Orleans Water Quality Advisory Panel

Permeable Reactive Barrier (PRB) Stakeholder Workshop

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James Begley, MT Environmental Restoration
Julianne Marrion, AECOM Technical Services, Inc.

March 15, 2017

AECOM PRB Team Activities

We have been busy implementing projects in the field!

AECOM PRB Team Activities

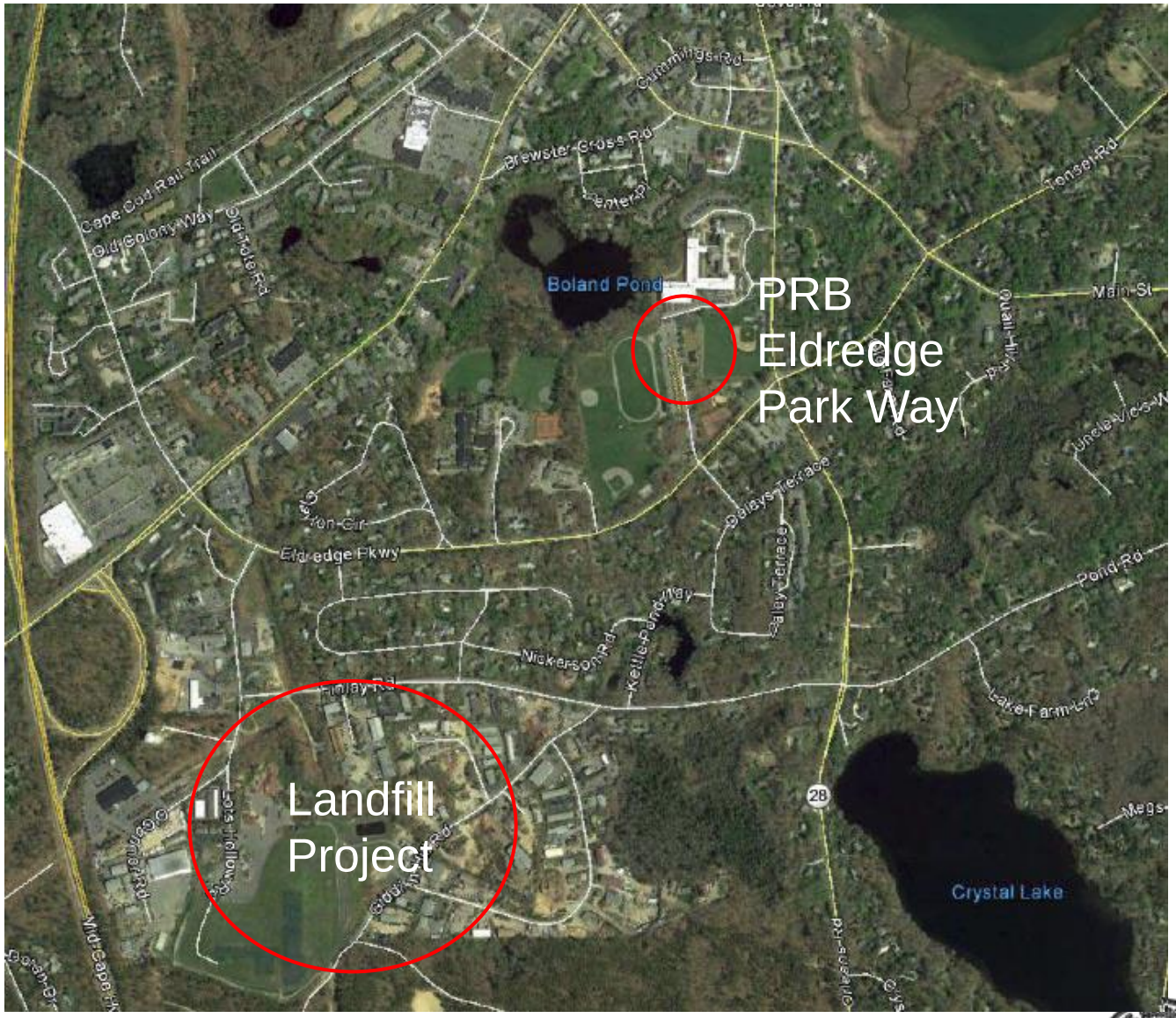
Reports Produced:

- *Technical Memorandum for Eldredge Park Permeable Reactive Barrier - Demonstration Overview of Baseline Sampling, Injection Activities and Post-Injection Groundwater Monitoring - March 1, 2017*

- *Technical Memorandum for Landfill Field Investigation Plan -February 24, 2017*

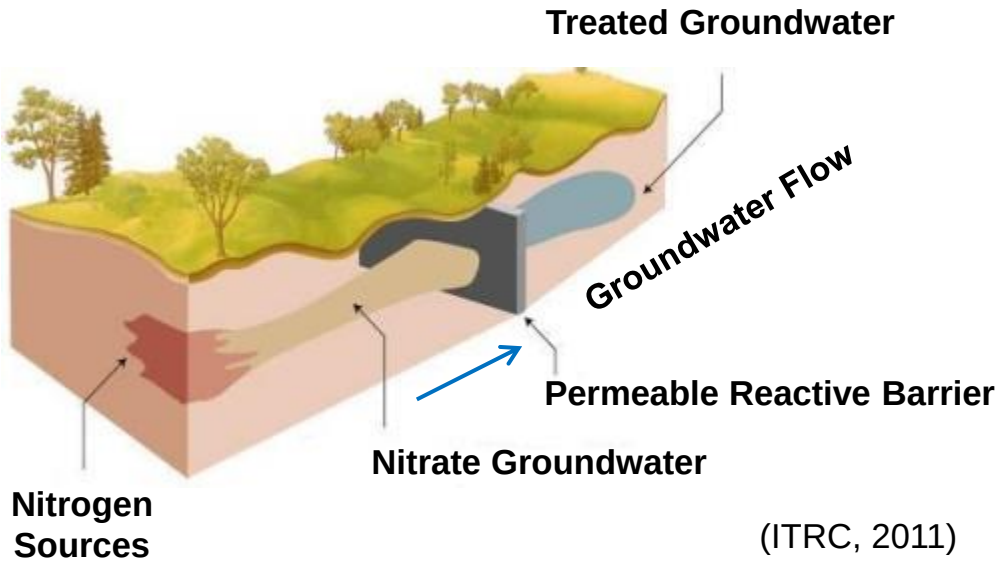
❖ Final Technical Memos available on Town website

Project Locations

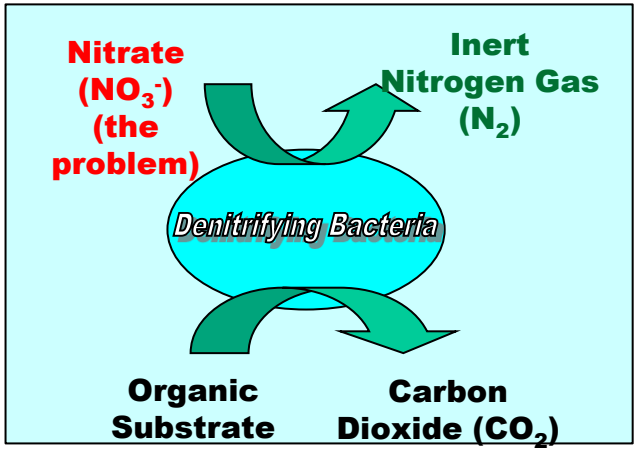


PRB Overview

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



(ITRC, 2011)

