



Town of

Orleans
Massachusetts

Permeable Reactive Barrier (PRB) PRB Workgroup Meeting

PRB Team Update

Mark Owen, AECOM

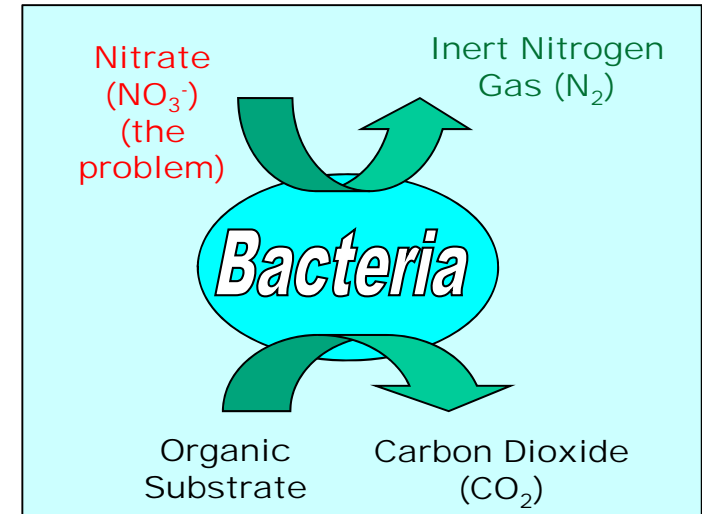
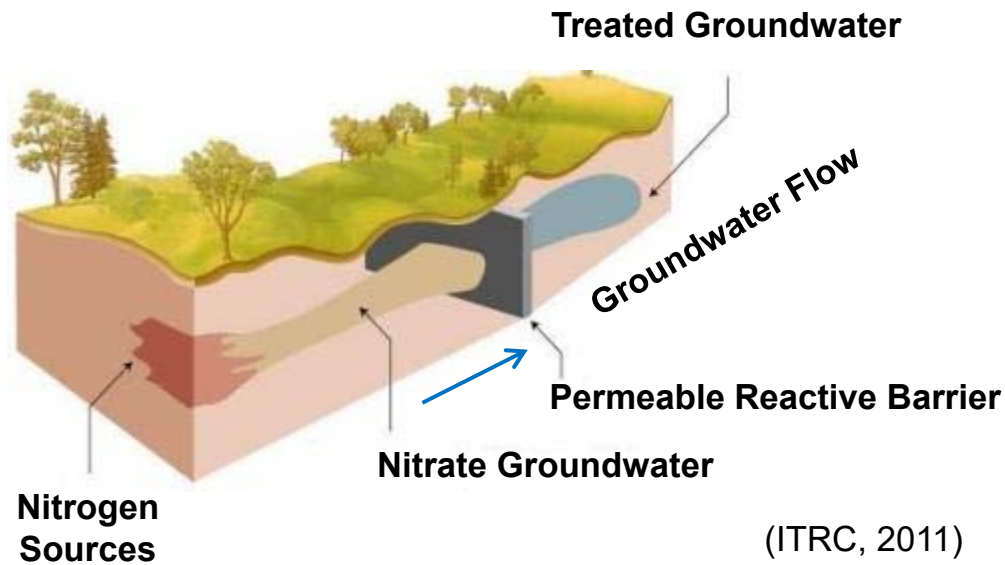
Jim Begley, MT Environmental Restoration

October 26, 2016

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Subsurface PRB

- ❖ A PRB consists of a zone of reactive material installed in the path of a plume (e.g. nitrate)



- ❖ Naturally-occurring bacteria to convert nitrate to inert nitrogen gas (N₂)
- ❖ Requires anoxic (low oxygen conditions)



AECOM PRB Team Activities

- ❖ Evaluated numerous sites in Orleans for placement of PRB
- ❖ Collected groundwater and soil samples
- ❖ Recommend PRB Demonstration Test sites
 - Eldredge Park
 - Town Landfill
- ❖ Preliminary Engineering Work Plan for PRBs
 - Conceptual design
- ❖ Final Technical Memos available on Town website
<http://www.town.orleans.ma.us/water-quality-advisory-panel/pages/aecom-contract-and-deliverables>



PRB Amendment – Emulsified Vegetable Oil (EVO)

- ❖ Food-grade substrate made with soybean oil
 - Consistency similar to soy milk
- ❖ Slowly releases dissolved organic carbon and provides a long term carbon source for denitrifying bacteria
- ❖ Relatively immobile once injected into groundwater
 - AECOM experience at 10s of sites
 - Never travels more than 100 feet (mostly less than 20 feet)
- ❖ Laboratory studies with Cape Cod sand used to develop an EVO mixture that does not migrate
 - Less than 3 feet in a column study



