Micro-siting and Nitrogen Removal Efficiency of a Liquid Injection Permeable Reactive Barrier (PRB)

Residential Area: Lagoon Pond Rd

MARTHA'S VINEYARD COMMISSION

SNEP Southeast New England Program

Coastal Systems Program SMAST

Problems with Nitrogen Enrichment

- Nitrogen enrichment can lead to eutrophication
- Eutrophication of estuaries and bays is a widespread issue

Eutrophication in Coastal Communities Can Cause:

- Environmental Impacts
- Financial Impact
  - Tourism
  - Fisheries
  - Property Value
- Quality of Life
  - Beach Access
  - Native American Subsistence Rights

Nitrogen Enrichment

While eutrophication is a natural process, anthropogenic sources of nutrients can exacerbate the process

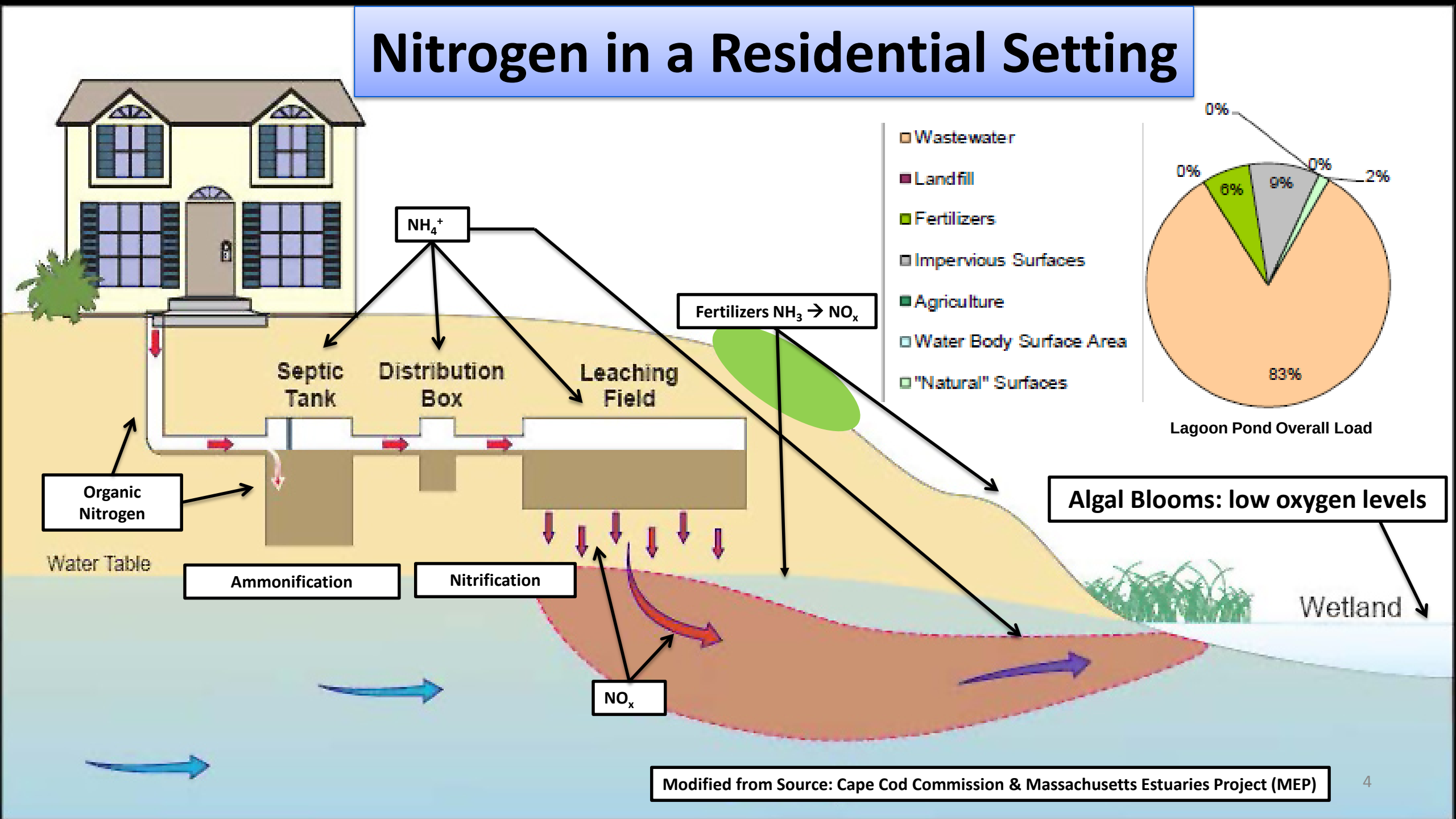
Point Sources:

- **Wastewater Treatment Facility Discharges**
- **Stormwater Discharges**

Non-Point Source:

- **Atmospheric Deposition**
- **Agricultural (Crop/Animals)**
- **Lawn Fertilization**
- **Septic Systems**

