

# Permeable Reactive Barriers for Reduction of Nitrate Discharge from Septic Systems – *Preliminary Results from a Great Bay Pilot Study*

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Haley & Aldrich, Inc.



# Project Purpose

- To install pilot systems and test effectiveness of Permeable Reactive Barriers (PRBs) in the Great Bay Watershed for nitrogen removal
- To gather shallow groundwater quality data adjacent to existing septic systems to determine septic system nitrogen contribution
- **To implement effective nitrogen removal solutions in the Great Bay Watershed as part of the watershed management plan.**

# Project Partners

**Lead Agencies** – Rockingham County Conservation District and Strafford County Conservation District

**Truslow Resource Consulting LLC** –  
Project Management, Hydrogeology

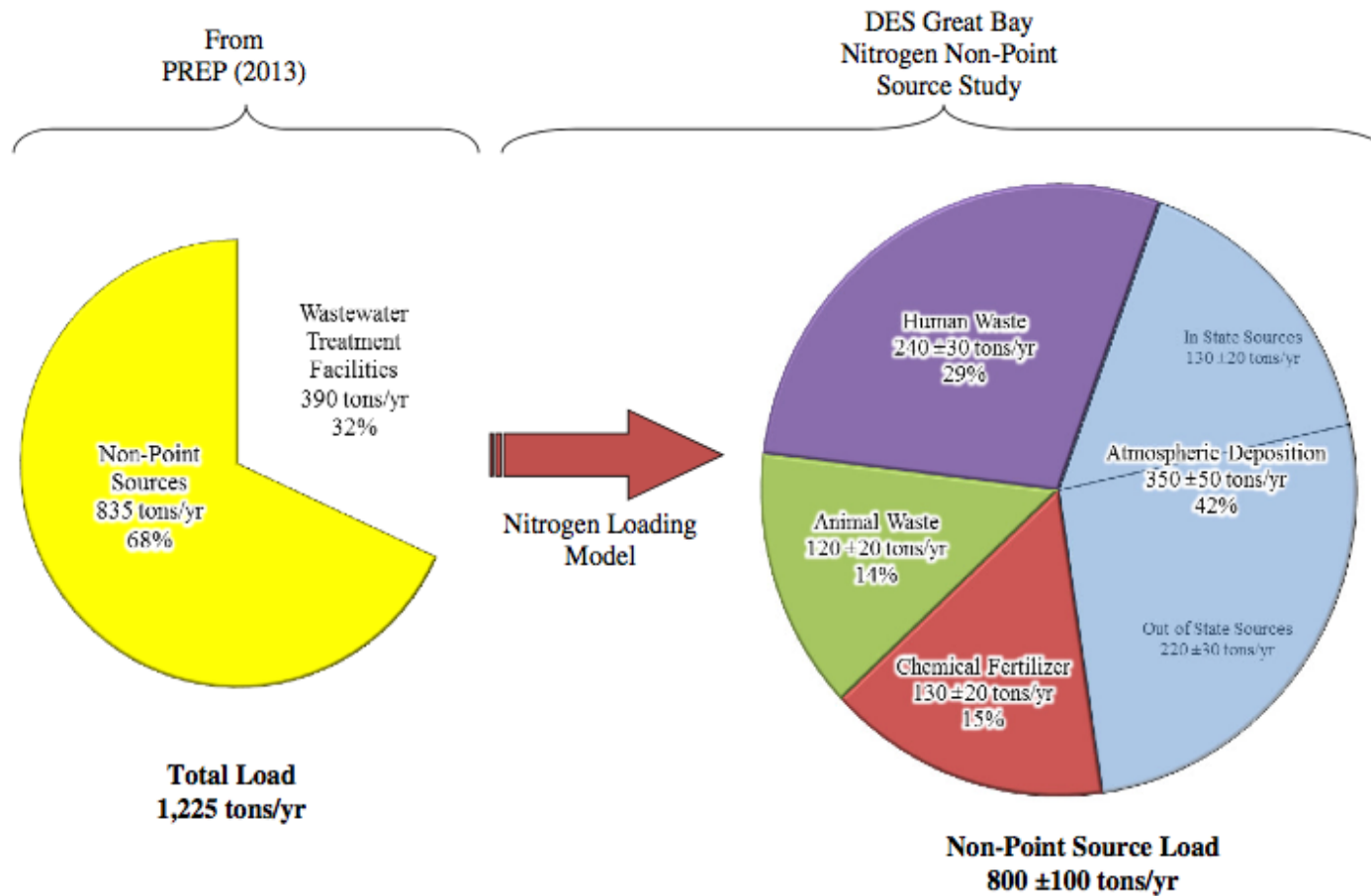
**Haley & Aldrich Inc. and Lombardo Associates** –  
Permeable Reactive Barrier Design and Installation

**Site Owners** – Durham and Brentwood

**Towns of Brentwood and Durham** –  
PRB Construction Manpower, Equipment, and Materials

**Absolute Resource Associates** - Laboratory

# Septic Load to Great Bay Watershed – 29% of Estimated Non Point Source Load



# What are some measures that can be taken to reduce nitrogen loading from septic systems?

- Regularly maintain systems and pump septic tanks
- For new systems site properly and use nitrate-removing systems
- Control inorganic nitrogen migration from sources through *PRBs and other passive treatment technologies*.

# Pilot Project Tasks

- Well installation and testing to determine site hydrogeology – 2014
- Pre- installation GW and SW design sampling and baseline monitoring – Year 2014, 2015 – Nitrogen species, BOD, dissolved metals, alkalinity, field measured pH, DO, SC
- Brentwood PRB design and installation –October 2015
- Durham PRB design and permitting - 2015, Installation 2016
- Post installation monitoring – 2015 and 2016
- Evaluation and Outreach – 2015 and 2016