PRB Application Method – Injection

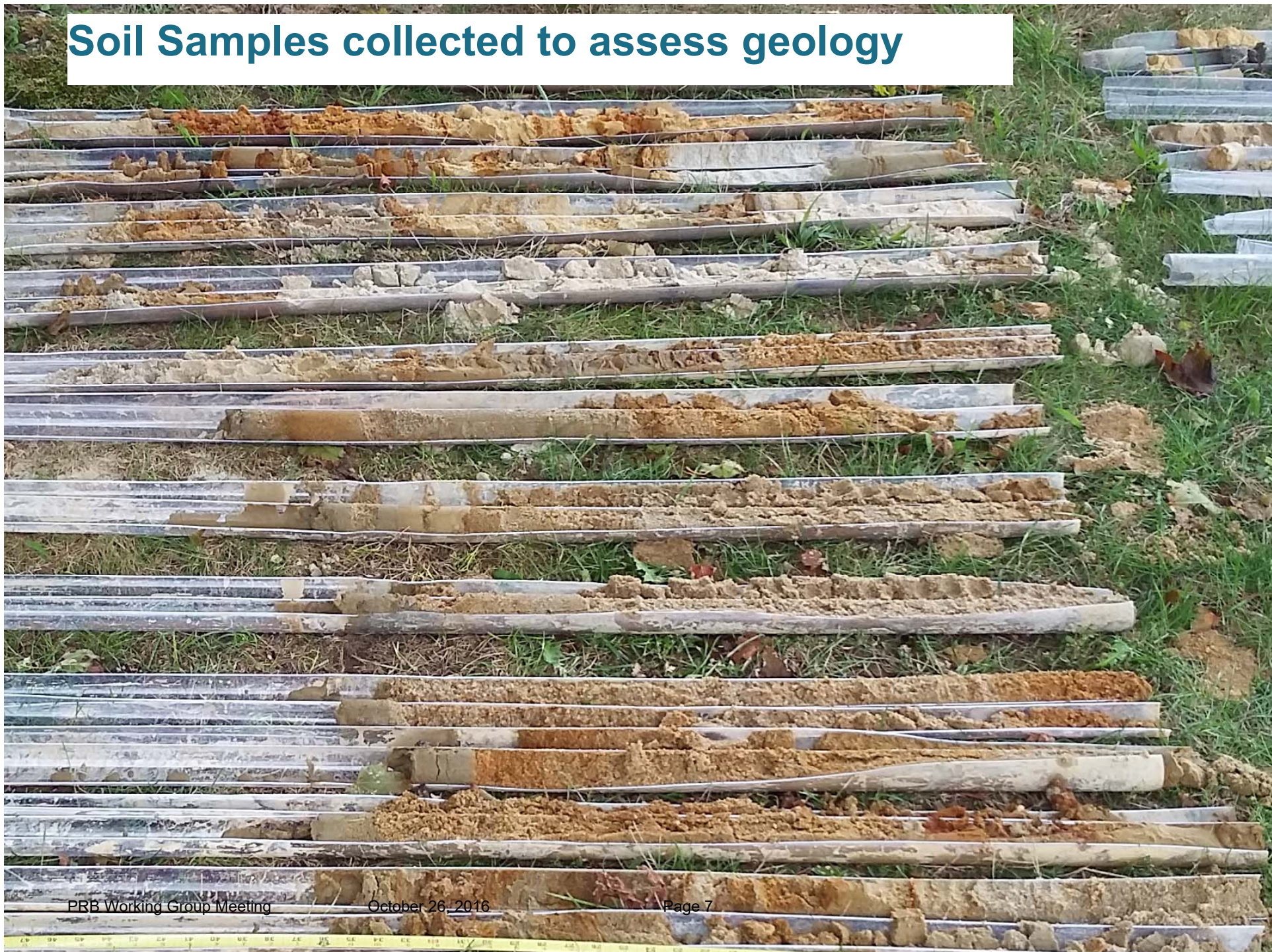
- ❖ Widely accepted groundwater treatment method and equipment readily available.
- ❖ Small equipment footprint
 - Small drill rig
 - All pumps and mixing tanks contained to box truck/trailer
 - All points temporary
- ❖ Injection can be performed under roadways/parking lots
 - Hose ramps can be used to keep street open to traffic
 - Limited impact to traffic and abutters



Soil Boring/Well Installation at Eldredge Park PRB Location



Soil Samples collected to assess geology



Eldredge Park PRB Monitoring Well Installation and Testing

- ❖ 4 new monitoring wells installed
- ❖ Groundwater flow confirmed to northeast
- ❖ Test results suggested a shift of the PRB line ~ 100 feet to the north