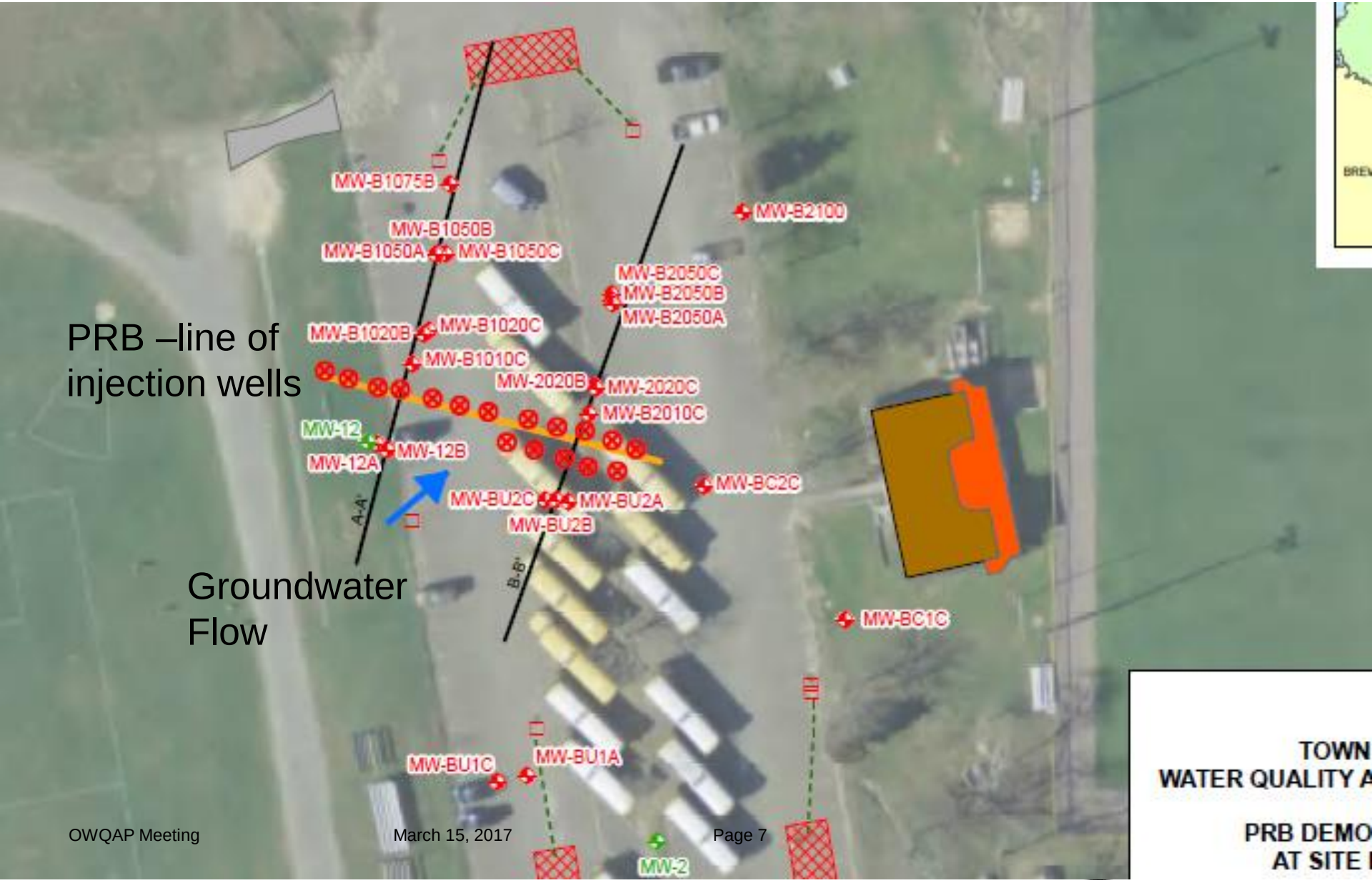


- Denitrification - Biological Process by Bacteria Ubiquitous in the Environment
  - Nitrate converted to inert nitrogen gas (N_2)
  - Requires anoxic (low oxygen conditions)

PRB Amendment – Emulsified Vegetable Oil

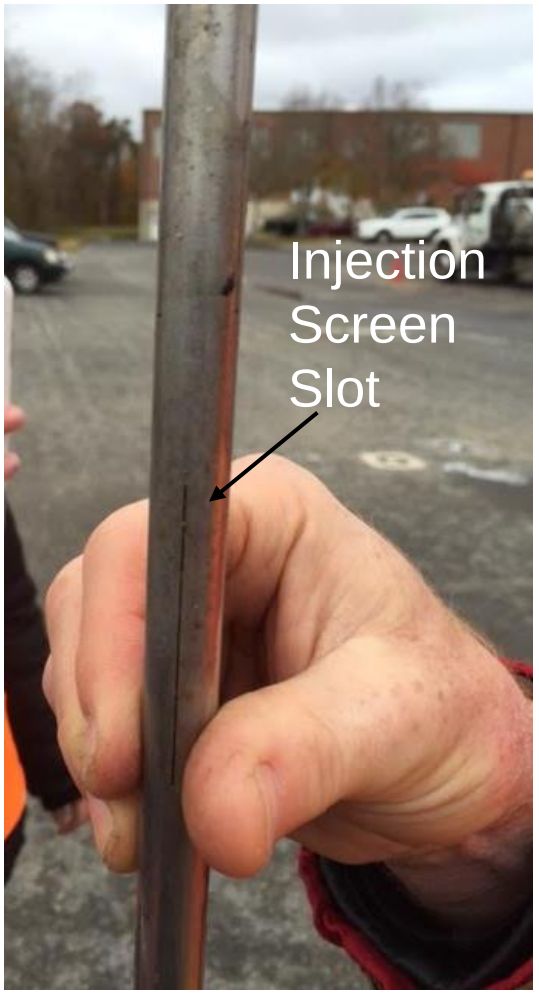
- Emulsified Vegetable Oil is a food-grade substrate made with soybean oil (oil-in-water emulsion with consistency similar to soy milk)
- Emulsion slowly releases dissolved organic carbon and provides a long term carbon source for denitrifying bacteria
- Emulsions are designed to be immobile once injected into groundwater
- A special formulation was used to make the emulsion “stickier” to reduce migration after injection and increase persistence

Eldredge Park Way PRB



PRB Construction

PRB Injection Completed week of 14 November 2016



Eldredge Park PRB Groundwater Monitoring

- Prior to injection – baseline sampling
- During injection to monitor distribution
- Initial post-injection sampling in early January 2017
- 1st quarterly sampling round late February 2017

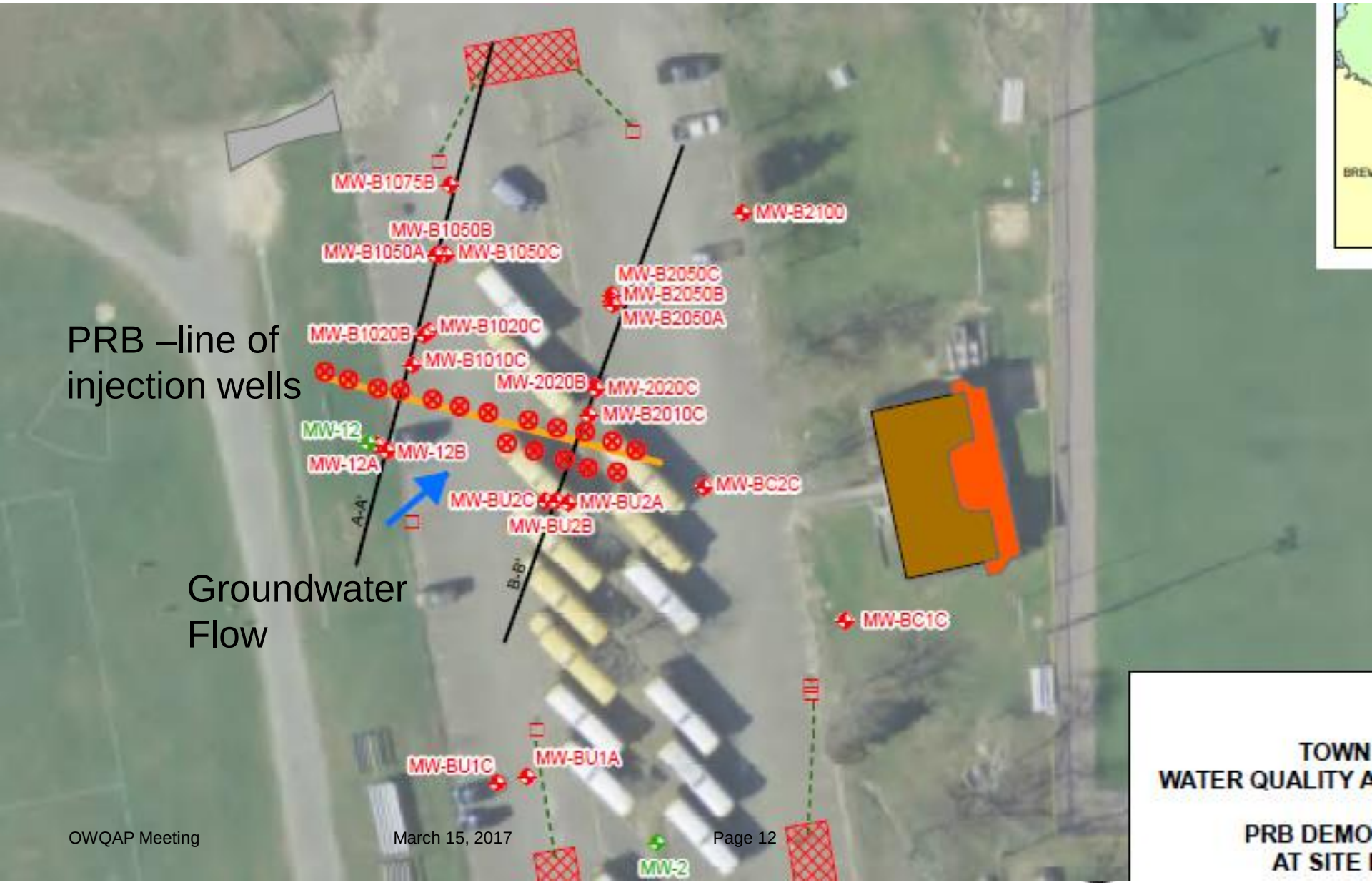
Field Measurements
pH (SU)
Temperature (°C)
Dissolved Oxygen (DO, mg/L)
Redox Potential (ORP; mV)
Specific Conductivity (µS/cm)[c]
Turbidity (NTU)
Laboratory Analyses
Nitrogen
Nitrate as N (mg/L)
Nitrite as N (mg/L)
Ammonia (mg/L)
Total Kjeldahl Nitrogen (TKN) (mg/L)
Total Nitrogen (mg/L)
Anions
Chloride (mg/L)
Sulfate (mg/L)
Elements
Dissolved Iron (mg/L)
Dissolved Manganese (mg/L)
Boron (mg/L)
Other
DOC (mg/L)
Methane (µg/L)
Alkalinity as CaCO3 (mg/L)

