# SURFACTANT ENHANCED PUSH-PULL METHOD FOR IN-SITU REMEDIATION OF PETROLEUM CONTAMINATED SOIL AND GROUNDWATER


**Presenter**

**George (Bud) Ivey**
**Ivey International Inc.**


**22nd International Petroleum Environmental Conference**
**November 17 to 19, 2015**
**Denver, CO**
**Grand Hyatt Downtown Denver**

# Chester River Hospital Center

## Fuel Oil Spill Release Discovery 1991

## vey-sol® Surfactant Pilot Scale Application July 2014

### (Evaluation Report January 2015)

### Remediation Team Members

Ivey International Inc.

"Today's Environmental Solutions For A Better Tomorrow"

HESTER RIVER OSPITAL CENTER

HB SOLUTIONS

EBA

BrightFields, Inc. Environmental Services

IVEY-SOL Surfactant Technology

www.iveyinternational.com

# Public Domain Presentation

**CHESTER RIVER HOSPITAL CENTER**

**GROUNDWATER REMEDIATION**

**2013/2014 ACTION PLAN MODIFICATIONS**

**CASE NO. 1987-2534-KE**

**PILOT TEST EVALUATION REPORT AND PROPOSED 2015 ACTION PLAN**

**JANUARY 19, 2015**

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"Today's Environmental Solutions For A Better Tomorrow"