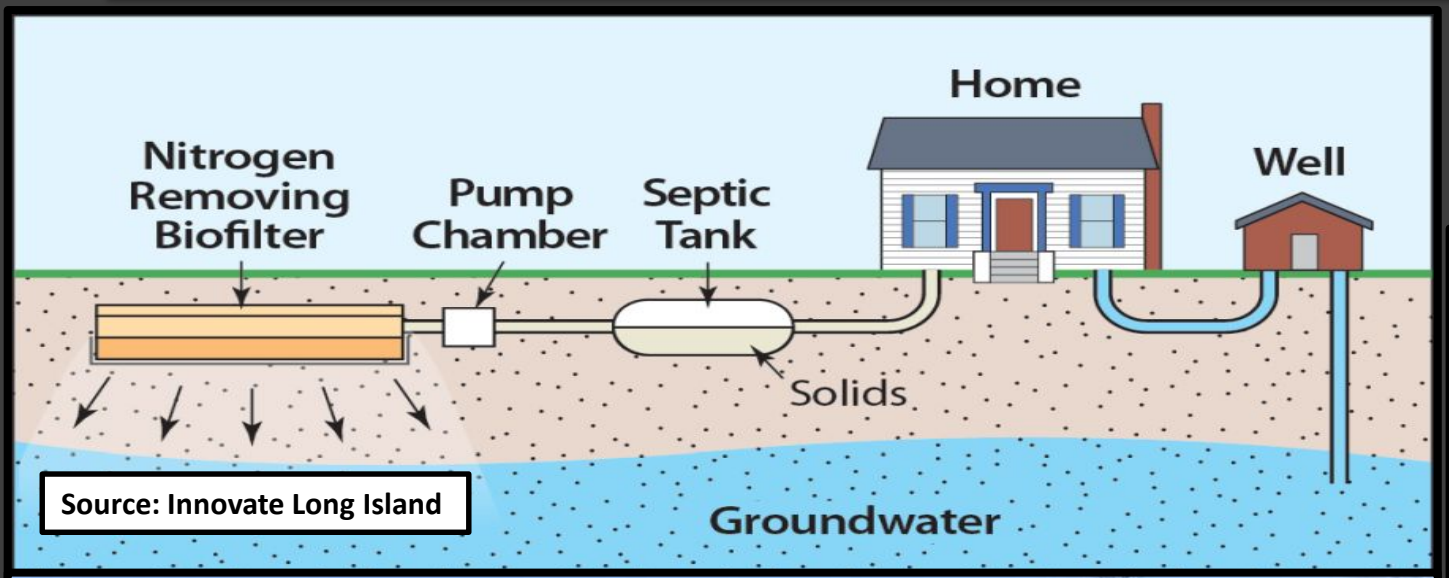
Nitrogen in a Residential Setting



Lagoon Pond Overall Load

Modified from Source: Cape Cod Commission & Massachusetts Estuaries Project (MEP)