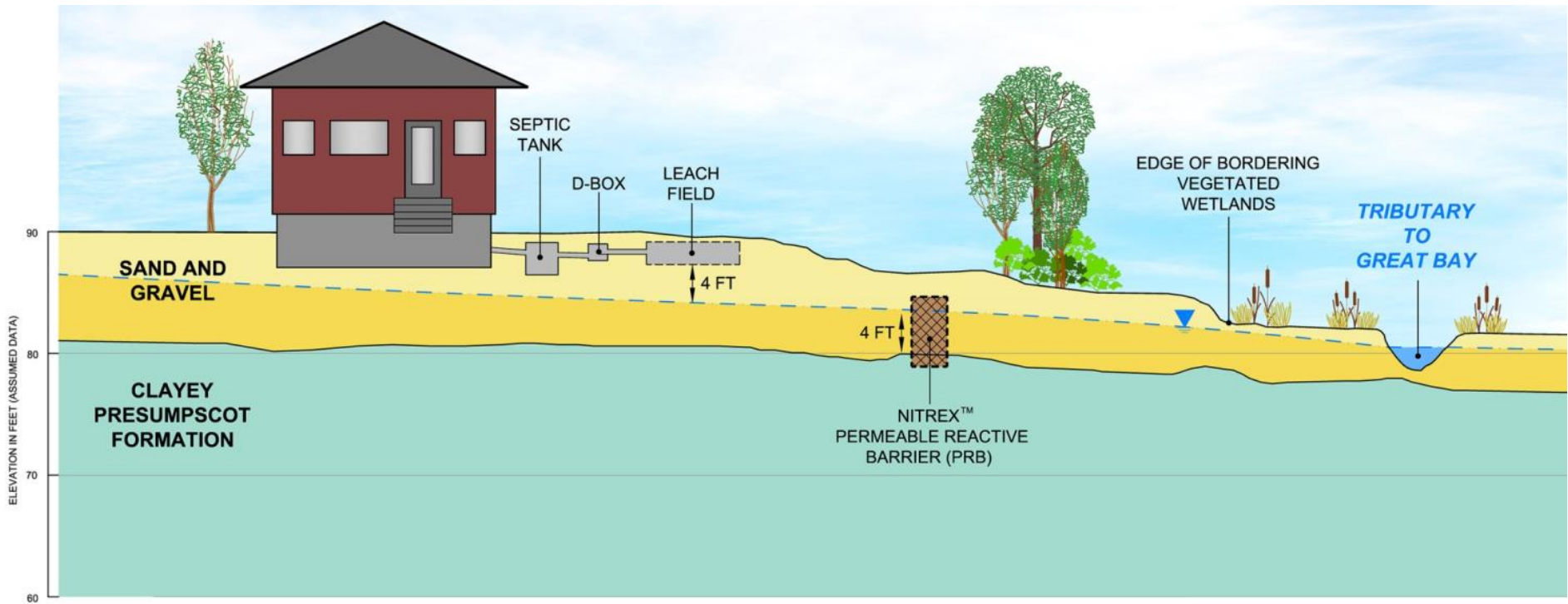
# Criteria for Project Sites

- Active septic system
- Shallow groundwater with predictable flow path
- Sandy overburden underlain by restrictive silt/clay
- Nearby surface water
- Willing landowner
- Accessible site for PRB installation





# Permeable Reactive Barrier (PRB) Demonstration: Showing Nitrate Removal Using PRB



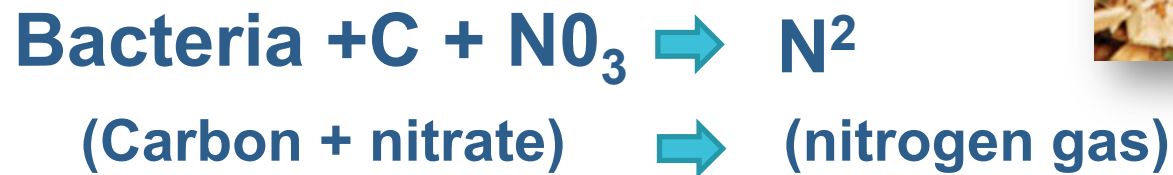
SITE DESIGNATION	LENGTH OF NITREX™ PRB	DEPTH OF NITREX™ PRB
RESIDENTIAL SYSTEM (600 GPD ±) DURHAM, NH	50 FT	5 FT
COMMUNITY SYSTEM (8,000 GPD ±) BRENTWOOD, NH	110 FT	8 FT

## NOTES:

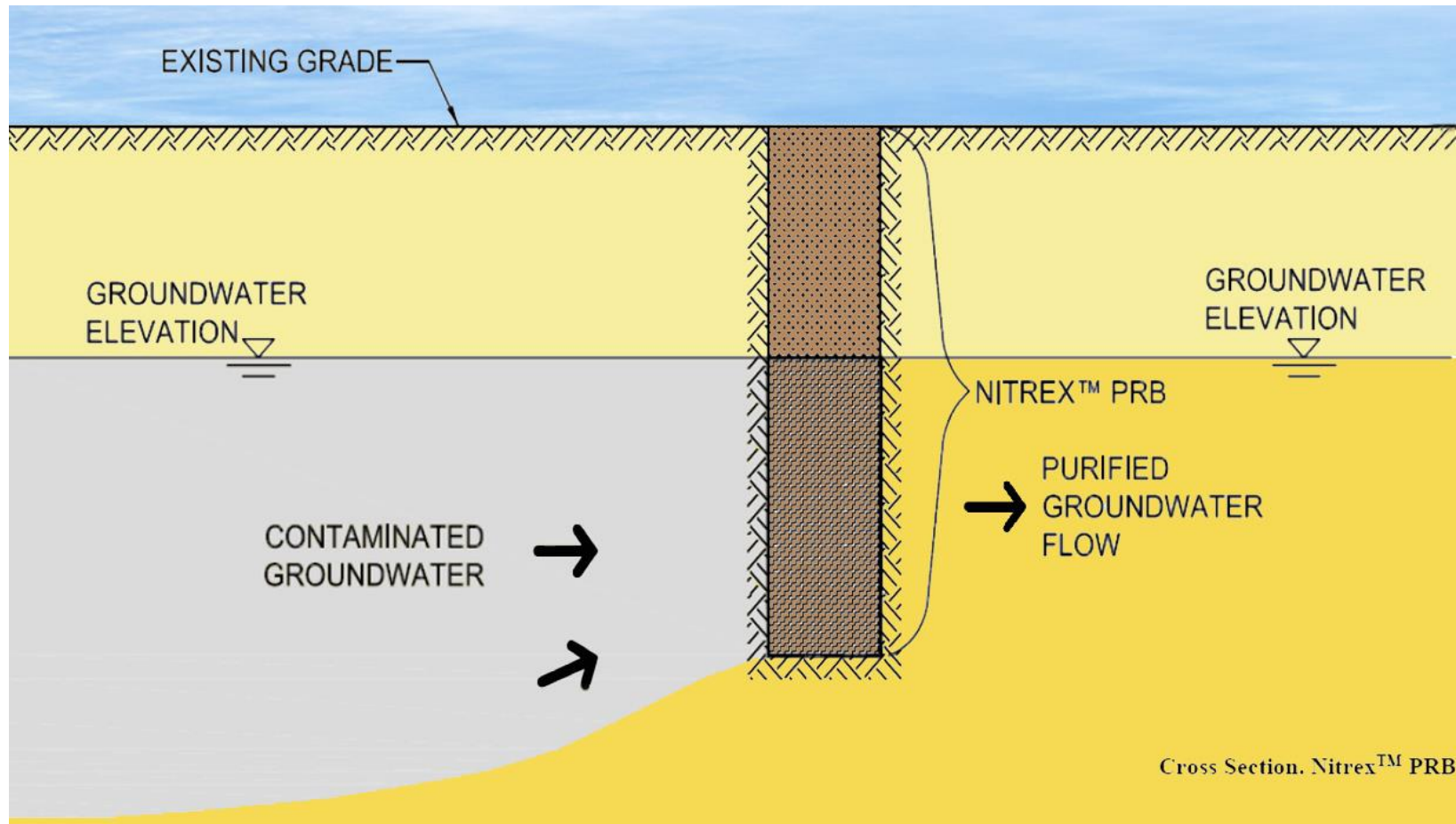
1. ASSUME DEPTH IS 1 FT INTO CLAY AND 1 FT ABOVE TYPICAL GROUNDWATER DEPTH.
2. TYPICAL NITREX PRB WIDTH TO BE 6 FT.

