

ENVIRONMENTAL CONSULTING GROUP

St.Germain ■ Collins



Green Remediation of Petroleum Contaminated Groundwater Using Oxygen Injection in Western Maine

Brian Bachmann, CG

Keith Taylor, CG

2012 Maine Water Conference

March 14, 2012

EXPERIENCE YOU CAN RELY ON WHEN IT COUNTS



Introduction

Typically in Maine, petroleum contamination is remediated utilizing:

- techniques that don't take into account energy consumption, or
- the overall “environmental footprint” of the remedial option.

EXPERIENCE YOU CAN RELY ON WHEN IT COUNTS

Soil Excavation

- Environmental impacts from excavator, trucks, recycling plant:
 - Air emissions
 - Fossil fuel consumption



EXPERIENCE YOU CAN RELY ON WHEN IT COUNTS

Pump and Treat

- Groundwater extraction and treatment systems (GETS) are used for sensitive groundwater resources.
- Environmental Impacts from GETS:
 - High electricity needs
 - Air emissions
 - Waste from pretreatment and post treatment (e.g., iron removal)



EXPERIENCE YOU CAN RELY ON WHEN IT COUNTS

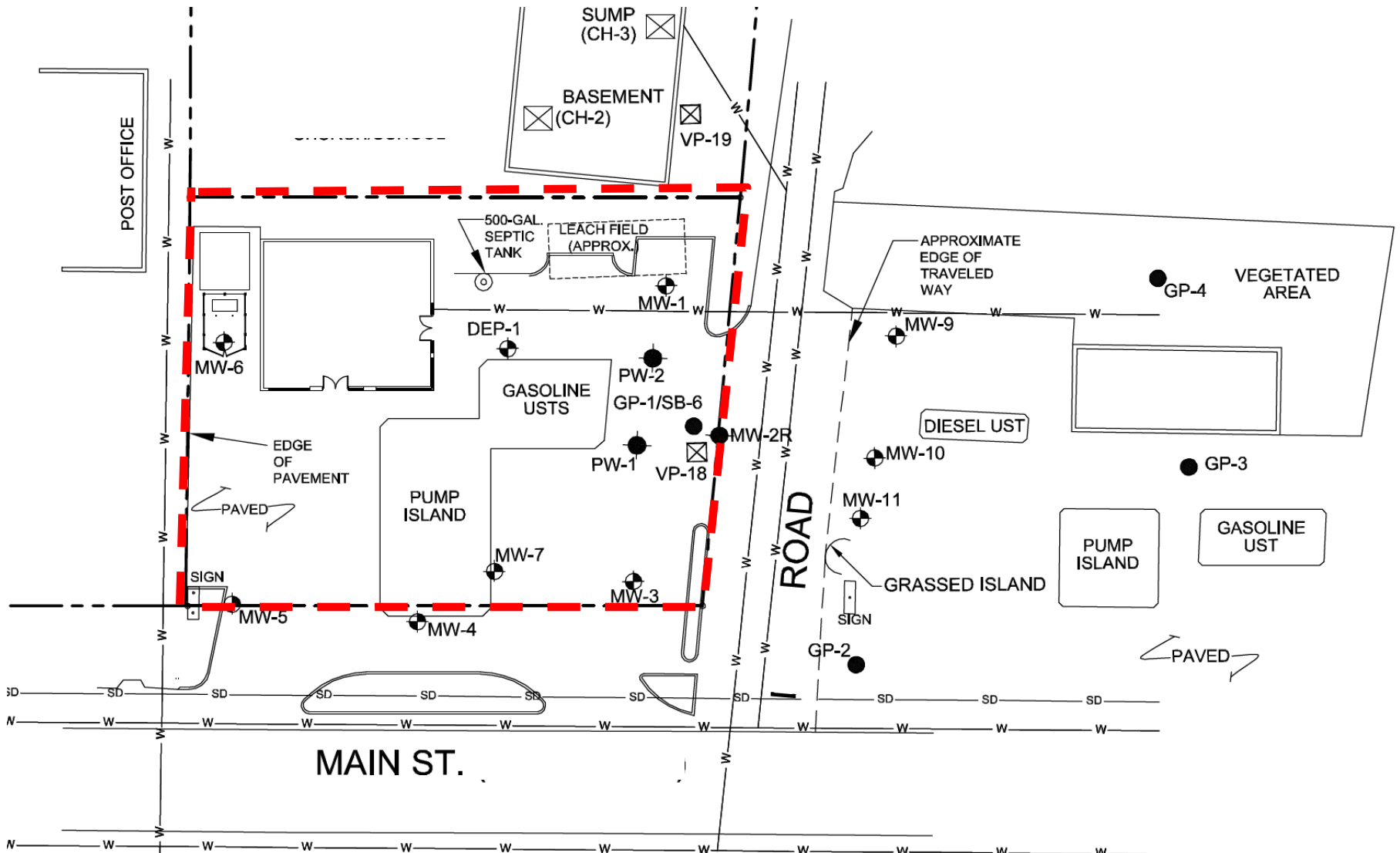
Natural Attenuation

- Allows hydrocarbons to biodegrade completely on their own; we only monitor
- Low-carbon footprint
- But it takes a very long time--some sites have been monitored since the 1990s.
- Monitoring for decades still requires vehicle usage