Solutions for Nitrogen Enrichment

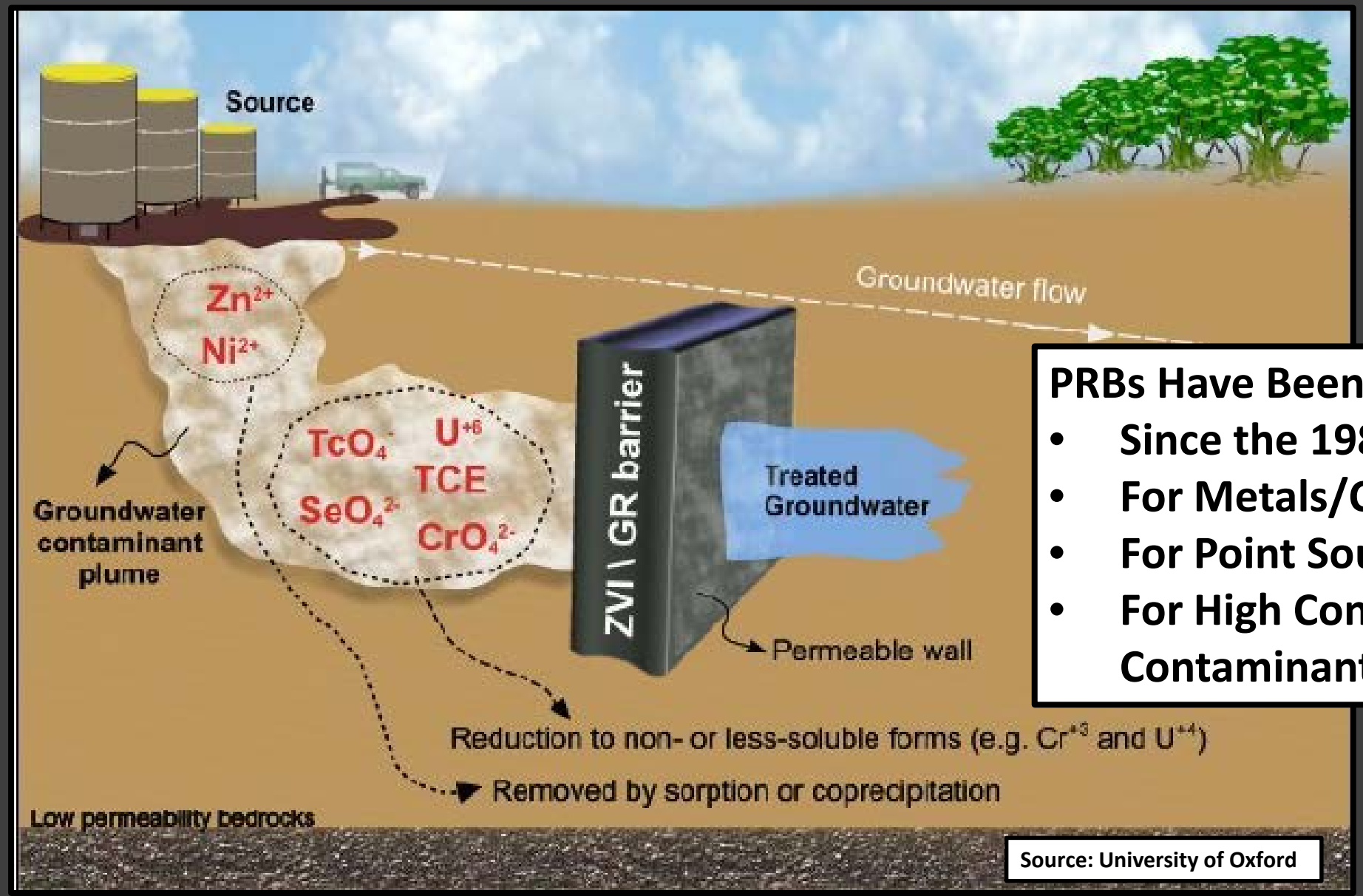


Source: Innovate Long Island

Aquaculture Project
Source: Coastal Systems Program

- Wastewater Treatment Facilities
- Innovative Septic Systems
- Wetland Restoration/Construction
- Pond Construction/Modification
- Increased Tidal Flushing
- Aquaculture
- Permeable Reactive Barriers

PRBs as a Mitigation Solution

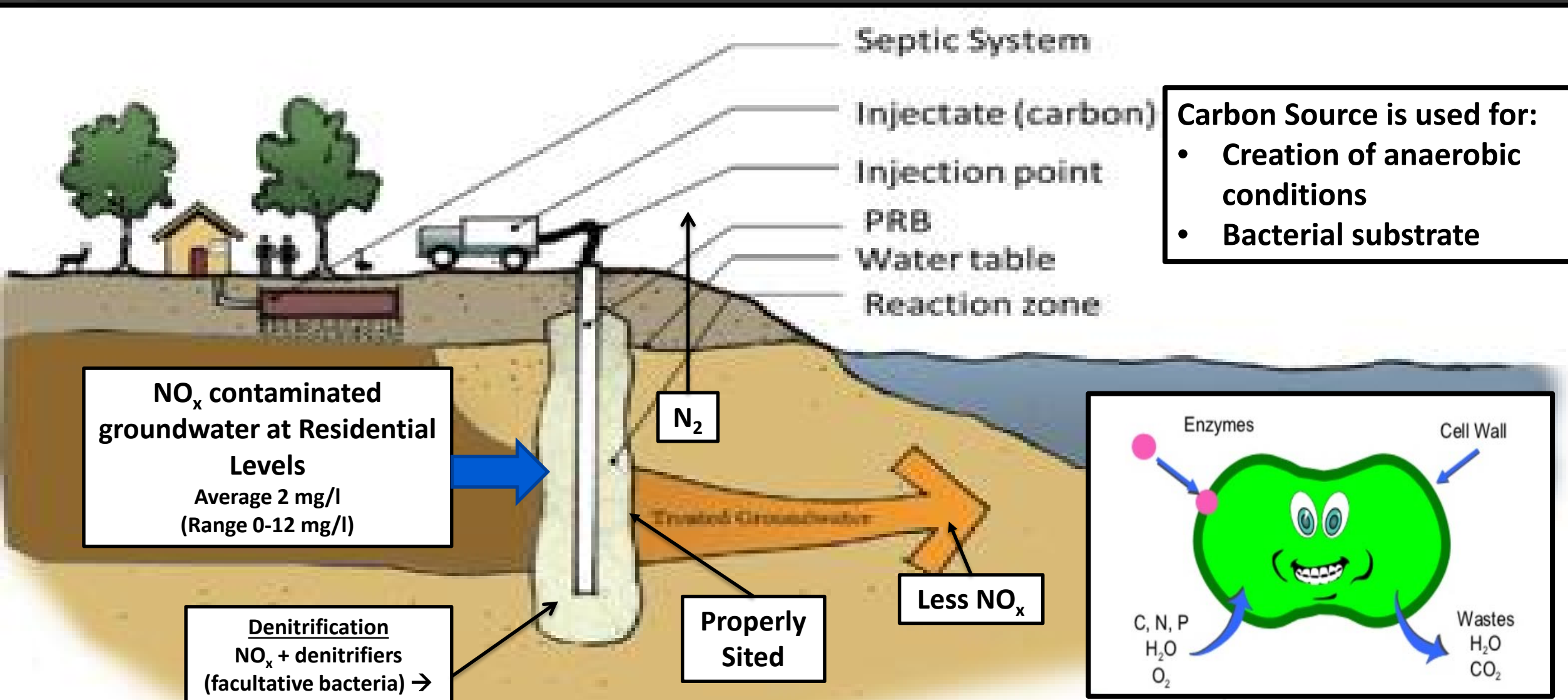


PRBs Have Been Used:

- **Since the 1980s**
- **For Metals/Chlorinated Solvents**
- **For Point Sources**
- **For High Concentrations of Contaminants.**

Source: University of Oxford

What is a Liquid Injection PRB?