# Wood Chip Bioreactors

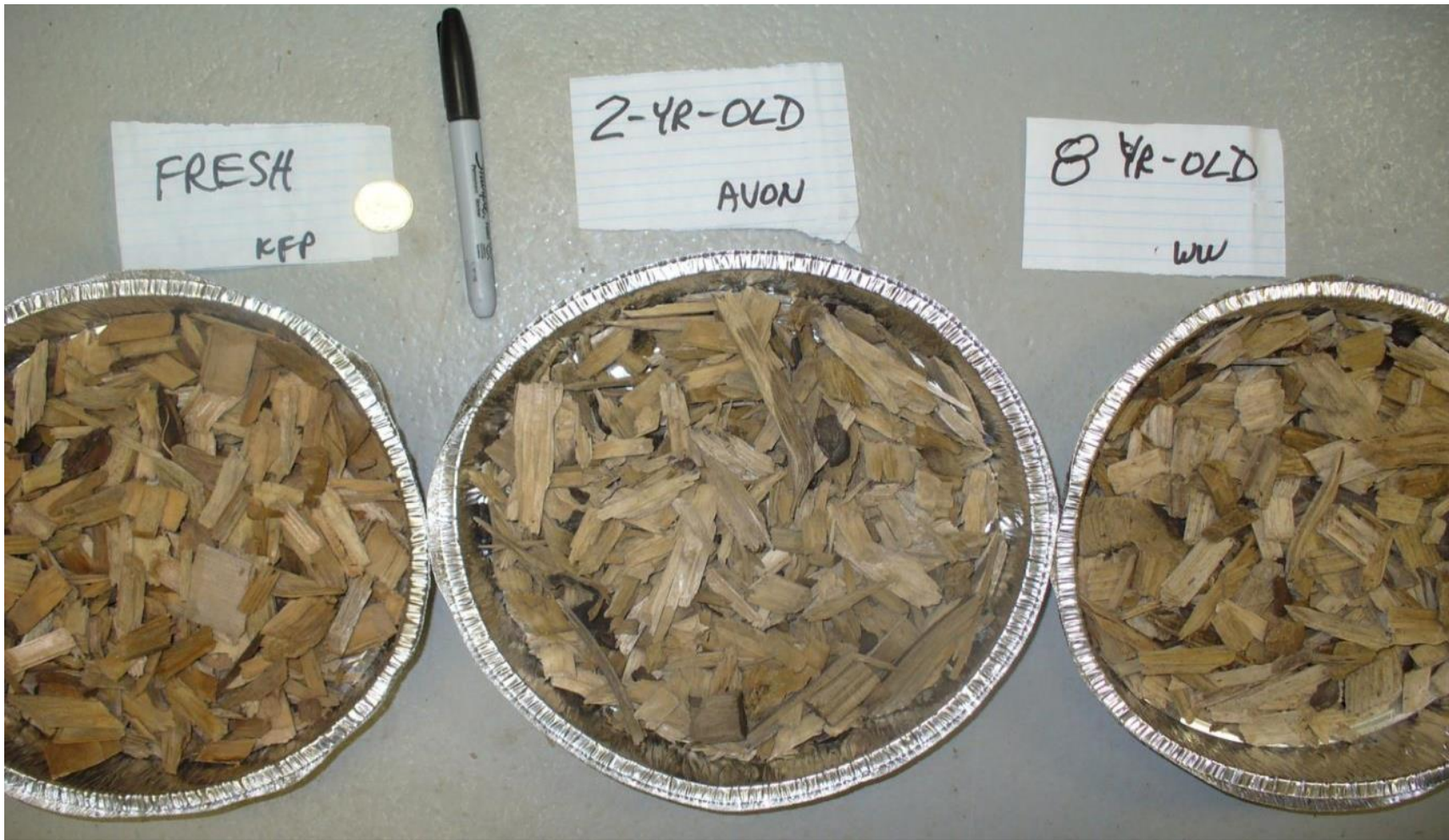
- Low-cost carbon source for denitrification
- In-stream reactors and shallow subsurface reactive barriers are simple to install and maintain