EXPERIENCE YOU CAN RELY ON WHEN IT COUNTS

Site Description



Site Description

- Contamination first documented in 2004.
- Free product diesel fuel present, but erratic in location and thickness.
- Also mixed diesel and gasoline dissolved phase contamination.
- Petroleum fingerprinting indicates both old and new contamination.



EXPERIENCE YOU CAN RELY ON WHEN IT COUNTS

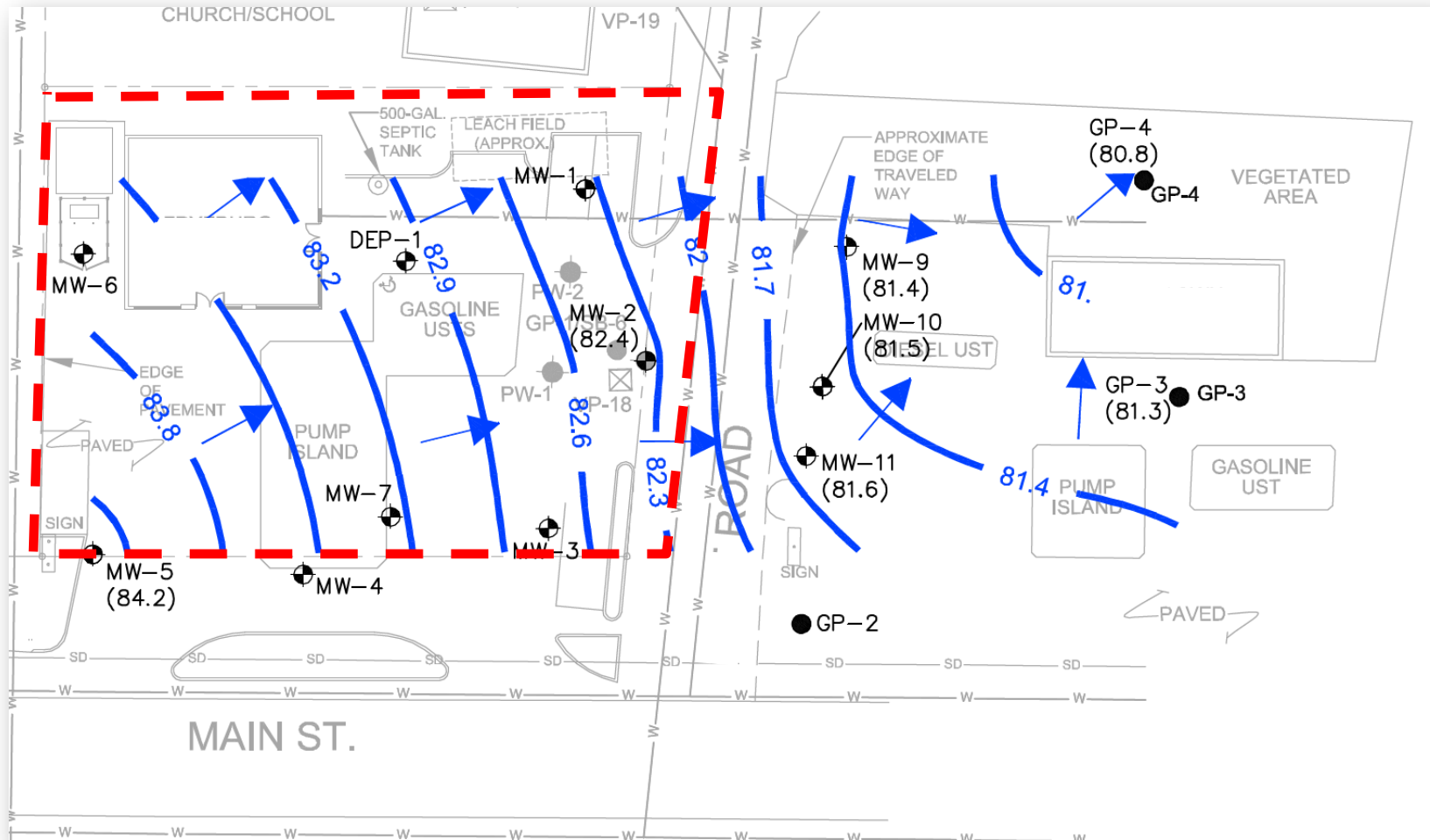
Hydrogeology

- Glaciofluvial, deltaic, and eolian sand deposits mapped in area.
- Soil borings at site penetrated up to 30 feet of interbedded fine to coarse sand with minor silt.
- No clay or low permeability material.

