

Nitrogen Removal from Municipal Wastewater

An aerial photograph showing a coastal city with a large body of water in the background. The city is built on a peninsula or near a large bay, with a winding waterway or canal cutting through the green, forested areas. The sky is blue with some light clouds.

Amy Lowell
Assistant Wastewater Manager

March 6th, 2013

Town of Falmouth Overview



Falmouth Wastewater Overview

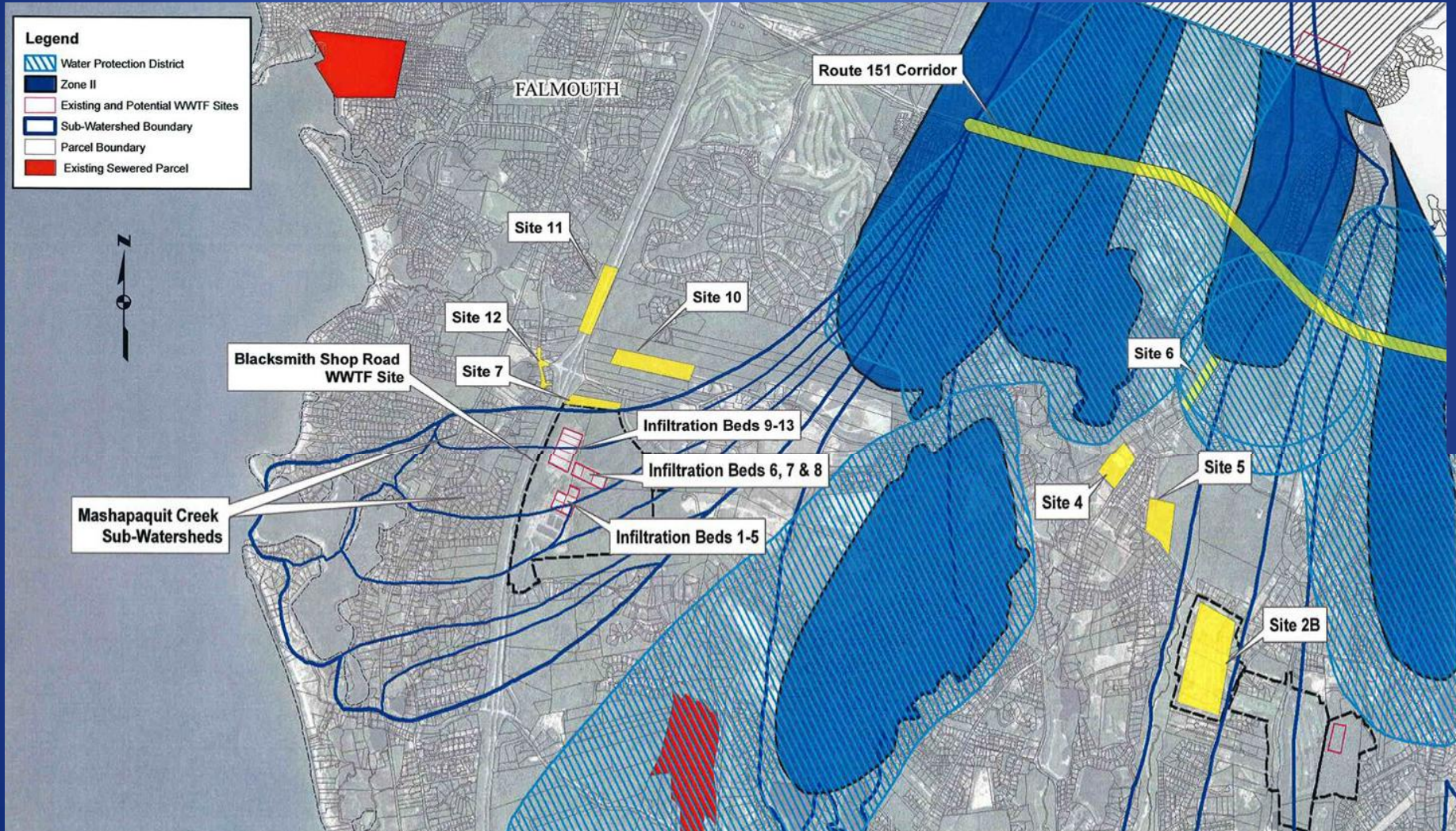
- ~ 3% of developed properties (~700) in town connected to Main WWTF collection system
- Majority of the rest of the properties have septic systems or cesspools – WWTF handles this septage as well
- Municipal New Silver Beach WWTF serves an additional ~ 200 properties
- Some clusters and advanced individual systems