# Bioreactor for Treating Nitrate in Shallow Groundwater



# 1, 2 and 8-yr-old woodchips



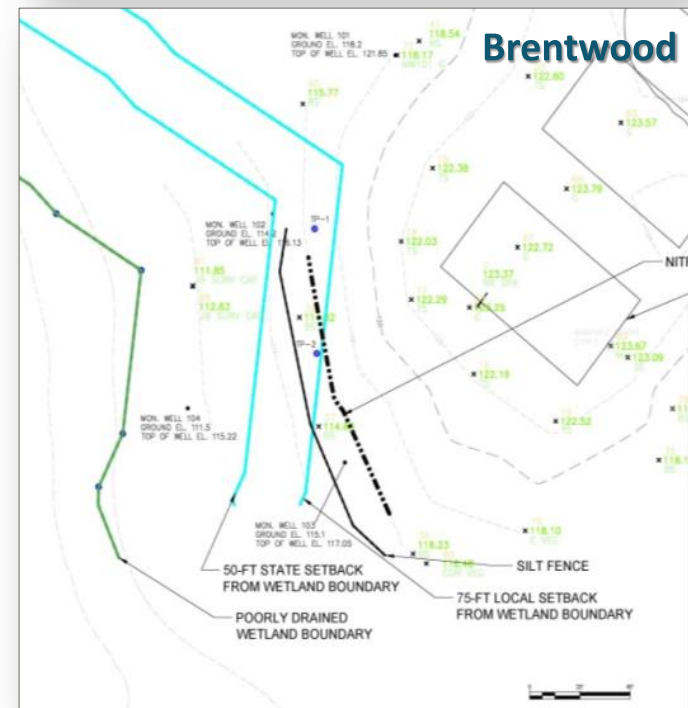
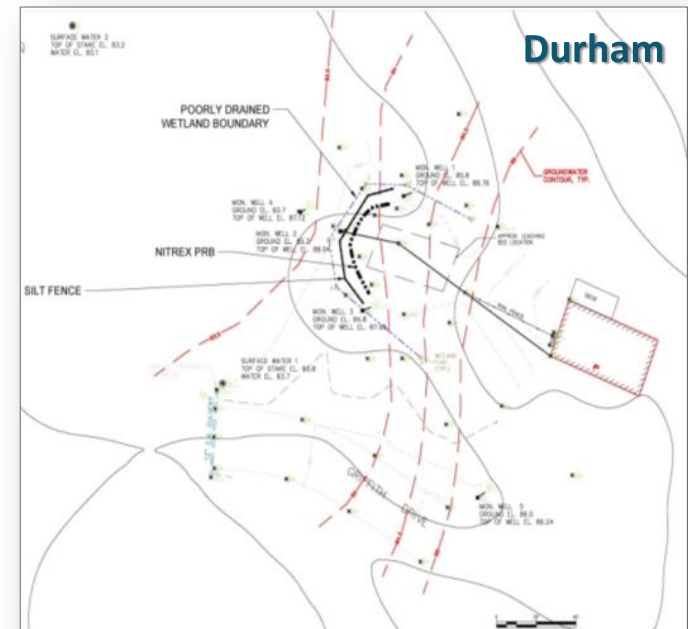
# Nitrate PRB Demonstrations Projects

- 2 PRBs installed in Waquoit Bay, Massachusetts in July 2005 – Reductions of NO<sub>3</sub> from 10 to <0.1 mg/L
- 2 PRBs proposed in Durham and Brentwood, New Hampshire
- Many additional sites at University of Waterloo, Canada

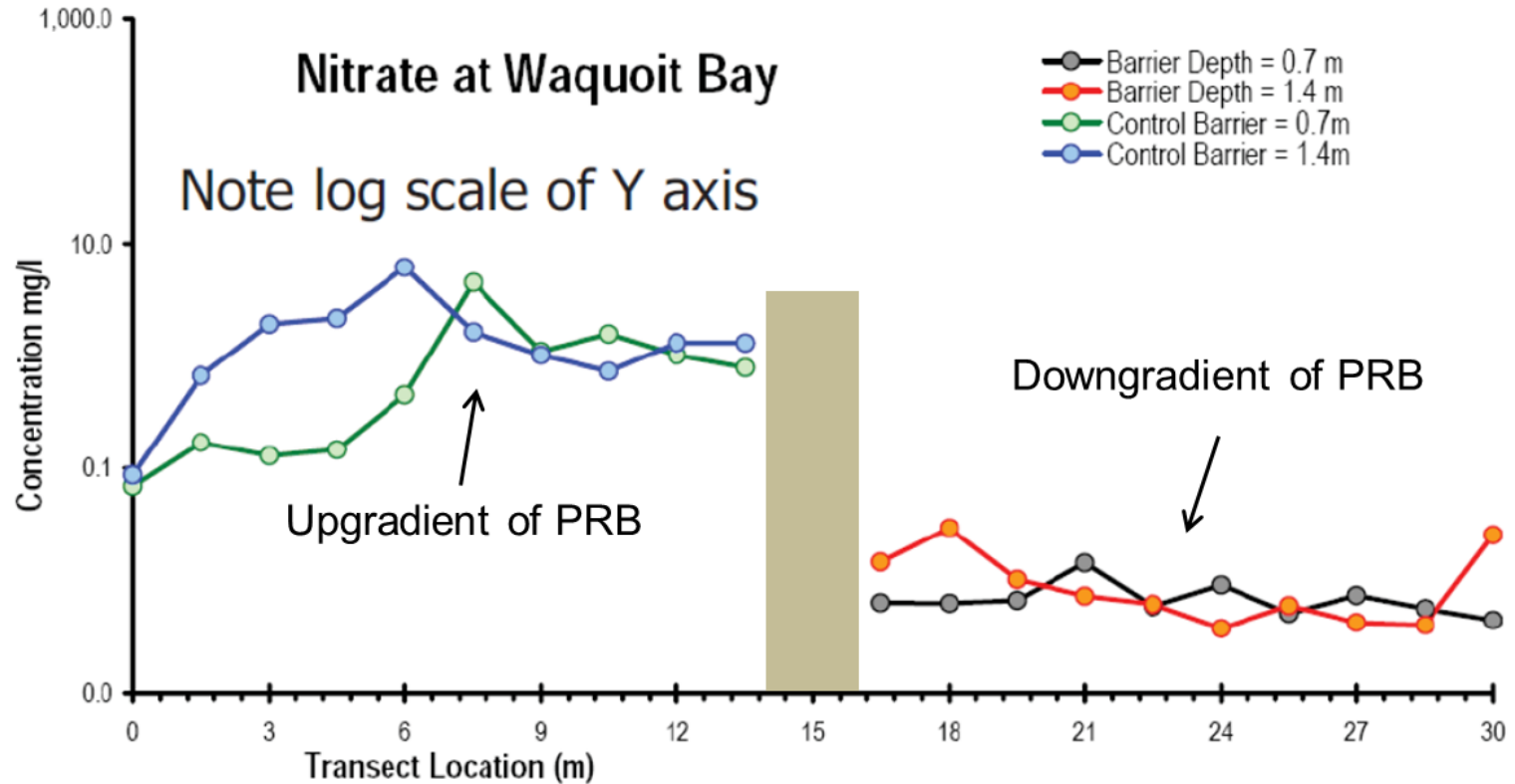


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Great Bay PRB Pilot Study



# Groundwater Quality at Waquoit Bay Data Collected by Woods Hole MBL



Environmental Engineers/Consultants

**LOMBARDO ASSOCIATES, INC.**



CONSERVATION DISTRICT

# Design Challenges

## Durham:

Low transmissivity (shallow groundwater with small saturated thickness) and fluctuating groundwater table