Eldredge Park PRB

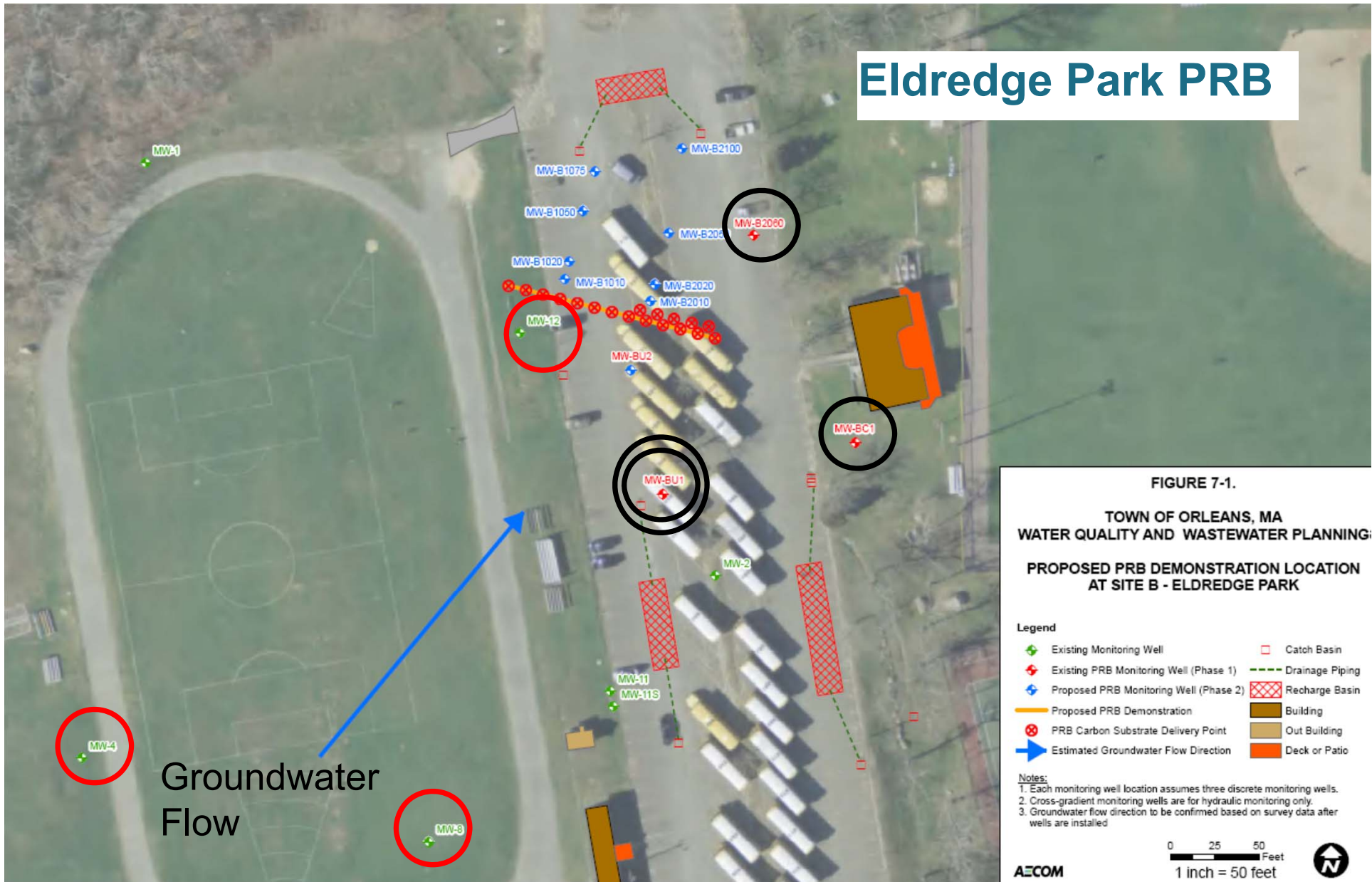


FIGURE 7-1.
TOWN OF ORLEANS, MA
WATER QUALITY AND WASTEWATER PLANNING:
PROPOSED PRB DEMONSTRATION LOCATION
AT SITE B - ELDRIDGE PARK

- Legend**
- Existing Monitoring Well
 - Existing PRB Monitoring Well (Phase 1)
 - Proposed PRB Monitoring Well (Phase 2)
 - Proposed PRB Demonstration
 - PRB Carbon Substrate Delivery Point
 - Estimated Groundwater Flow Direction
 - Catch Basin
 - Drainage Piping
 - Recharge Basin
 - Building
 - Out Building
 - Deck or Patio

