Town of Orleans Massachusetts

Orleans Water Quality Advisory Panel

Permeable Reactive Barrier (PRB) Breakout Group

Paul Dombrowski, AECOM Technical Services, Inc.
James Begley, MT Environmental Restoration
Mark Owen, AECOM Technical Services, Inc.

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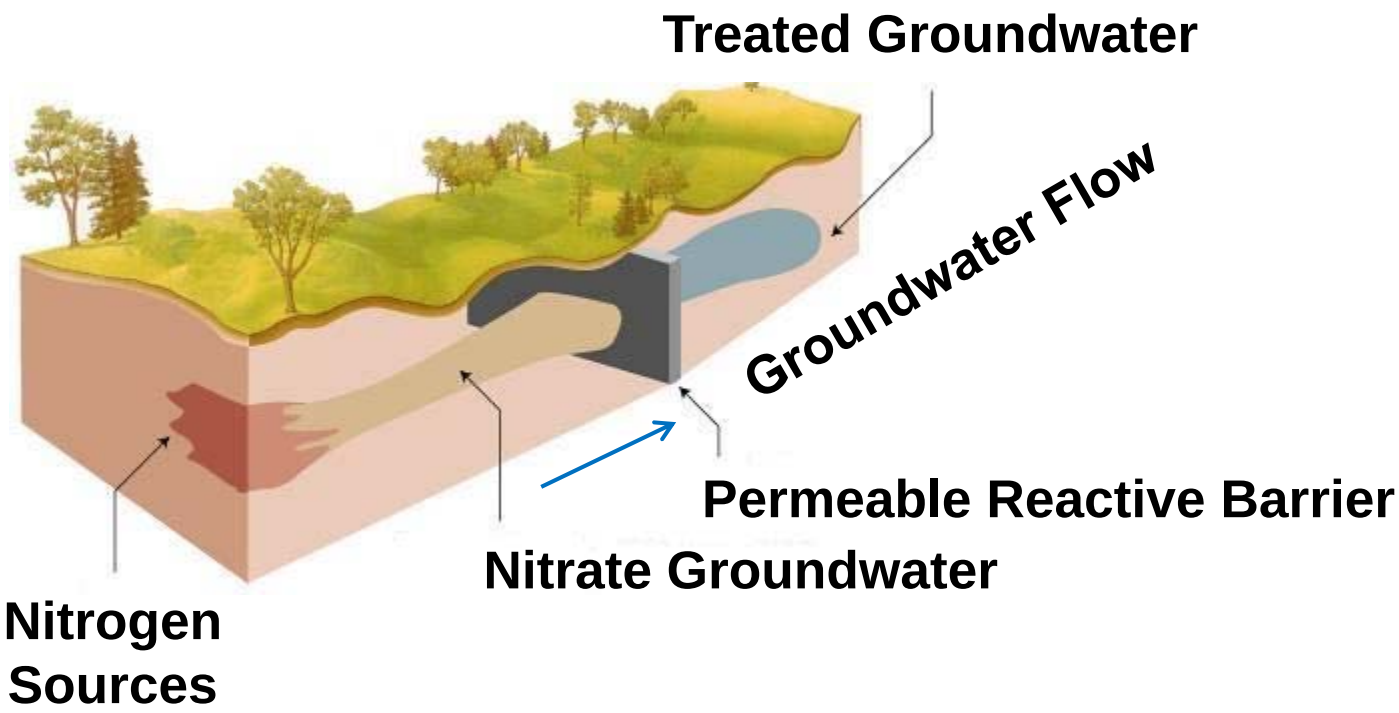
AECOM

