Nitrogen Removal from Municipal Wastewater

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Town of Falmouth Overview
Falmouth Wastewater Overview

• ~ 3% of developed properties (~700) in town connected to Main WWTF collection system

• Majority of the rest of the properties have septic systems or cesspools – WWTF handles this septage as well

• Municipal New Silver Beach WWTF serves an additional ~ 200 properties

• Some clusters and advanced individual systems
Falmouth Main WWTF

Original WWTF Constructed in 1980s; Upgrade completed 2005
Groundwater Discharge Permit Limits

- 800,000 gpd (no more than 570,000 gpd from outside the West Falmouth Watershed)
- Total Nitrogen: 10 mg/L daily maximum
- Additional TN targets:
  - Effluent TN: 3 mg/L
  - Annual effluent TN load of no more than 5,204 lbs/year to the West Falmouth Harbor watershed
- TSS / BOD: 30 mg/L
- Oil / Grease: 15 mg/L
- Fecal coliform 200 cfu/100 mL
WWTF Background

• Variable influent flow and load: seasonal community + septage receiving
• Flow ranges from 200,000 gpd to 700,000 gpd
• Influent BOD and TSS range from < 100 to > 350 mg/L; average < 200 mg/L
• Effluent BOD average < 3 mg/L, TSS average < 5 mg/L
• Effluent TN average < 5 mg/L since start up; lower in past 2011 and 2012
Biological Nitrogen Removal

Bacteria do work of nitrogen removal
Influent contains nitrogen in 2 forms: ammonia and organic nitrogen

**Ammonification:**
Organic matter → ammonia
(much of this occurs in collection system)
Biological Nitrogen Removal

Nitrification:

two-step oxidation of ammonia to nitrate by bacteria, summarized:

\[ \text{NH}_4^+ + 2 \text{O}_2 \rightarrow \text{NO}_3^- + 2\text{H}^+ + \text{H}_2\text{O} \]

Requires oxygen (and alkalinity)
Biological Nitrogen Removal
(Continued)

Denitrification:
Conversion of nitrate to nitrogen gas by bacteria, summarized:

\[ 6 \text{NO}_3^- + 5 \text{CH}_3\text{OH} \rightarrow 5 \text{CO}_2 + 3 \text{N}_2 + 7 \text{H}_2\text{O} + 6 \text{OH}^- \]

Requires carbon, absence of oxygen
<table>
<thead>
<tr>
<th>Phase</th>
<th>Description</th>
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<tr>
<td>MIXED FILL</td>
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<td>REACT FILL</td>
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<td>DECANT/SLUDGE</td>
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<td>WASTE/IDLE</td>
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Sequencing Batch Reactor
Nitrogen Removal Limits

• 3 mg/L is generally achievable for our WWTF
• However would be concerned about enforceable 3 mg/L effluent limit because:
  – 3 mg/L is “limit of technology” for “enhanced nitrogen removal processes” like SBRs + denit
  – Insufficient flexibility for issues that arise under normal operation: variation in influent characteristics (flow, load, toxicity, etc), operator error, mechanical problems
  – Biological processes take time to recover, particularly in cold weather
  – “refractory nitrogen” – eff TKN sometimes > 3 mg/L
Falmouth WWTF Effluent Nitrogen - 2011 thru 2012

- NH4
- NO3
- TKN
- NO2
- Eff TN (mg/L)
The Value of Falmouth’s Estuaries

Falmouth has more estuaries than any other town in Massachusetts (15 total)

Home to a wide variety of marine life

A focal point for community recreation - fishing, boating, passive enjoyment
Our Estuaries are in Trouble

Excess nitrogen is the main cause of the decline of our estuaries

At least 75% of the controllable nitrogen input comes from septic systems
Estimated % Wastewater Nitrogen Removal to Meet TMDLs
April 2011 Town Meeting unanimously passed Article 17, appropriating $2.7 million to proceed with sewer design and alternative demonstration projects.

Voters approved this measure on a town-wide ballot, supporting it by a 2:1 margin in every precinct.

In August 2013, Board of Selectmen unanimously approved a Draft Comprehensive Wastewater Management Plan (DCWMP) with these elements and submitted it to the state.
Included in Plan Approved by Selectmen and Town Meeting:

- Eco-toilets
- Shellfish Cultivation
- Permeable Reactive Barriers
- Denitrifying Septic Systems
- Road Runoff Remediation
- **Bournes Pond Inlet Widening**
- **Lower Little Pond Sewering**
Bournes Pond Inlet Widening

- 90 foot opening provides optimal flushing
- Could remove as much nitrogen as sewering over 350 homes
- Cost of inlet widening is less than 40% of sewering costs
- Benefits to Bournes Pond are immediate
Sewering Lower Little Pond Watershed

An important and cost-effective project:

- Little Pond is town’s most degraded estuary
- Many very small lots (5000 square feet or less)
- Area almost at build-out
- Many homes still have cesspools
Lower Little Pond Collection System
Preliminary Design
Discussion