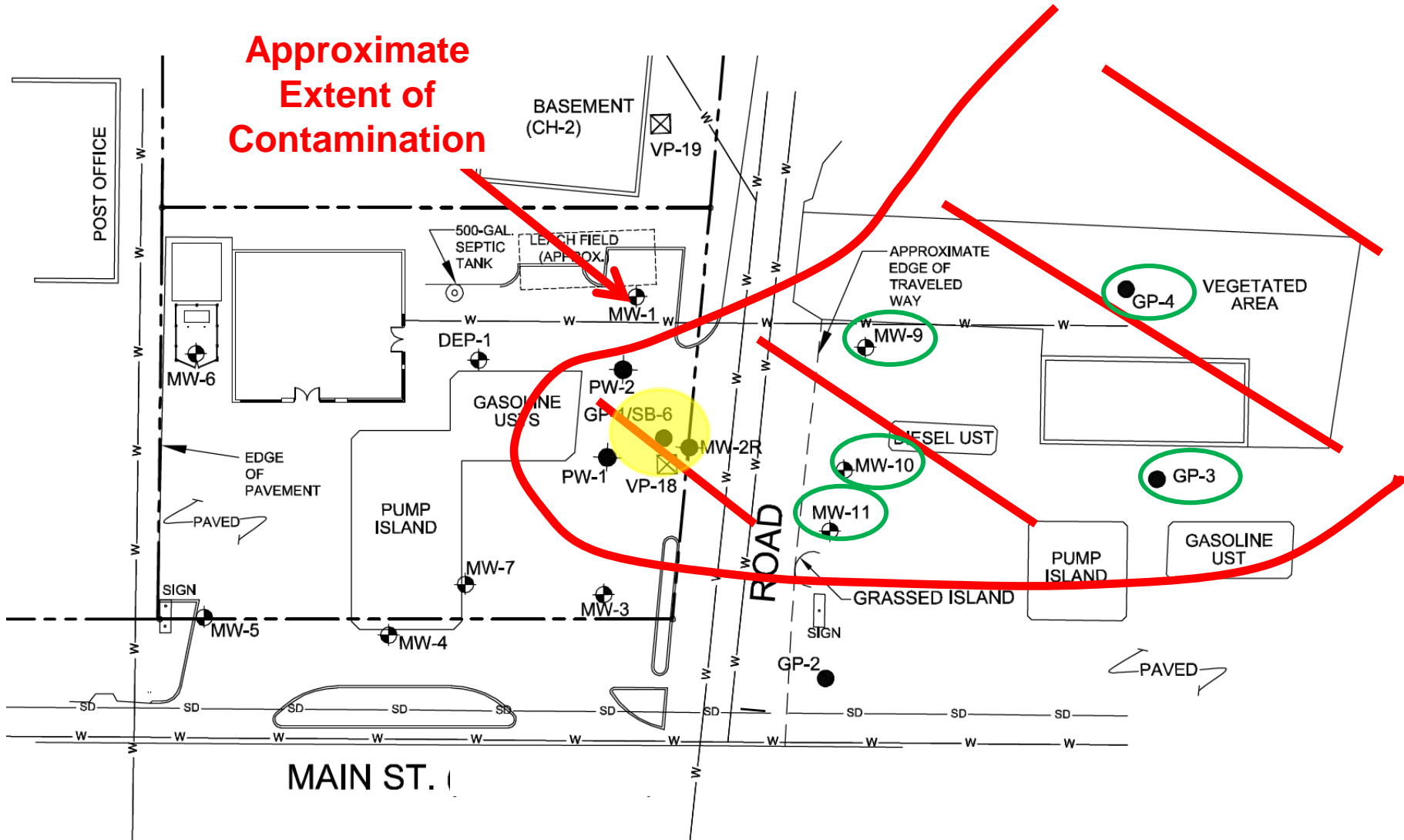


EXPERIENCE YOU CAN RELY ON WHEN IT COUNTS

Hydrogeology



Contamination



Remedial Goals

- The goal of remediation was to reduce the high concentrations of dissolved petroleum downgradient of the site.
- DEP were primarily concerned with vapor migration and free product.
- Owner wanted to reduce dissolved phase concentrations to reduce vapor risk
- A clean site was not the goal.

