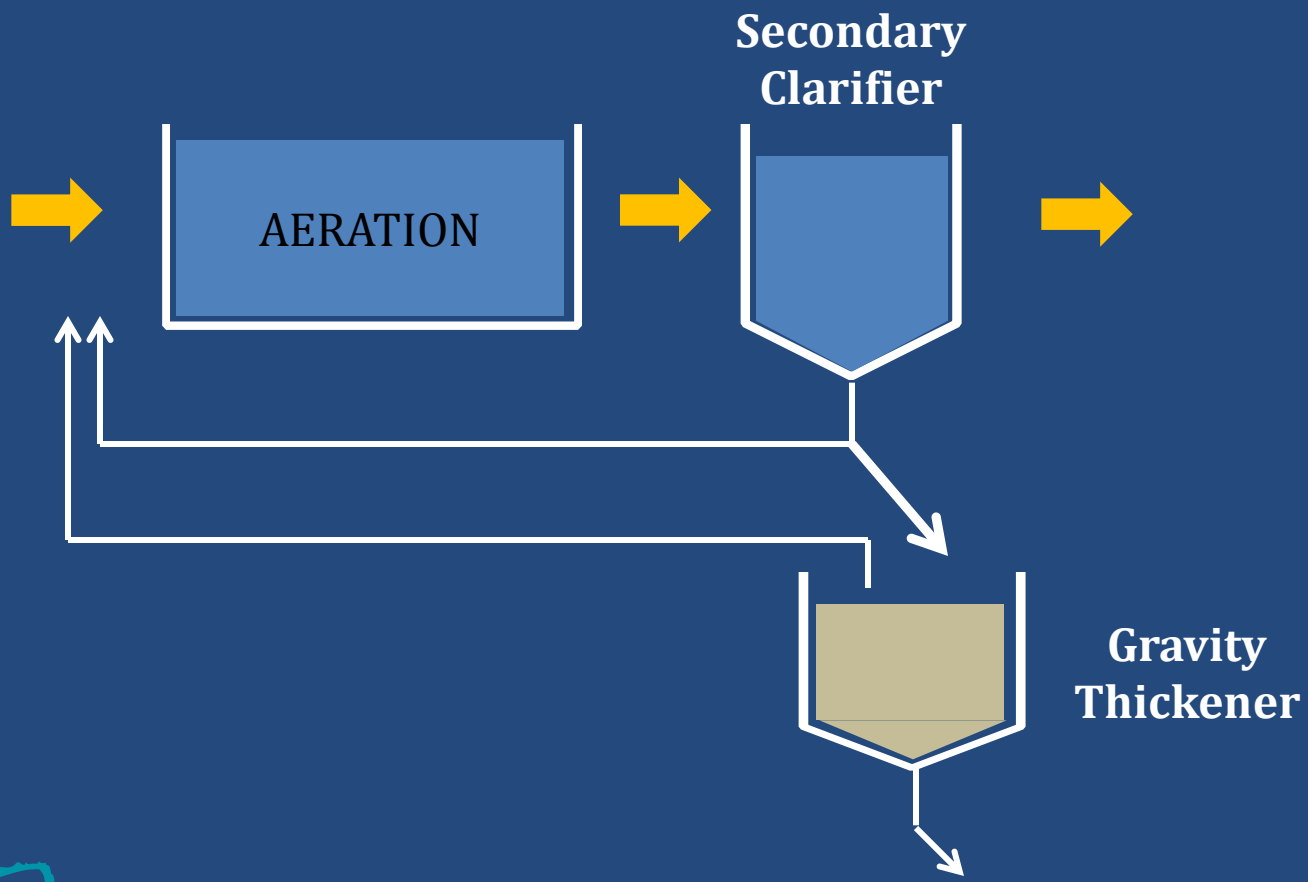
Before Changes:	3 mg/L
After Operational Changes:	0.75 mg/L
After Renovation (anticipated):	0.5 mg/L