## Brentwood:

Radial flow away from raised leaching fields – for demonstration of PRB a finite trench will be designed



# PRB Design Parameters



- **Understanding of Site Hydrogeology:**  
Groundwater velocity about 0.1 ft/day at both sites  
(Hydraulic conductivity is about  $4 \times 10^{-4}$  cm/sec)
- **PRB Residence time:**  
Function of removal goal: Published Values range from  
0.7 to 32 mg/L N/day
- **Width and Depth of PRB:**  
Width is determined by specified PRB residence time,  
and depth by site specific geology





# Conceptual PRB Designs



- **Design Parameter:** 2 mg/L N/day Removal
- **Residence time of 10 to 20 days:**  
Groundwater Travel time or Groundwater Velocity is about 0.1 ft/day at Durham and Brentwood Sites
- **Design Width of PRB** = 1.5 to 2.0 ft wide for a 10 to 20 days Res. Time
- **Depth:** Durham = 5 ft.  
Brentwood = 8 ft.
- **Length:** Durham = 50 ft.  
Brentwood = 110 ft.



# Durham Site




- Near Chesley Brook tributary of Oyster River
- Failed septic close to house, new septic 2008
- Glaciomarine sand underlain by silt
- $K = 2 \times 10^{-4}$  to  $9 \times 10^{-3}$  cm/s
- Nitrate 6.2 mg/L at one field-side monitoring well,
- Installation Summer 2016?



## Groundwater Elevations (December 2014)



### Legend

-  Groundwater Elevation 0.5' Contours
-  Hydrography
-  Septic System Leach Fields

Great Bay PRB Pilot Study

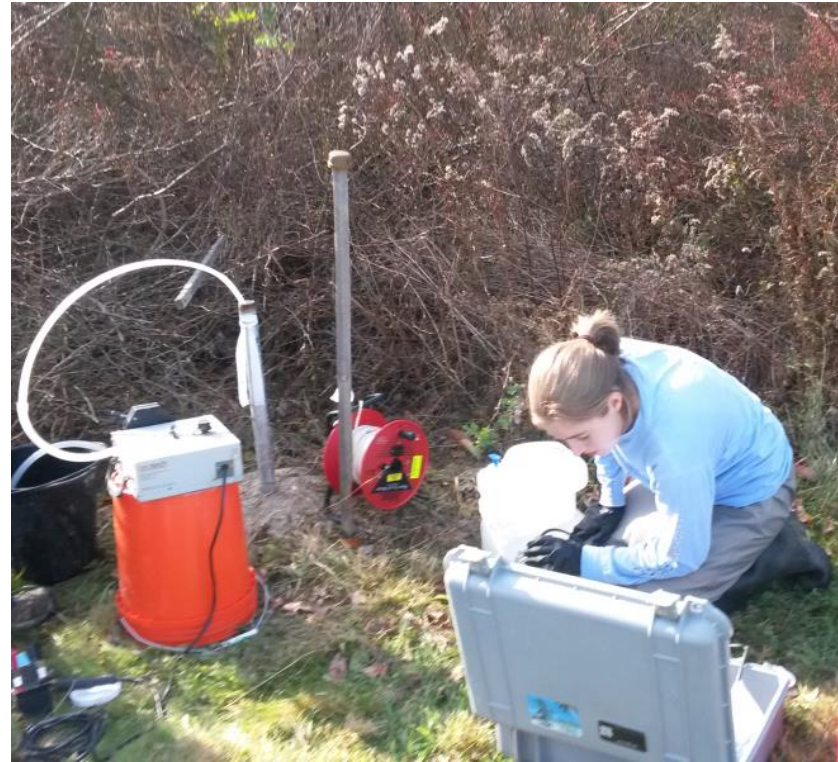
Rockingham County Conservation District  
 Strafford County Conservation District  
 Permeable Reactive Barrier Demonstration Project  
 Durham, NH