Carbon Source is used for:

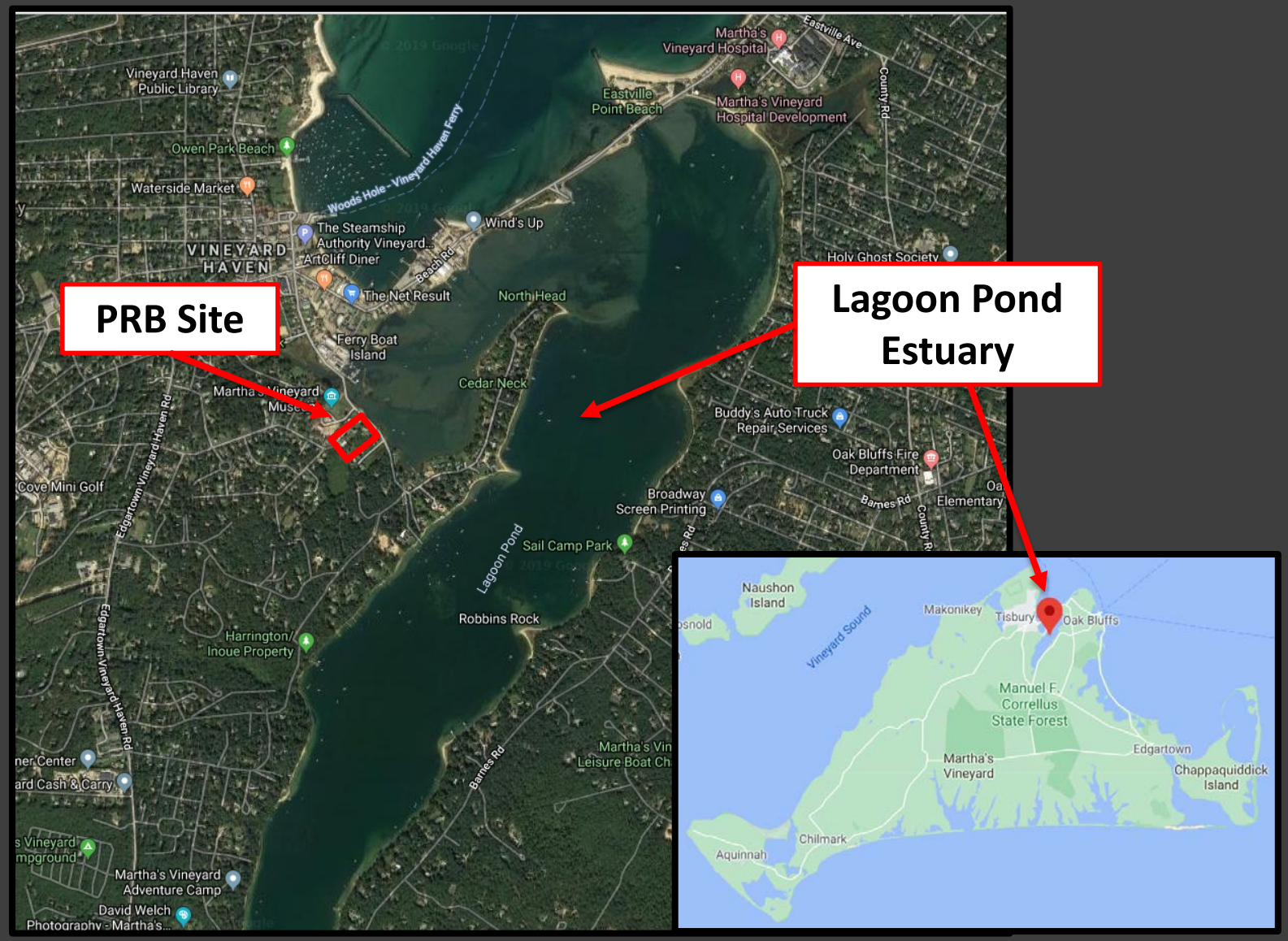
- **Creation of anaerobic conditions**
- **Bacterial substrate**

Modified from Source: Cape Cod Commission

Can PRBs be utilized in a cost-effective manner for the reduction of non-point source, residential levels of nitrogen?

- How do micro-siting techniques influence the installation and design of a PRB to maximize reduction of nitrogen per unit cost?
- How much nitrogen reduction can be achieved in groundwater from residential areas?