Groundwater Flow at Intermediate Depth

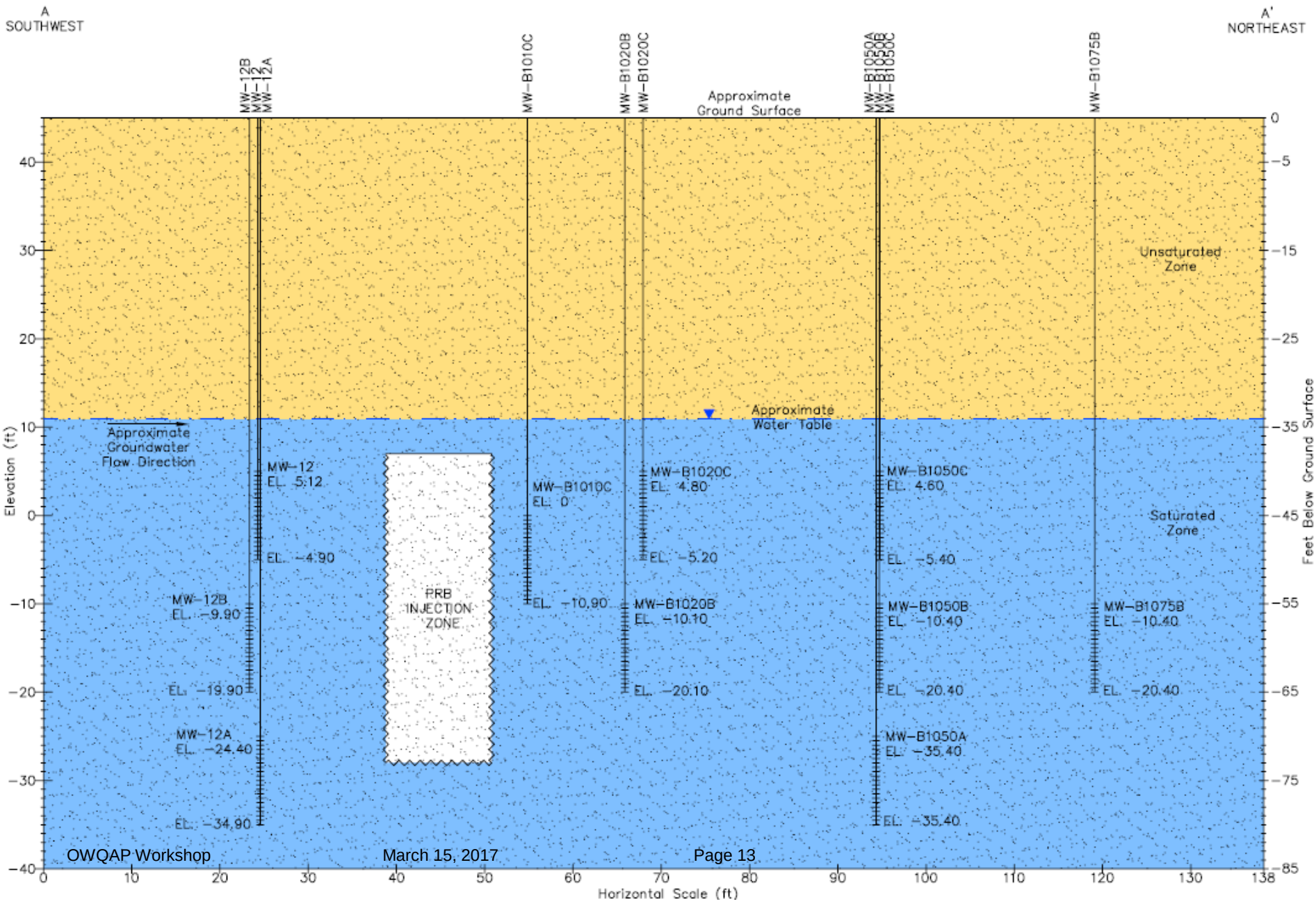
Eldredge Park PRB Monitoring

- Initial testing of PRB monitoring wells - baseline concentrations measured as high as 35 mg/L nitrate-nitrogen
- Wide range of nitrate concentrations at different sampling locations
- No unwanted migration of EVO detected during injection (monitoring turbidity and dissolved organic carbon 10, 20, 50 and 100 ft. downgradient)
- Initial monitoring indicates positive developments at some of the downgradient wells

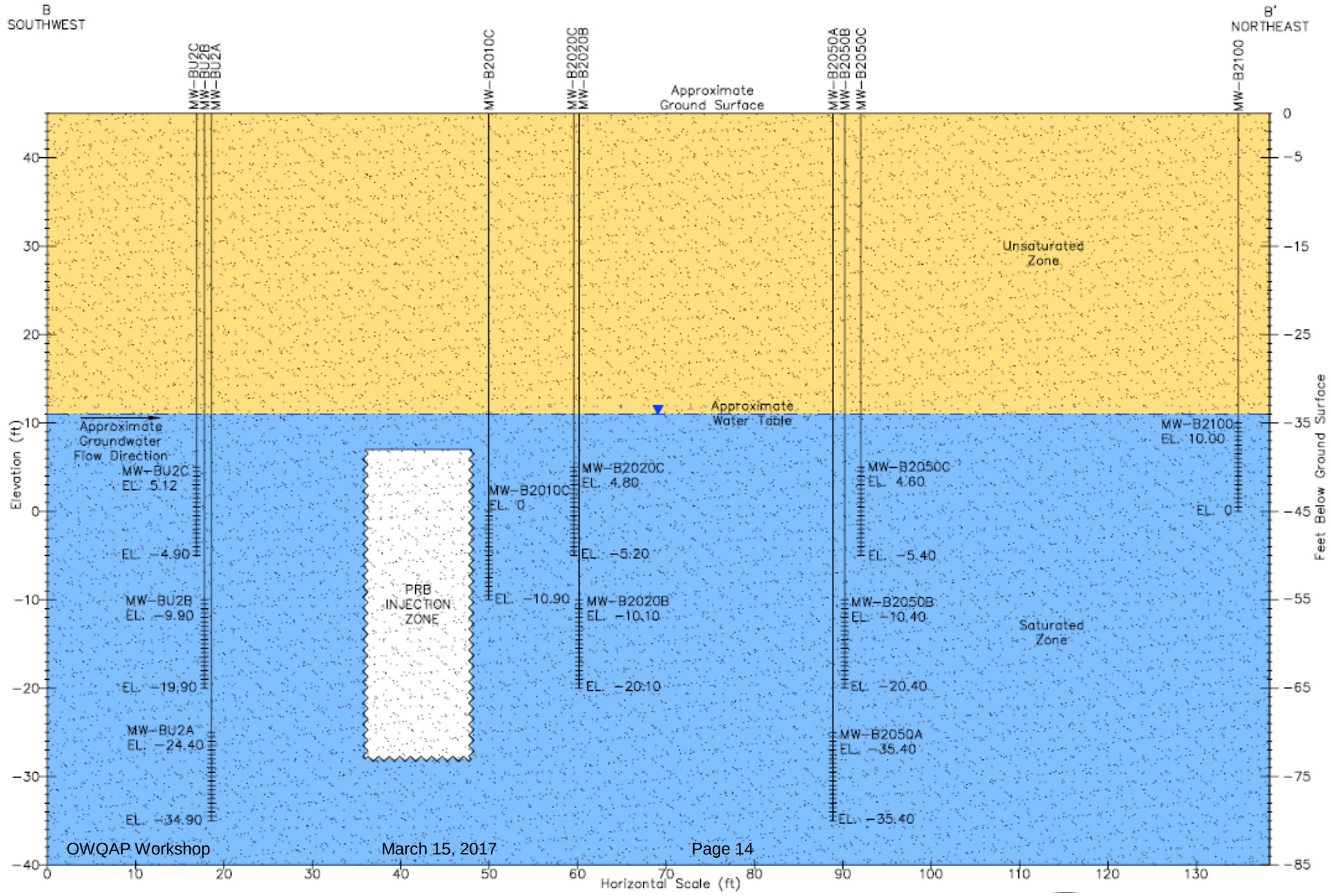
Eldredge Park Way PRB Cross Section Lines