Chester River Hospital Center

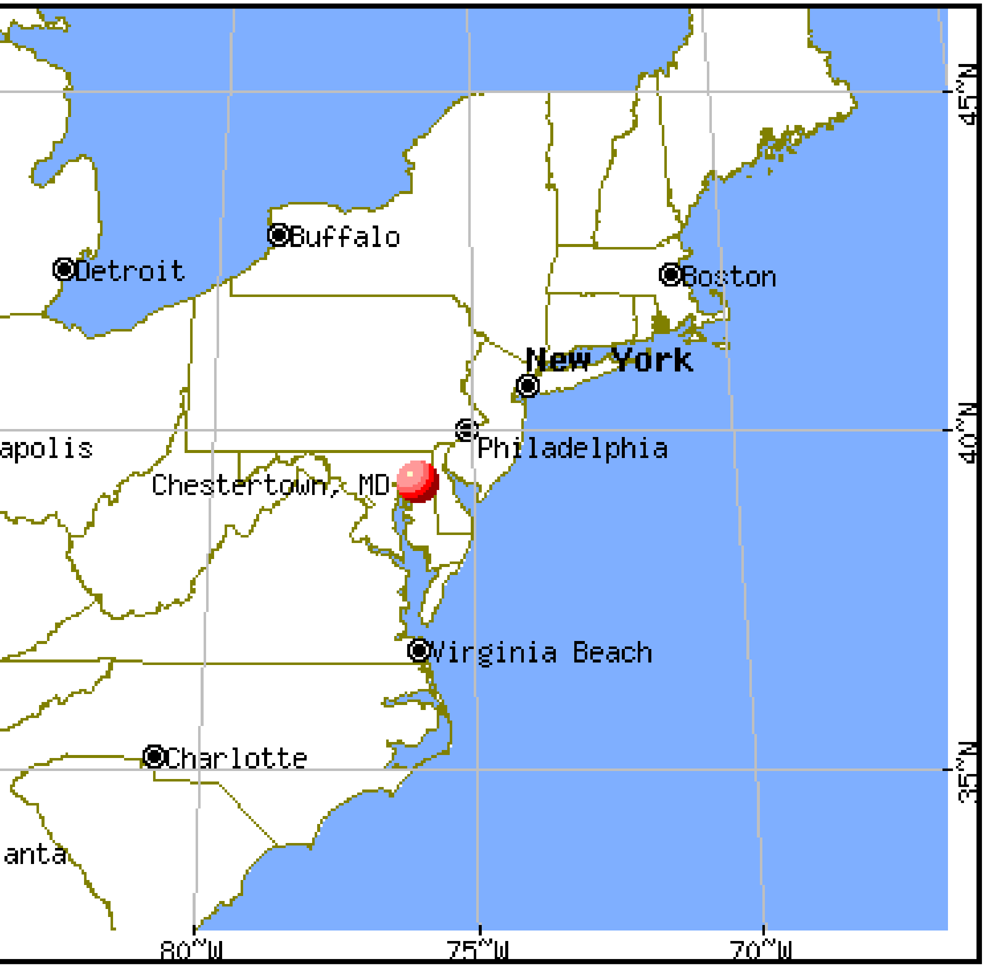
HB Solutions

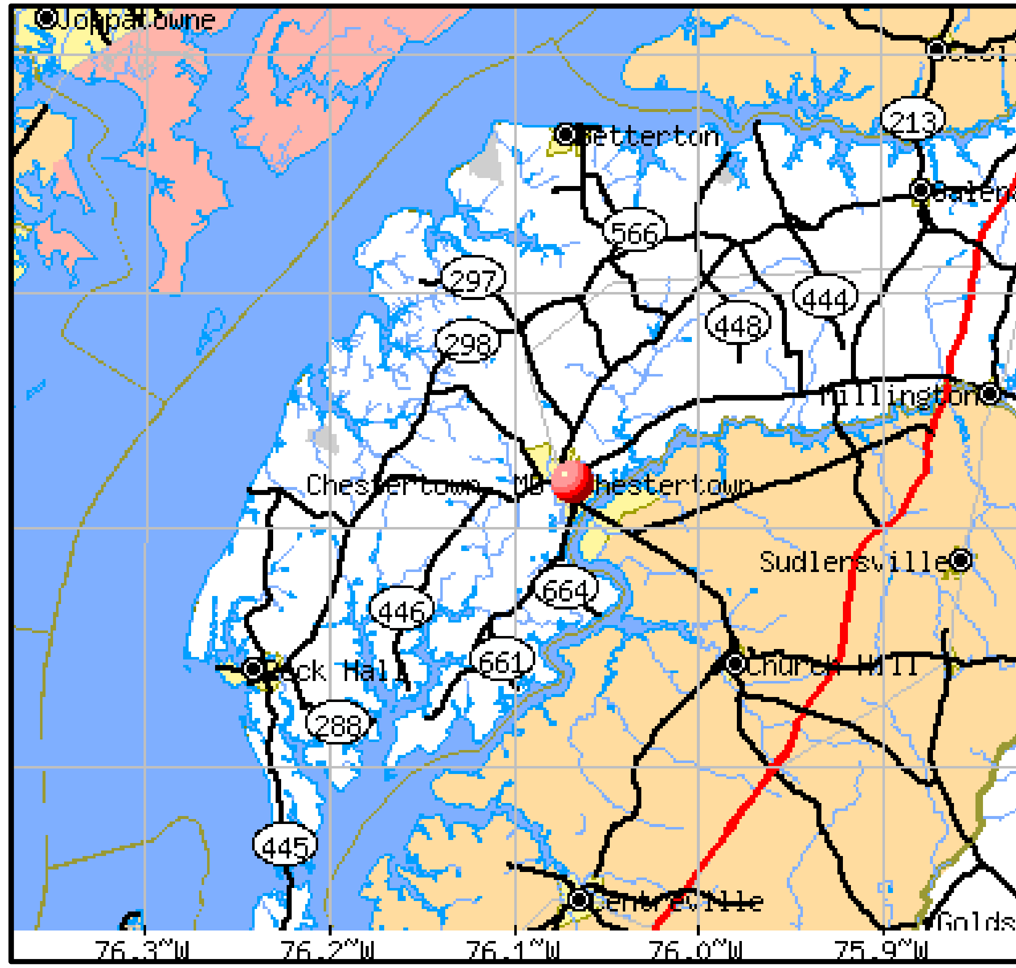
EBA

BrightFields, Inc.
Environmental Services

IVEY-SOL
Surfactant Technology
www.iveyinternational.com

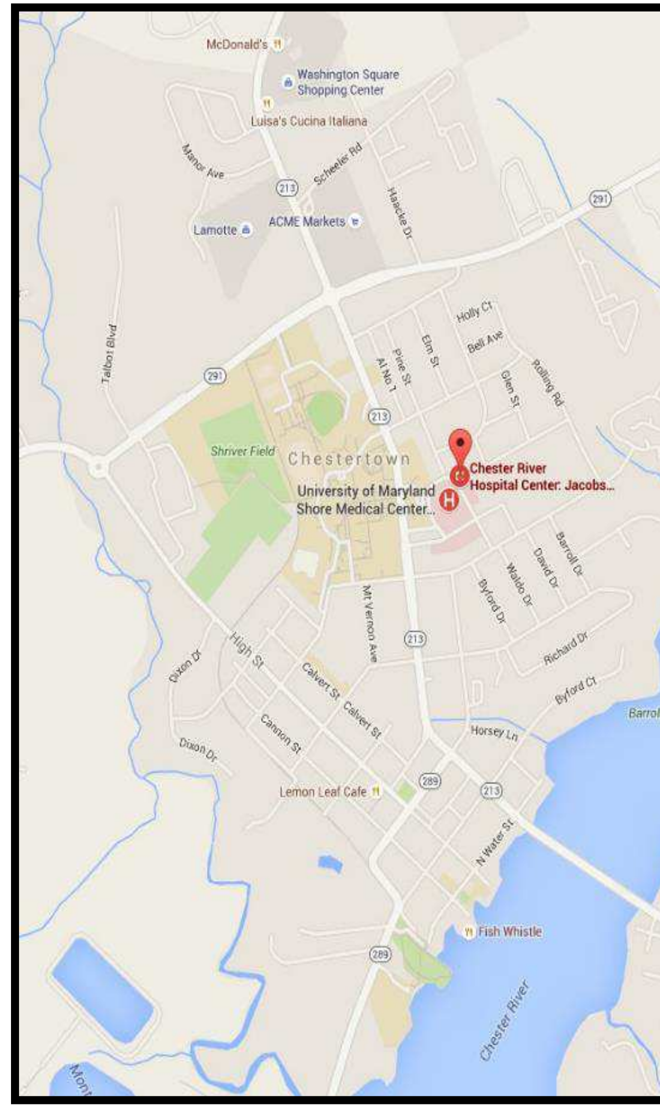
# Site Location
# Chestertown MD USA



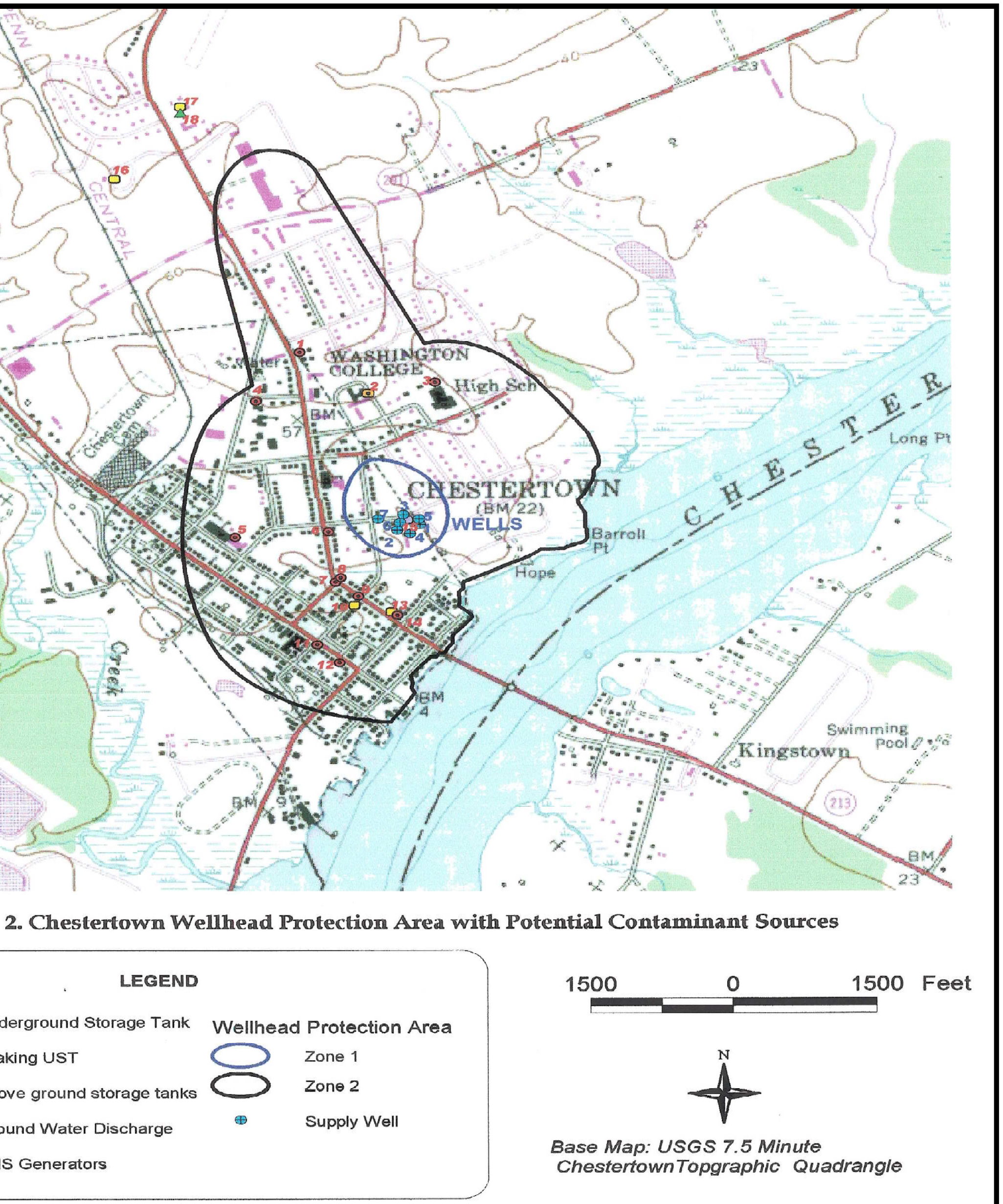



# te Background Information

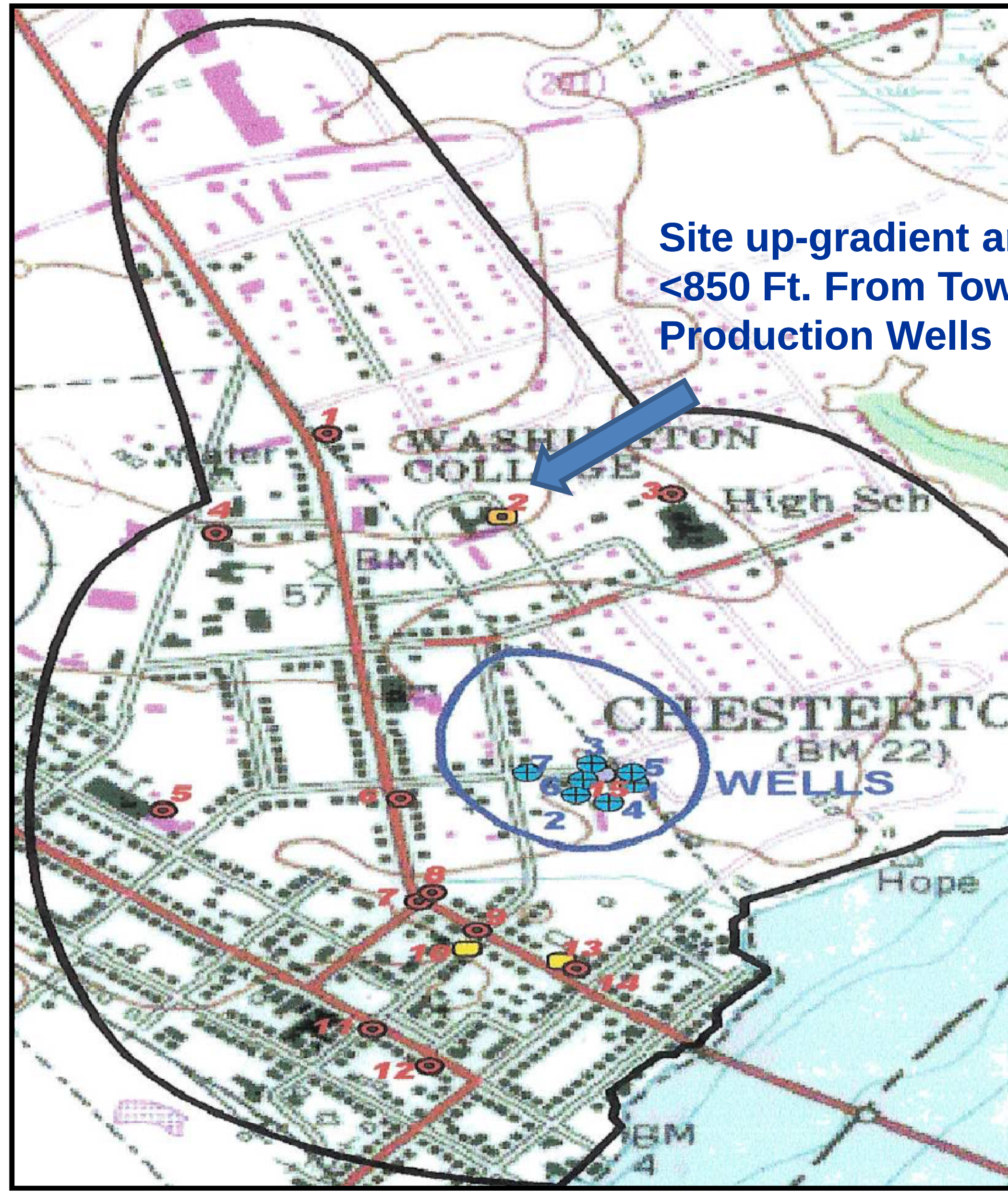
- ter River Hospital Center 7.1 Acres
- development since 1935 as hospital
- Oil release discovered May 1991 (10,000 Gal. tank was y over a weekend)…*likely leaking for years*
- c Water supply well 850 ft. (259 m) down gradient, shut until remediation system was installed
- ndwater remediation system installed 1991
- Earth Data report indicated ≈ 83,452 Gal. (315,900 L) of PL removed from site between 1991 to July 2012
- tion of MDE 12 month Closeout Monitoring July 2012 to 2013, and the treatment system was shut off;
- evels of TPH (DRO) detected in June 2013 at Eight (8) of nteen (17) downgradient monitoring wells ☹
- *& Treatment System Turned Back On!*
- *eholder Concerns Started Mounting!*



# stertown Wellhead Protection Area (Unconfined Aquifer)




2. Chestertown Wellhead Protection Area with Potential Contaminant Sources



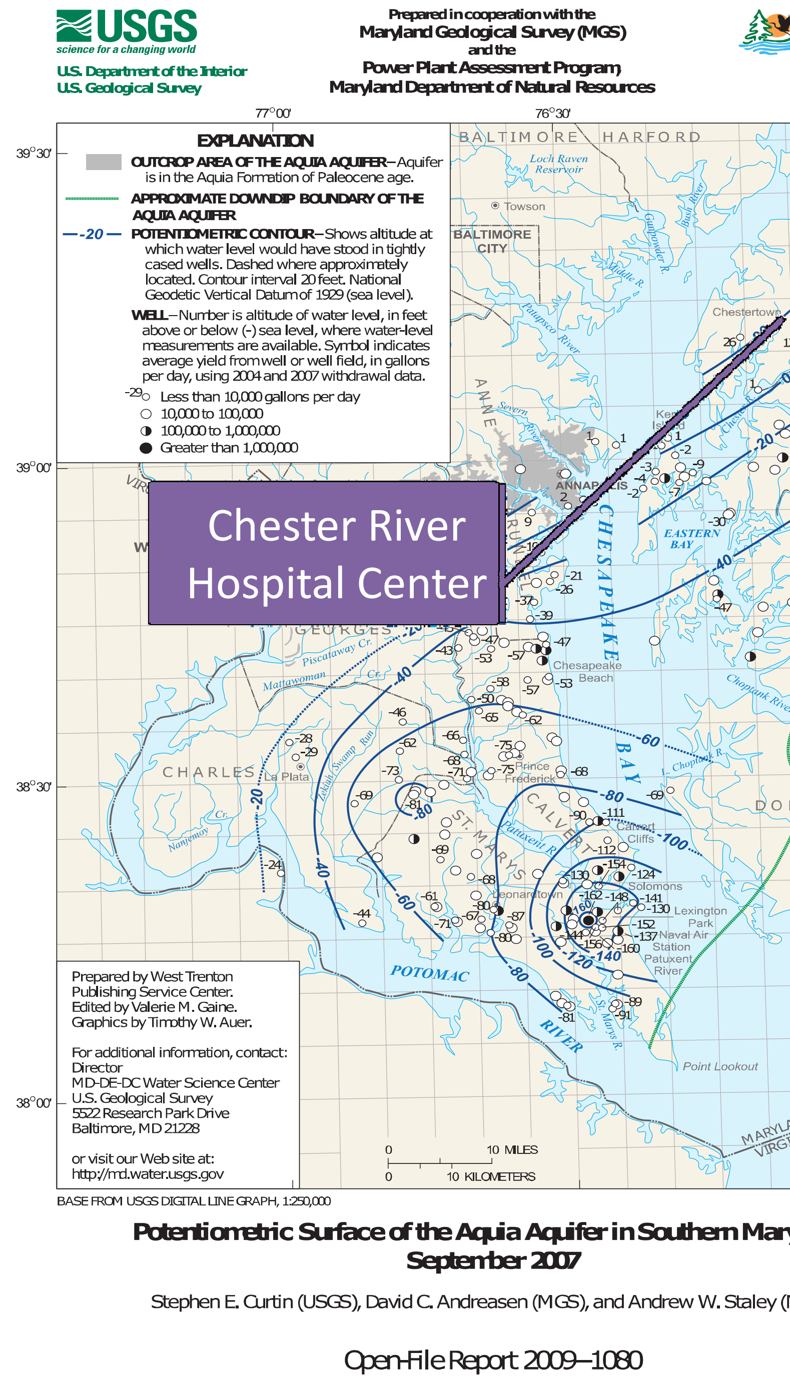
# ology & Hydrogeology

ndwater and Surface water drains into the ter River, a tidal tributary of Chesapeake Bay th west)