Falmouth Main WWTF



Original WWTF Constructed in 1980s; Upgrade completed 2005

West Falmouth Harbor Watershed

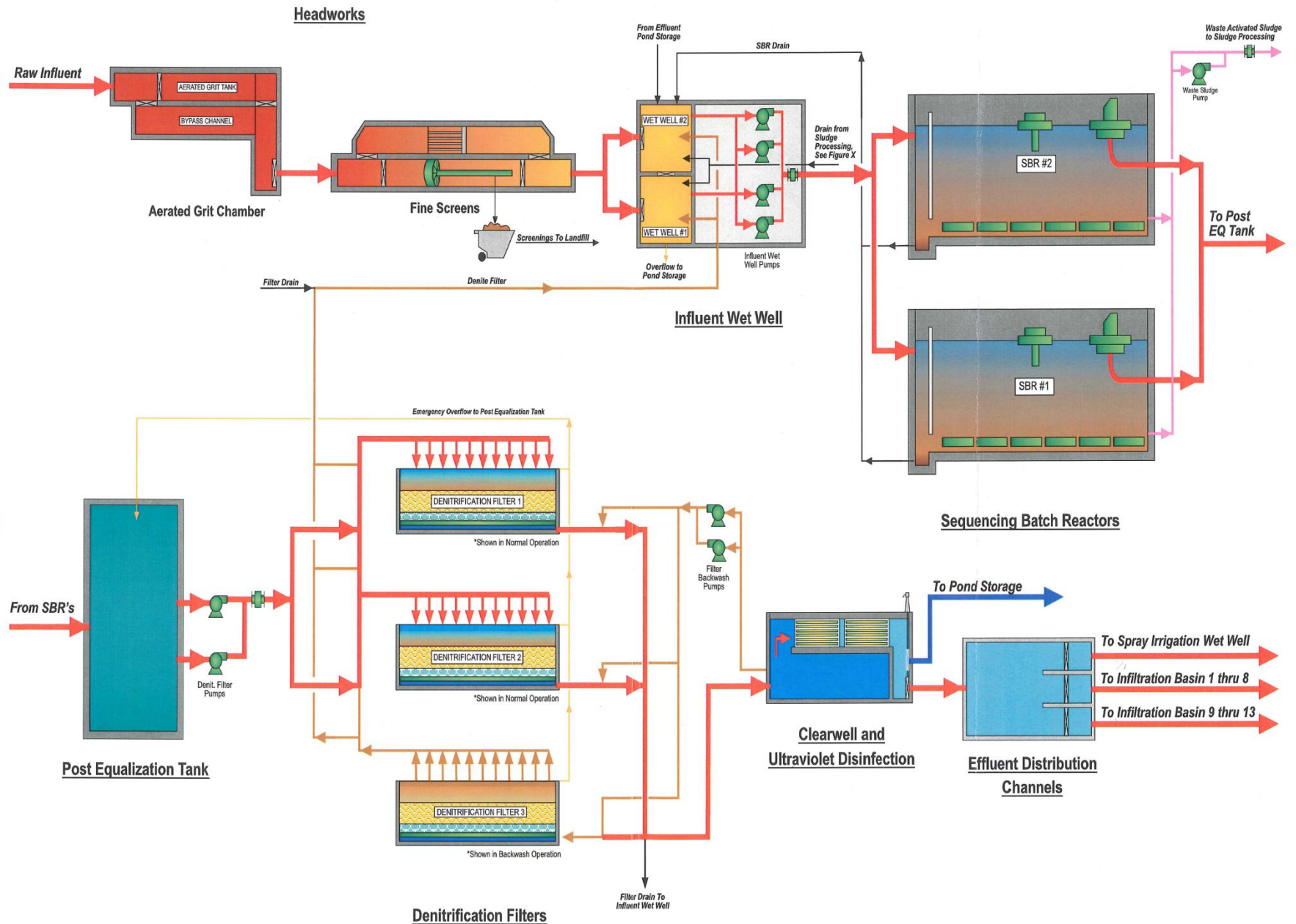


Groundwater Discharge Permit Limits

- 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**



Falmouth Main WWTF



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:



Requires oxygen (and alkalinity)

Biological Nitrogen Removal (Continued)

Denitrification:

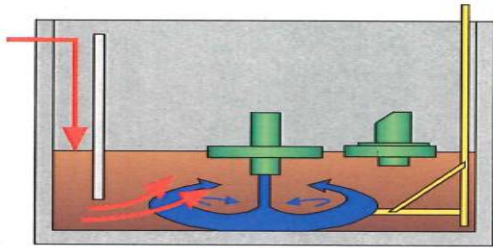
Conversion of nitrate to nitrogen gas by bacteria, summarized:



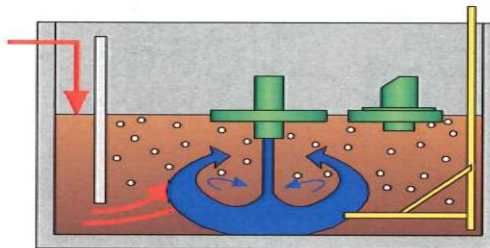
Requires carbon, absence of oxygen

SBR Phases

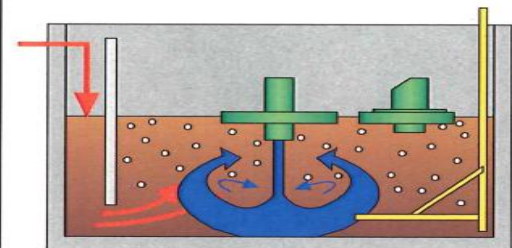
MIXED FILL



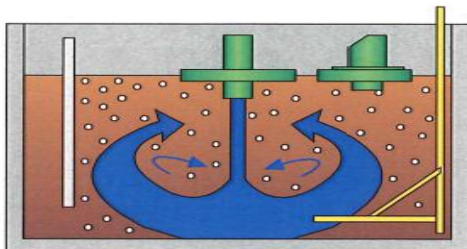
REACT FILL



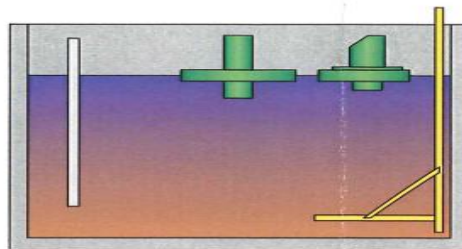
REACT FILL



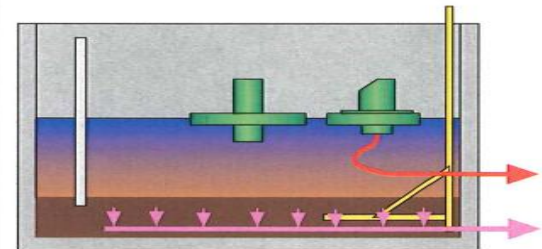
REACT



SETTLE



DECANT/SLUDGE
WASTE/IDLE



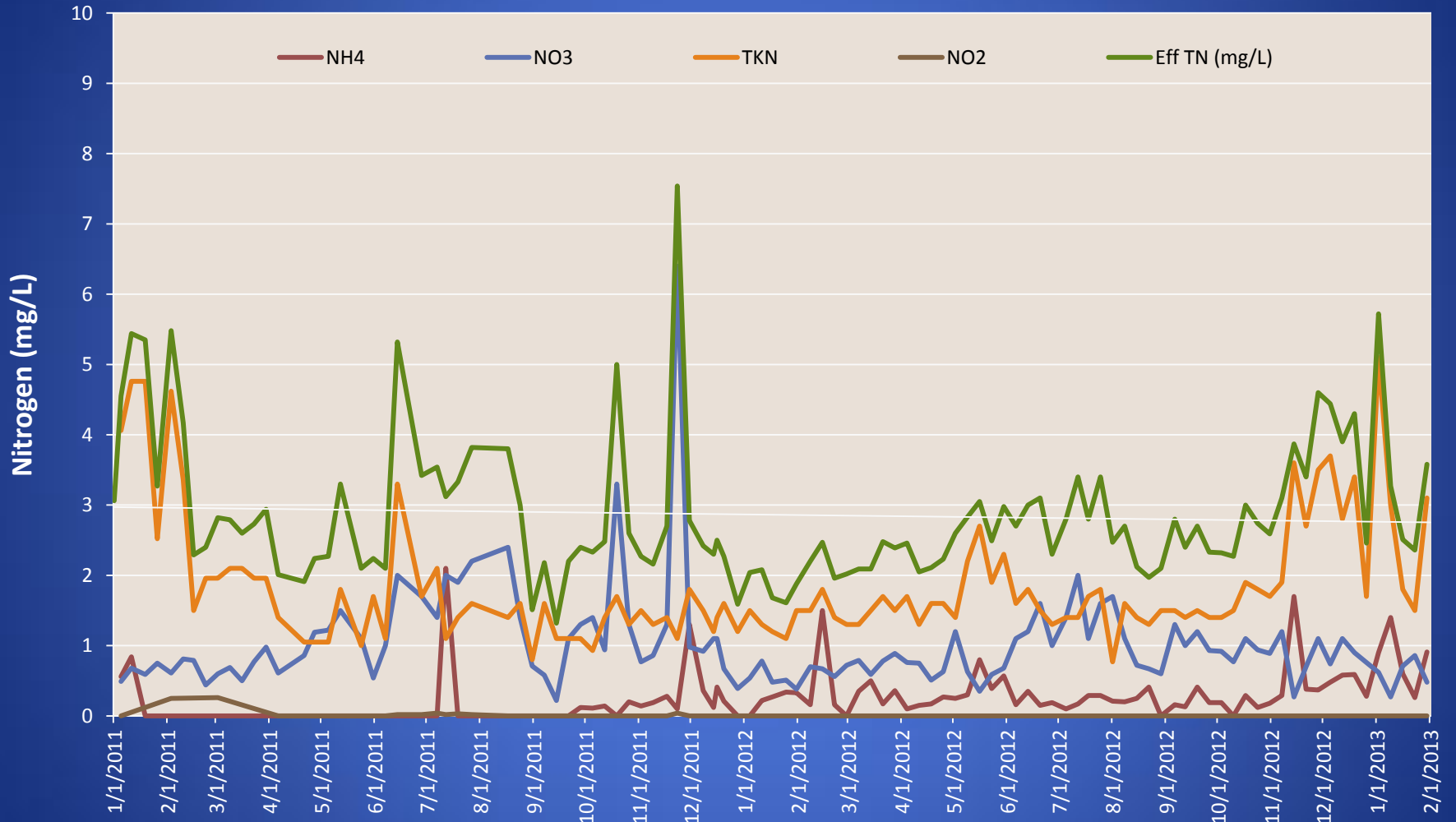
Sequencing Batch Reactor



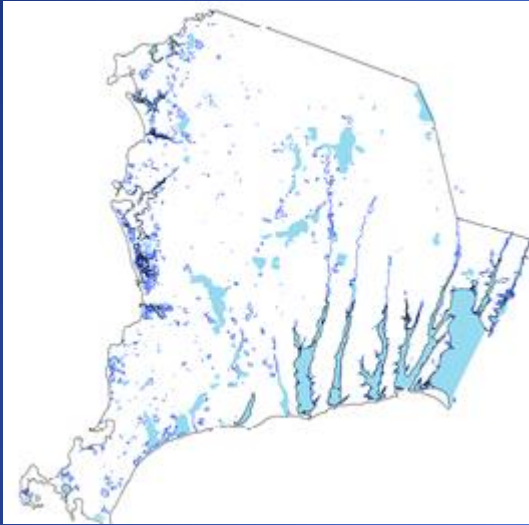
Nitrogen Removal Limits

- 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



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



Little Pond, 1950

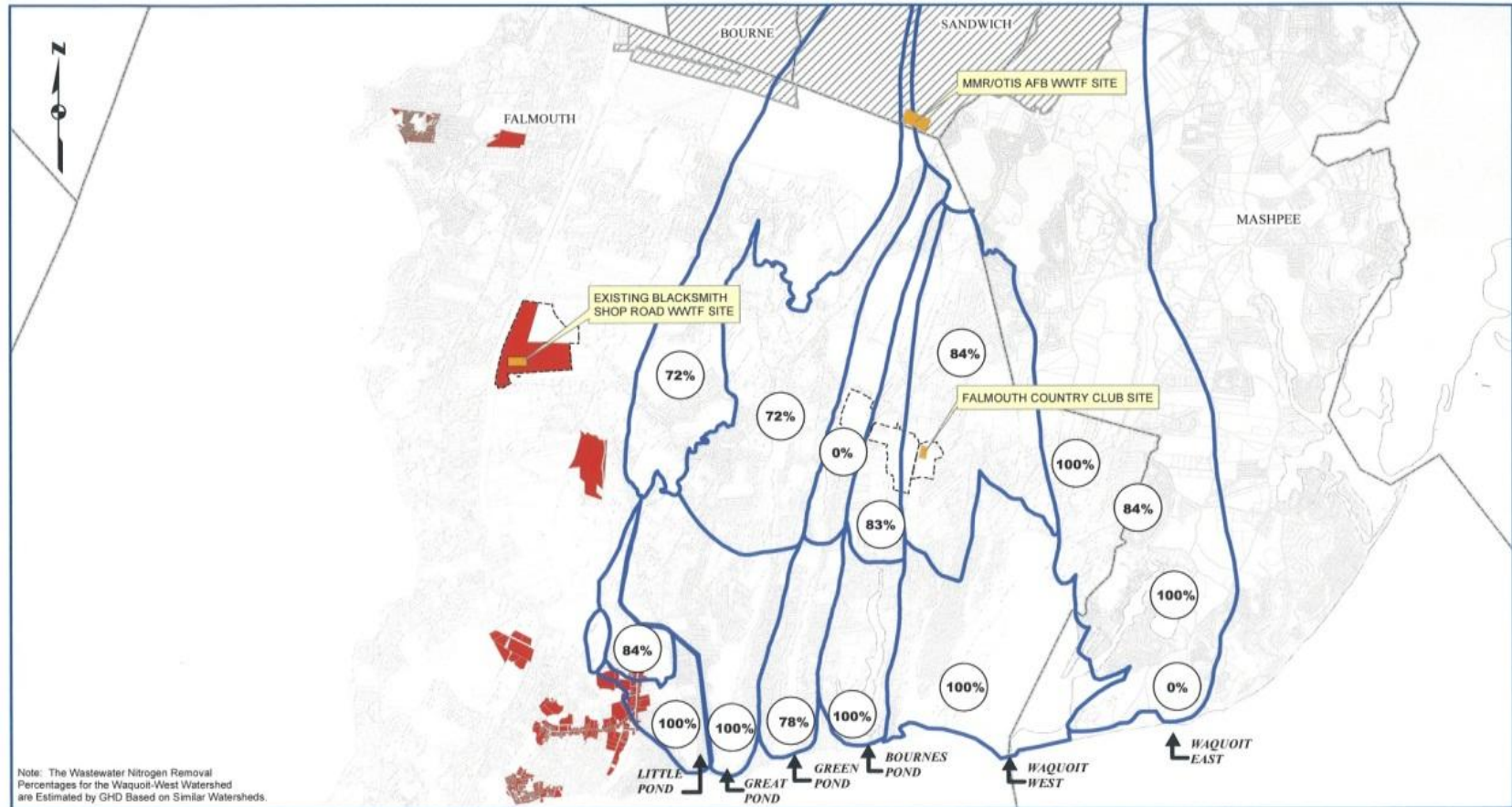


Little Pond, 2009

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