Case Study: Locus Map

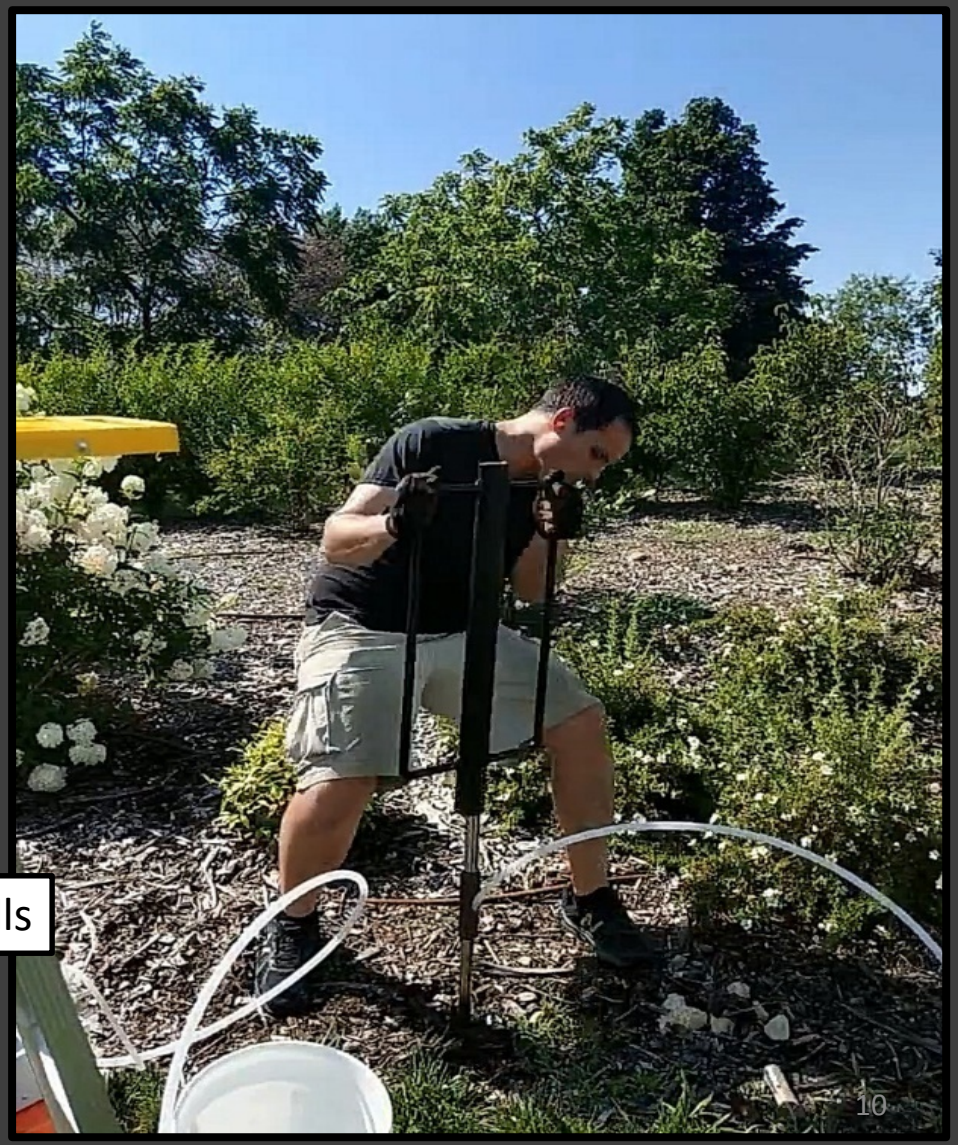


Lagoon Pond Estuary

- Coastal Systems Program (CSP): MEP Assessment
- Impaired by N enrichment:
  - 0.33-0.42 mg/l
- CSP helped establish TMDL for N:
  - 74.1 kg/day
- Nitrogen Removal Goal:
  - 5,900 kg/y
- Stewards:

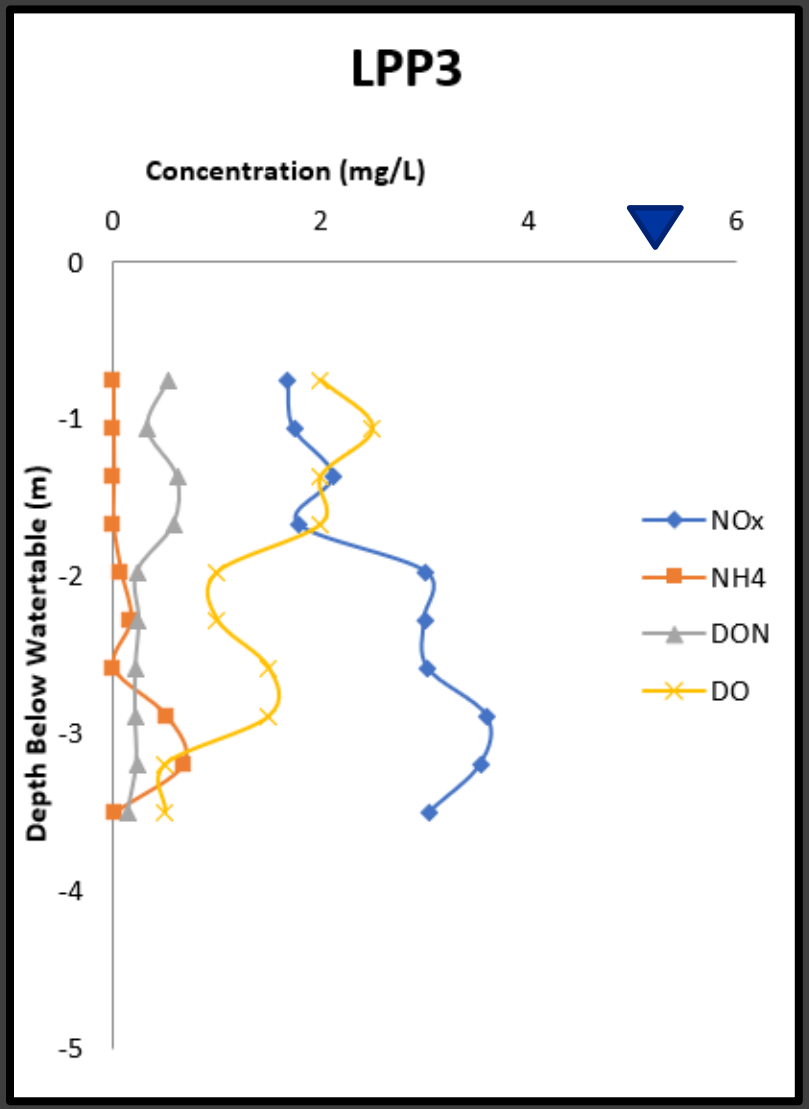
  Oak Bluffs
  Tisbury
  MV Commission

Case Study: Site Map



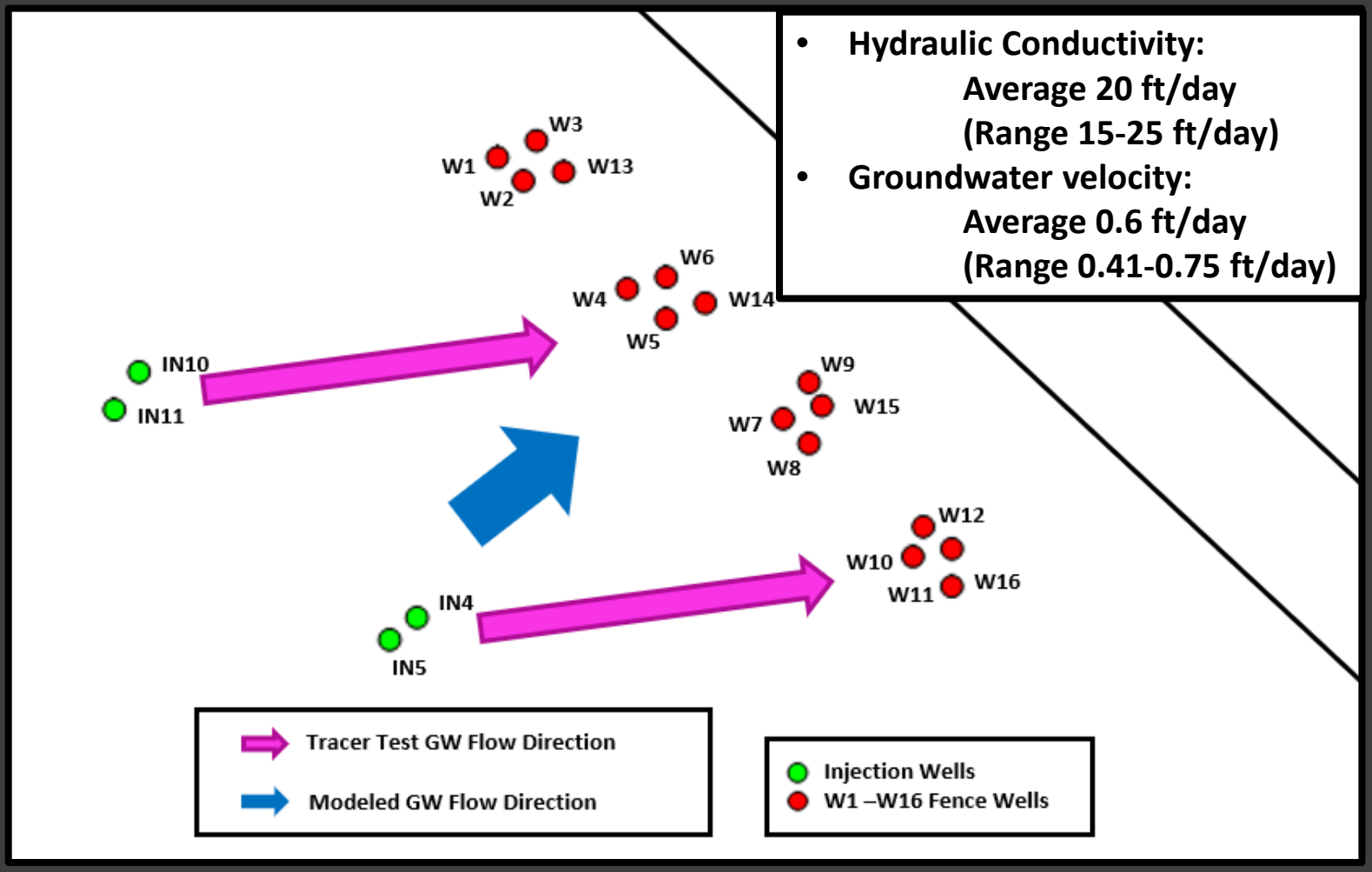
Case Study

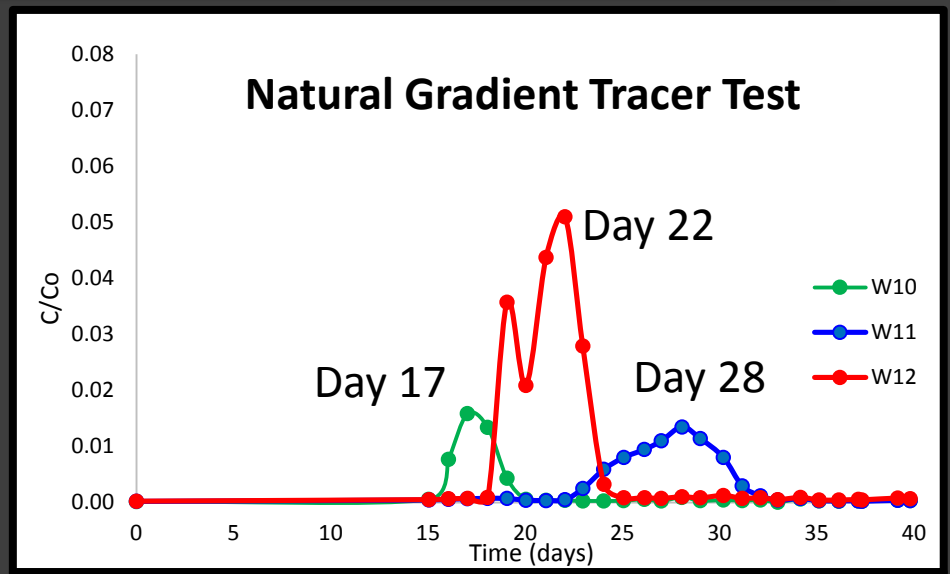

Lagoon Pond
Predicted Groundwater Flow
0.25
0.5
LPP11
LPP2
LPP7
LPP4b
KH
LPP3
LPP1
LPP12
LPP8
LPP5
LPP10
LPP6
LPP9

