Mike
Mazzarese

Remediation
Support Services

Vironex
.com

Search and Destroy™

Intelligent MIP and Injection Integration For In Situ Treatment

In-Situ Remediation Success

Success is enough reagent cost effectively delivered in contact with contaminant for a long enough period of time to react effectively.

“contact with contaminant”

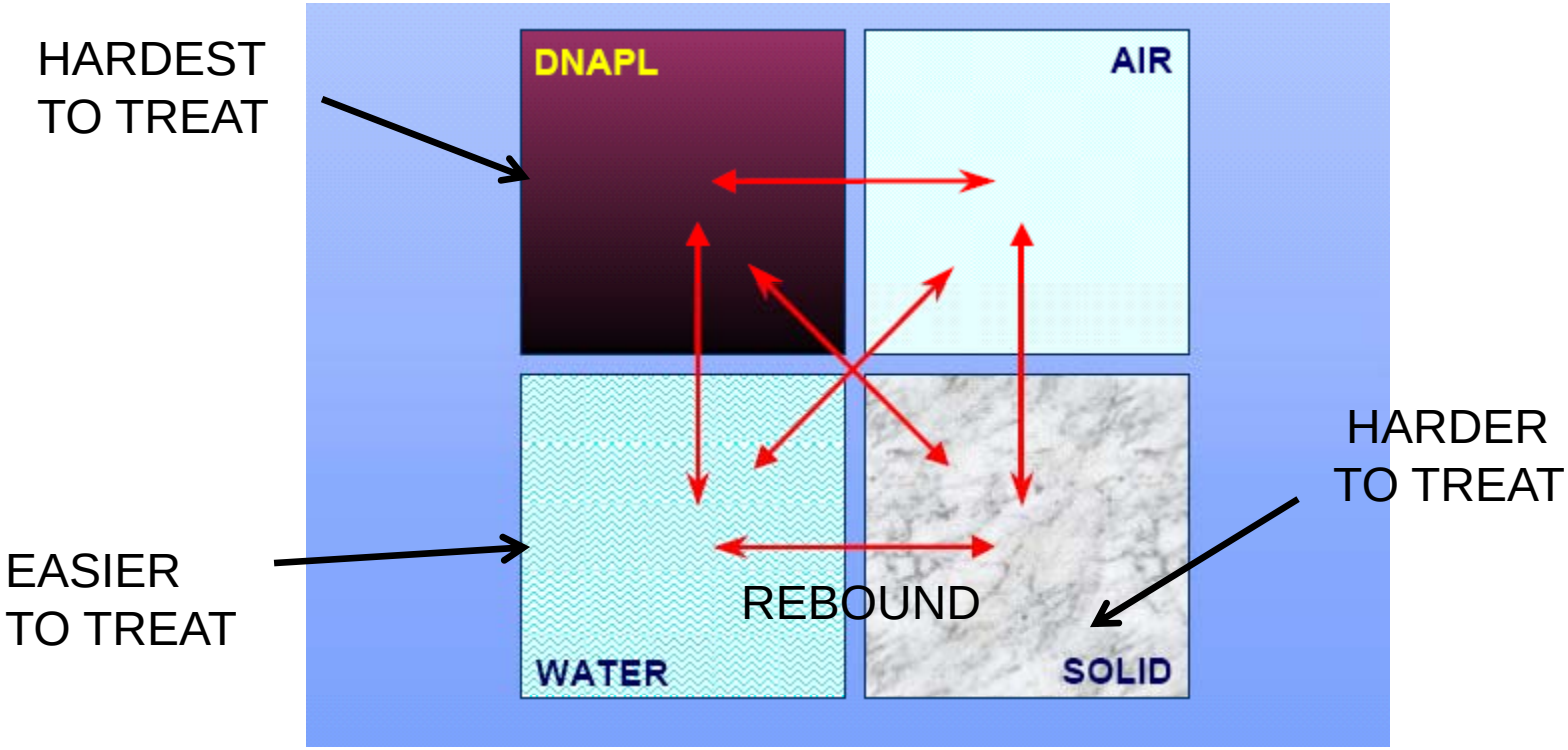
Contact - Basic Remediation

Monitoring Well Data

No Identification of Mass Distribution In Relation to Lithology

No Targeting of Contaminant Mass/lithology

Contact – Solid and DNAPL Challenges



Contact – Mass vs. Lithology Difficulty To Treat Matrix

Contaminant Mass