<p>Paper Size ANSI B</p> <p>0 0.225 0.45 0.9</p> <p>Miles</p> <p>Map Projection: Lambert Conformal Conic Horizontal Datum: North American 1927 Grid: NAD 1983 StatePlane Massachusetts Mainland FIPS 2001</p>	<p>LEGEND</p> <ul style="list-style-type: none"> Sub-Watershed Boundary Town Boundary Parcel Boundary MMR 75% Estimated Future Wastewater Nitrogen Removal Percentage Sewered Parcel 	 <p>CLIENTS' PEOPLE' PERFORMANCE</p>	<p>TOWN OF FALMOUTH, MASSACHUSETTS CWMP</p> <p>ESTIMATED FUTURE WASTEWATER REMOVAL PERCENTAGES TO MEET TMDLs</p>	<p>Job Number 86-12163 Revision A Date 15 Jun 2012</p>
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Figure 1-3

Falmouth's Estuaries Restoration Plan

April 2011 Town Meeting unanimously passed Article 17, appropriating **\$2.7 million** to proceed with sewer design and alternative demonstration projects

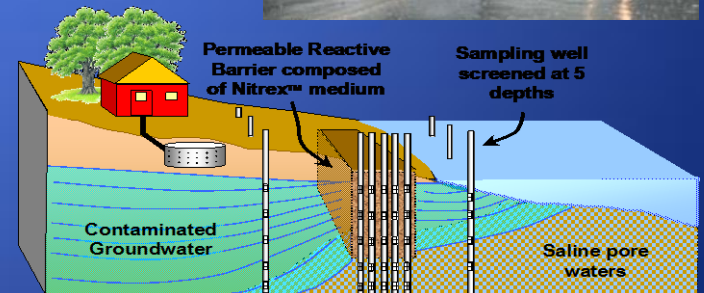