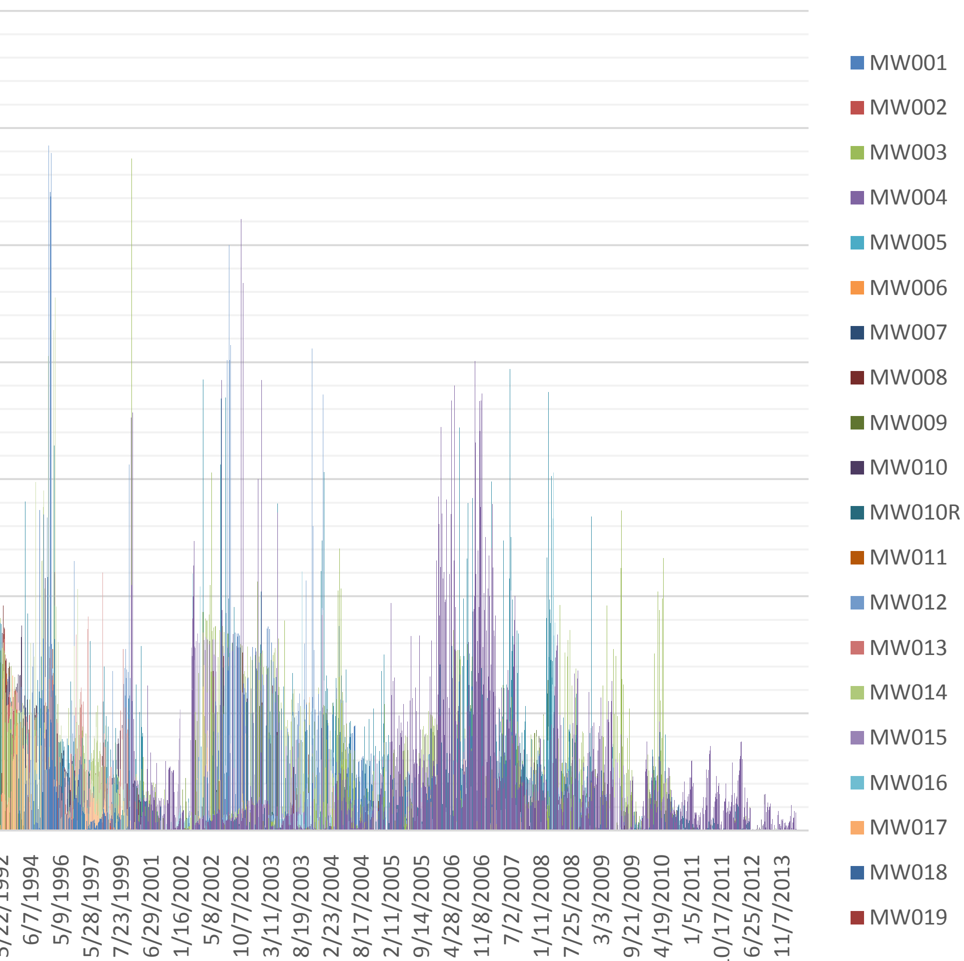
red sand and silty sand to approximately 120 ft. ia Formation, primary aquifer near site; sauken Formation, generally absent near site)

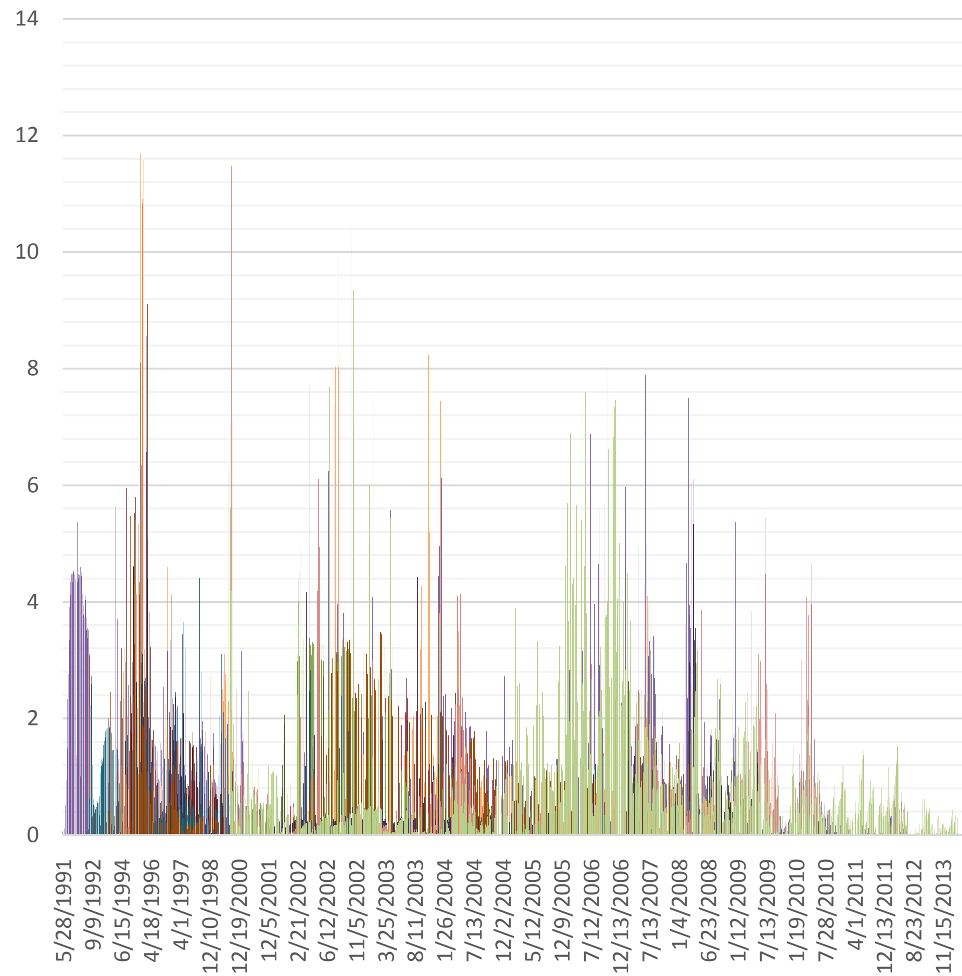
er-table elevations fluctuate seasonally between 5 feet [*Smear Zone*] with depth to groundwater nd 30 - 50 ft. bgs on-site

tertown's water supply from an '*Unconfined fer*'

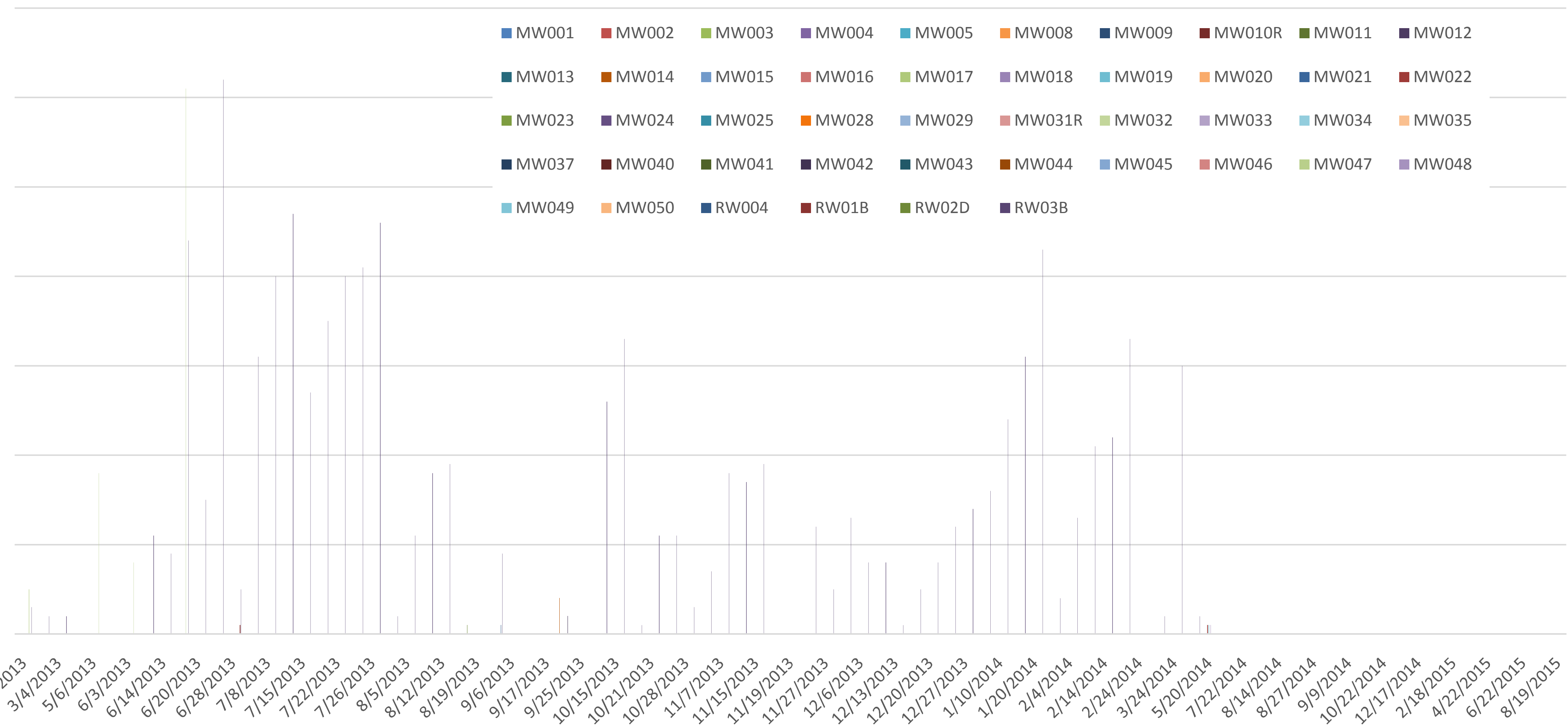


# Historical Product Levels (ft.) 1991 - 2013



# Recent Product Levels (ft.) 2013-2015



# takeholder Concerns

**Chester River**
**Hospital Center**

- **ime to Closure**
  **>20 Yrs.)**
- **igh Costs $$$/yr. O&M**
- **nvironmental Risks**
- **egal Liability**
- **edia Relations**
- **ublic Perception**