Lithology: Hydrogeology	Mobile Dissolved (Degrades/ Volatilizes)	Mobile Dissolved	Strongly Sorbed, Dissolved	Strongly Sorbed, Dissolved (Degrades/ Volatilizes)	Separate Phase LNAPL	Separate Phase DNAPL
Homogeneous, Single Layer	1	1-2	2	2-3	2-3	3
Homogeneous, Multiple Layers	1	1-2	2	2-3	2-3	3
Heterogeneous, Single Layer	2	2	3	3	3	4
Heterogeneous, Multiple Layers	2	2	3	3	3	4
Fractured Bedrock	3	3	3	3	4	4

1= Least Difficult 4 = Most Difficult

1	2	3	4

Search and Destroy™ Remediation

Making Contact / Minimizing Costs

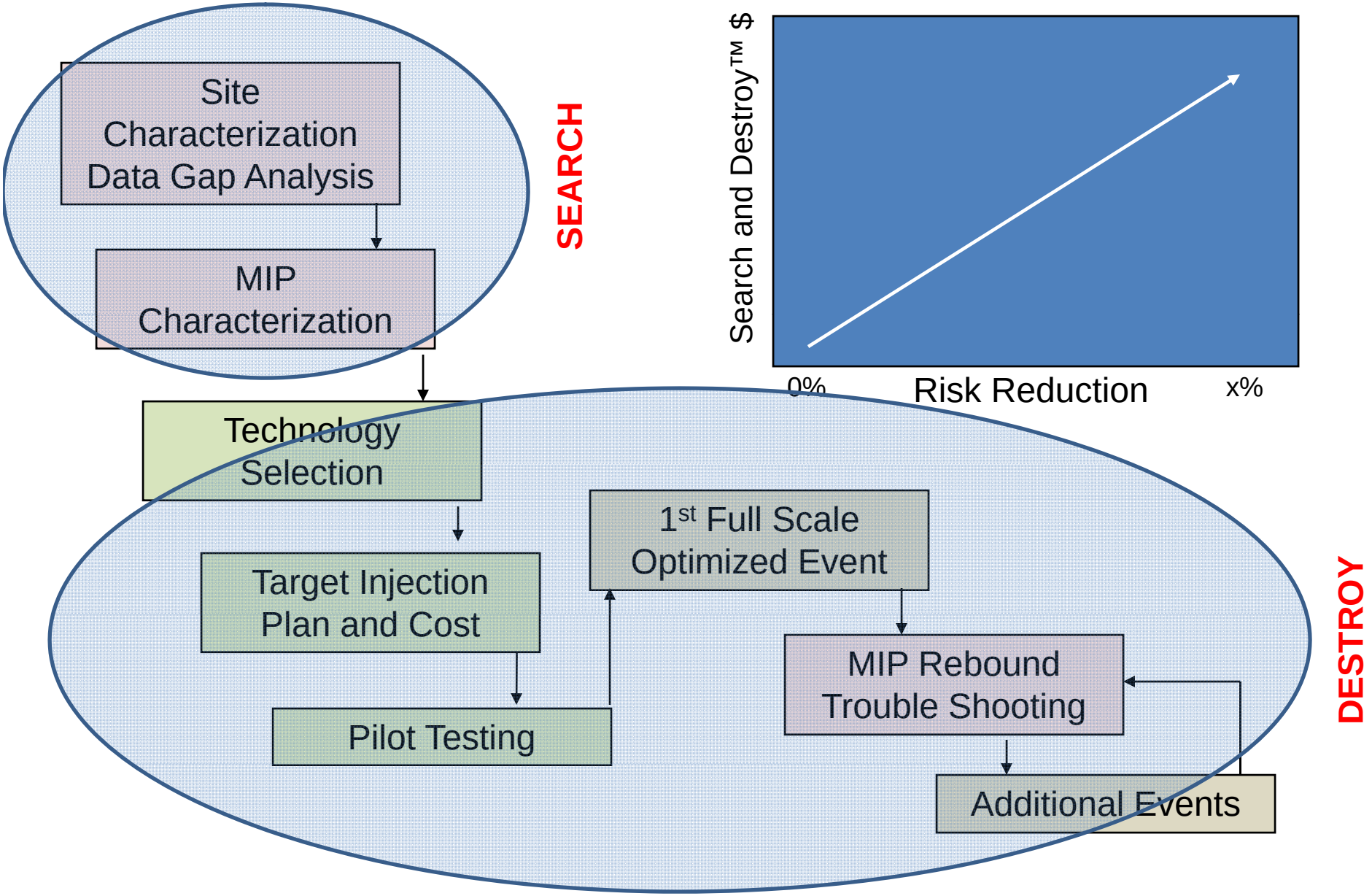
- **Identify Contaminant Mass Location Vertically and Horizontally**
- **Identify Contaminant Mass Location In Relation To Lithology**