EXPERIENCE YOU CAN RELY ON WHEN IT COUNTS

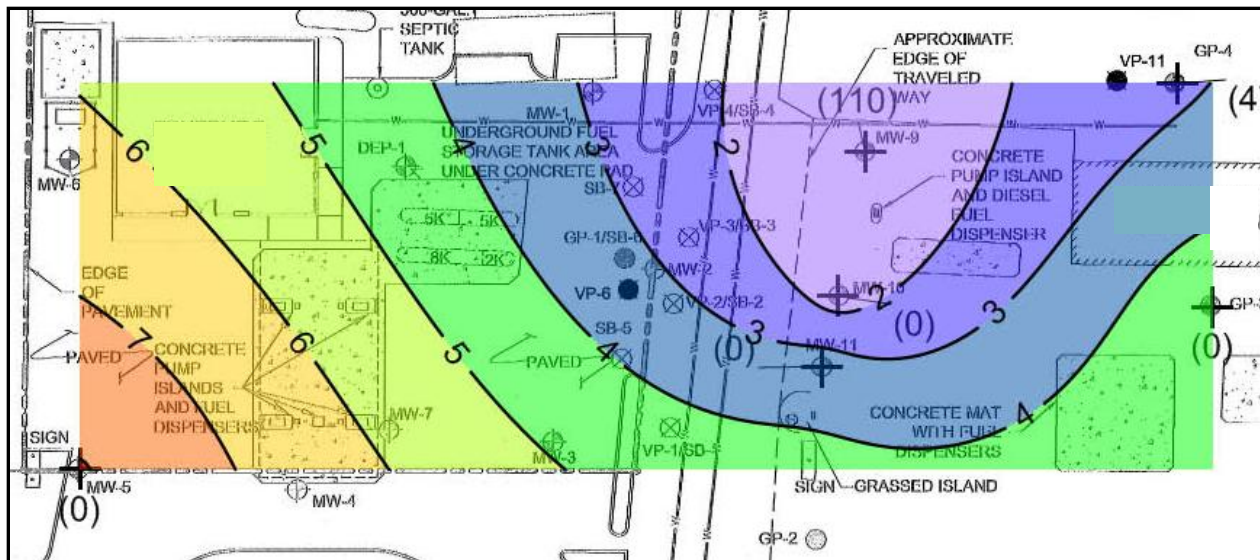
Remediation

- Certain conditions lead to choosing oxygen injection:
 - High permeability (easy for oxygen to move)
 - Deep water table (precluded soil excavation)
 - Relatively inexpensive, small carbon footprint
 - Strong evidence of anaerobic biodegradation.
- Aerobic biodegradation is more efficient at removing petroleum hydrocarbons.

EXPERIENCE YOU CAN RELY ON WHEN IT COUNTS

Remediation

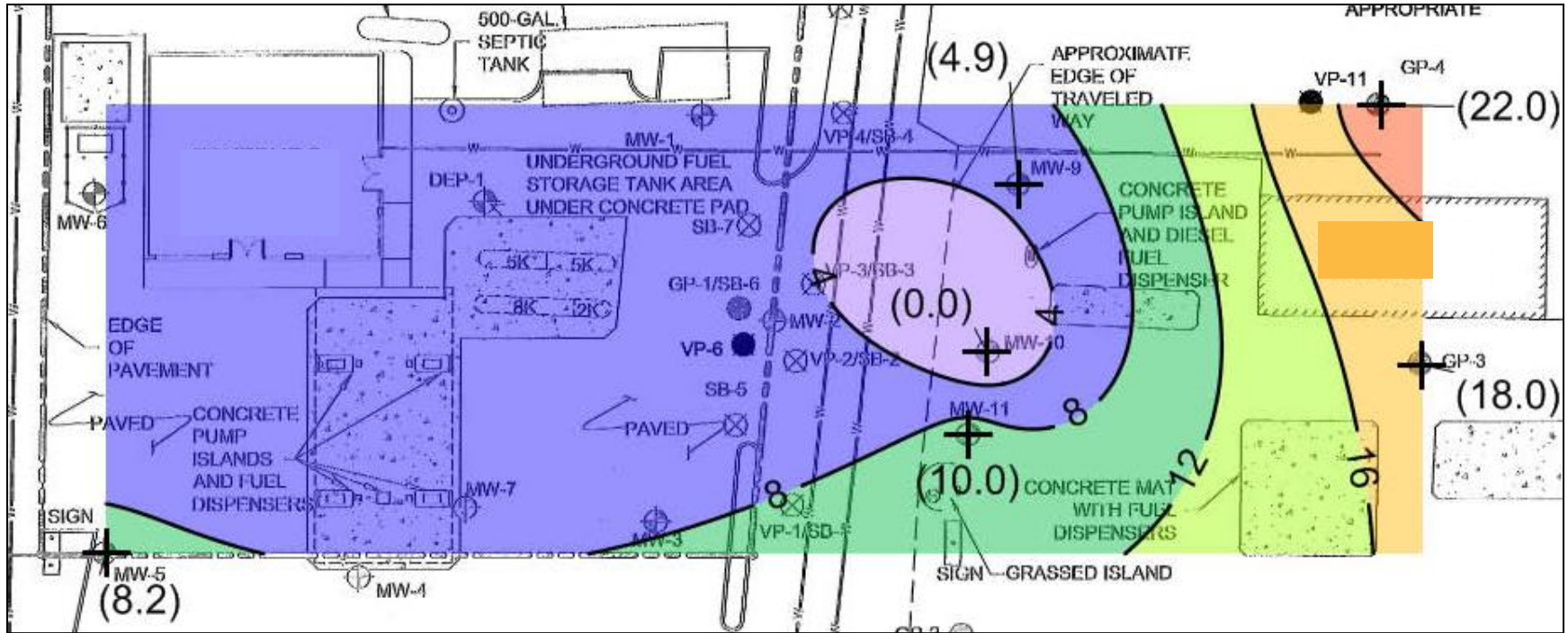
- Evidence of anaerobic biodegradation:
 - Low DO, SO_4 , NO_3 in the middle of the plume
 - High Fe, Methane, Heterotrophic Plate Count (bacteria) in the middle of the plume