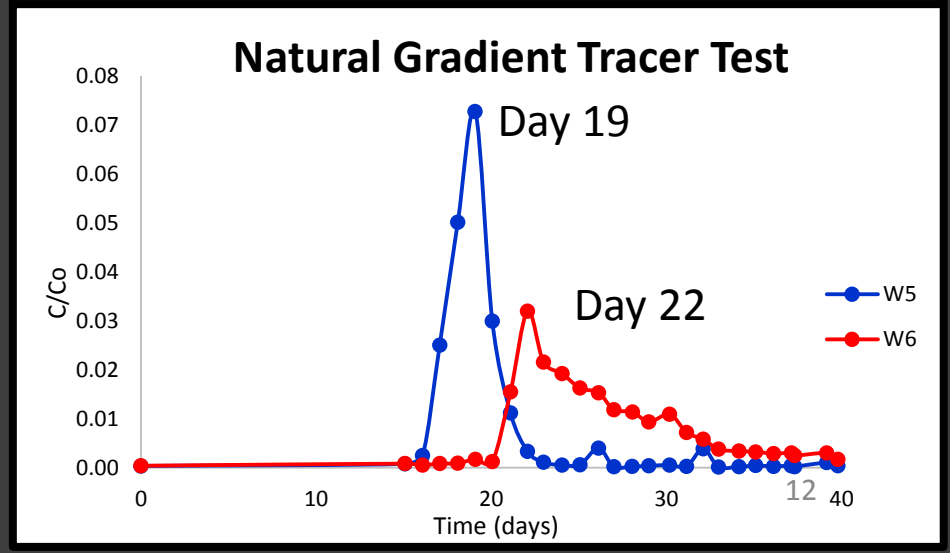

LPP3
Concentration (mg/L)
0
2
4
6
0
-1
-2
-3
-4
-5
Depth Below Watertable (m)
NOx
NH4
DON
DO

Case Study: Natural Gradient Tracer Test

- **Hydraulic Conductivity:**
  Average 20 ft/day
  (Range 15-25 ft/day)
- **Groundwater velocity:**
  Average 0.6 ft/day
  (Range 0.41-0.75 ft/day)







Pre-Injection Findings

- Groundwater only 0.5 – 2.5 m below ground surface
- Soils are coarse to fine sand with some silty/clay
- Nitrate is the dominant form of nitrogen and corresponds with average residential levels
  - Total Dissolved Nitrogen: Average 2.7 mg/L (0-13 mg/L)
  - Nitrate + Nitrite: Average 2.0 mg/L (0-12 mg/L)
  - Ammonium: Average 0.3 mg/L (0-0.68 mg/L)