Search

- **Contact Delivery**
- **Full Scale Performance**

Destroy

Search and Destroy™ Stages



Delivery Systems / Pressure

	Injection Pressure
Direct Push	
❑ Bottom-Up or Top-Down tools (screens 1 to 5 feet) targeting of discrete lithologies	➢ Low to Moderate
Injection Wells	
❑ Injection wells	➢ Low
❑ Packer isolation of open bore holes	➢ Low to High
Fracturing	
❑ Fracturing of tight formations	➢ Moderate to High

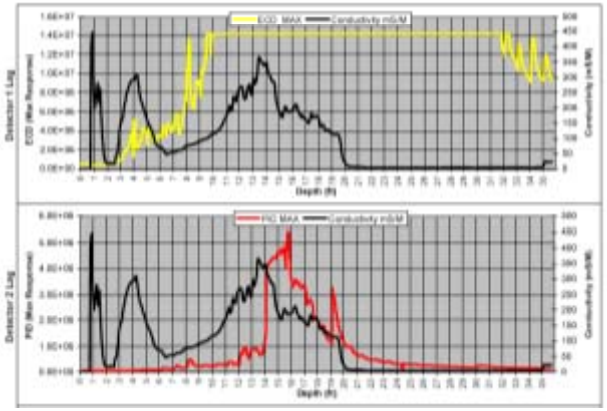
Depth/Soils/Pressure/GPM

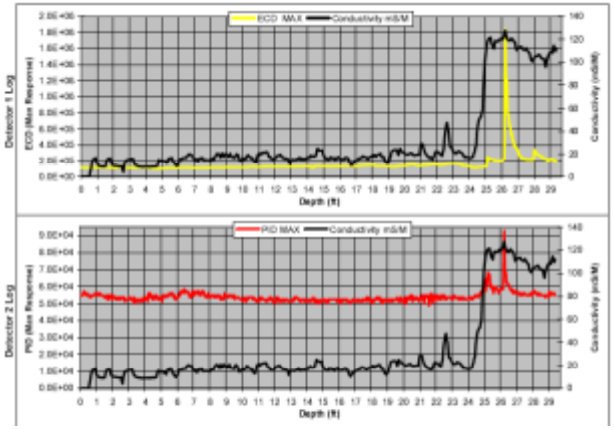
I_P = Injection Pressure
I_{GPM} = Injection Rate
PV_I = % pore volume to be injected
L = Lithology
D_C = Depth To Contamination
R_{SP} = Reagent Surfacing Potential

PV_I	L	D_C	R_{SP}	I_P	I_{GPM}
20%	Sand	Deep	Low	Moderate	Moderate
20%	Sand	Shallow	Low	Low	Low
5%	Clay	Deep	Moderate	High	Moderate
5%	Clay	Shallow	High	Moderate	Very Low