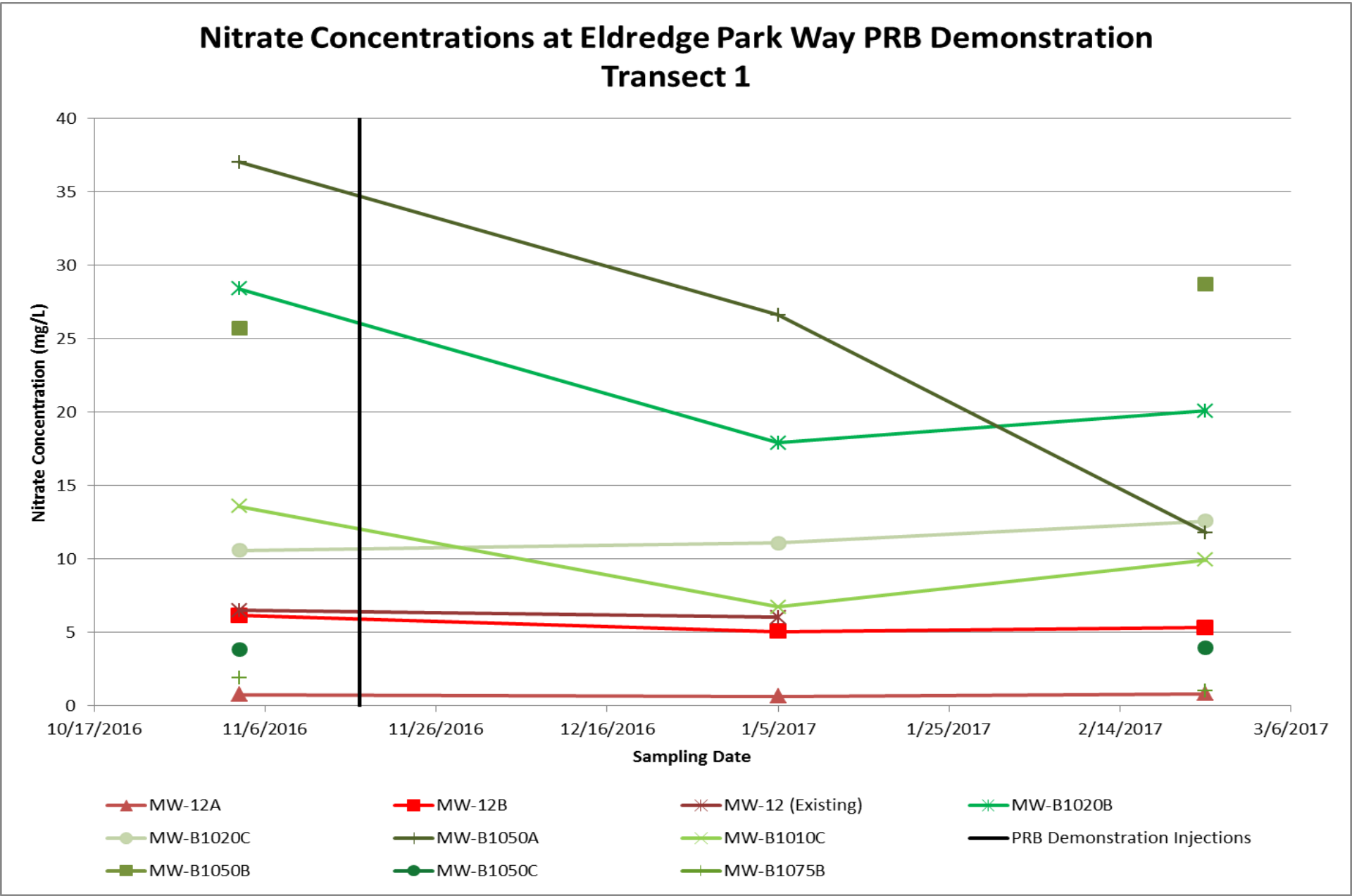
Cross Section A-A’



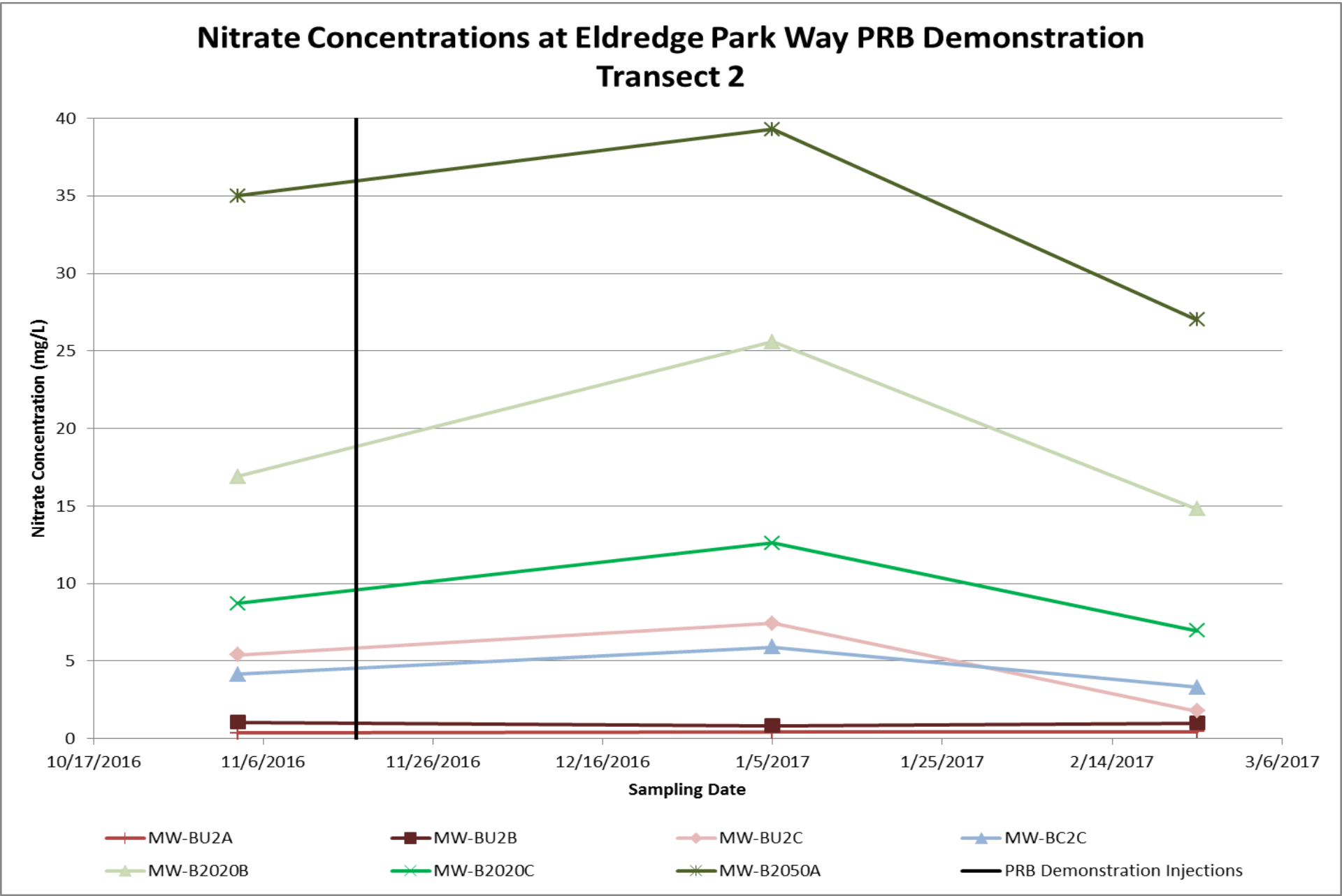
Cross Section B-B’



Eldredge Park PRB – Preliminary Data



Eldredge Park PRB – Preliminary Data (cont.)