PRB Overview

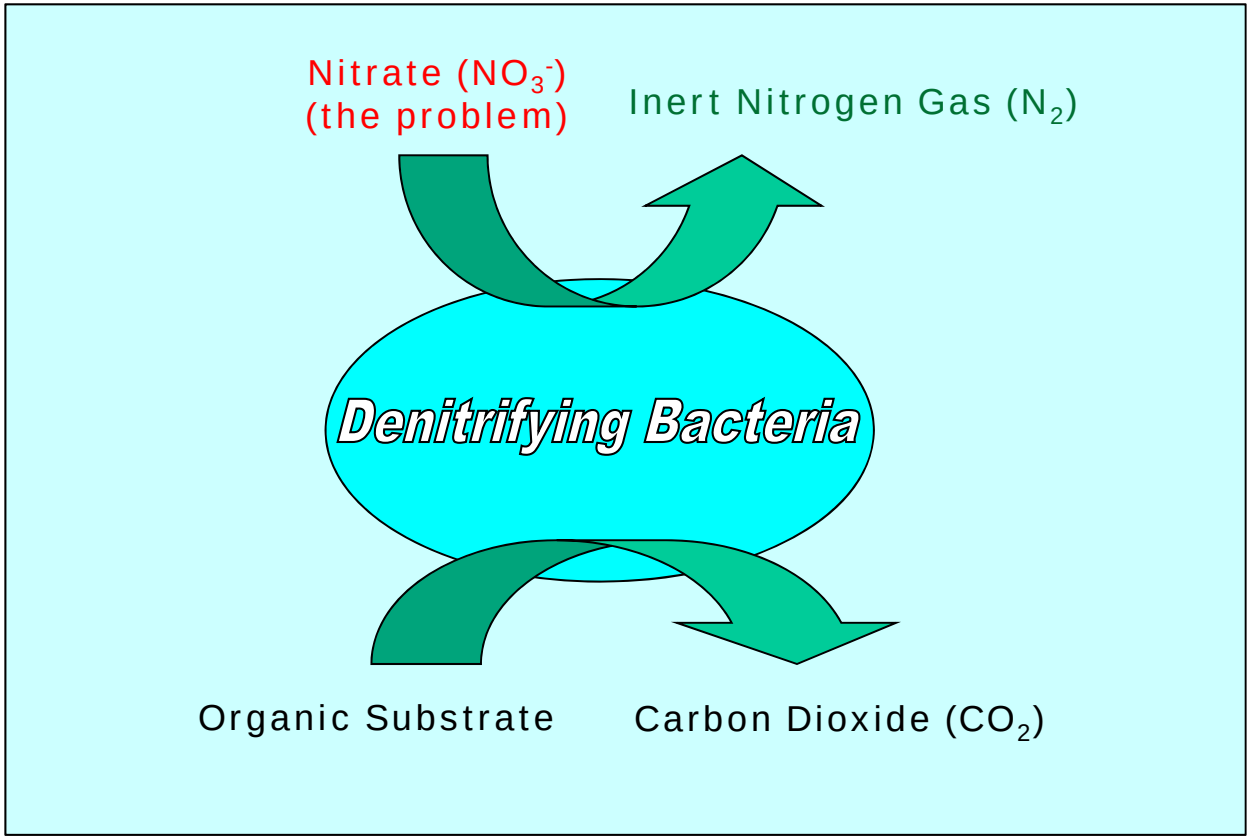
- A PRB Consists of a Zone of Reactive Material Installed in the Path of a Dissolved Contaminant (e.g. nitrate) Plume



(ITRC, 2011)

PRB Treatment Process for Nitrate

- Denitrification - Biological Process by Bacteria Ubiquitous in the Environment



Objectives Statement for Demo and Full Scale Projects

- Demonstration Test
  - Conduct Testing Representative of Full Scale Application
  - Providing Proof of Nitrogen Concentration and Load Reduction (Extrapolate to TMDL Reduction Targets at Full Scale)
  - Obtaining Data for Engineering Evaluations and Full Scale Cost Estimates
  - Confirm Time Frame for Technology Performance
  - Demonstrate Programs for Performance, Compliance Monitoring, and Assessment of Treated Water Quality.
- Full Scale PRB
  - Significantly Reduce Nitrogen Load to Surface Water Resources
  - Implement Cost Effective PRB Design
  - Evaluate Performance Over Time and Replenishment Frequency

PRB Demo and Full Scale Siting Evaluation Criteria

- Site Suitability
  - Depth to Groundwater
  - Groundwater Nitrogen Profile (concentration/depth)
  - Groundwater Flow Direction and Velocity
- Permitting
  - Potential Regulatory Concerns
  - Site Use
- Project Evaluation
  - PRB Nitrogen Removal Efficiency
  - Accessible Well Locations
- Other/Overriding Considerations
  - Potential for Watershed/Estuary Impacts
  - Potential for Full Scale Implementation