Targeted DPT Delivery

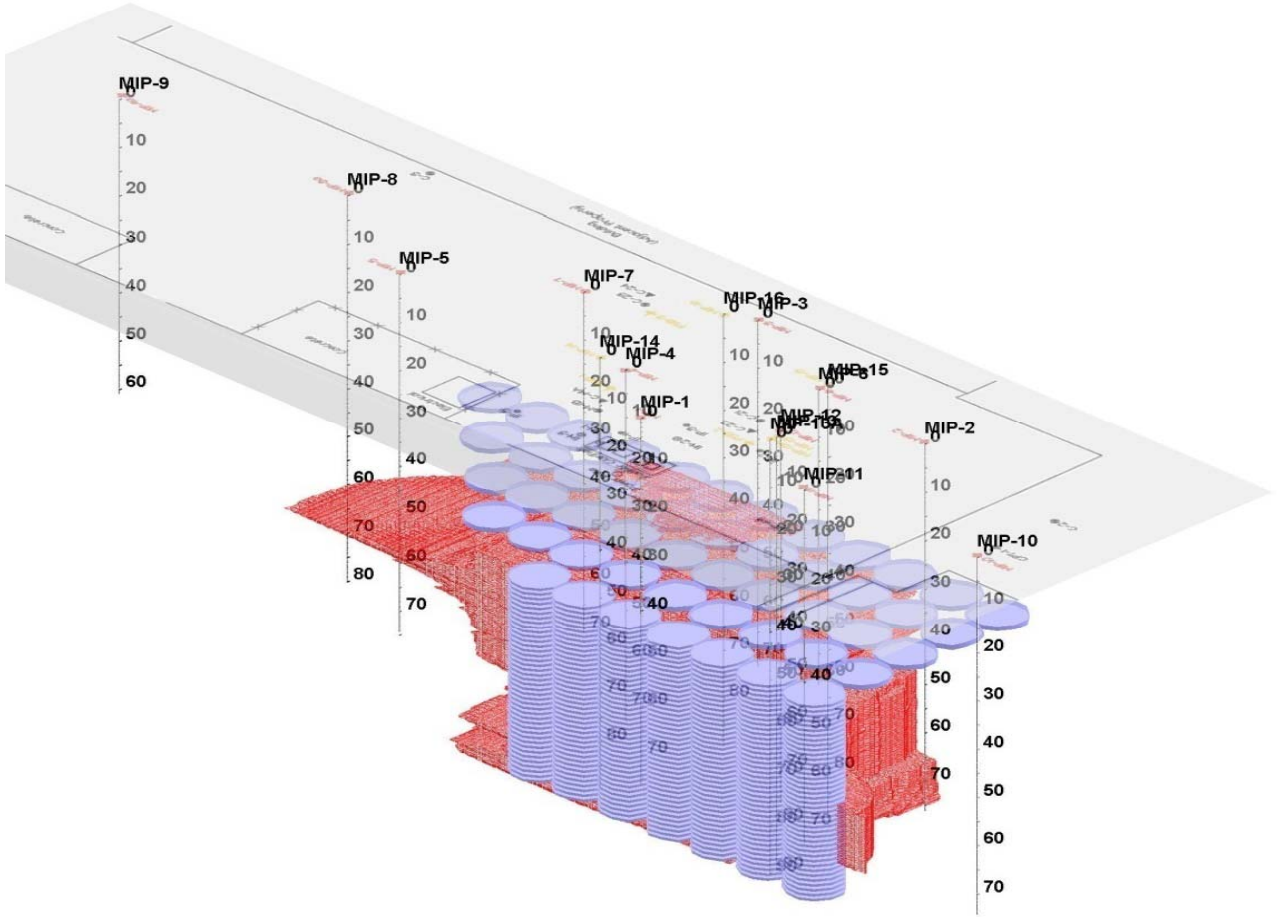
Scenario	Tooling	Screen Lengths
Homogeneous Sands	Bottom-Up	5 Feet
Heterogeneous Sands, Silts and Clays	Bottom- Up	1 Foot
Silts and Clays	Bottom-Up or Top Down	1 Foot
Sands Over Clays	Bottom-Up	1 Foot
Clays Over Sand	Top -Down	1 Foot