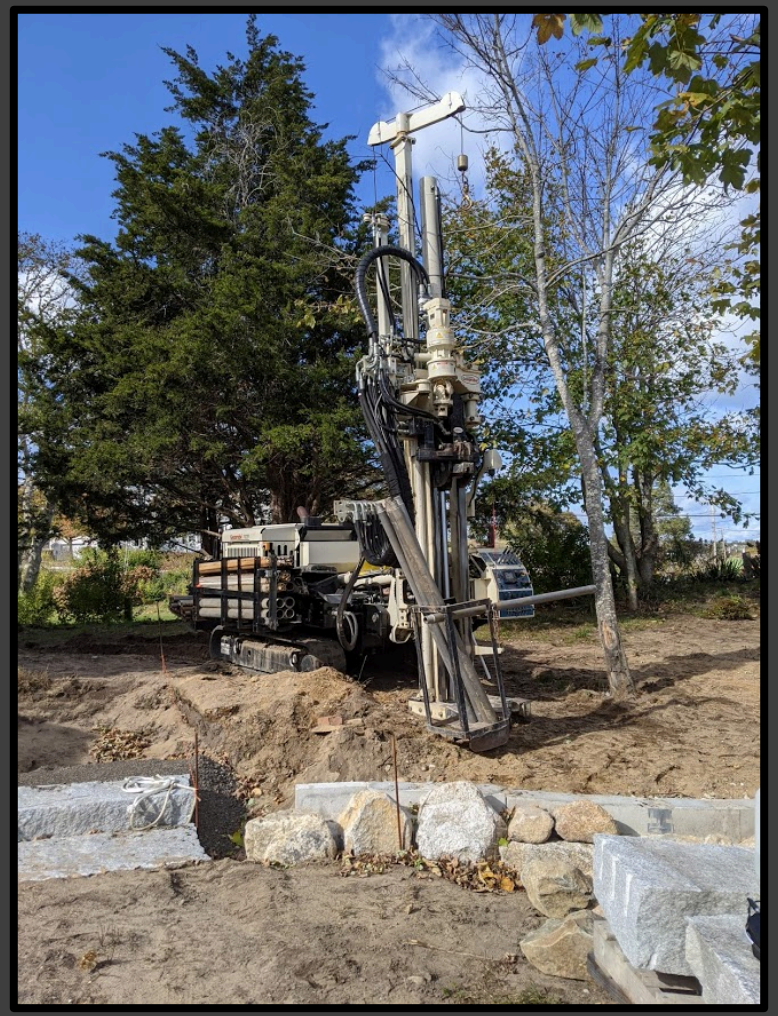
Pre-Injection Findings

- Freshwater (Salinity <0.2 PSU)
- High nitrate levels - oxygenated groundwater
- Hydraulic Conductivity: 20 ft/day (15-25 ft/day)
- Groundwater velocity: Average 0.6 ft/day (0.41-0.75 ft/day)
- Tracer tests indicate groundwater flow towards Lagoon Pond and perpendicular to the PRB location
- Elevated levels of Mn, Fe, and As were observed in the *Phragmites* root zone at the edge of Lagoon Pond

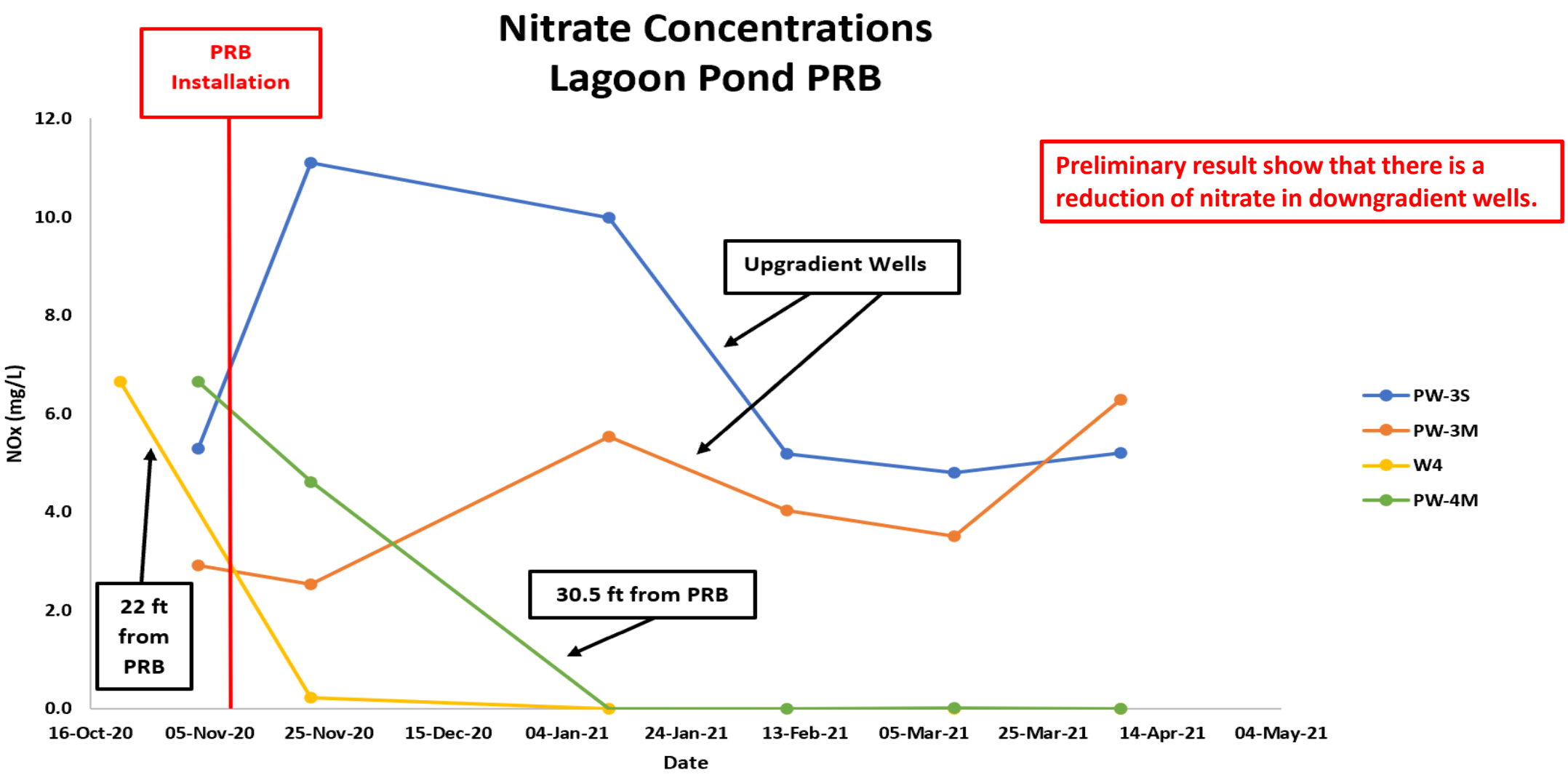
PRB Design

- 150 linear ft
- 80 ft from Pond
- Injections 10 ft & 15 ft apart
- 17,155 Gal Total (4:1 Water:EVO)

Liquid Injection PRB Installation



Preliminary Findings



Case Study: Work to Come

- Groundwater sampling for tracking:
  - Nitrate/Nitrite
  - Ammonium
  - Total dissolved nitrogen
  - Phosphate
- Conduct denitrification confirmation tests
  - Tracer Test
  - Changes in Groundwater N_2

Thank You!

Martha's Vineyard Commission
EPA's Southeast New England Program
ES&M
Terra Systems, Inc.
Coastal Systems Program