**Chestertown**
**Water Supply**

- Hydraulic Control
- Off-site TPH Migration
- Risk to Well Field
  (Town Aquifer)
- Legal Concerns
- *Communications*
  *[Did not know about 2012 closure]*
- Public Perception

**Maryland Department of Environment (MDE)**

- Regulatory Oversight
- Off-site Migration
- Clean-up Standards
- Mediation
- Legal Concerns
- Public Perception

# reatment System Background

over twenty (20) years CRHC's focus was:

emove liquid petroleum hydrocarbons (free product)

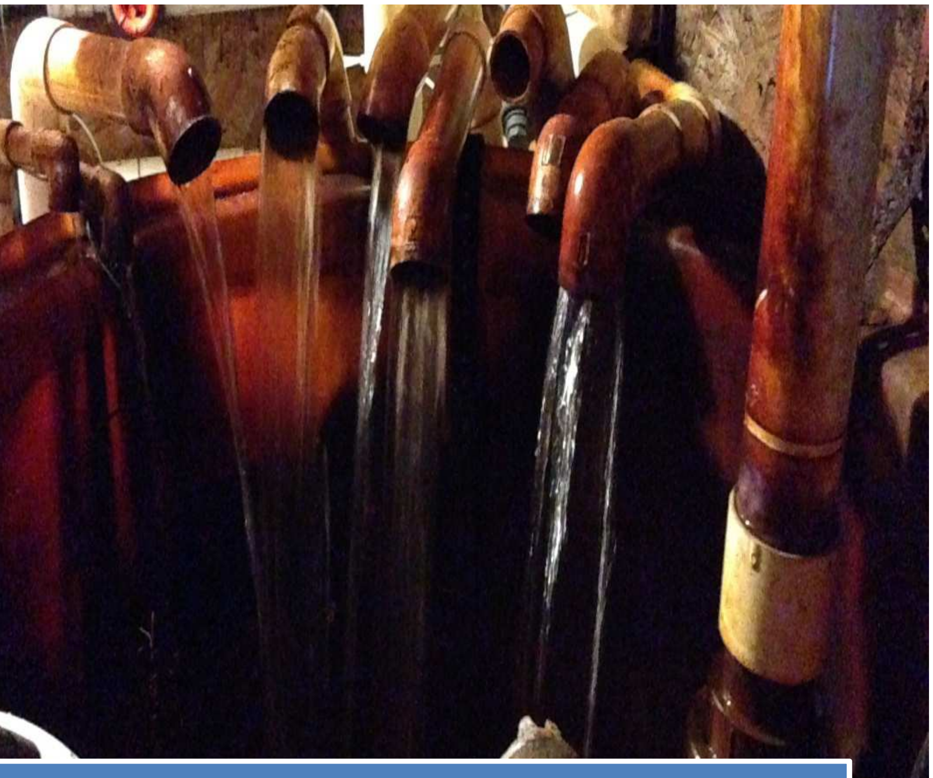
emediate the groundwater using a "Pump and Treat" P&T) system consisting of six (6) recovery wells, four (4) re-filters (sediment and Fe), and two (2) MYCELXCELX® tration units, with discharge to storm sewer

r expanded to Seven (7) Recovery wells and present tion/treatment system

System Designed for 100-120 Gallons of groundwater minute (379 to 455 L/min) extraction rate requiring ment (*They have effective hydraulic control on-site*)

***3,452 Gallons (315,900 L) of LNAPL product recovered between 1991 - July 2012***

# Treatment System



Recovery wells pump into holding tank (wet well)


Pre-treatment Filtration system (sediment)

# ‘Pump and Treat’ - Treatment System

Wet Well

Bag Filters

MYCELX Treatment

**Discharge to Storm Sewer – Under MDE Discharge**

# ‘Pump and Treat’ - Treatment System

Maryland Department of Environment GW Cleanup Standards for Type I and II Aqu

| Benzene | Toluene | Ethylbenzene | Xylenes | Total BTEX | MTBE | Naphthalene | TPH-DRO | TP |
|---|---|---|---|---|---|---|---|---|
| *ug/L* | | | | | | | *mg/L* | |
| 5 | 1,000 | 700 | 10,000 | NA | 20 | NA | 0.047 | 0 |

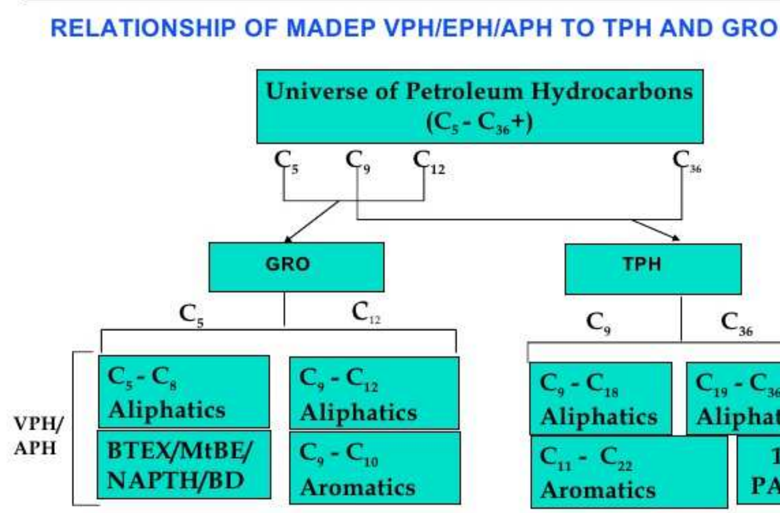
**Interim Risk Based Goal: < 1 r**

| | Agency | n-Alkane Range | Aromatic Range | Boiling Point Range | Sample Preparation | Analysis |
|---|---|---|---|---|---|---|
| ge Organics) | US EPA | C10-C28 | n/a | 170-430 °C | solvent extraction | GC-FID |
| | Alaska | C10-C25 | n/a | 170-400 °C | solvent extraction | GC-FID |
| | Wisconsin | C10-C28 | n/a | 170-430 °C | solvent extraction | GC-FID |
| Petroleum Hydrocarbons) | Massachusetts | C9-C36 | C11-C22 | 150-265 °C | solvent extraction + SPE fractionation | GC-FID |
| e Total Petroleum Hydrocarbons) | Connecticut | C9-C36 | n/a | n/a | solvent extraction | GC-FID |
| ange Organics) | US EPA | C6-C10 | n/a | 60-170 °C | purge/trap or direct injection | GC-FID |
| | Alaska | C6-C10 | n/a | 60-170 °C | purge/trap | GC-FID |
| | Wisconsin | C6-C10 | n/a | 60-220 °C | purge/trap | GC-FID |
| Range Organics) | Florida | C8-C40 | n/a | n/a | solvent extraction | GC-FID |
| n Volatile Organic Compounds) | Wisconsin | ▲ | n/a | 60-220 °C | purge/trap | GC-PID |
| nology and Remediation Series) | New York | ◆ | ◆ | ◆ | ◆ | GC-MS |
| eum Hydrocarbons) | Texas | C6-C35 | n/a | n/a | solvent extraction | GC-FID |
| | Washington | C7-C30 | n/a | n/a | solvent extraction | GC-FID |
| roleum Hydrocarbons) | Massachusetts | C5-C12 | C9-C10 | 36-220 °C | purge/trap | GC-PID-FID |

nes the PVOC analyte list as the Wisconsin GRO list minus naphthalene.

e of New York document that provides guidance on the handling, disposal, and/or reuse of excavated petroleum-contaminated soil, with -MS per US EPA Methods 8260 and 8270, modified with short, specific analyte lists.

*BACKGROUND: Analytical Methods*



MADEP VPH/EPH/APH Guidance Document June 2001.