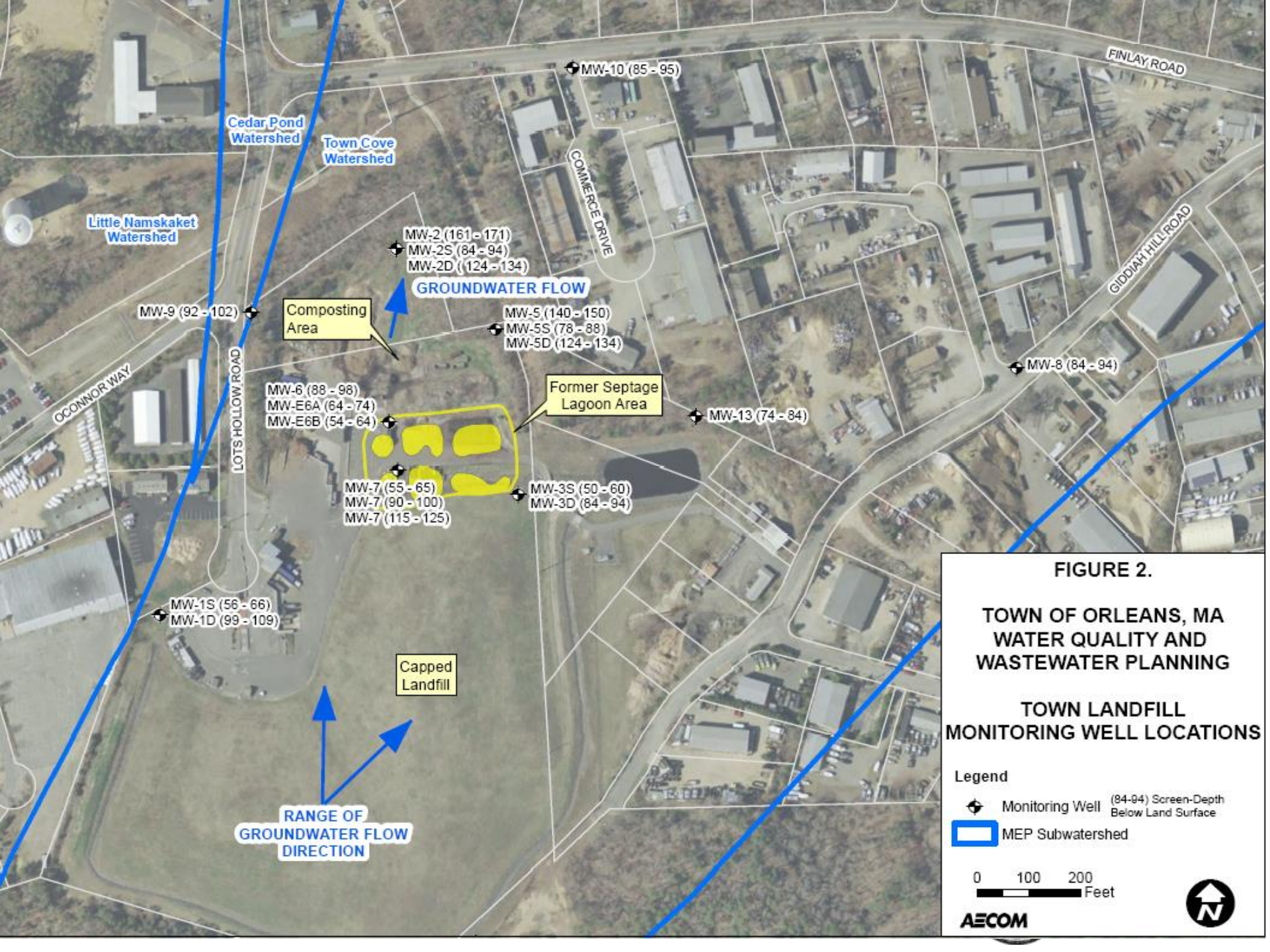


Next Steps Eldredge Park Way PRB Demonstration Test

- Evaluate PRB layout and test results to determine if modifications required
- Install four additional monitoring wells to expand range of monitoring network (completed week of 3/6/17)
- Continue Monitoring Demonstration Test at Eldredge Park – FY 2017 through FY 2019

Town Landfill – Project Objectives

- Implement Groundwater Assessment to confirm groundwater nitrogen flux based on groundwater flow and concentrations and to evaluate the distribution of 1,4-dioxane
  - Significant vertical section of aquifer potentially affected
  - Large area potentially affected
- Identify and Evaluate Response Actions for Nitrogen and 1,4-dioxane
- Conceptual Design and Cost Estimate for Response Actions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FINLAY ROAD
Cedar Pond Watershed
Town Cove Watershed
COMMERCE DRIVE
Little Namskaket Watershed
MW-2 (161 - 171)
MW-2S (84 - 94)
MW-2D (124 - 134)
GROUNDWATER FLOW
GIDDIAH HILL ROAD
MW-9 (92 - 102)
Composting Area
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O'CONNOR WAY
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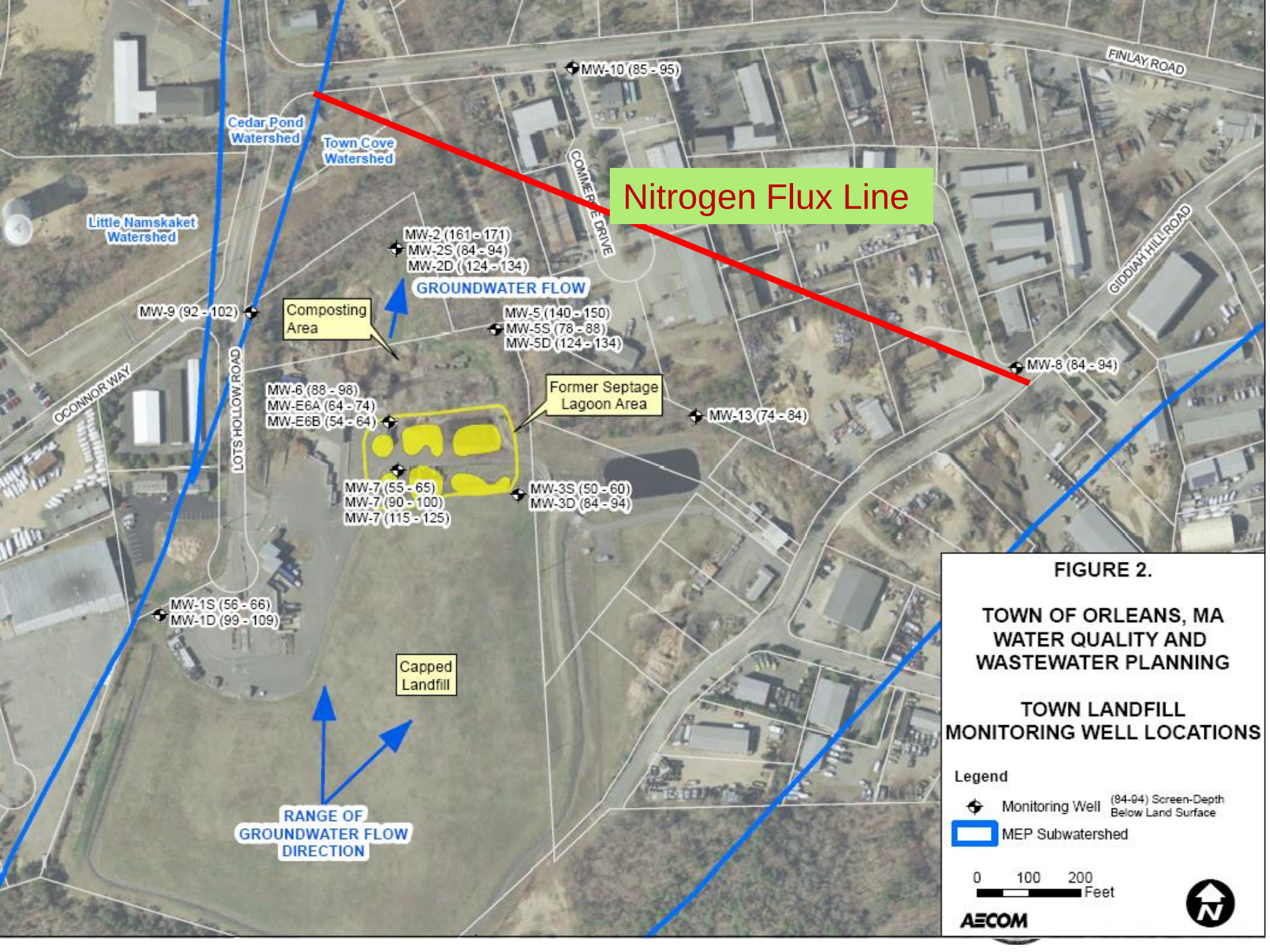
Capped Landfill
RANGE OF GROUNDWATER FLOW DIRECTION
FIGURE 2.
TOWN OF ORLEANS, MA
WATER QUALITY AND WASTEWATER PLANNING
TOWN LANDFILL MONITORING WELL LOCATIONS
Legend
Monitoring Well
(84-94) Screen-Depth Below Land Surface
MEP Subwatershed
0 100 200
Feet
AECOM
N


Nitrogen Flux Line
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Town of Orleans, Massachusetts
Water Quality and Wastewater Planning
Non-Traditional Technologies - Landfill Nitrogen Flux
Estimated Nitrogen flux (mass per time) from the Orleans Landfill.