PRB Locations Evaluated

A. Main Street and Tonset Road (Main Street)

B. South Orleans Road at Tonset/Eldredge Parkway (Route 28 site)

C. Town Cove Gibson Road

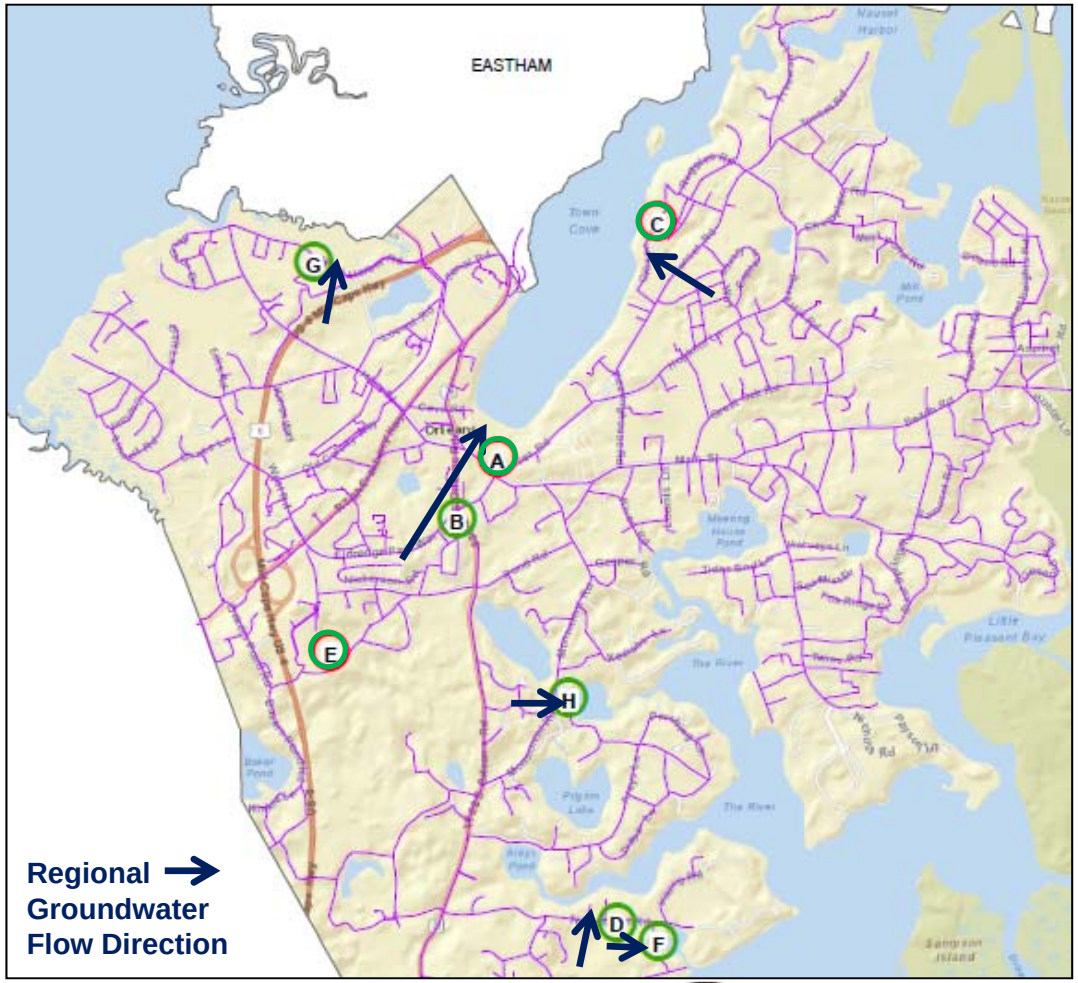
D. Namequoit Road

E. Town Landfill

F. Paw Wah Pond

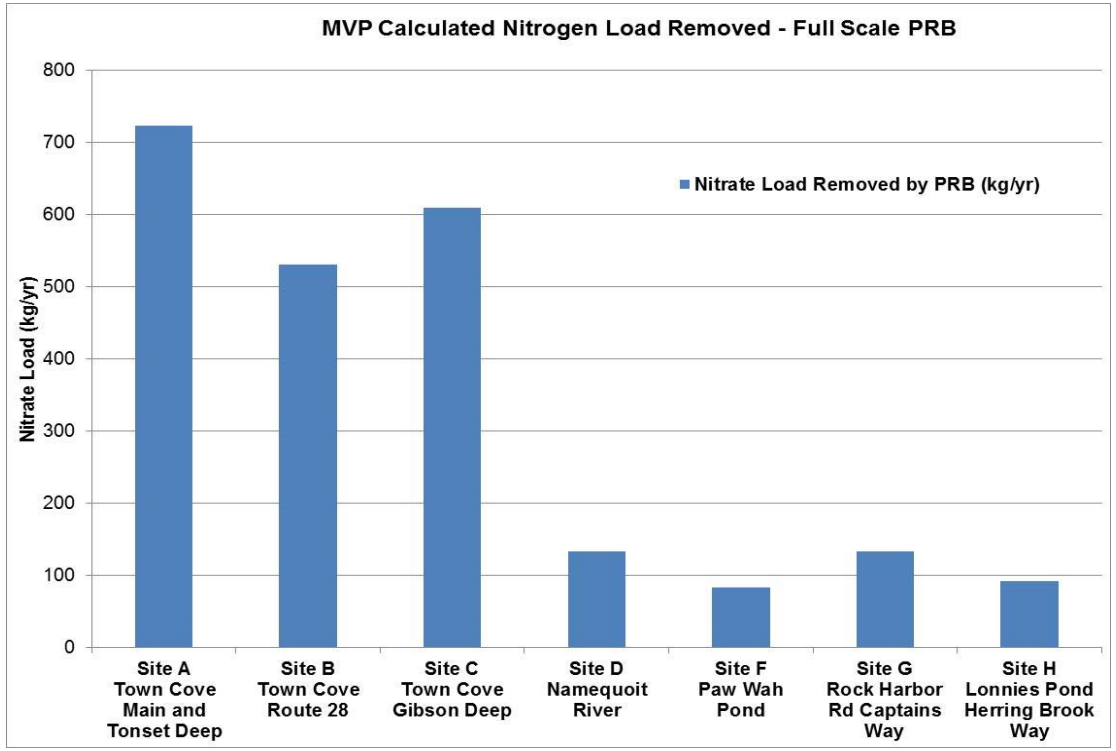
G. Rock Harbor Road Area

H. Kescayo Gansett Pond (Lonnie's Pond)

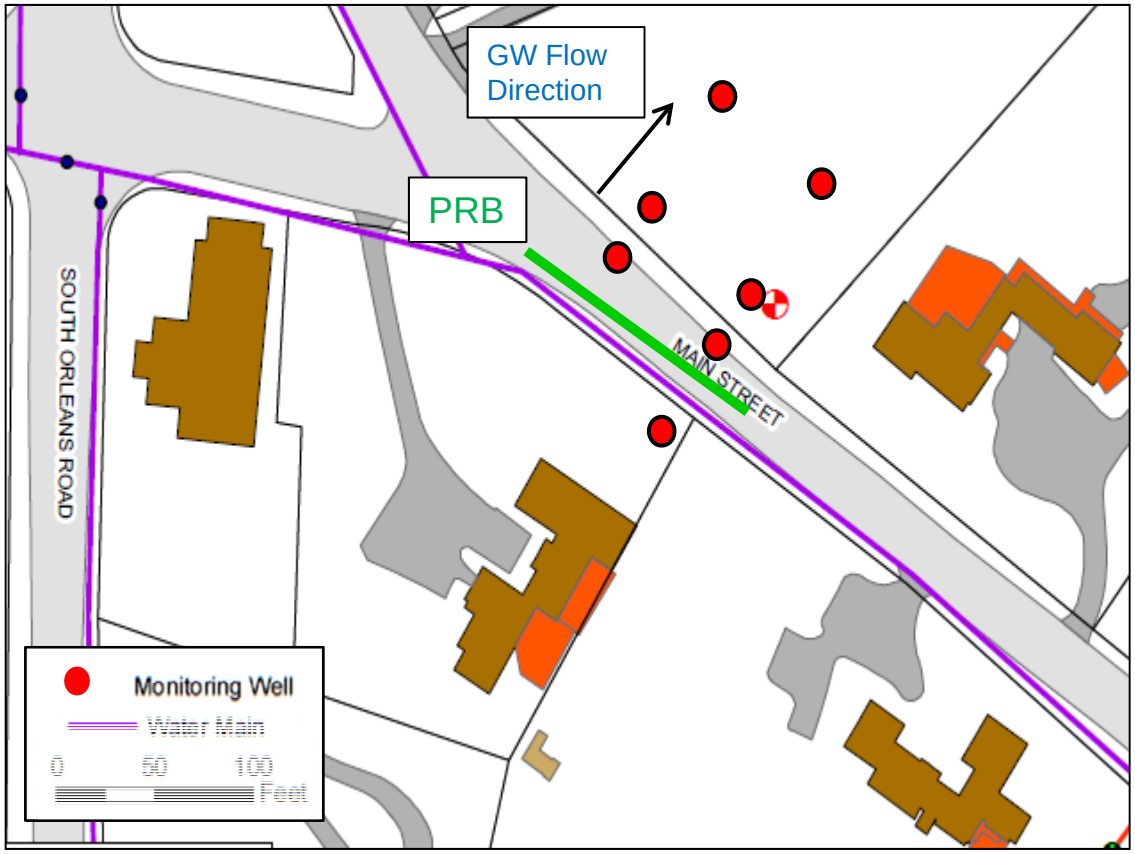


PRB Locations Evaluated – Nitrogen Loads

- WatershedMVP – Tool Developed by the Cape Cod Commission that Estimates Theoretical Nitrogen Load and Potential Reduction at Each Site
- Landfill Not Evaluated by WatershedMVP - Actual Data Necessary



PRB Demonstration Conceptual Layout



- PRB Layout Considerations
  - GW Flow Direction
  - Depth to GW
  - Site Use/ Ownership
  - Road Layout
  - Subsurface Utilities
  - Locating Monitoring Wells Upgradient and Downgradient

PRB Application Methods

- Trenching
  - Solid Reactive Media (Mulch) Placed in Excavated Trench
  - Trenches 3 to 4 Feet Wide
  - Disturbance to Abutters, Traffic and Utilities
  - Requires Future Rejuvenation (Often by Injection)
- Soil Boring/Wells
  - Liquid Amendments (Food-Grade Carbon Substrate)
  - Solid Amendments Placed in Soil Borings
  - No Limitation on Depth
  - Limited Disturbance with All Injection Pumps and Tanks Operating from Truck/Trailer

ITRC, 2011

http://www.dewindonepasstrenching.com

PRB Application Methods (cont.)