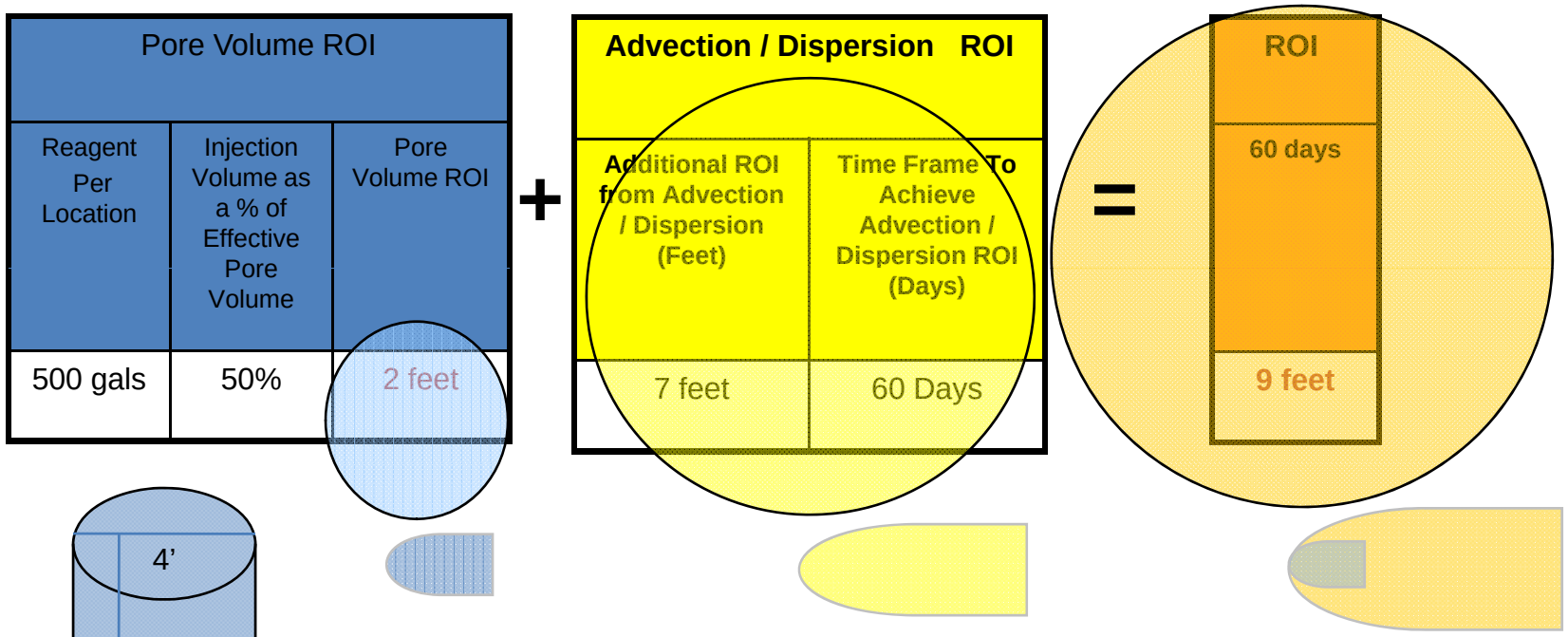


Targeted DPT Delivery

MIP Integration
Into Targeted Injection Design



Radius of Influence (ROI)

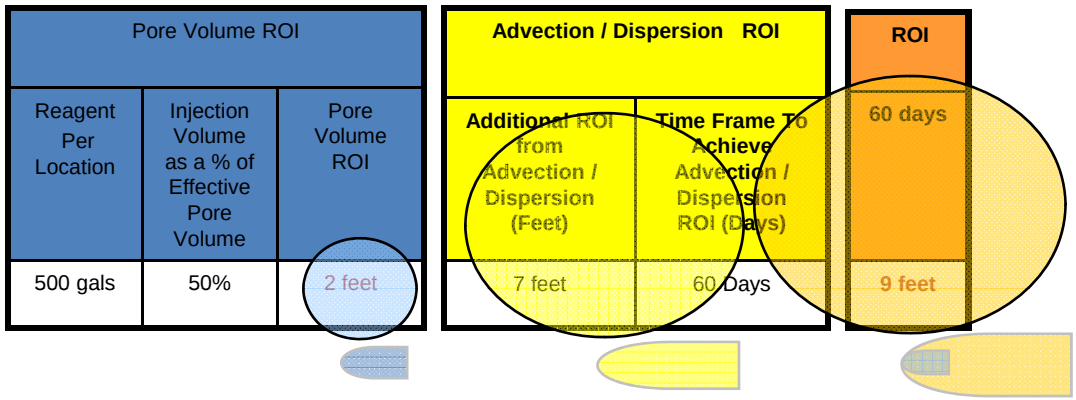


$$ROI = P_{ROI} + A/D_{ROI}$$

ROI = pore volume ROI (ft) + advection/dispersion ROI (ft)