Plainfield Village



Plainfield Village
Gravity Thickener as Post-Anoxic Denitrification



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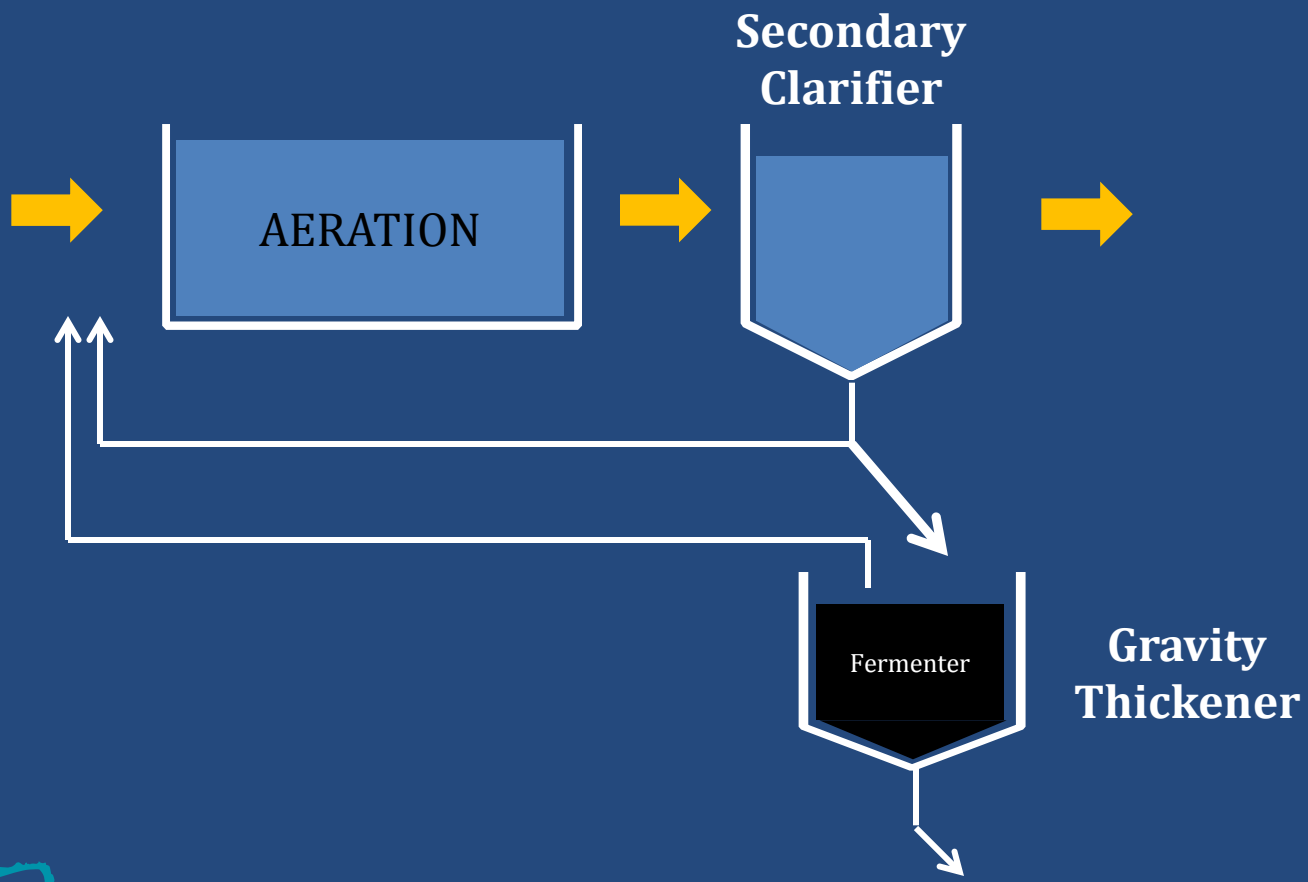


Plainfield, Connecticut

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

Case Study
Amherst, Massachusetts

Population: 38,000

Design Flow: 7.2 MGD
Actual: 5.0 MGD (school in session)
3.5 MGD (school break)