- Trenching
  - Requires Large Construction Equipment (excavator, trenchers, and/or other earth moving vehicles)
  - Requires Soil Handling and Disposal Plus Area to Stage Soils
  - Standard Excavators Limited to Depth of 20 feet and Would Require Placing PRB Adjacent to Surface Water
  - One-pass Trencher Can Install Trenches to Maximum Depth of 40-50 Feet

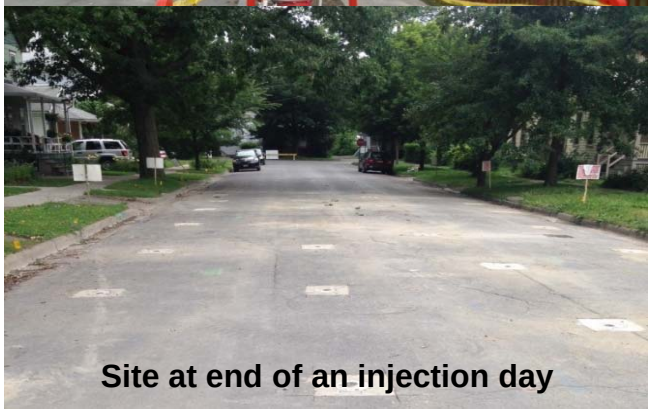
    (5 to 10 Trucks Required for Mobilization - Mobilization Costs Start at $100,000)

ITRC, 2011

http://www.dewindonepasstrenching.com

PRB Application Methods (cont.)

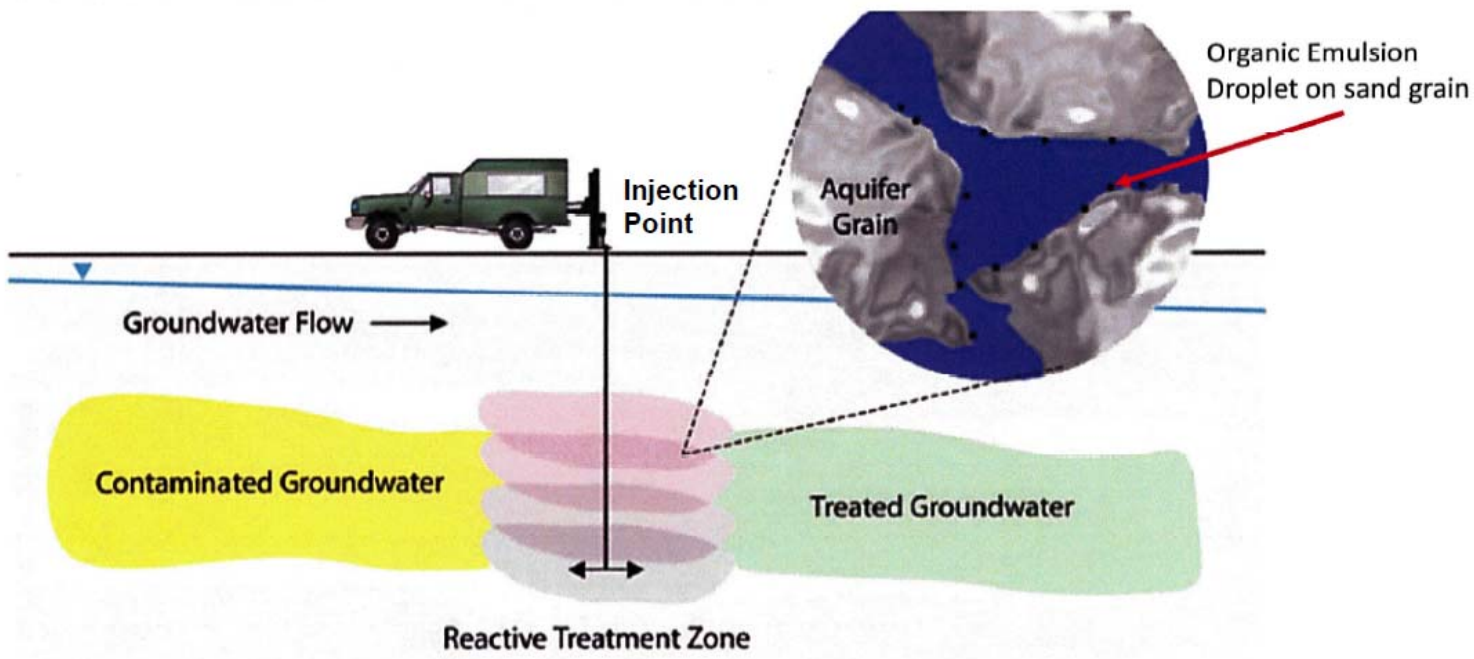
- Injection
  - All Pumps and Mixing Tanks Centrally Located in a Box Truck or Trailer
  - Only Hoses and Adaptors at Each Point are Located Within the Work Area
  - Hose Ramps Can be Used to Keep Street Open to Traffic, if necessary.