Dissolved
Oxygen
(ppm)

EXPERIENCE YOU CAN RELY ON WHEN IT COUNTS

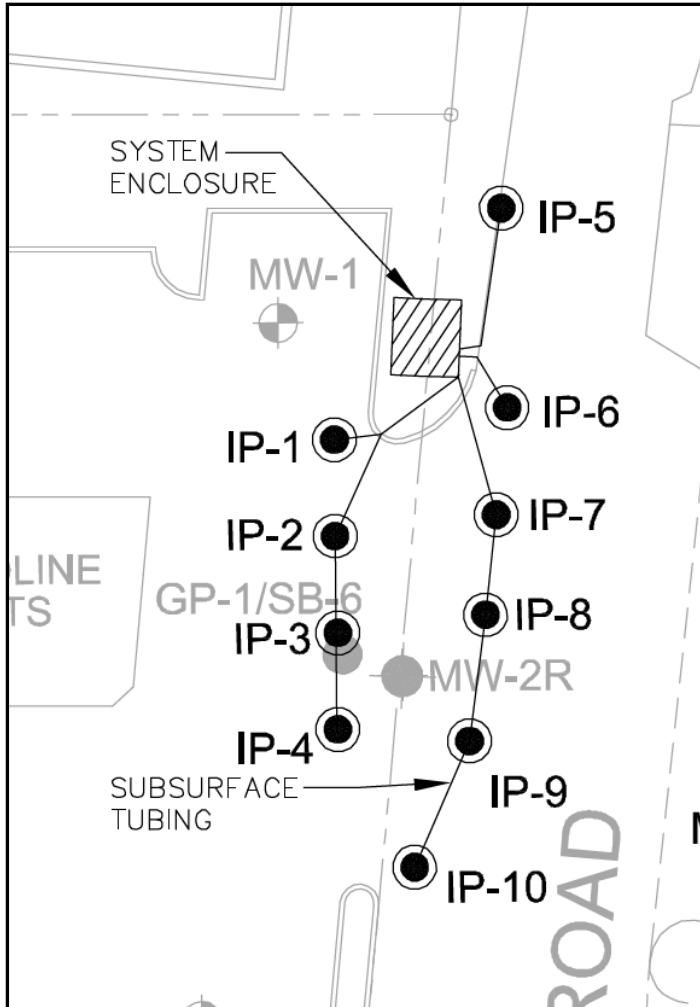
Remediation



Sulfate (ppm)

EXPERIENCE YOU CAN RELY ON WHEN IT COUNTS

Remediation



- 10 oxygen injection wells installed:
 - 4 up-gradient of source
 - 6 down-gradient of source
- 1-inch diameter
- 3 feet of 200-micron micro-porous screen at the bottom
- 30-foot depth

System Design



- Each well connected to the oxygen source by 0.25-inch tubing sealed in road cut
- Oxygen source is 200-pound liquid oxygen cylinder.