Parameter	Units	Low Range Flux	High Range Flux	Mid Range Flux
Groundwater Seepage Velocity (variable)[1]	ft/d	2.00	4.00	3.00
Porosity	unitless	0.25	0.25	0.25
Darcy Velocity	ft/d	0.50	1.00	0.75
Vertical Extent	feet	60	60	60
Length of Affected Aquifer[2]	feet	1,540	1,540	1,540
Groundwater Flux	ft3 / d-ft length	30	60	45
Groundwater Flux	ft3 / day	46,200	92,400	69,300
Groundwater Flux	L/day	1,308,236	2,616,472	1,962,354
Groundwater Flux	Gallons/min	240	480	360
Nitrate Concentration (variable)[3]	mg/L	6.00	24.00	12.00
Nitrate Flux	kg /yr-ft length	1.86	14.88	5.58
Nitrate Flux	kg/year	2,865	22,920	8,595

1. Variable - sensitive to hydraulic conductivity Groundwater velocity is variable based on a range of hydraulic conductivity (Low 60 - High 250 ft./day)

2. Affected Aquifer length - line across watershed from corner Lots Hollow Rd and Finlay Rd. to Giddiah Hill Rd. at corner Industrial Way

3. Variable -sensitive to total nitrogen concentration - Data set average concentration 12 mg/L, range 1 mg/L to 27 mg/L, n=32

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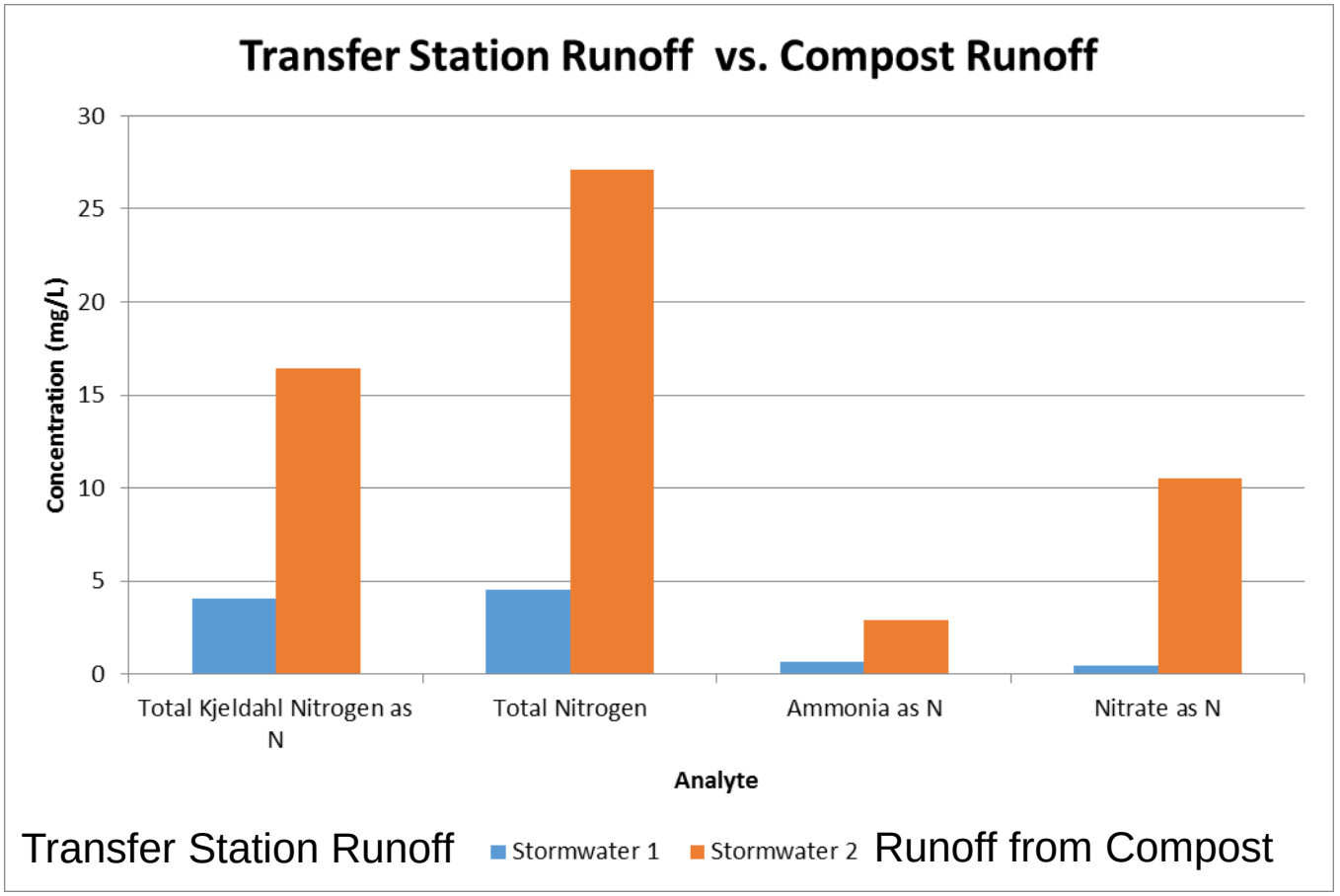
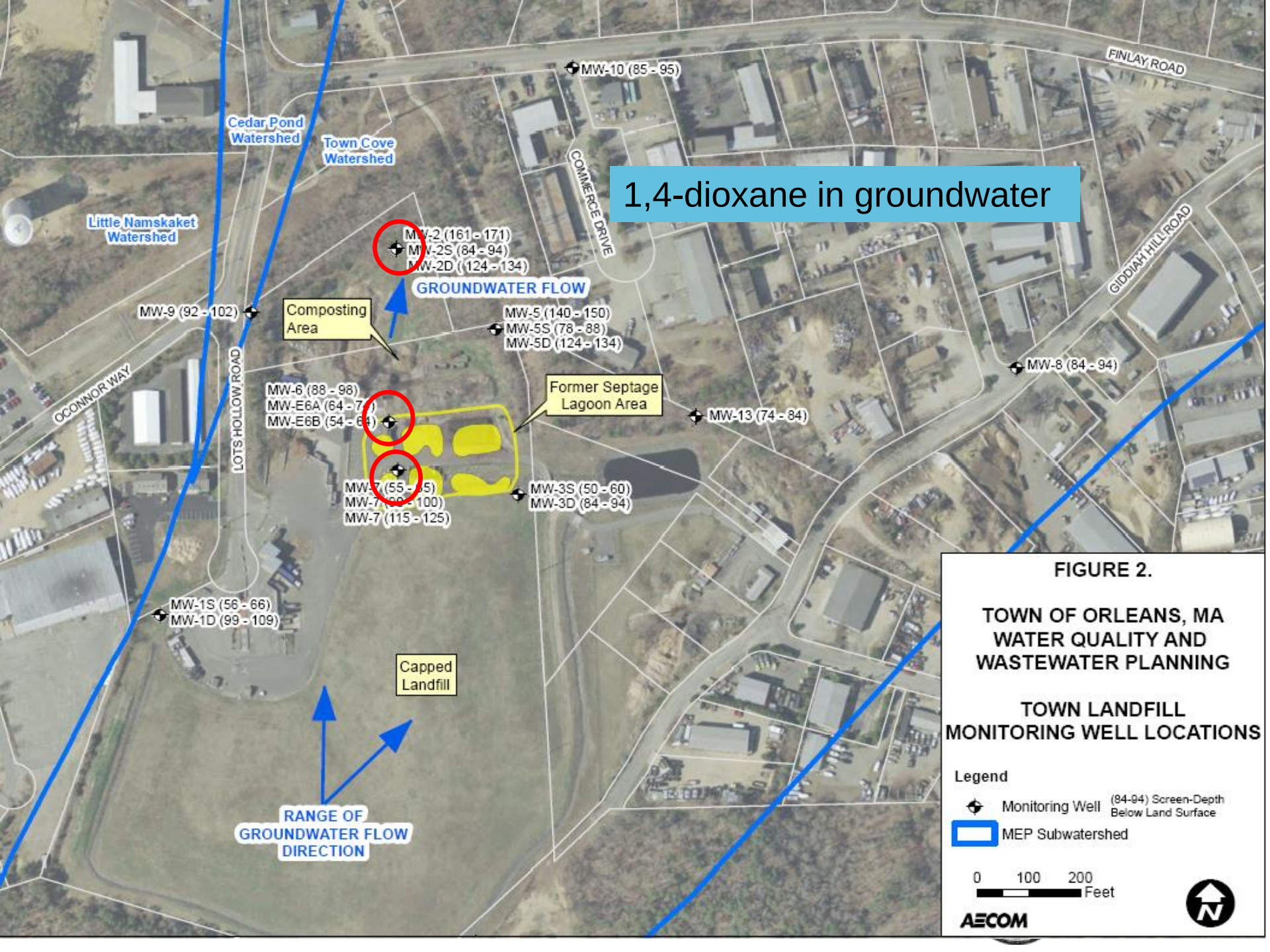
Sources of Nitrogen at the Landfill