Effluent total-N

Before: 25 mg/L

After: 10 mg/L

Effluent total-P

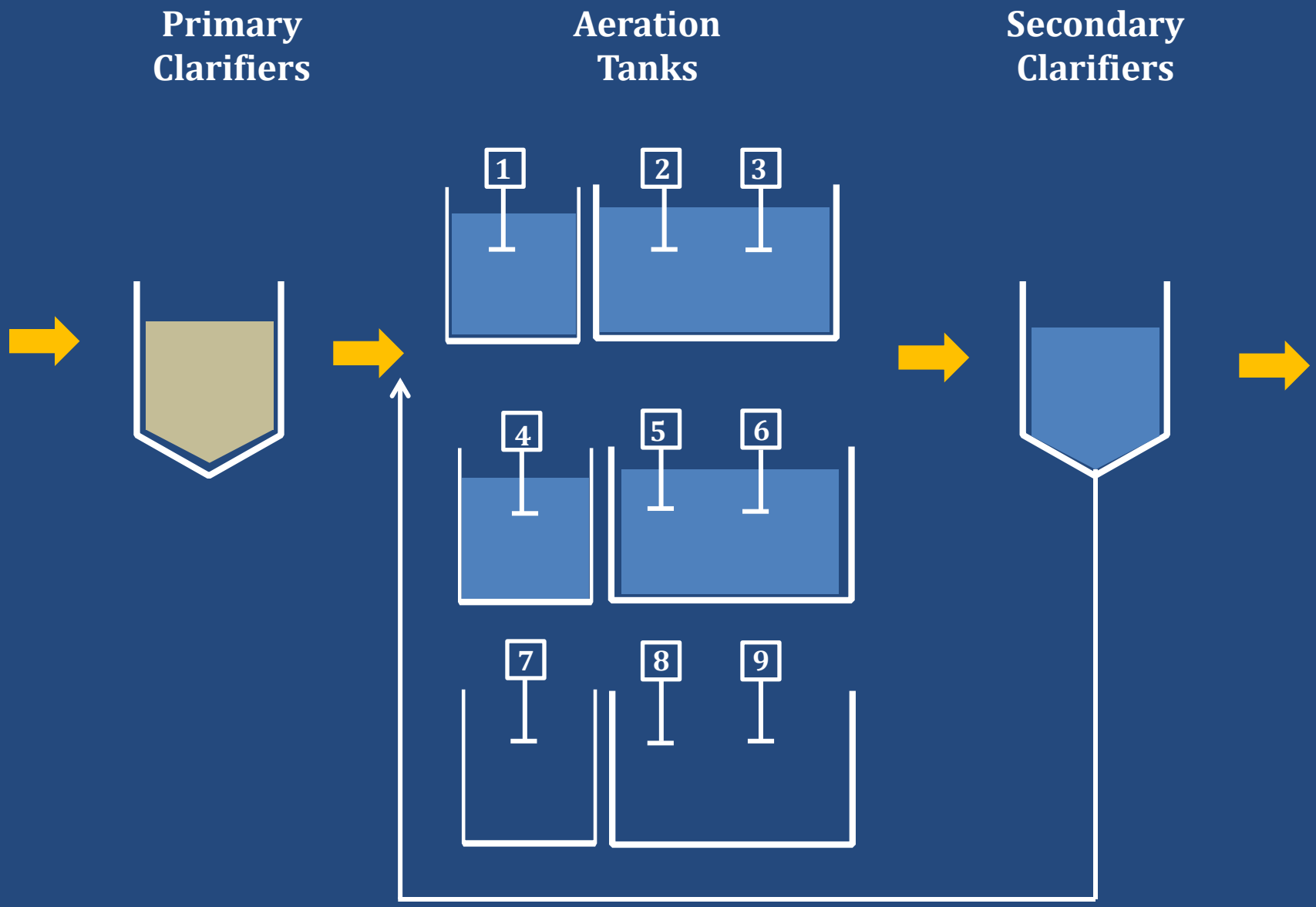
Before and After: 3 mg/L