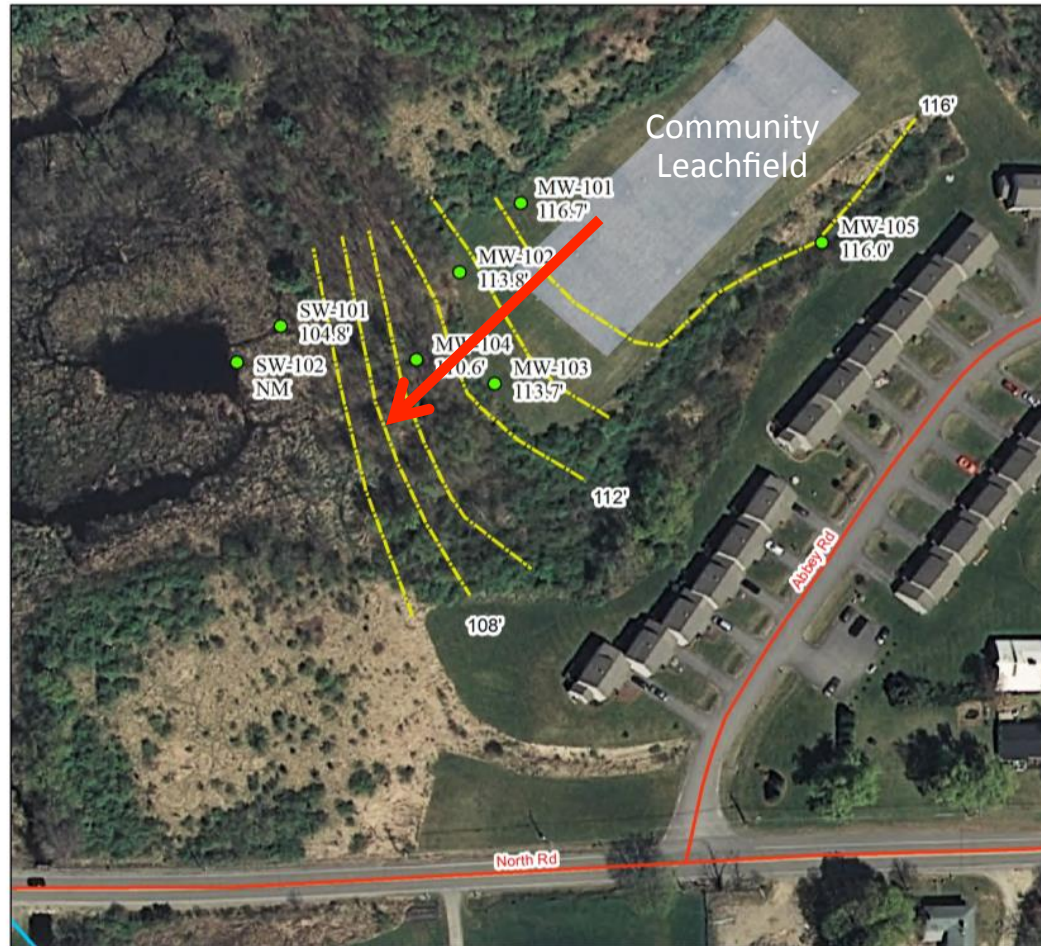
# Brentwood Site

- Near Dudley Brook, tributary of Exeter River
- Failed septic area in community septic field
- New area installed in 2012
  - Glaciomarine sand with underlying silt
- $K = 1.5 \times 10^{-4}$  to  $3.6 \times 10^{-4}$  cm/s
- Nitrate 12 to 42 mg/L at wells
- 1.9 mg/L in nearby SW
- Installed October 2015



## Groundwater Elevations (December 2014)

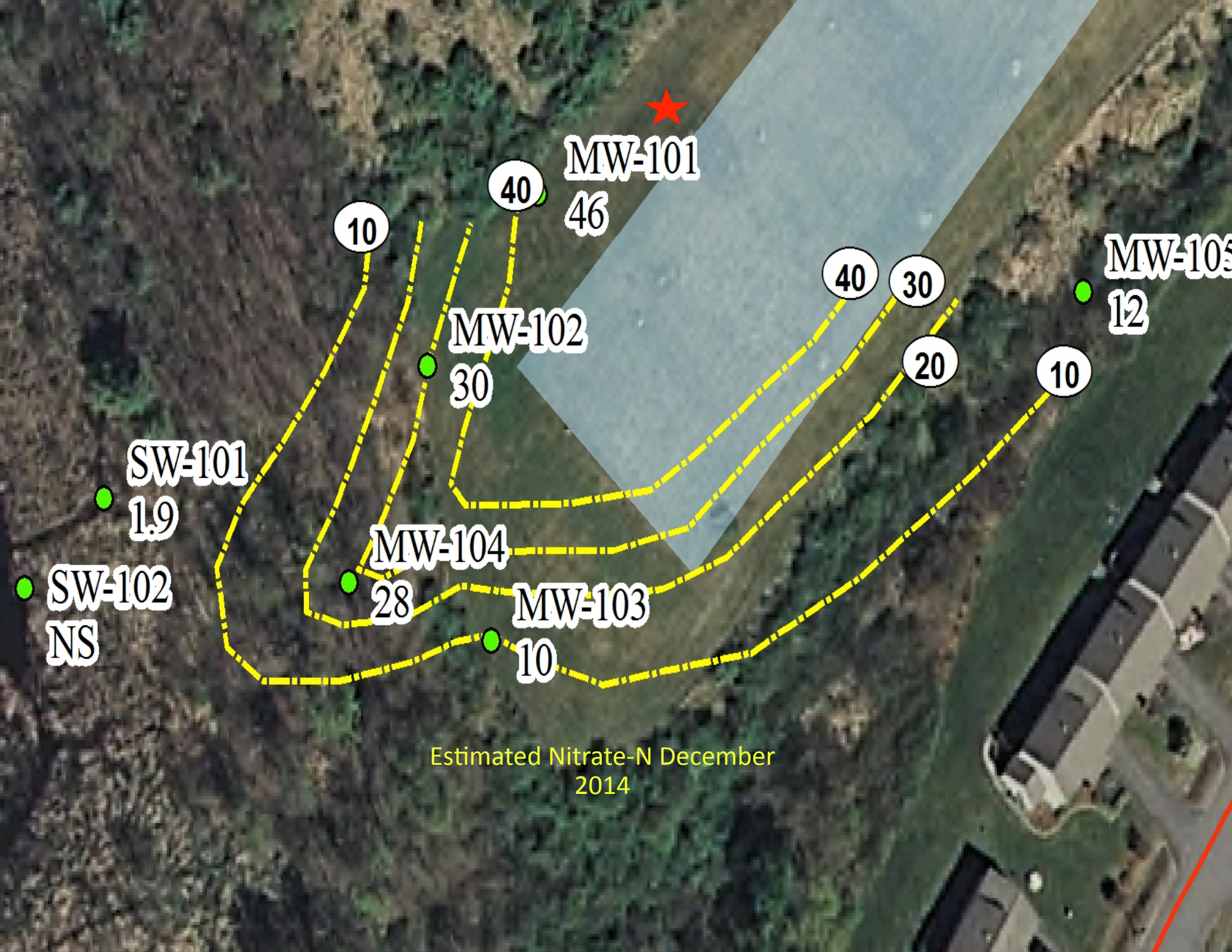
Pond flows to  
Dudley  
Brook



### Legend

-  Groundwater Elevation 2' Contours
-  Hydrography
-  Septic System Leach Fields
-  Roads
-  Monitoring Wells (MW)

Rockingham County Conservation District  
Strafford County Conservation District  
Permeable Reactive Barrier Demonstration Project  
Brentwood, NH