# How Did We At IVEY Get Involved…

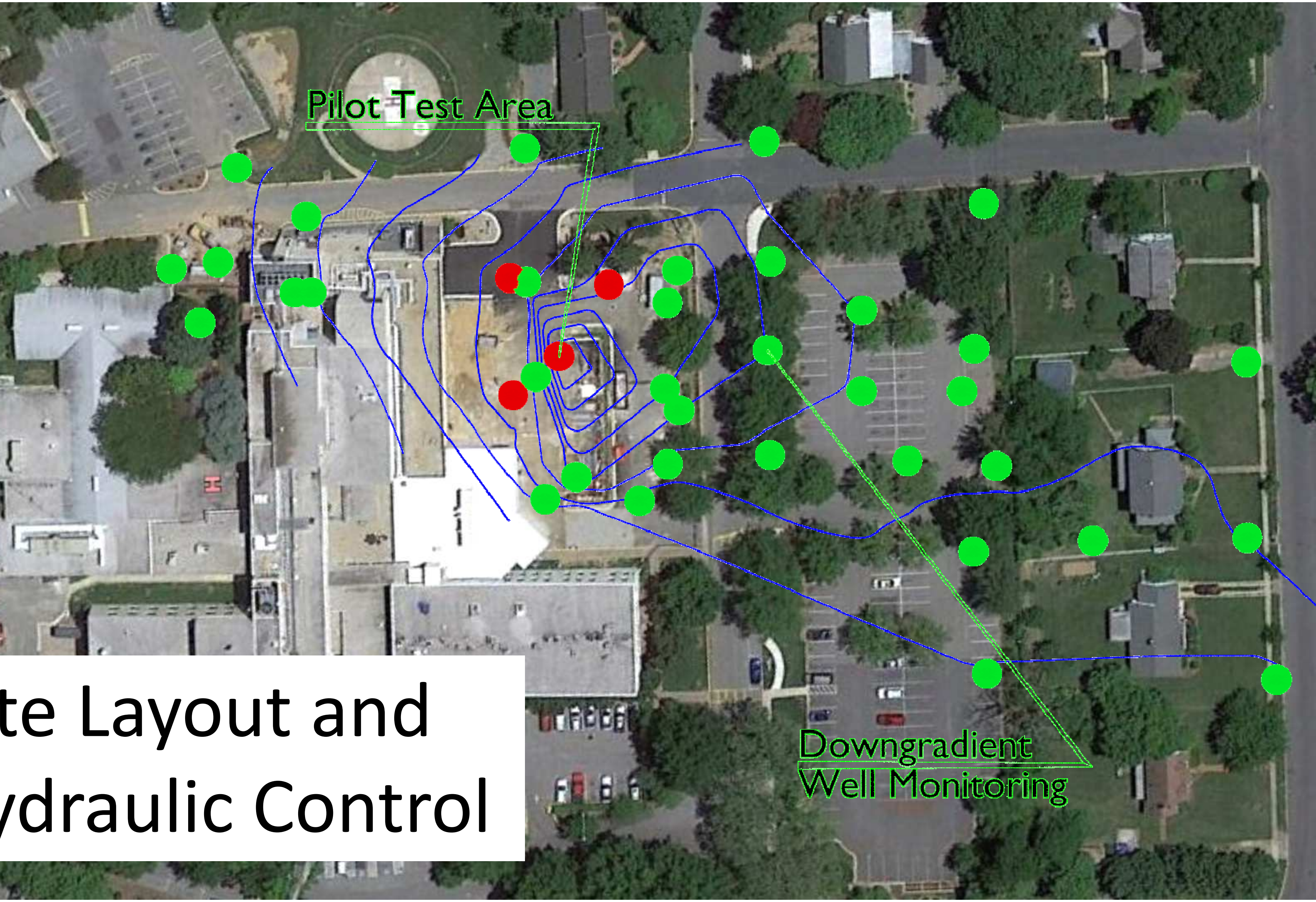
"TODAY'S ENVIRONMENTAL SOLUTIONS FOR

# SURFACTANT ENHANCED PUSH-PULL METHOD

## Pilot Scale In-situ Application

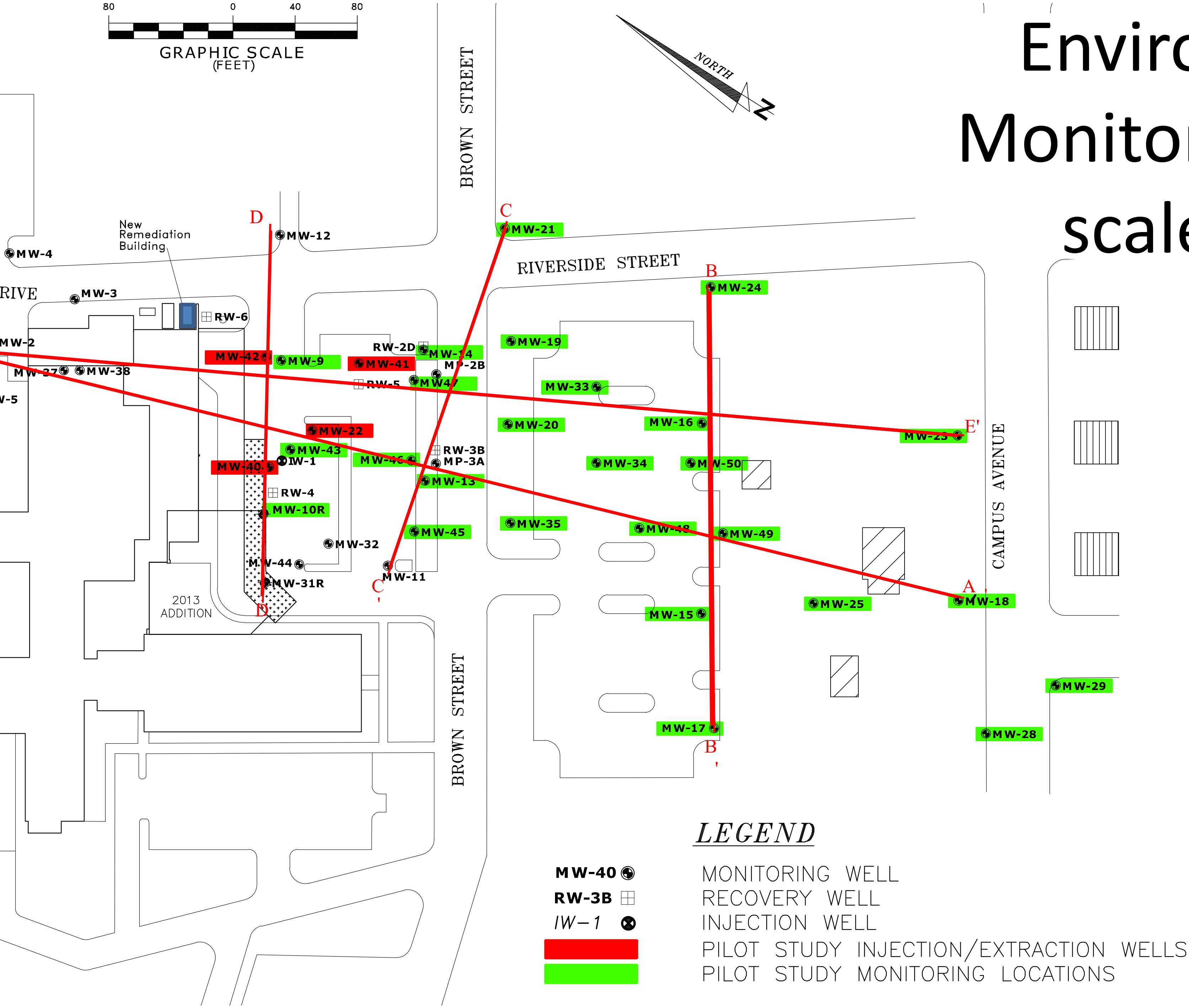
## July – August 2014

## Completion of Three (3) Push-Pull Applications

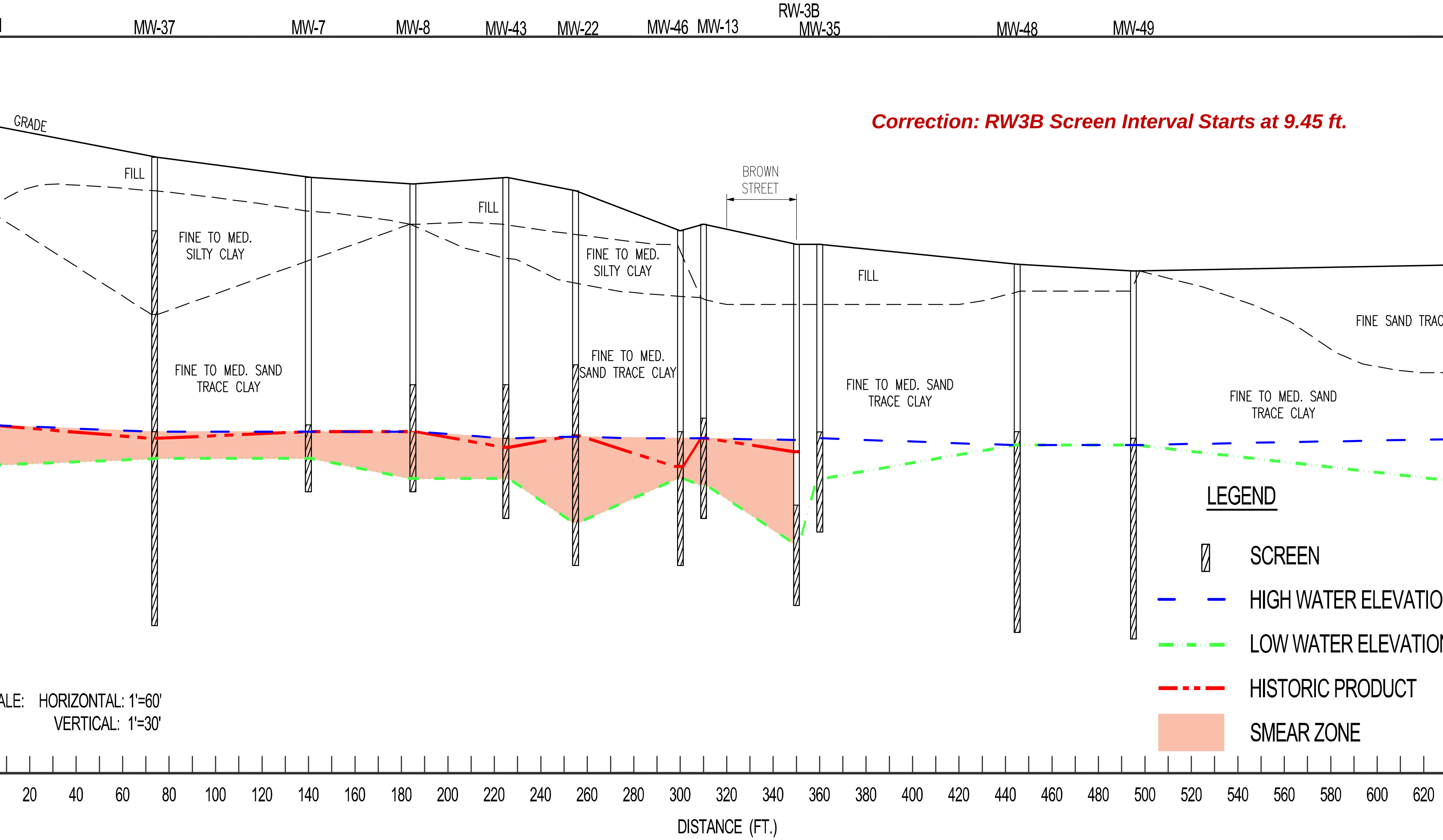


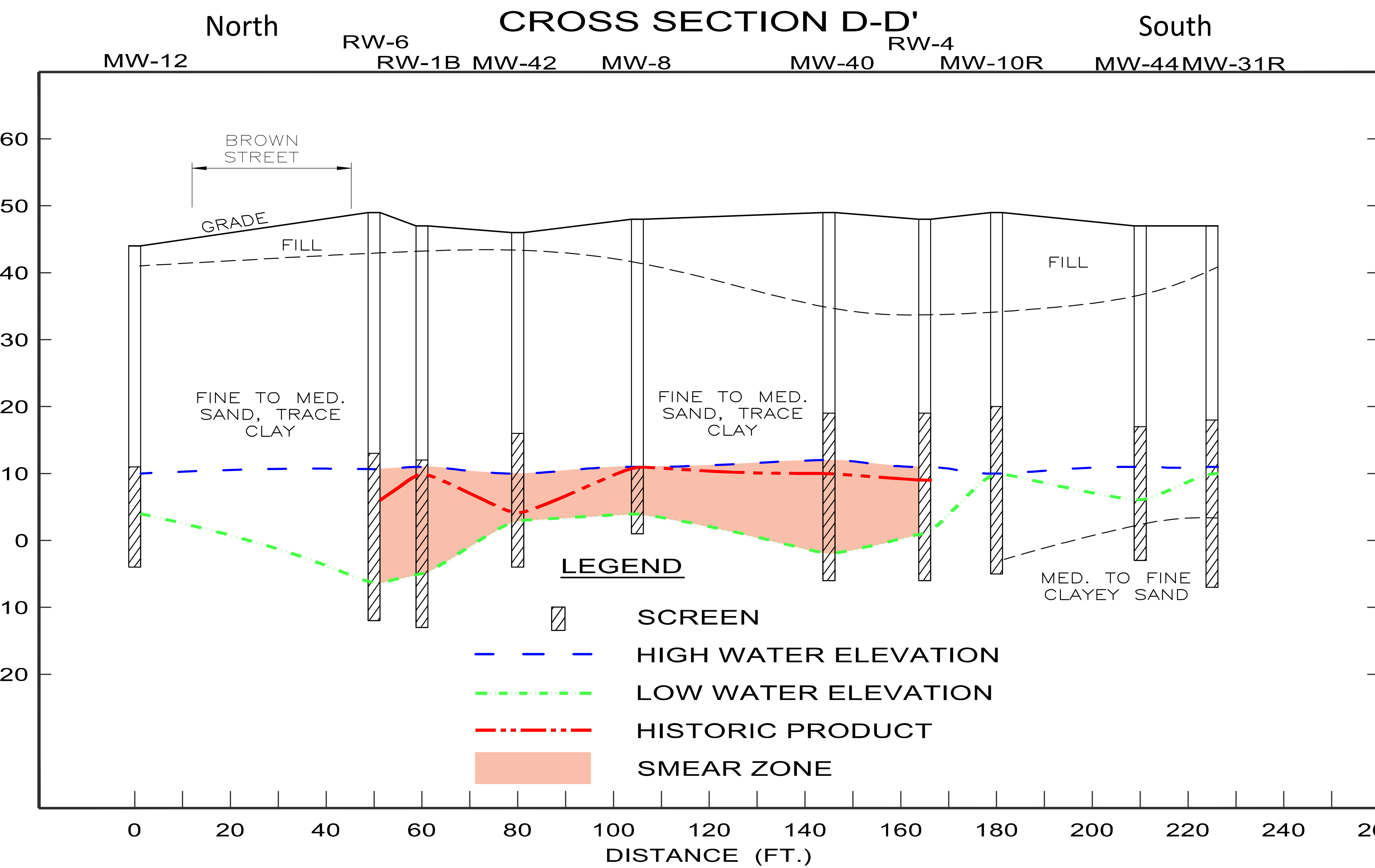

# te Layout and
# ydraulic Control

# Environmental Monitoring & Pilo scale layout



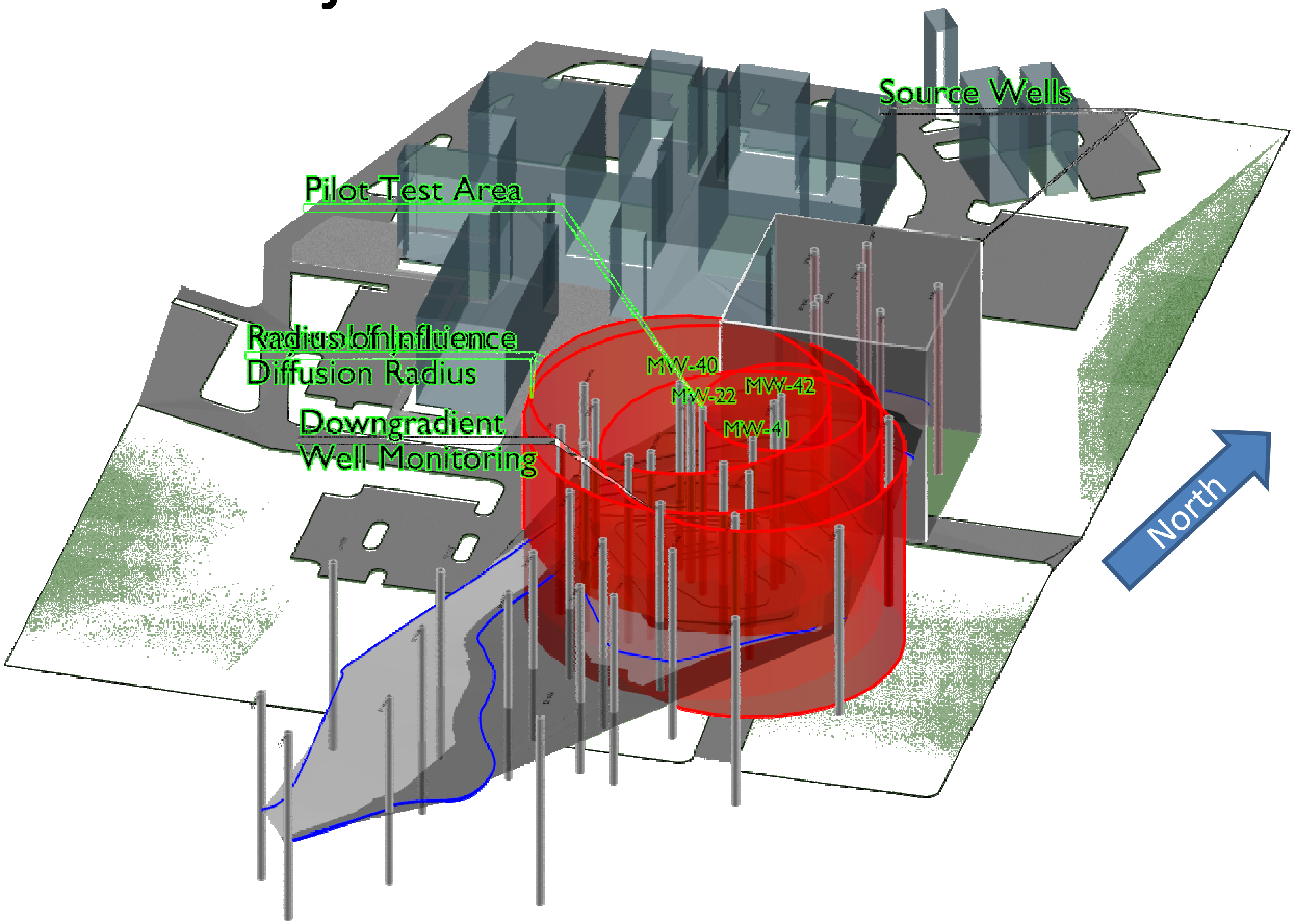