EXPERIENCE YOU CAN RELY ON WHEN IT COUNTS

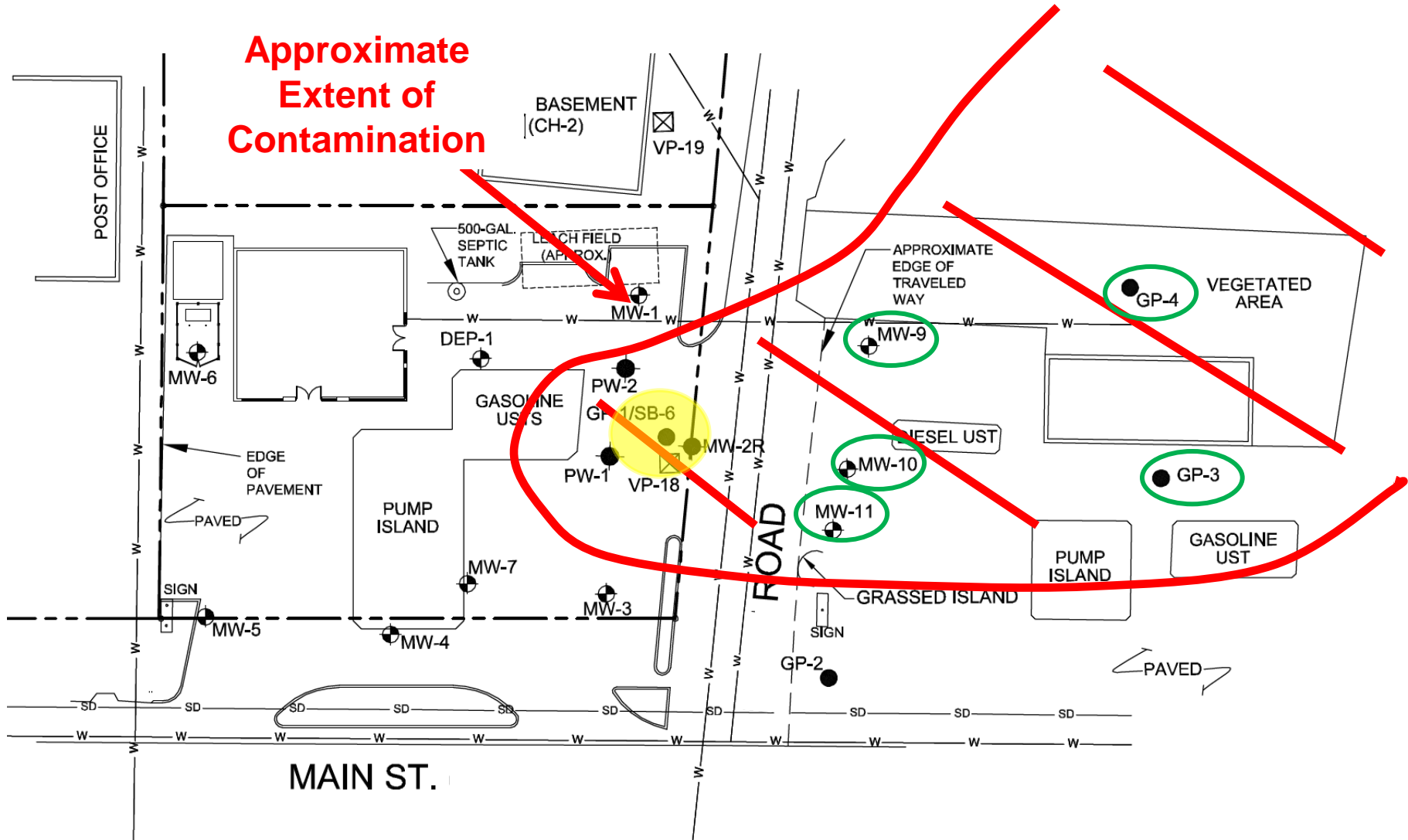
Oxygen Source and Delivery



- Cylinder connected to a manifold designed to regulate the amount of oxygen delivered to each well.

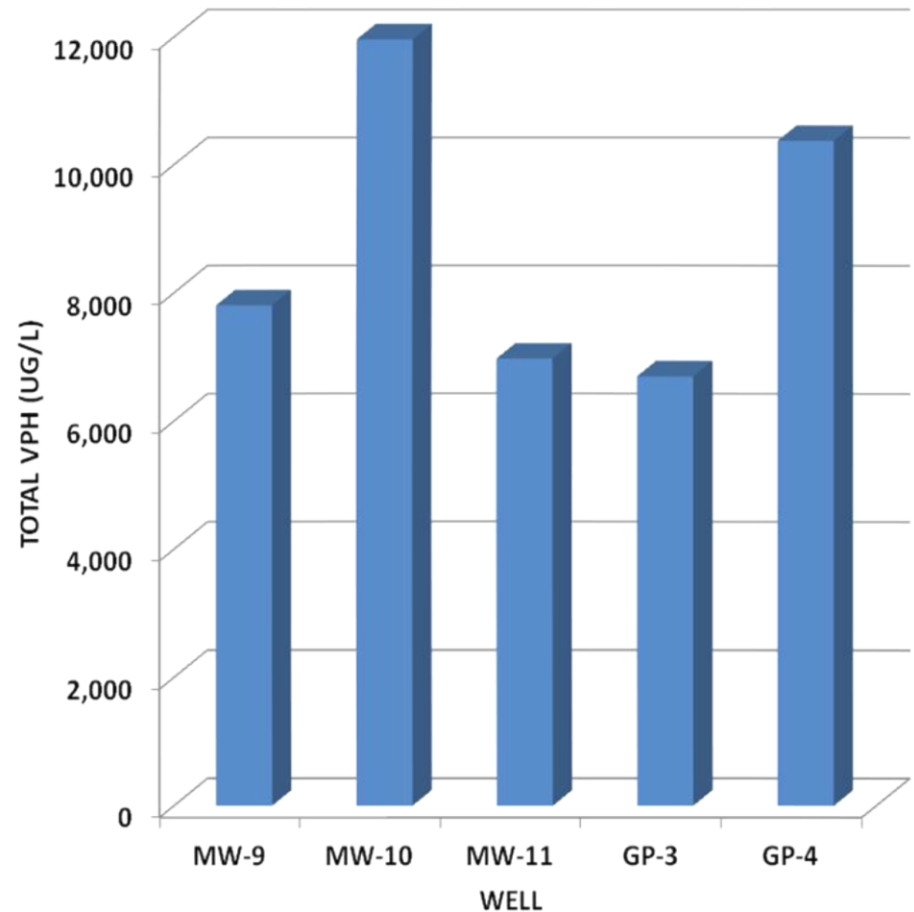
EXPERIENCE YOU CAN RELY ON WHEN IT COUNTS