Amherst, Massachusetts

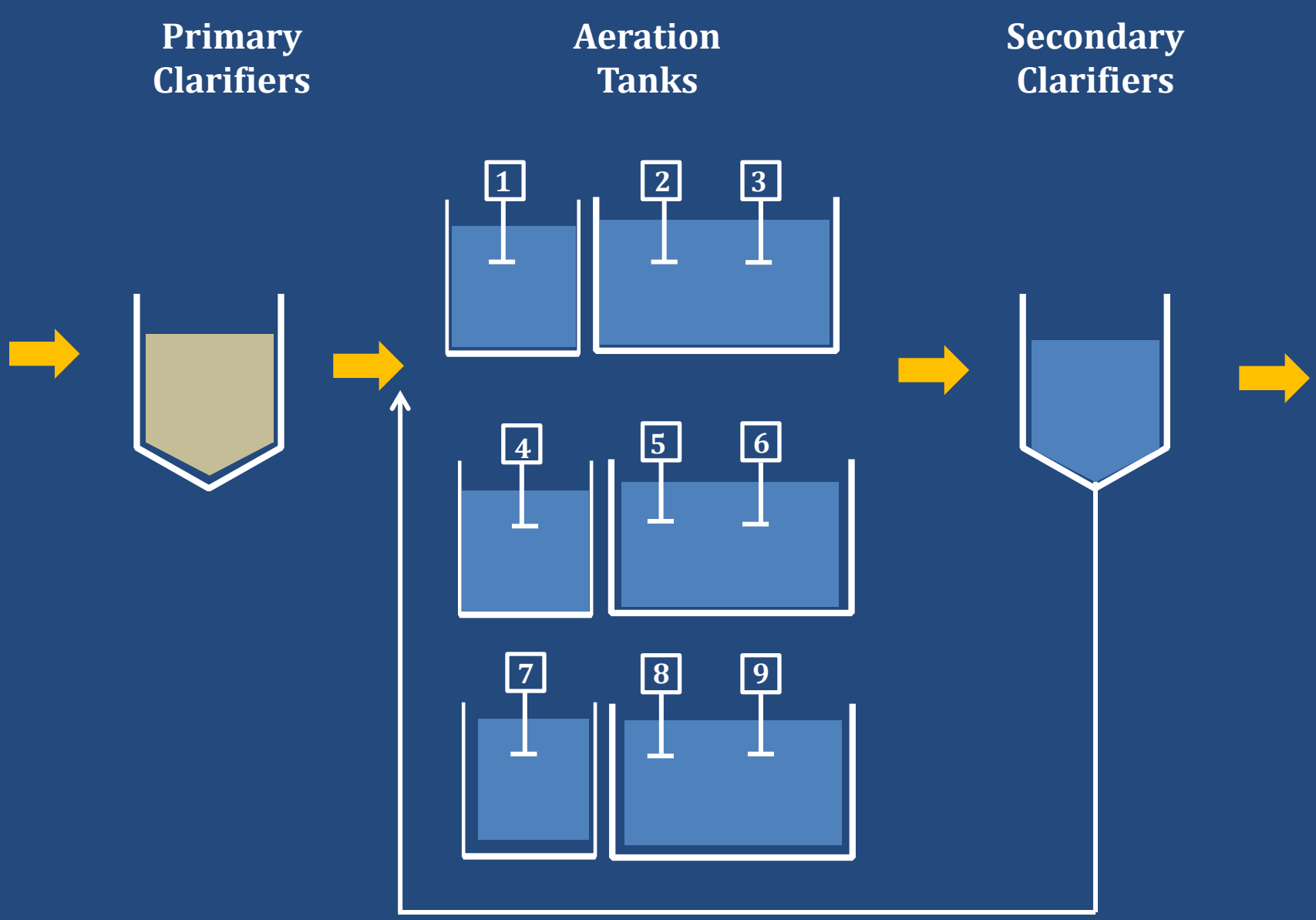
New Nitrogen Limit: 546.5 pounds/day, approximately 13 mg/L