Compost Operation Significant Nitrogen Source




1,4-dioxane in groundwater
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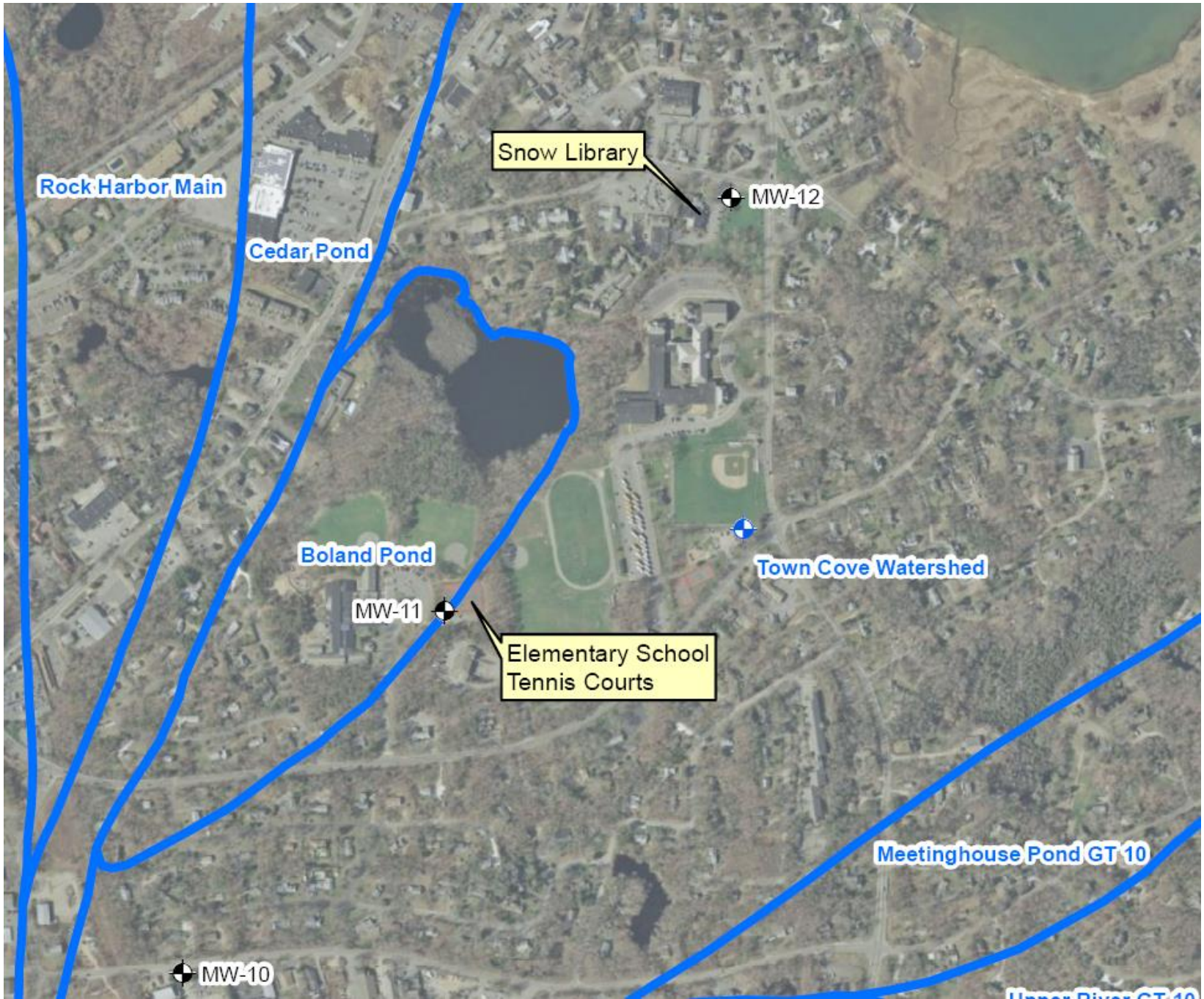
Landfill - Summary

- Groundwater affected by significant nitrate concentrations shallow and by ammonia and 1,4-dioxane deep
- Sources of 1,4-dioxane and nitrogen identified
  - 1,4-dioxane source appears to be solid waste in the landfill
  - Nitrogen sources:
    - Landfill (mainly ammonia)
    - Septage Lagoons (ammonia and nitrate)
    - Compost operation (organic nitrogen, ammonia, and nitrate)
    - Transfer Station runoff (ammonia and nitrate)
- Landfill Area Nitrogen flux Estimated –Mid-range estimate ~ 8,500 kg/yr
- 1,4-dioxane detected in more monitoring wells > 0.0003 mg/L standard
- Potential area of downgradient migration area in watershed identified

Downgradient Watershed Wells



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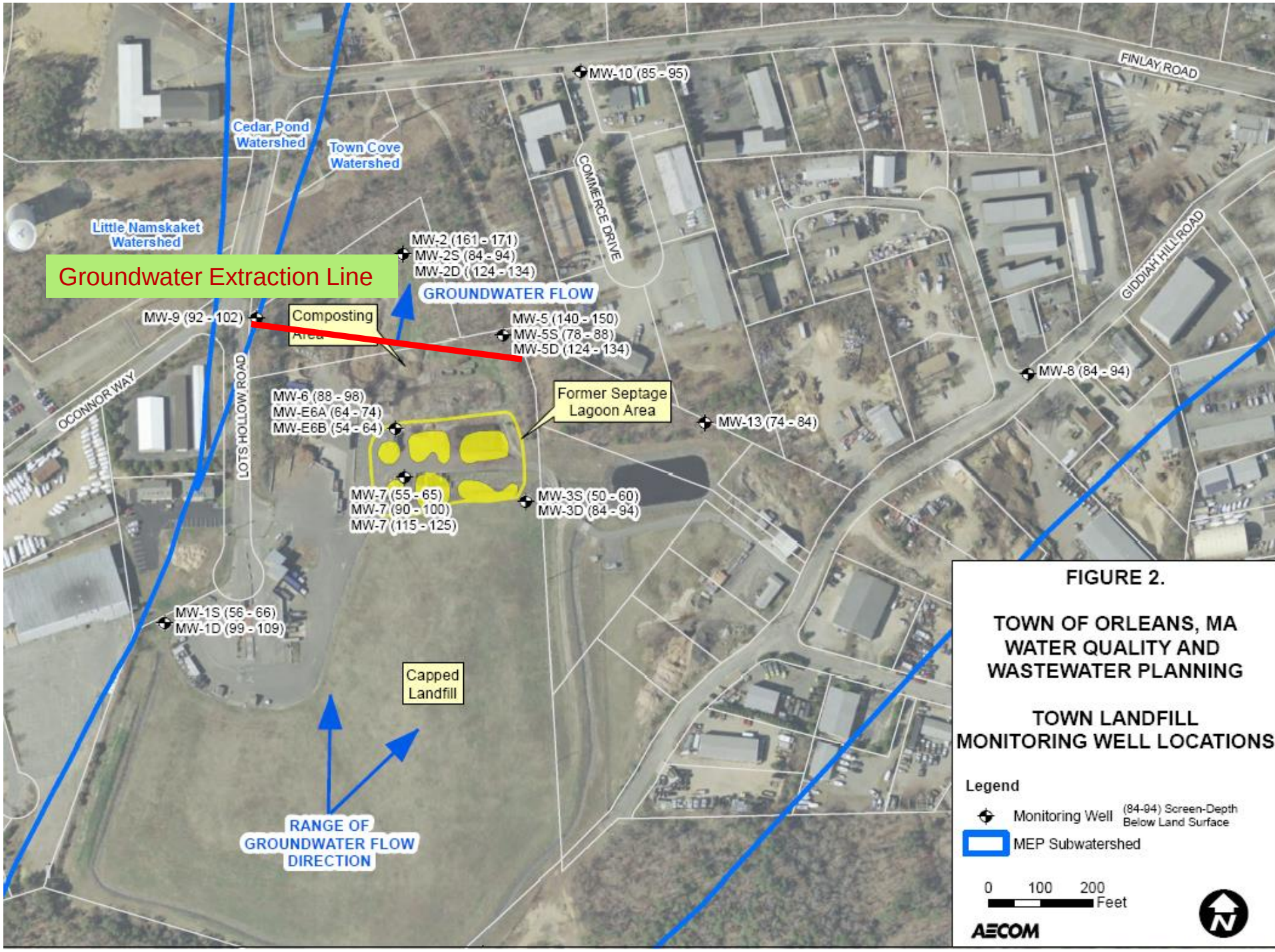
Landfill Potential Corrective Actions for Nitrogen - Nitrogen Flux