Contamination



Initial Groundwater Quality

- In January 2011, impacts dominated by volatile petroleum hydrocarbons (VPH)
- Highest total VPH level in January 2011 was 11,961 ug/L at MW-10.



Operation and Maintenance

- The system ran for six months without interruption.
- Visit the site every two weeks, install new liquid O₂ tank, collect monitoring well measurements.
- All site visits were coordinated with company supplying oxygen. They were already traveling to the area so additional trip was not needed.

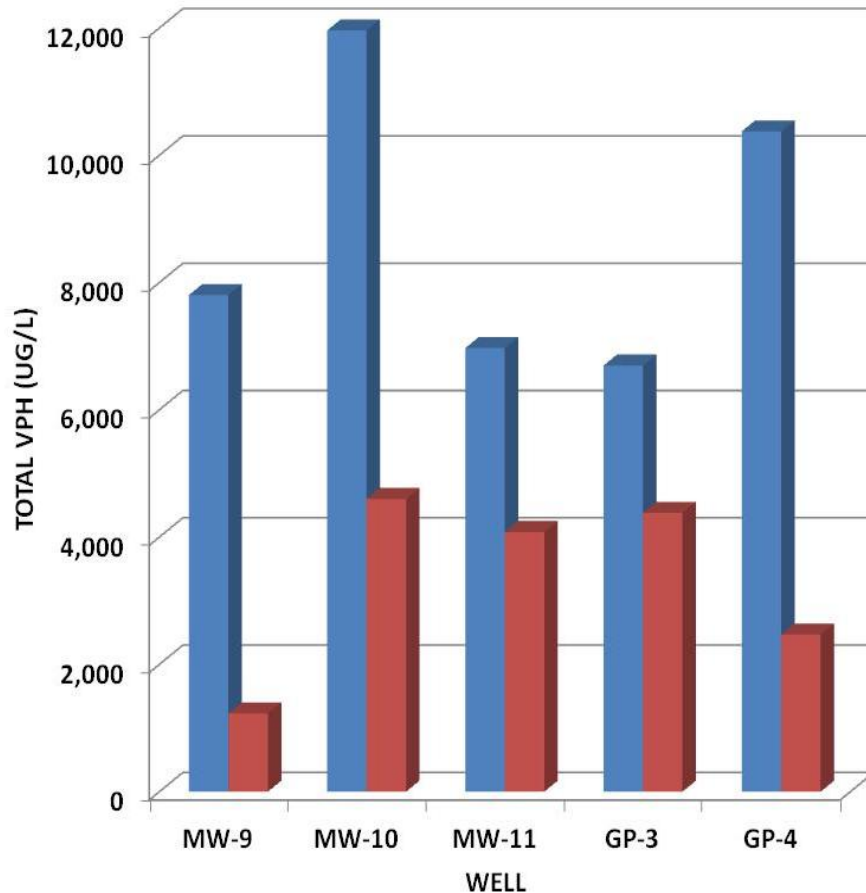
EXPERIENCE YOU CAN RELY ON WHEN IT COUNTS

Dissolved Oxygen Trends

- System operated without problems from January 2011 until shutdown in June 2011.
- Background DO levels before system startup were 1 to 3 mg/l.
- DO level of 40 mg/l was measured at well MW-11 on May 27, 2011.
- Aquifer had become highly oxygenated, even within the plume.