# CROSS SECTION A-A'

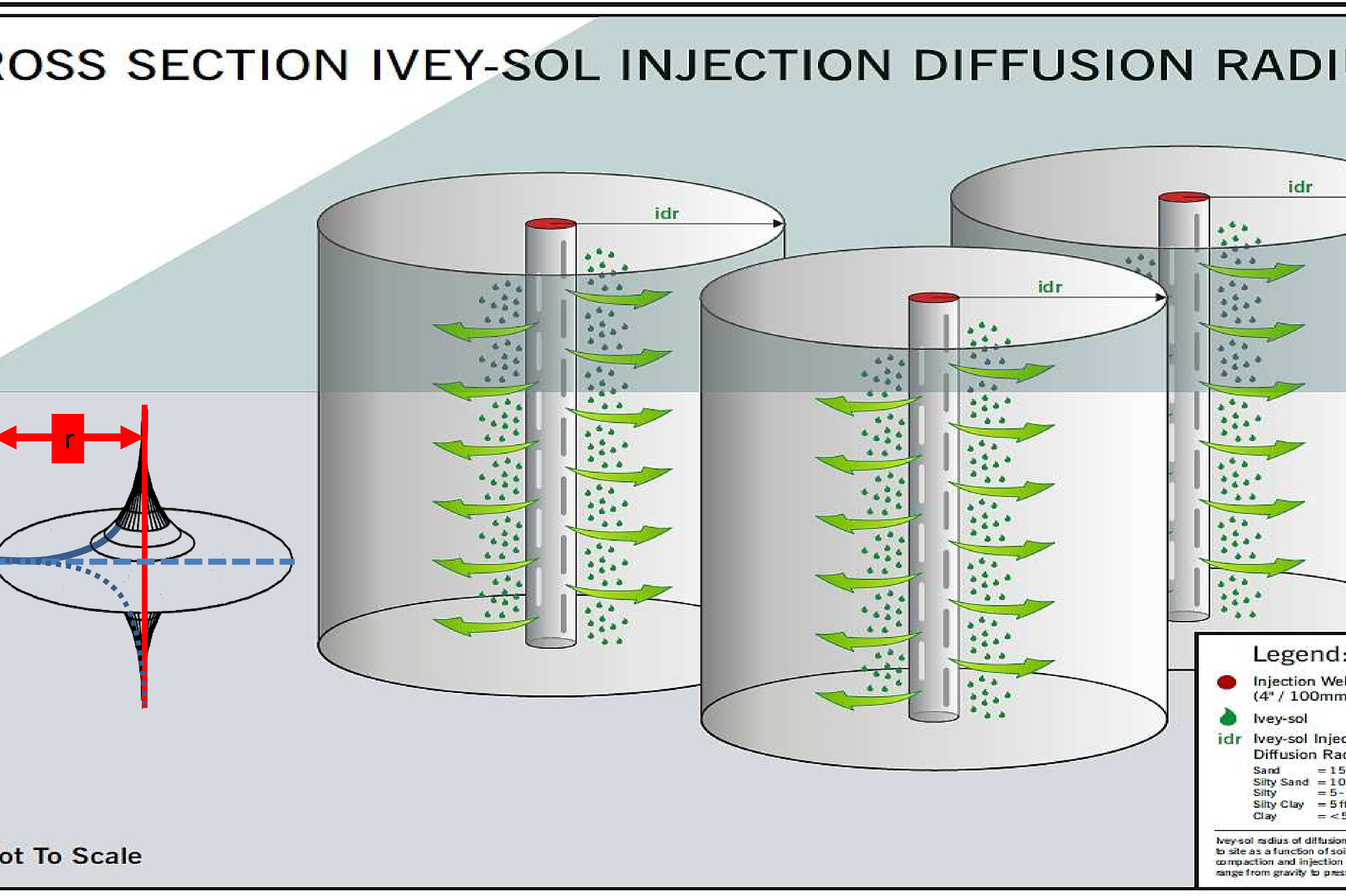




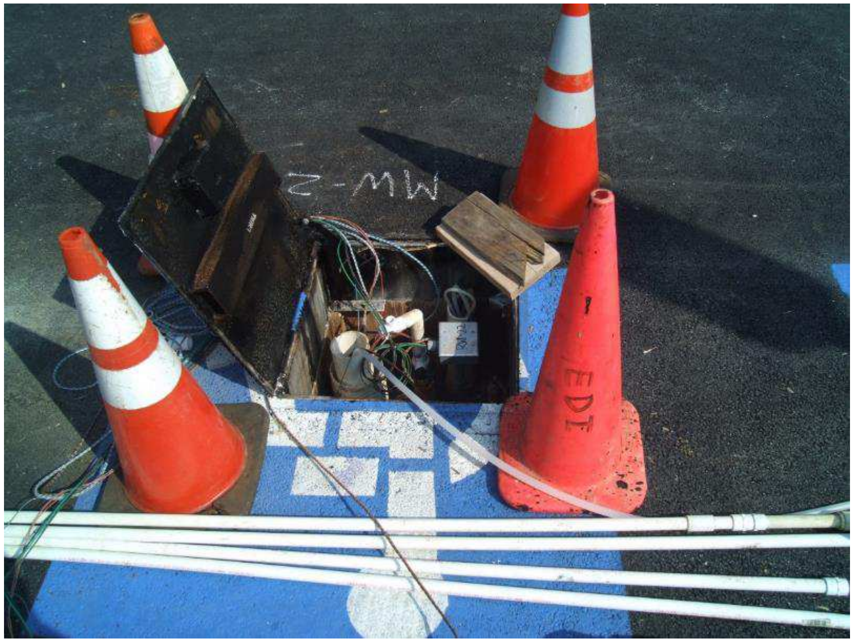
CROSS SECTION D-D'
North
South
MW-12
RW-6
RW-1B
MW-42
MW-8
MW-40
RW-4
MW-10R
MW-44
MW-31R
BROWN STREET
GRADE
FILL
FILL
FINE TO MED. SAND, TRACE CLAY
FINE TO MED. SAND, TRACE CLAY
MED. TO FINE CLAYEY SAND
60
50
40
30
20
10
0
10
20
LEGEND
SCREEN
HIGH WATER ELEVATION
LOW WATER ELEVATION
HISTORIC PRODUCT
SMEAR ZONE
0
20
40
60
80
100
120
140
160
180
200
220
240
DISTANCE (FT.)