MW-101  
46

MW-102  
30

MW-105  
12

SW-101  
1.9

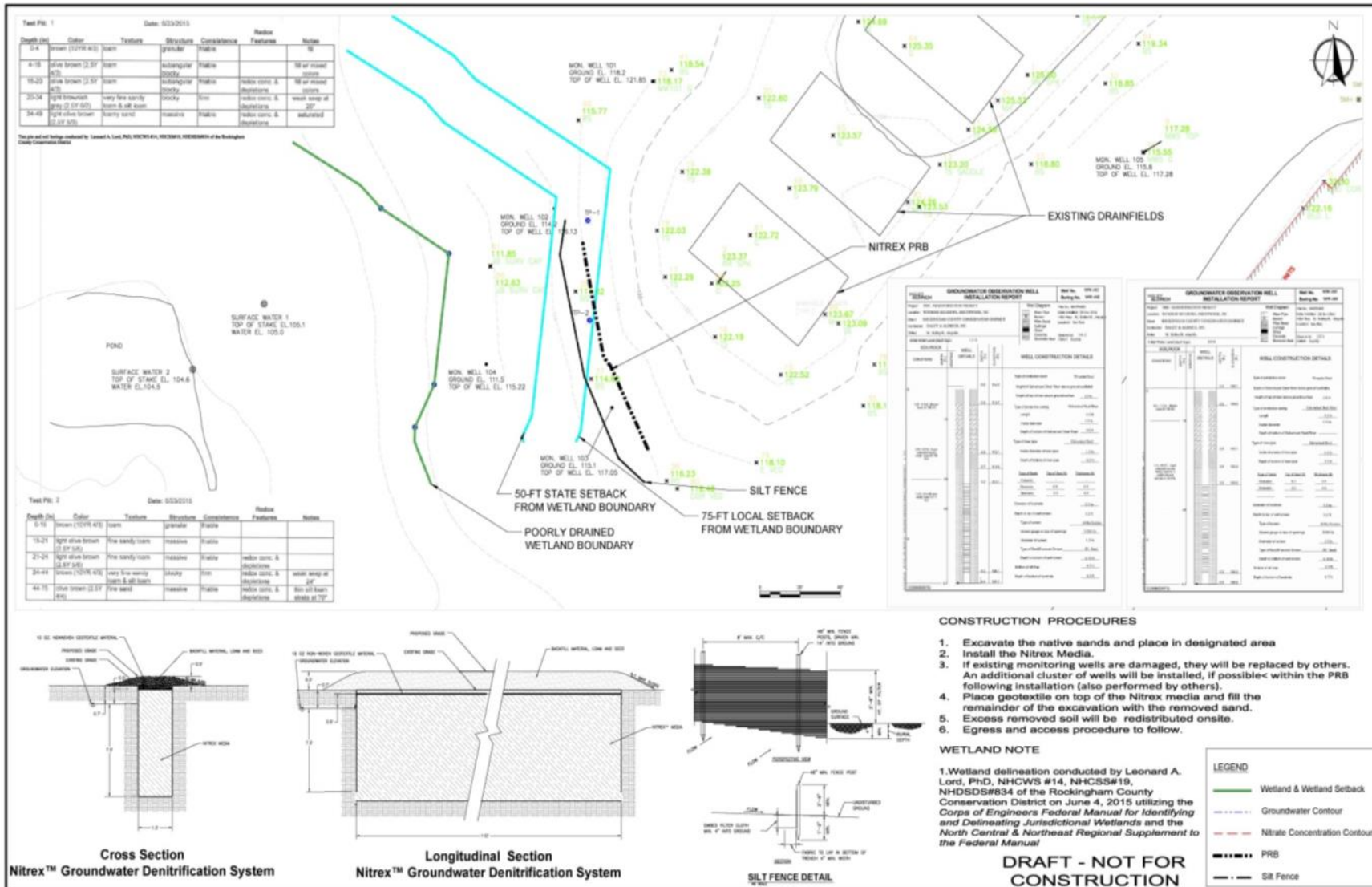
SW-102  
NS

MW-104  
28

MW-103  
10

Estimated Nitrate-N December  
2014

# Brentwood PRB Design: 110 ft. x 1.5 ft. x 8 ft.(deep)





# Construction of Brentwood, NH PRB – 13 October 2015



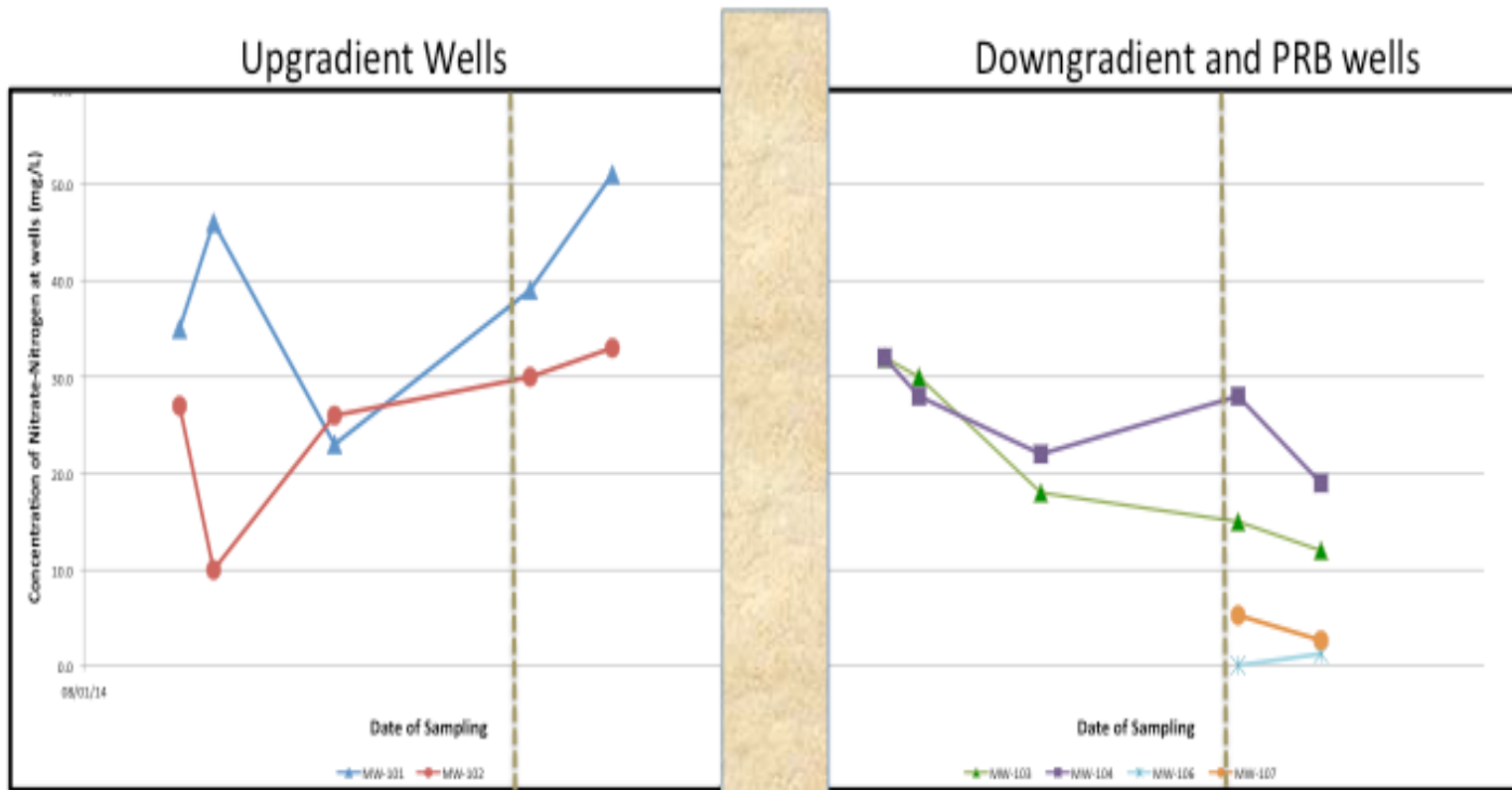
# PRB Placement and Site Restoration



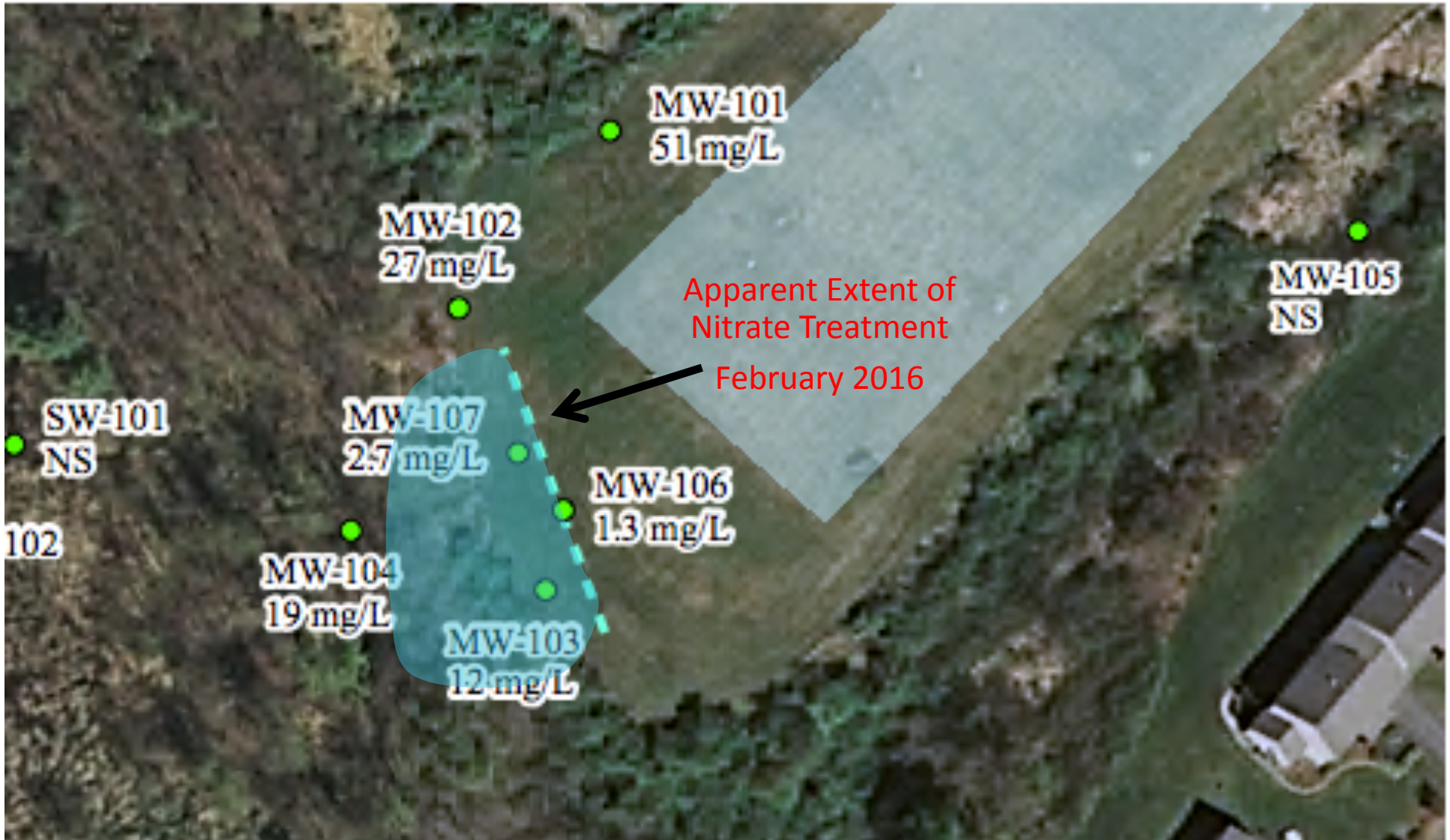
# Monitoring Results

- New monitoring wells installed in and just downgradient of trench
- Nitrate-Nitrogen decline in and near trench
  - 20 to 30 mg/L pre installation
  - Less than 2 to 12 mg/l in and adjacent to trench – four months post installation
- Biological Oxygen Demand
  - Pre-installation concentrations - < 0.5 to 15 mg/L
  - One month after installation – 320 to 408 mg/L in or near trench
  - Four months after installation – 32 to 85 mg/L
- Dissolved Oxygen
  - 4 mg/L pre-installation to < 1.0 mg/L post installation at near trench
- Dissolved metals to be monitored in Fall 2016

# Nitrate-Nitrogen Concentration at Monitoring Wells Brentwood Permeable Reactive Barrier Pilot Site



PRB Installation – October 2015



Nitrate Concentrations in Wells February 2016

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## Questions?