Site at end of an injection day

PRB Application Methods (cont.)

- Injection Can Generate a Wider Treatment Zone for Greater Treatment Residence Time than a Trench Filled with Solid Reactive Media



Modified from Tratnyek and Johnson, 2006

PRB Site Evaluation Matrix

Criteria	Site A		Site B		Site C		Site D		Site E		Site F		Site G		Site H	
	Main Street and Tonset Road		South Orleans Road at Tonset (RT-28 Site)		Town Cove Gibson Road		Namequoit Road		Town Landfill		Paw Wah Pond		Rock Harbor Road		Kescayo Gansett (Lonnie's Pond)	
	Rating	Score	Rating	Score	Rating	Score	Rating	Score	Rating	Score	Rating	Score	Rating	Score	Rating	Score
Site Suitability																
Downgradient Potable Water Use - Wells																
Topography																
Depth to Groundwater																
Groundwater Nitrogen Profile (concentration/depth)																
Groundwater Flow Direction and Velocity																
Ease of Access/Use of Property																
Representativeness																
Permitting																
Outside ACEC, Upland Areas																
Abutter Compatibility																
Property Ownership/Road Layout																
Utility Conflicts																
Project Evaluation																
PRB Nitrogen Removal Efficiency																
Overall Ease of Monitoring																
Accessible Well Locations																
Quantity/Quality of Existing Information																
Other/Overriding Considerations																
Community Acceptability																
Potential for Public Education																
Potential for Watershed/Estuary Impacts																
Funding Potential																
Potential for Full Scale Implementation																
Total Criteria Points		-		-		-		-		-		-		-		
Rank		-		-		-		-		-		-		-		-

- Scoring
  - A good ranking (1) was assigned if the criterion could be met fully.
  - A neutral ranking (0) was assigned if the criterion could be met in part, but there were some potential issues and/or difficulties
  - A poor ranking (-1) was assigned if the criterion could not be met.

PRB Site Preliminary Draft Ranking

Criteria	Site A		Site B		Site C		Site D		Site E		Site F		Site G		Site H	
	Main Street and Tonset Road		South Orleans Road at Tonset (RT-28 Site)		Town Cove Gibson Road		Namequoit Road		Town Landfill		Paw Wah Pond		Rock Harbor Road		Kescayo Gansett (Lonnie's Pond)	
	Rating	Score	Rating	Score	Rating	Score	Rating	Score	Rating	Score	Rating	Score	Rating	Score	Rating	Score
Site Suitability																
Downgradient Potable Water Use - Wells	1	1	1	1	1	1	0	0	1	1	0	0	1	1	1	1
Topography	1	1	1	1	0	0	-1	-1	0	0	-1	-1	1	1	1	1
Depth to Groundwater	1	1	-1	-1	0	0	-1	-1	-1	-1	1	1	1	1	1	1
Groundwater Nitrogen Profile (concentration/depth)																
Groundwater Flow Direction and Velocity	0	0	1	1	0	0	0	0	1	1	0	0	-1	-1	1	1
Ease of Access/Use of Property	1	1	1	1	-1	-1	1	1	1	1	-1	-1	1	1	0	0
Representativeness	1	1	1	1	1	1	-1	-1	0	0	-1	-1	0	0	-1	-1
Permitting																
Outside ACEC, Upland Areas	1	1	1	1	1	1	-1	-1	1	1	-1	-1	1	1	-1	-1
Abutter Compatibility	0	0	1	1	0	0	0	0	1	1	0	0	0	0	0	0
Property Ownership/Road Layout	0	0	1	1	1	1	1	1	1	1	-1	-1	0	0	-1	-1
Utility Conflicts	-1	-1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Project Evaluation																
PRB Nitrogen Removal Efficiency	1	1	1	1	0	0	0	0	1	1	0	0	0	0	0	0
Overall Ease of Monitoring	0	0	1	1	0	0	0	0	0	0	-1	-1	0	0	-1	-1
Accessible Well Locations	0	0	1	1	1	1	1	1	0	0	-1	-1	0	0	0	0
Quantity/Quality of Existing Information	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0
Other/Overriding Considerations																
Community Acceptability	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0
Potential for Public Education	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Potential for Watershed/Estuary Impacts	0	0	1	1	0	0	0	0	1	1	0	0	0	0	0	0
Funding Potential	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Potential for Full Scale Implementation	1	1	1	1	1	1	0	0	0	0	-1	-1	-1	-1	0	0
Total Criteria Points		**9**		**14**		**7**		**1**		**10**		**(6)**		**4**		**1**
Rank		**3**		**1**		**4**		**6**		**2**		**-**		**5**		**6**