# Injection and Extraction



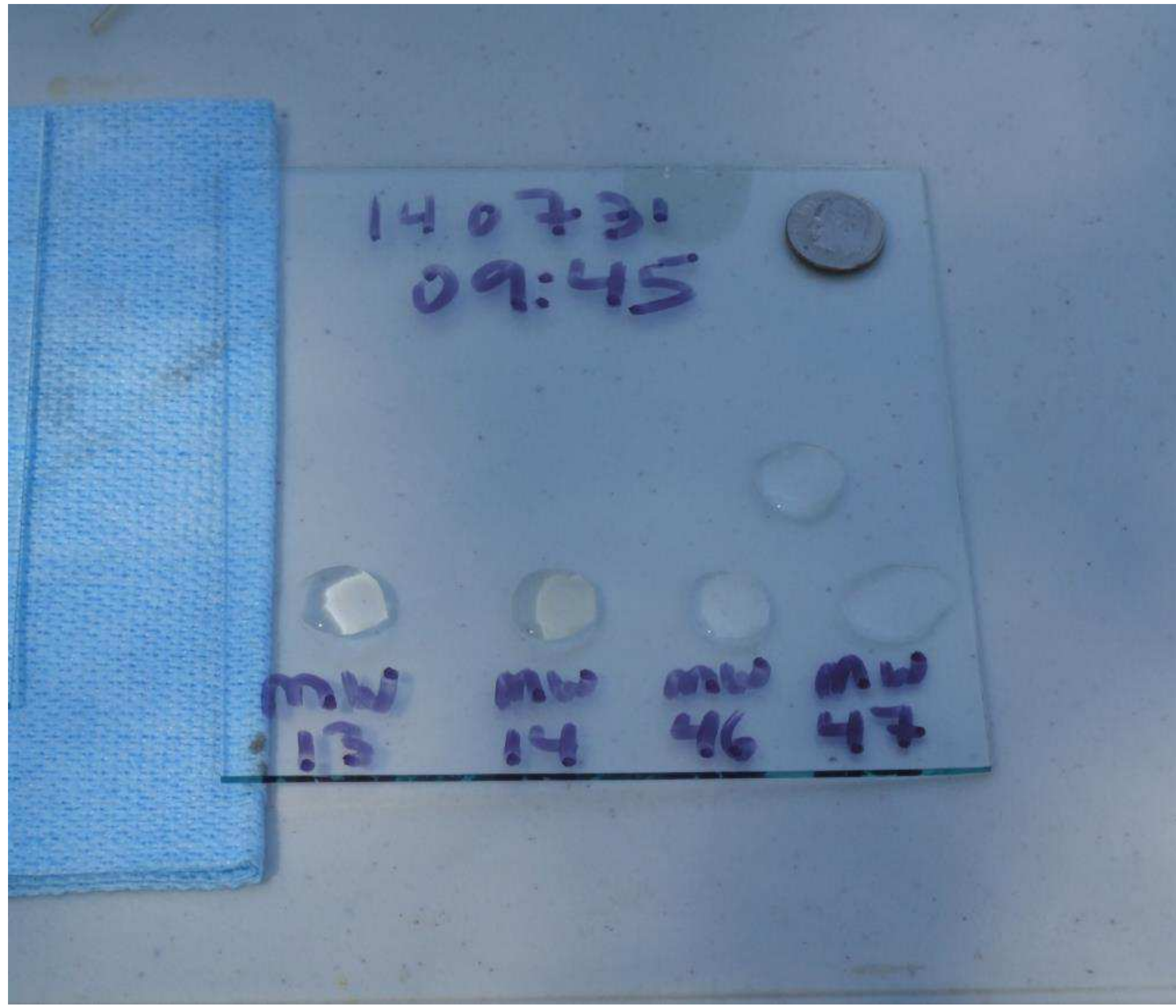


ROSS SECTION IVEY-SOL INJECTION DIFFUSION RADI
idr
idr
idr
r
Legend:
Injection Wel
(4" / 100mm
Ivey-sol
idr Ivey-sol Injec
Diffusion Rad
Sand = 15
Silty Sand = 10
Silty = 5 -
Silty Clay = 5 ft
Clay = < 5
Ivey-sol radius of diffusion
to site as a function of soi
compaction and injection
range from gravity to pres
ot To Scale