2008 BioWin modeling found facility “not capable of removing nitrogen.”

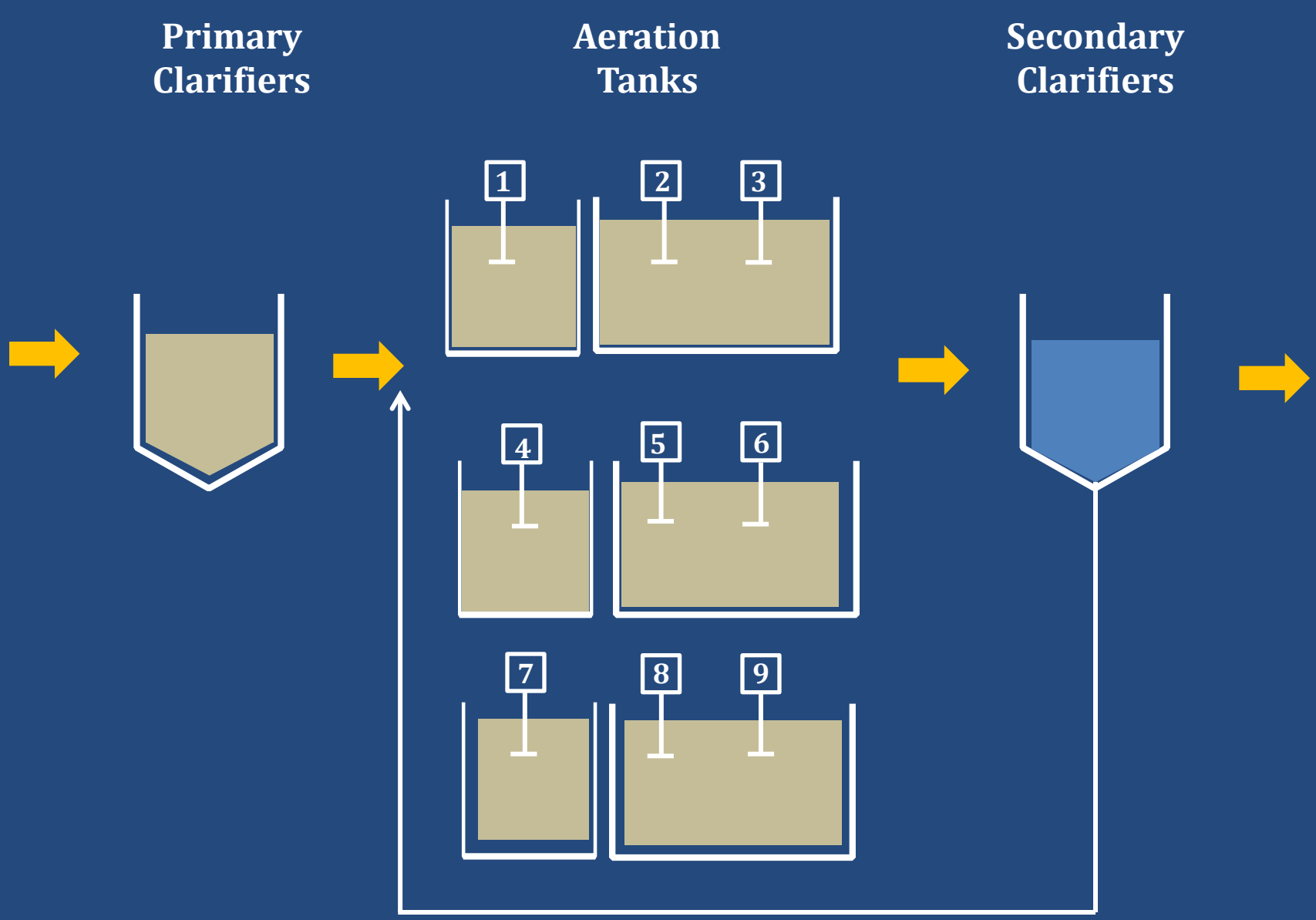
Facility Upgrade cost estimate: $61,000,000