- Reduce/Eliminate infiltration of transfer station stormwater/landfill cap drainage through the septage lagoon area
- Move compost operation to a location with an impermeable surface (already in planning by DPW)
- Consider treatment of stormwater, landfill cap drainage and compost area runoff with best management practices to maximize denitrification
- Consider active capture and treatment of landfill area nitrogen flux with groundwater extraction and treatment with nitrification/denitrification bio-filter systems

Potential Landfill Corrective Action for Nitrogen - Nitrogen Flux - Nitrification/Denitrification Bio-Filter System

- System Components:
  - Groundwater extraction pumping system (could be solar powered)
  - 1st Stage - nitrification system (convert ammonia to nitrate) with nitrification bio-filters
  - 2nd stage denitrification treatment with denitrification bio-filters
  - Re-infiltration to groundwater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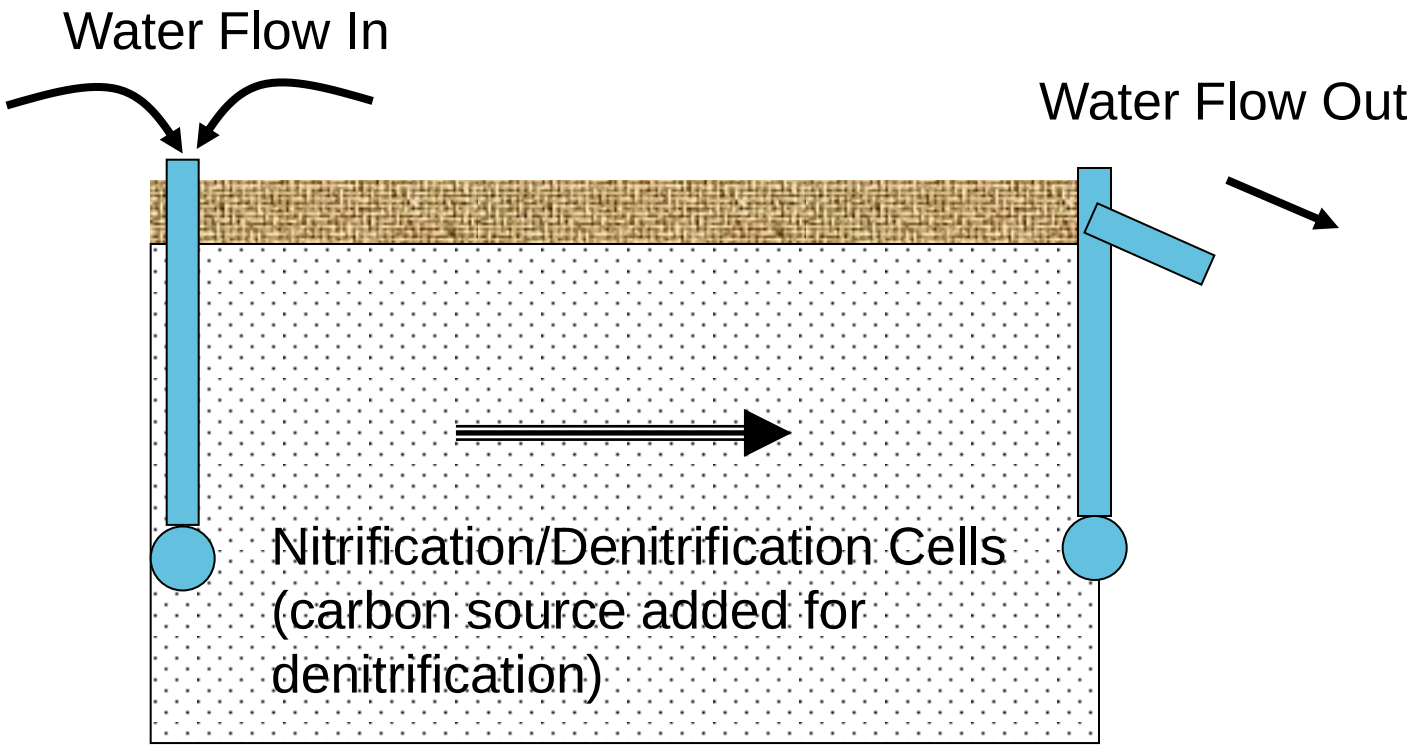
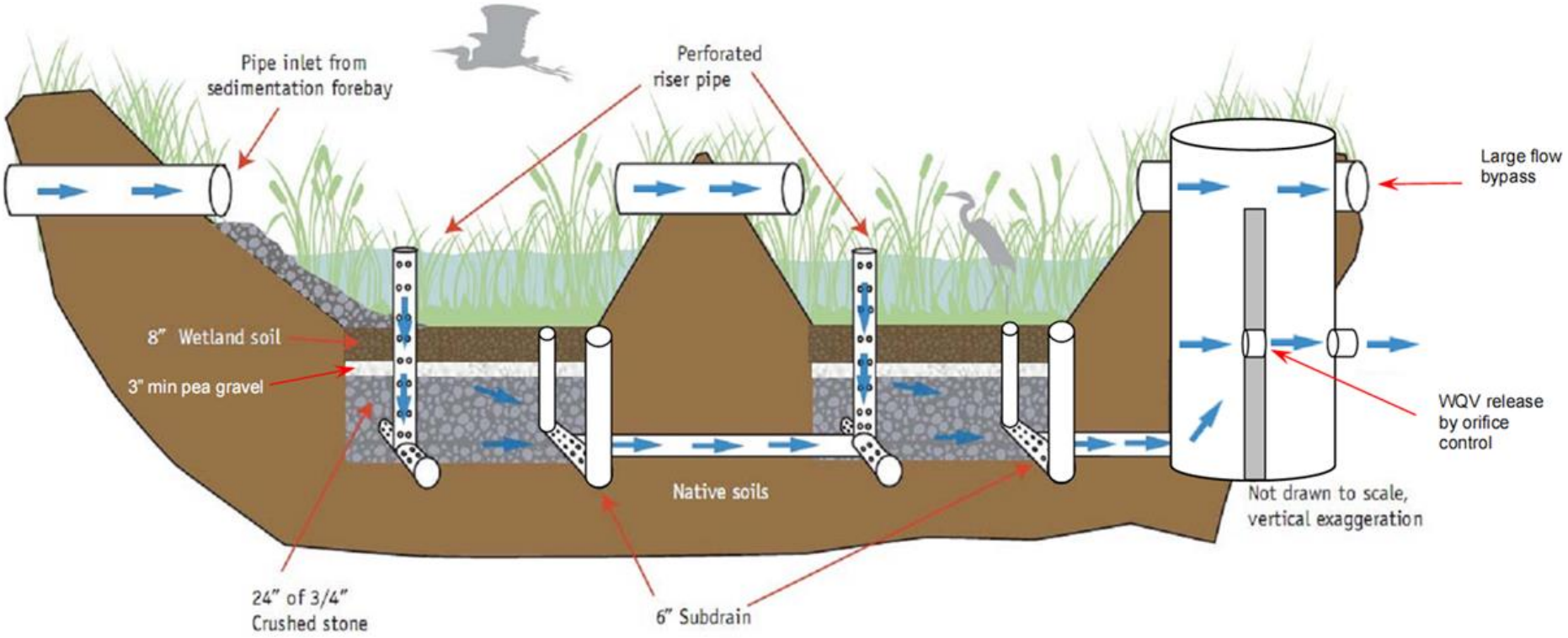
Bio-Filter Treatment System Concept



Nitrification/Denitrification Bio-Filter System



Next Steps Landfill Site

- Evaluate risks associated with 1,4 –dioxane and complete initial conceptual design and cost estimate to reduce nitrogen flux
- Implement final design, permit, and construct landfill nitrogen flux corrective actions in FY-18

Town of Orleans Massachusetts

Thank You

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