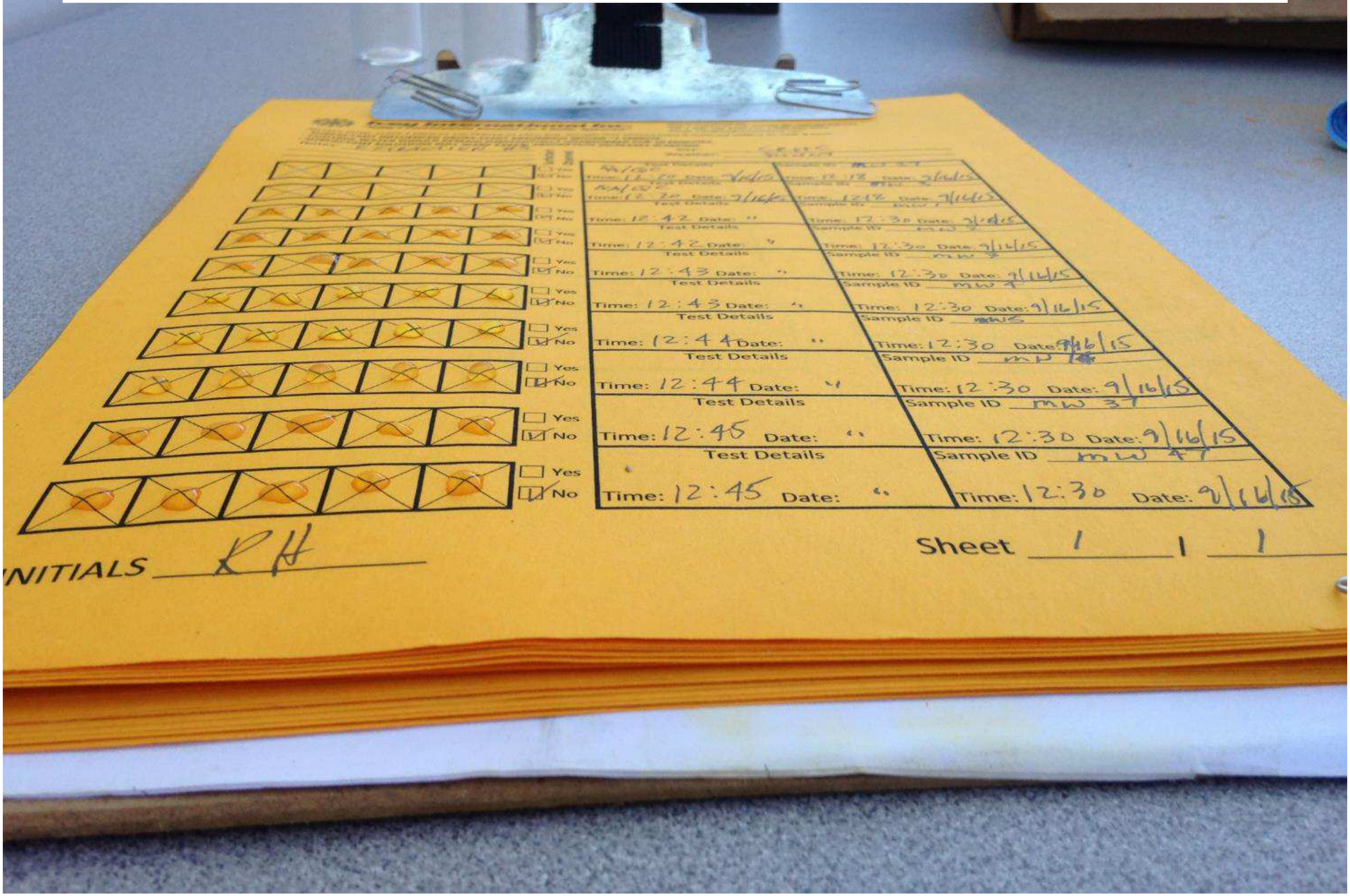



## 1:50 Ratio of Ivey-sol To Water For The Pilot Scale Application

# IVEY Developed Field Testing Method for Surfa
# Has >96% correlation with laboratory testin



# THE FUTURE OF FIELD TESTING FOR SURFACTANT

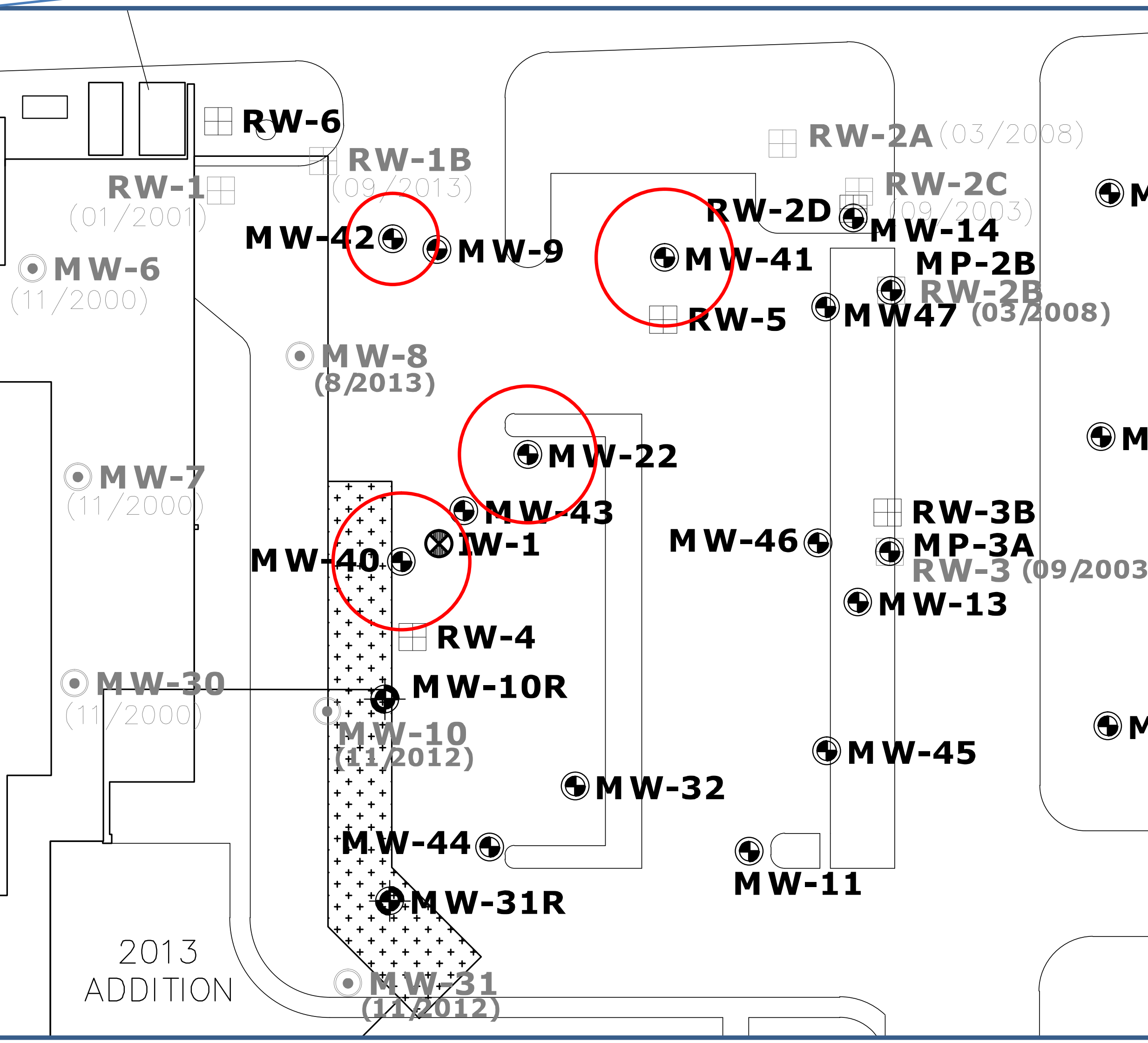


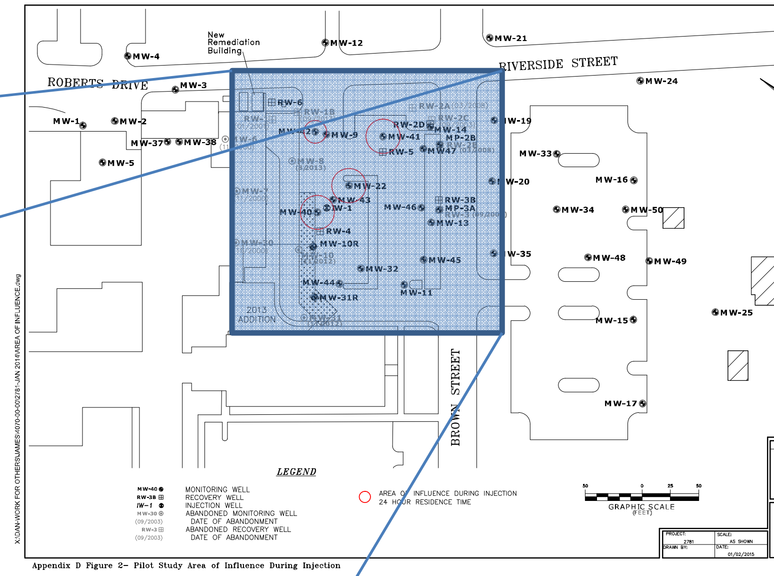
# IVEY-SOL

# IVEY-SOL

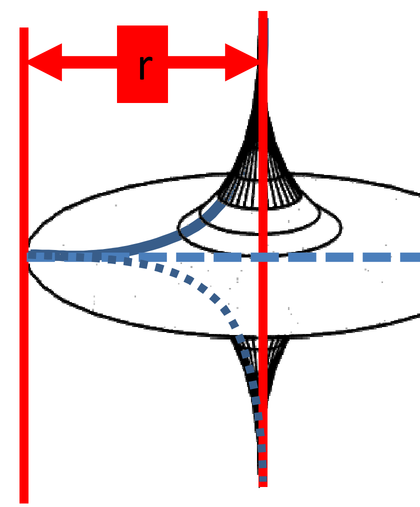

Recovery Well
Injection Well #1
Injection Well #4
Injection Well #3
Injection Well #2
ey-sol® Injection and Recovery We
Groundwate Table

# Injection Radius of Influence

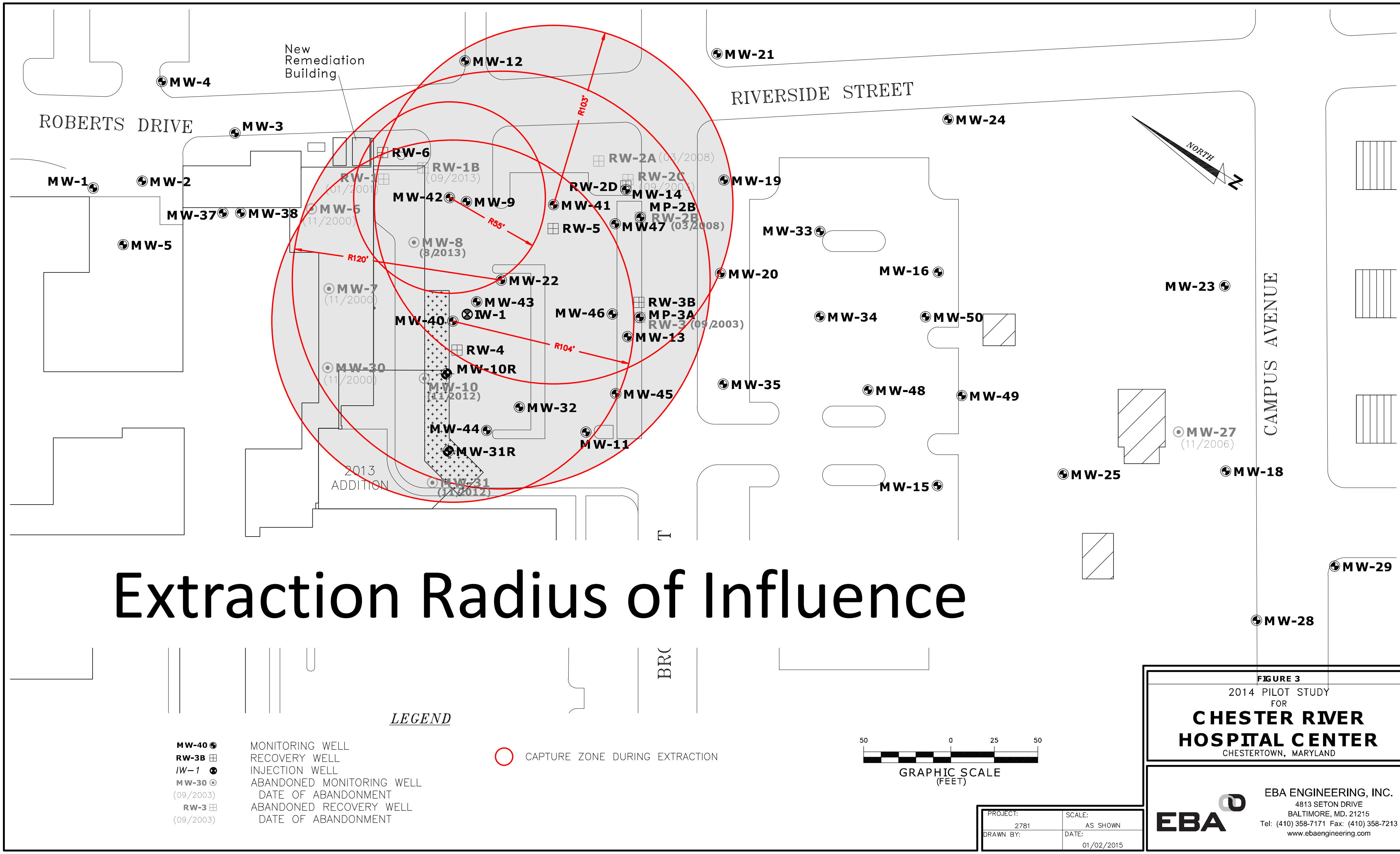



Area of Influence
r = 10 to 15 feet



# Extraction Radius of Influence




Appendix D Figure 3– Pilot Study Capture Zone During Extraction

# TPH-DRO Mass Recovery Calculations

y-sol® Injection #1 **426%** Increase in **TPH-DRO**
y-sol® Injection #2 **6,240%** Increase in **TPH-DRO**
y-sol® Injection #3 **6,846%** Increase in **TPH-DRO**

y-sol® Injection #1 **7,333%** Increase in **TPH-DRO**
y-sol® Injection #2 **5,133%** Increase in **TPH-DRO**
y-sol® Injection #3 **5,156%** Increase in **TPH-DRO**

y-sol® Injection #1 *Not Calculated (Missed Sample)*
y-sol® Injection #2 **18,966%** Increase in **TPH-DRO**
y-sol® Injection #3 **3,226%** Increase in **TPH-DRO**

y-sol® Injection #1 **948%** Increase in **TPH-DRO**
y-sol® Injection #2 **824%** Increase in **TPH-DRO**
y-sol® Injection #3 **3,737%** Increase in **TPH-DRO**

**Averaged TPH-DRO Concentration Pre Injection Eve**
[**Pre** Ivey-sol injection TPH-DRO (ppm) X Concentrations (

**Averaged TPH-DRO Concentration Post Injection Eve**
[**Post** Ivey-sol Injection TPH-DRO (ppm) X Concentrations

**Mass Recovery =**

[Averaged TPH-DRO Concentration Post Injection Event] X
[Averaged TPH-DRO Concentration Pre Injection Even

**= % Mass Recovery Increase For The Ivey-sol® Push-Pull Ev**

***Mass Recovery Calculations Completed by EBA Engineering***

EB
ENGINEER

# SUMMARY

result of the investigations, analysis, and calculations of mass recovery the Tech
n determined that in the Push-Pull wells recovery rates were significantly enhar

**ne thousand percent (1,000%) to Eighteen thousand percent (18,000%) TPH**

polation:

**ubstantial soil and groundwater remediation results can be achieved from usi**
**'ush-Pull' Ivey-sol® process at the original up-gradient source area and the sev**
**nid to down-gradient regions of the TPH plume**

**ffective for treating sorbed TPH in smear zone**

**asy to inject 'Push' and does not require pressure using gravity feed**

**eld surfactant test minimized volume of groundwater extracted during the 'P**
**hase**

cale:

**DE approved full scale application in June 2015 (Priority Zone 1, 2, 3, 4 Approach)**

**arted Full Scale applications on August 31, 2015 (Early results look very promising)**

# CONTACT INFORMATION

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