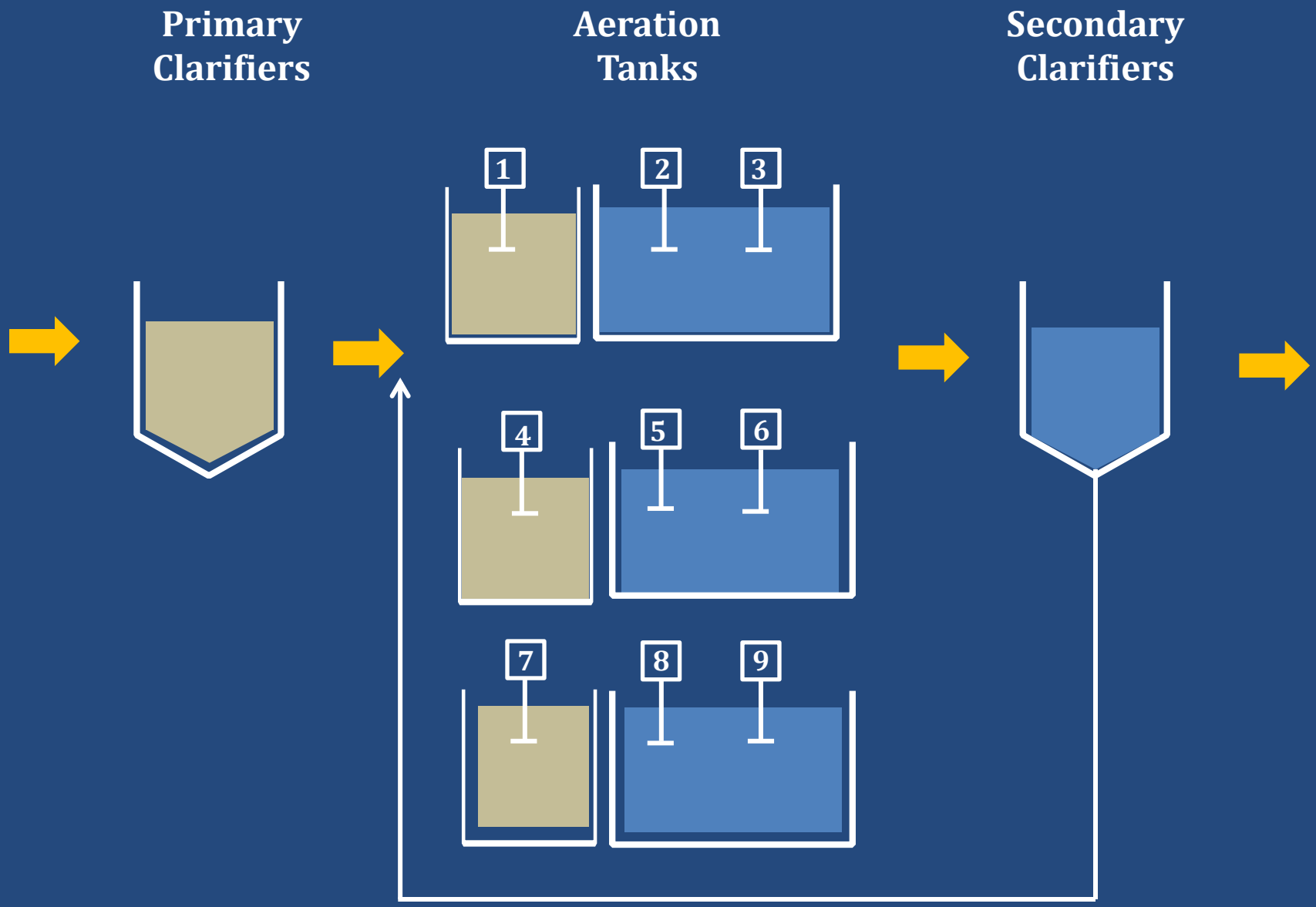
Amherst, Massachusetts



Amherst, Massachusetts



Amherst, Massachusetts



Amherst, Massachusetts

Amherst, Massachusetts

Cost of Compliance: **< $100,000**

Proposed Facility Upgrade: **$61,000,000**

2008 BioWin modeling results:

… "there are no operational or minor modifications/retrofits that could be implemented at this facility to consistently achieve nitrogen removal.

The existing facility has half of the necessary volume at the current flows …"