Voters approved this measure on a town-wide ballot, supporting it by a 2:1 margin in every precinct.

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 sewerage over 350 homes
- Cost of inlet widening is less than 40% of sewerage 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



<p>Paper Size ARCH D</p> <p>0 250 500 1,000 Feet</p> <p>Mtg Projection: Lambert Conformal Conic Horizontal Datum: North American 1983 Contour: NAD 1983 Contour Massachusetts Modified FIPS 2001 Feet</p>		<p>LEGEND</p> <ul style="list-style-type: none"> ● Existing MH ■ Pump Station — Proposed Gravity Sewer — Existing Gravity Sewer — Low Pressure — Force Main - - - Service Areas 		<p>TOWN OF FALMOUTH, MASSACHUSETTS Wastewater and Nutrient Management Services</p> <p>ALTERNATIVE NO. MODIFIED 1A GRAVITY AND LOW PRESSURE SEWER</p>	<p>Job Number 86-15007 Revision A Date 19 Dec 2012</p>
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C:\Users\pjohn@1927023\Documents\ALTERNATIVE 1A - GRAVITY & LP SEWER S-1-24.mxd
 8/12 While every care has been taken to prepare this map, GHD and DATA CUSTODIAN make no representation or warranty about its accuracy, reliability, completeness or suitability for any particular purpose and accept liability and responsibility of any use other than as intended, and is not intended for any purposes, loans, charges and/or credit including indirect or consequential damages which are or may be incurred by any party as a result of the map being inaccurate, incomplete or unusable in any way and for any reason.
 Revision: Data Collection, Data Set Name: 7/16, Version: 0/0, Created by: atouchman

Figure S-1-5

Discussion