Notes:
 1. Each monitoring well location assumes three discrete monitoring wells.
 2. Cross-gradient monitoring wells are for hydraulic monitoring only.
 3. Groundwater flow direction to be confirmed based on survey data after wells are installed

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0 25 50 Feet
 1 inch = 50 feet



Sample ID	MW-4	MW-8	MW-12	MA-BU1A	MW-BU1C	MW-BC1C	MW-B2060
Location							
Sampling Date	10/4/2016	10/4/2016	10/4/2016	10/4/2016	10/4/2016	10/4/2016	10/4/2016
Type of Sample	Sample	Sample	Sample	Sample	Sample	Sample	Sample
Field Measurements							
pH (SU)	5.52	5.23	4.98	5.44	5.27	5.48	5.26
Temperature (°C)	15.54	15.87	17.50	13.75	13.95	13.37	14.42
Dissolved Oxygen (DO; mg/L)	7.89	9.58	6.93	7.60	8.75	7.75	5.90
Redox Potential (ORP; mV)	57.90	135.00	167.80	70.90	130.90	70.10	110.50
Conductivity (mS/cm)	171.00	190.00	178.00	1464.00	351.00	1029.00	272.00
Laboratory Analyses							
Nitrogen							
Nitrate as N (mg/L)	2.45	9.24	6.74	0.443	1.97	0.481	1.29
Nitrite as N (mg/L)							
Ammonia (mg/L)	0.1	<0.1	<0.1	0.24	<0.1	-	<0.1
Total Kjeldahl Nitrogen (TKN) (mg/L)	0.71	1.7	1.34	0.38	0.4	-	0.72
Total Nitrogen (mg/L)	3.15	10.9	8.08	0.827	2.37	0.481	2.01
Anions							
Chloride (mg/L)	27.2	18.3	24.1	458	96.1	438	65.4
Sulfate (mg/L)	12.8	10.1	8.7	6.9	9.1	11.5	14.1
Elements							
Dissolved Iron (mg/L)	-	-	-	0.799	0.099	-	0.115
Dissolved Manganese (mg/L)	-	-	-	0.185	0.047	-	0.126
Boron (mg/L)	-	-	-	<0.05	<0.05	-	<0.05
Other							
DOC (mg/L)	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Methane (µg/L)	-	-	-	<2	<2	-	<2

Notes:

NS - Not Sampled / NM-Not Measured
 Bold - detected above the Minimum Detection Limit
 D -Duplicate



Phase 2 Well Installation and Eldredge Park PRB Injection

- ❖ Remaining monitoring wells to be install week of 10/31
- ❖ Injection Planned for week of 14 November



Landfill Overview Plan and Schedule

- ❖ Field investigation and analysis at Landfill to develop conceptual site model and alternatives to remove total nitrogen and address 1,4-dioxane
 - Phase I groundwater assessment planned to start in November/December 2016 depending on approval of funding
 - Phase 2 additional assessment, risk evaluation, feasibility assessment for alternatives, and conceptual design

- ❖ Coordination with DPW during facility redesign/construction to address source areas and corrective actions



Landfill Plan



Paper Size ANSI B
 0 70 140 280 Feet
 Map Projection: Lambert Conformal Conic
 Horizontal Datum: North American 1983
 Grid: NAD 1983 StatePlane Massachusetts Mainland FIPS 3201 Feet