Case Study
Keene, New Hampshire

Population: 23,000

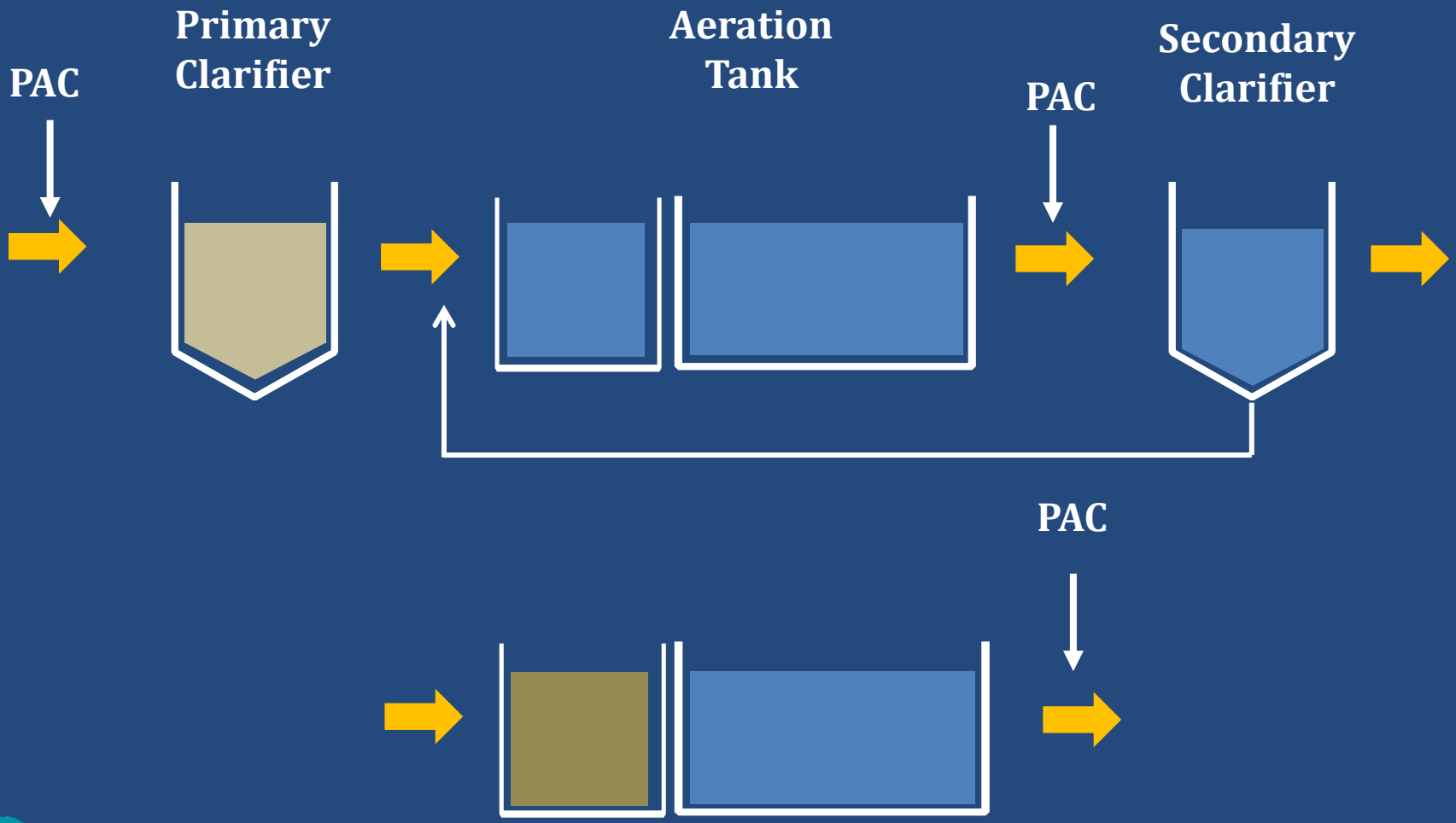
Design Flow: 6.0 MGD
Actual: 3.0 MGD

Effluent total-N

Before & After: 8 mg/L

Effluent total-P

Before Changes: 3.0 mg/L
After Changes: 0.2 mg/L



Keene, New Hampshire

Keene, New Hampshire

Modified Plant Upgrade: **$4,000,000**

Proposed Facility Upgrade: **$12,000,000**

Case Studies

Improved Treatment	Before (mg/L)	After (mg/L)
Nitrogen Removal	15-25	6-10
Phosphorus Removal	3.0	0.2-0.8

O&M Costs

Amherst, MA	$30,000/yr Savings (sludge disposal)
Plainfield, CT	Small Savings
Keene, NH	$50,000/yr Savings (chemical usage)

Findings

Wastewater treatment plants can remove Nitrogen &/or Phosphorus at fantastic savings: $ Billions

Instrumentation and computer controls are cost-effective; but, rarely purchased:

- Local funds (O&M budgets) are tight
- Clean Water Funds not practical

Wastewater Operators:

- Training & Support
- Low Expectations

Grant's Recommendations / Requests / Dreams …

Promote Optimization

- EPA Region 1 Permit Language
- Empower, Train & Raise Operator Expectations

Make Money Readily Available for $500K Projects

Instrumentation and Computer Control

- Installation
- Remote interpretation and on-going Support

"Means Test" Process Changes before Capital Improvement Funding

Projects worth packing my bags for …

Implementation Funding:

- 2014 NEIWPCC Study – Preliminary Findings (24 of 29)
- 2008 MA DEP Study (11^{+} of 21)
- Elsewhere (?)

"Innovative and Alternative" Funding for Regional Optimization Effort:

- State(s)
- Watershed(s)

THE WATER PLANET COMPANY

Making clean water affordable

GrantWeaver@theWaterPlanetCompany.com

Thank You!

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Wastewater fundamentals:

One organism's waste is another's food