Groundwater Nitrogen Profile – Not Scored Until Collect Groundwater Data

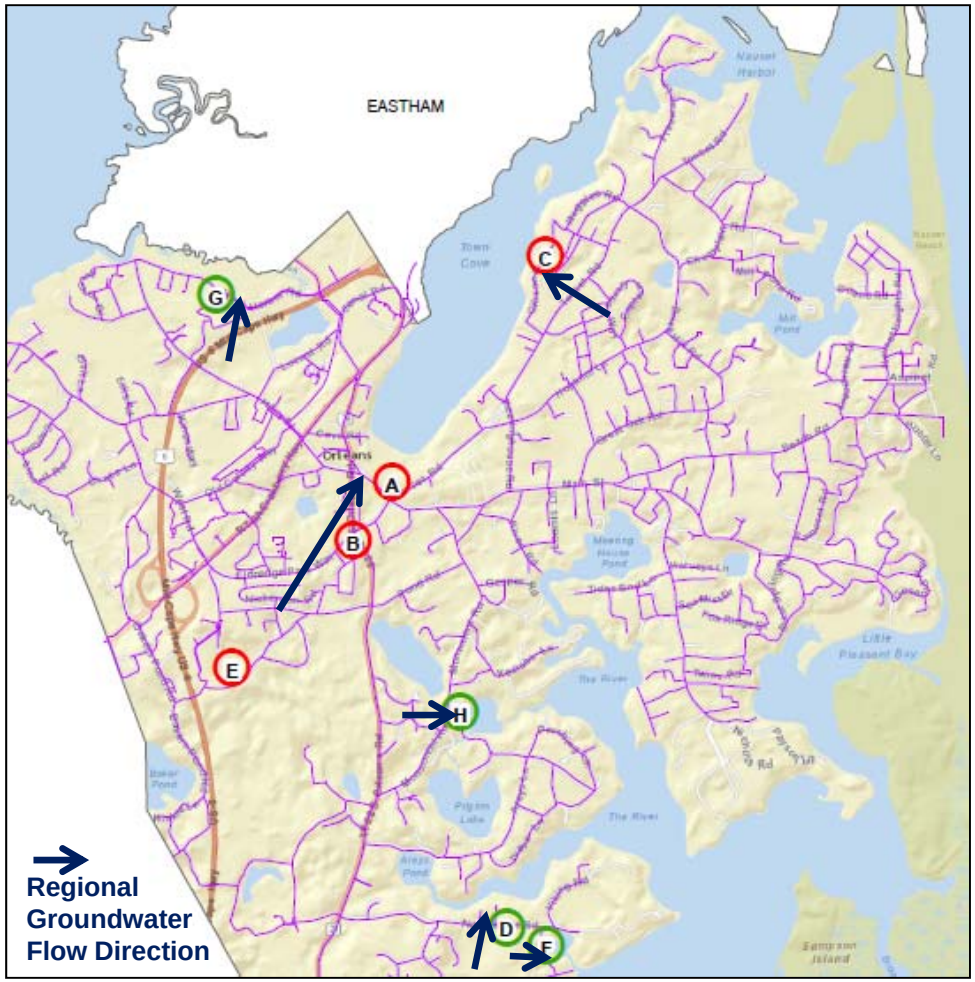
PRB Top Ranked Locations

A. Main Street and Tonset Road (Main Street)

B. South Orleans Road at Tonset/Eldredge Parkway (Route 28 site)

C. Town Cove Gibson Road

D. Town Landfill



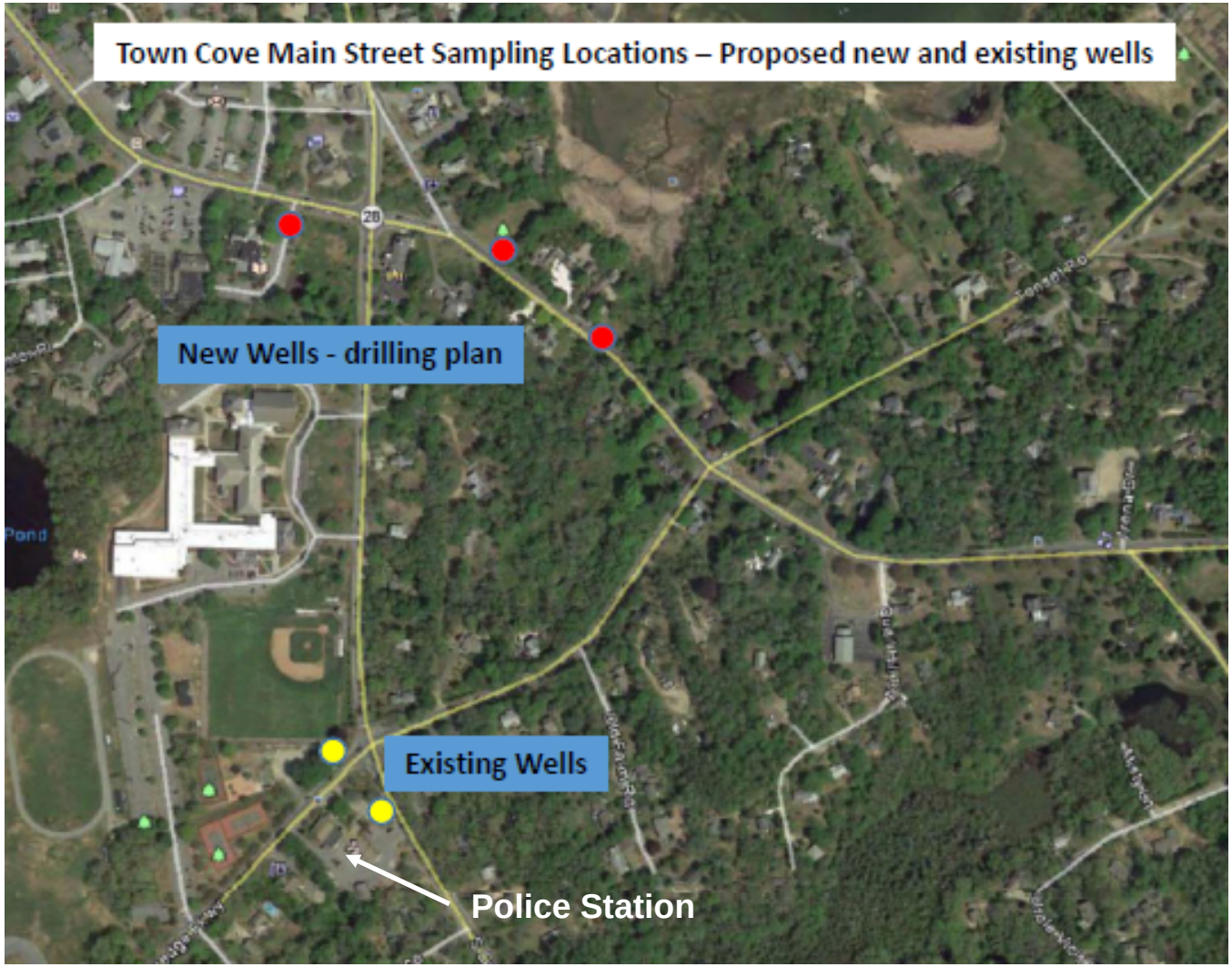
PRB Demonstration Siting Field Investigations

- Collect Soil and Groundwater Samples from Highest 4 Ranked Locations
  - New and Existing Monitoring Wells
  - South Orleans Road, Landfill, Tonset/Main, Gibson Road

- Measure Parameters to Support PRB Site Selection and Design
  - Vertical Profile of Nitrate (and ammonia) Concentrations
  - Depth to Groundwater
  - Groundwater Flow Velocity and Depth
  - Soil Types
  - Other Groundwater Analytes of Interest Include Total Organic Carbon, Metals, Competing Electron Acceptors

PRB Demonstration Siting Field Investigations

PRB Demonstration Siting Field Investigations



PRB Demonstration Siting Field Investigations

PRB Demonstration Test Monitoring Overview

- Performance Monitoring
- Evaluate Secondary Water Quality Impacts
- Engineering Design Optimization
- Monitoring Wells Located Upgradient and Downgradient of the PRB

PRB Next Steps

- Collect Feedback from You
- Complete Soil and Groundwater Sampling
- Finalize Site Evaluation
- Complete Engineering Work Plan
- Develop Cost Estimates (Project, O&M, Replacement and Monitoring)

Town of Orleans Massachusetts

Thank You

AECOM