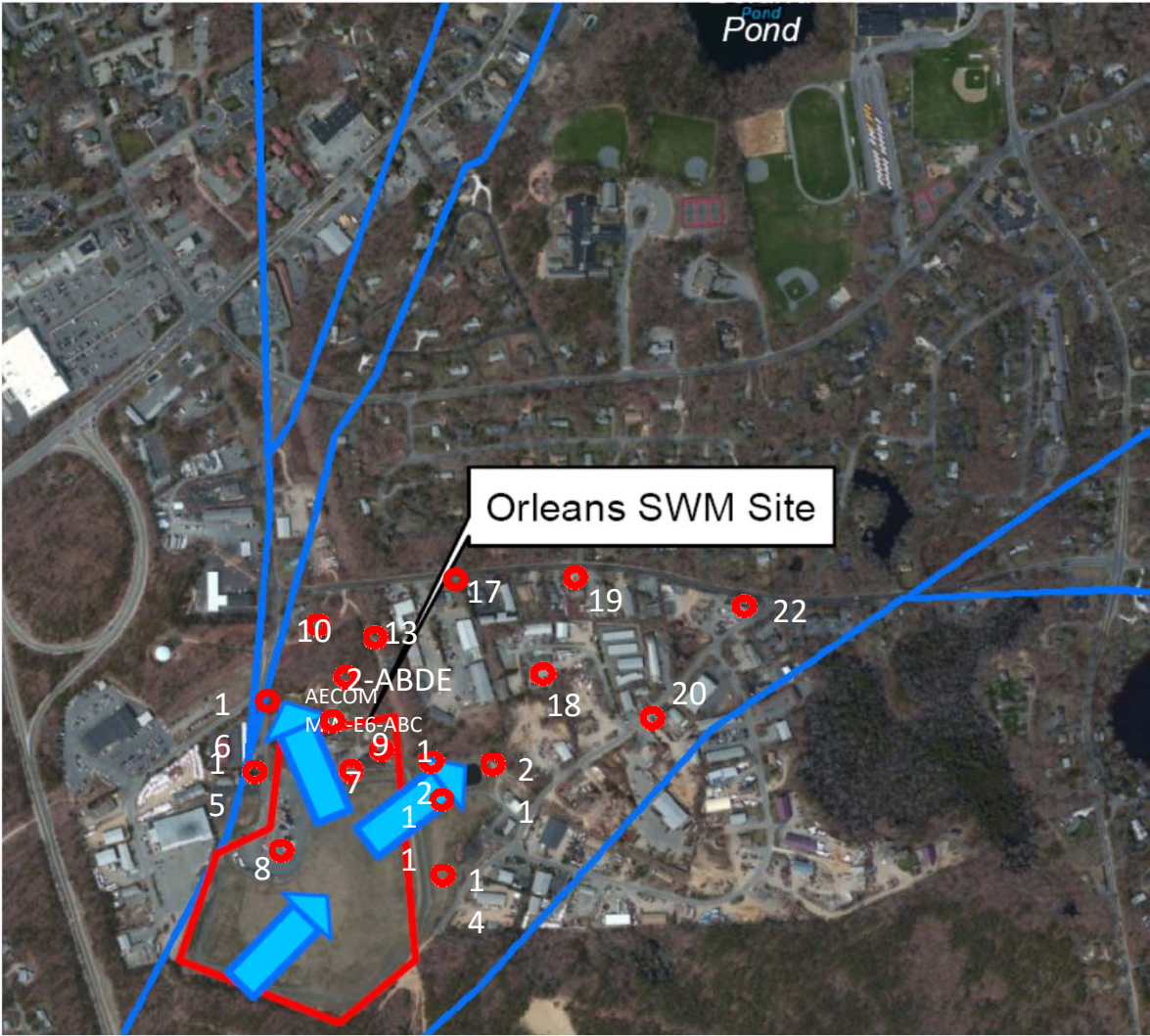


LEGEND

Monitoring Well Location

Phase 1 Proposed Monitoring Well Locations

All Potential
Monitoring
Well Locations





Town of

Orleans
Massachusetts

Thank You

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AECOM

Town of Orleans, Massachusetts
Water Quality and Wastewater Planning
Non-Traditional Technologies - Permeable Reactive Barriers
Estimation of Nitrogen Flux - Sensitivity Analysis Leaving the Landfill -10/12/2016

Calculation Summary: This calculation estimates the nitrogen flux (mass per time) traveling in groundwater leaving from the Orleans Town Landfill. Groundwater conditions can vary spatially and limited data has been collected to date to identify the extent of nitrogen vertically and spatially around the landfill. Therefore, a sensitivity analysis is provided in this calculation to quantify range of values and anticipated average conditions.

Parameter	Units	Low Range Flux	High Range Flux	Average Flux
Groundwater Seepage Velocity	ft/d	1.00	3.00	2.00
Porosity	unitless	0.25	0.35	0.30
Darcy Velocity	ft/d	0.25	1.05	0.60
Vertical Extent of Nitrogen Plume in Groundwater	feet	30.00	50.00	40.00
Groundwater Flux	ft ³ / d-ft length	7.50	52.50	24.00
Plume Width	feet	800	800	800
Groundwater Flux (within Plume Width)	ft ³ / day	6,000	42,000	19,200
Groundwater Flux (within Plume Width)	L/day	169,901	1,189,306	543,683
Average Nitrate Concentration	mg/L	10.00	40.00	20.00
Nitrate Flux	kg /yr-ft length	0.78	21.70	4.96
Landfill Nitrate Flux	kg/year	620	17,364	3,969
Landfill Nitrate Flux (5 years)	kg	3,101	86,819	19,844
Landfill Nitrate Flux (20 years)	kg	12,403	347,277	79,378



MW-2S