EXPERIENCE YOU CAN RELY ON WHEN IT COUNTS

Groundwater Quality at System Shutdown



- By June 2011, total VPH at MW-10 had been reduced to 4,599 ug/L.
- 62% reduction at MW-10
- 84% reduction at MW-9.

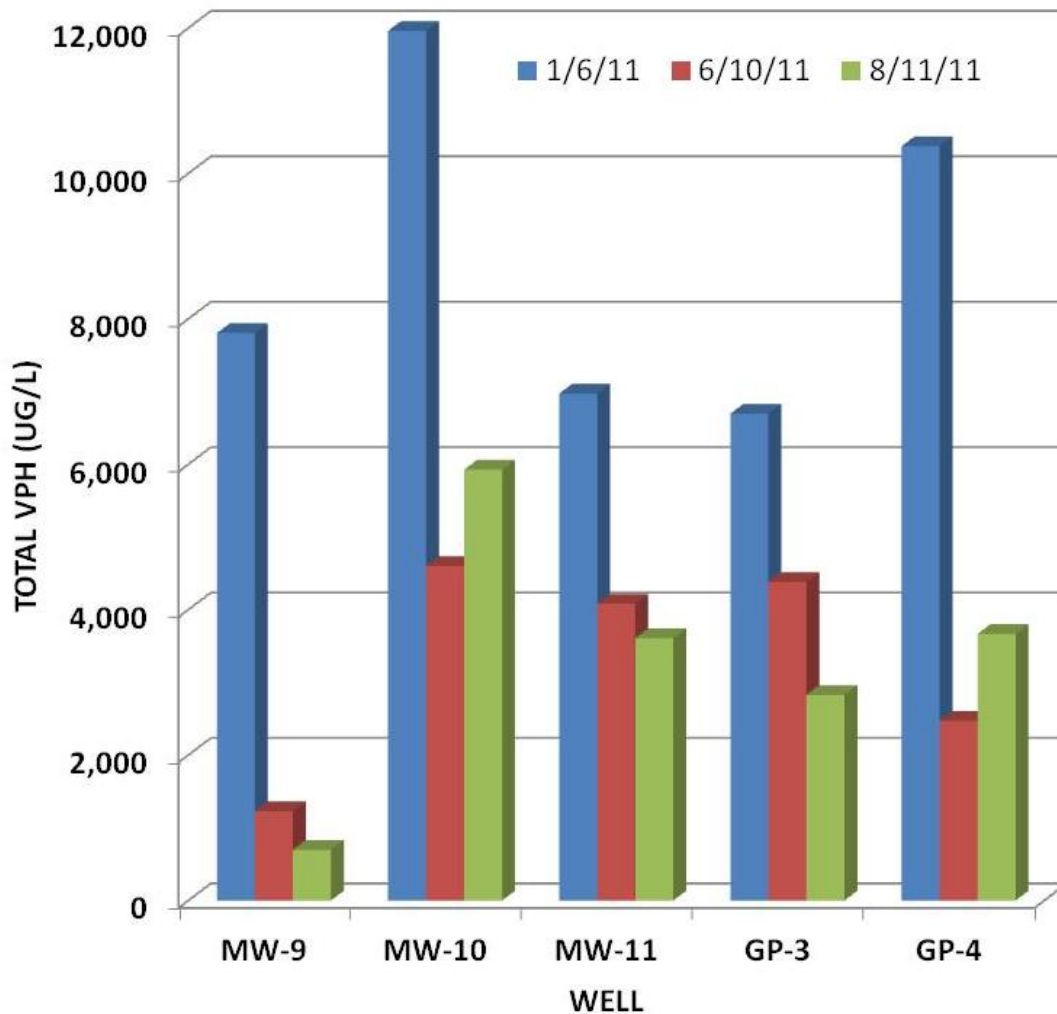
EXPERIENCE YOU CAN RELY ON WHEN IT COUNTS

Groundwater Quality 2 Months After Shutdown

- In August 2011, 2 months after system shutdown, another round of groundwater samples were collected.
- Wanted to assess potential for rebound.
- Rebounding of contaminant concentrations common in groundwater remediation.
- Reflects a return to equilibrium conditions.

EXPERIENCE YOU CAN RELY ON WHEN IT COUNTS

Groundwater Quality 2 Months After Shutdown



- Very little rebound
- Total VPH reduced an average of 61%

EXPERIENCE YOU CAN RELY ON WHEN IT COUNTS

How Green are these technologies?



IN SITU BIODEGRADATION?



EXPERIENCE YOU CAN RELY ON WHEN IT COUNTS

ENVIRONMENTAL CONSULTING GROUP

St.Germain ■ Collins



For More Information Contact:

St.Germain Collins

846 Main Street, Suite 3

Westbrook, ME 04103

info@stgermaincollins.com

(207) 591-7000

EXPERIENCE YOU CAN RELY ON WHEN IT COUNTS