9 feet = 2 feet + 7 feet @ 60 days

ROI Realities



Tight Soils

- Low Injection Pore Volumes
- Tighter Spacing
- Higher Reagent Concentrations

- Reagent Persistence
- May Exceed Fracture Pressure

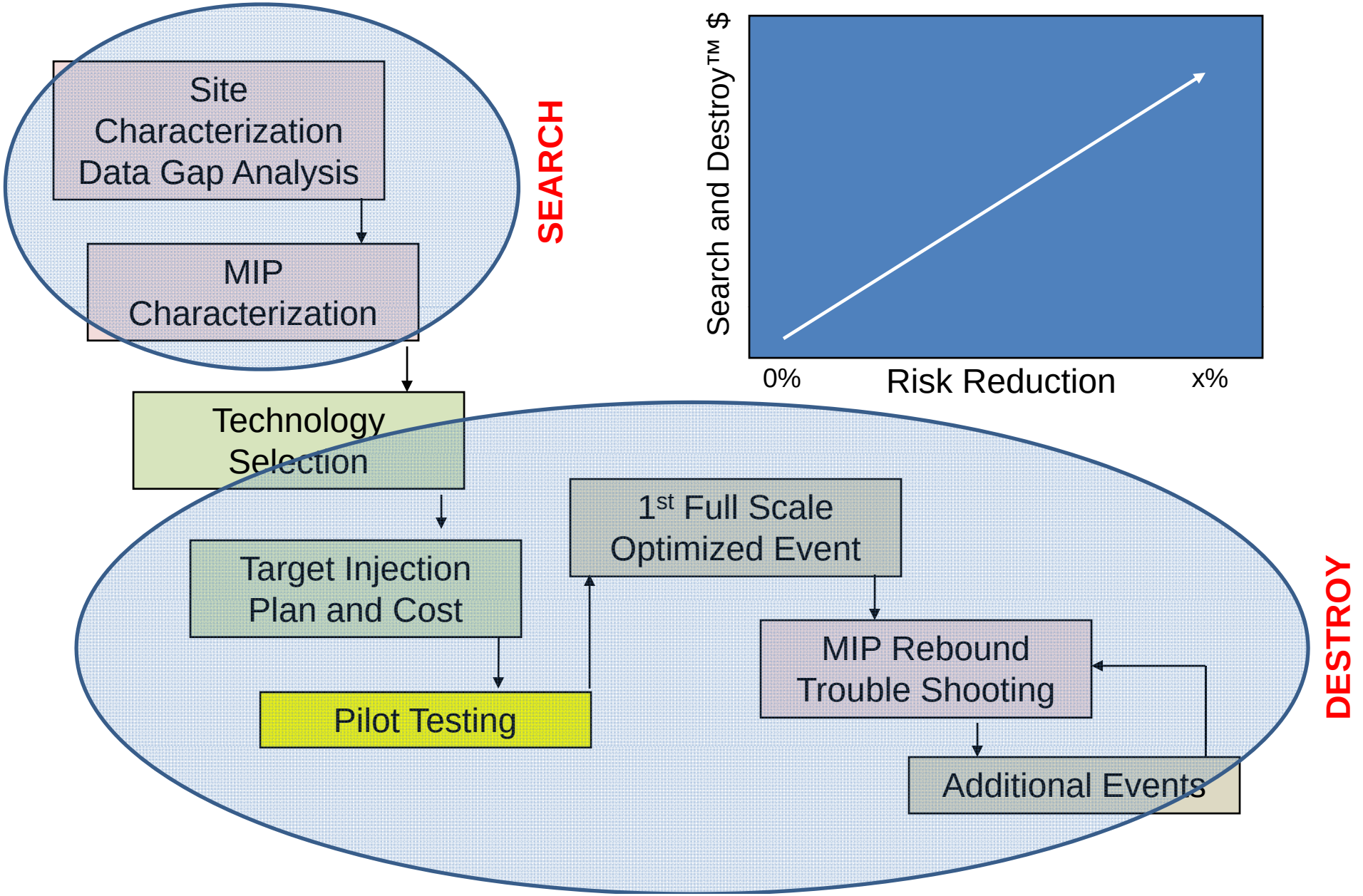
Permeable Soils / Flat Gradient

- Requires High Injection Pore Volume
- Stay Below Fracture Pressure

Permeable Soils / Steep Gradient

- Lower Residence Time

Search and Destroy™ Stages



Destroy - Pilot Testing

- Ability To Get To Depth
- Injection Rates / Pressures
- Injection Volumes
- Mixing Rates
- Surfacing Identification / Mitigation

Destroy - Pilot Testing ROI Confirmation

- Core samples to verify pore volume ROI (P_{ROI})
- Monitoring well sampling to determine ROI

Re-Search – Post Application Investigation

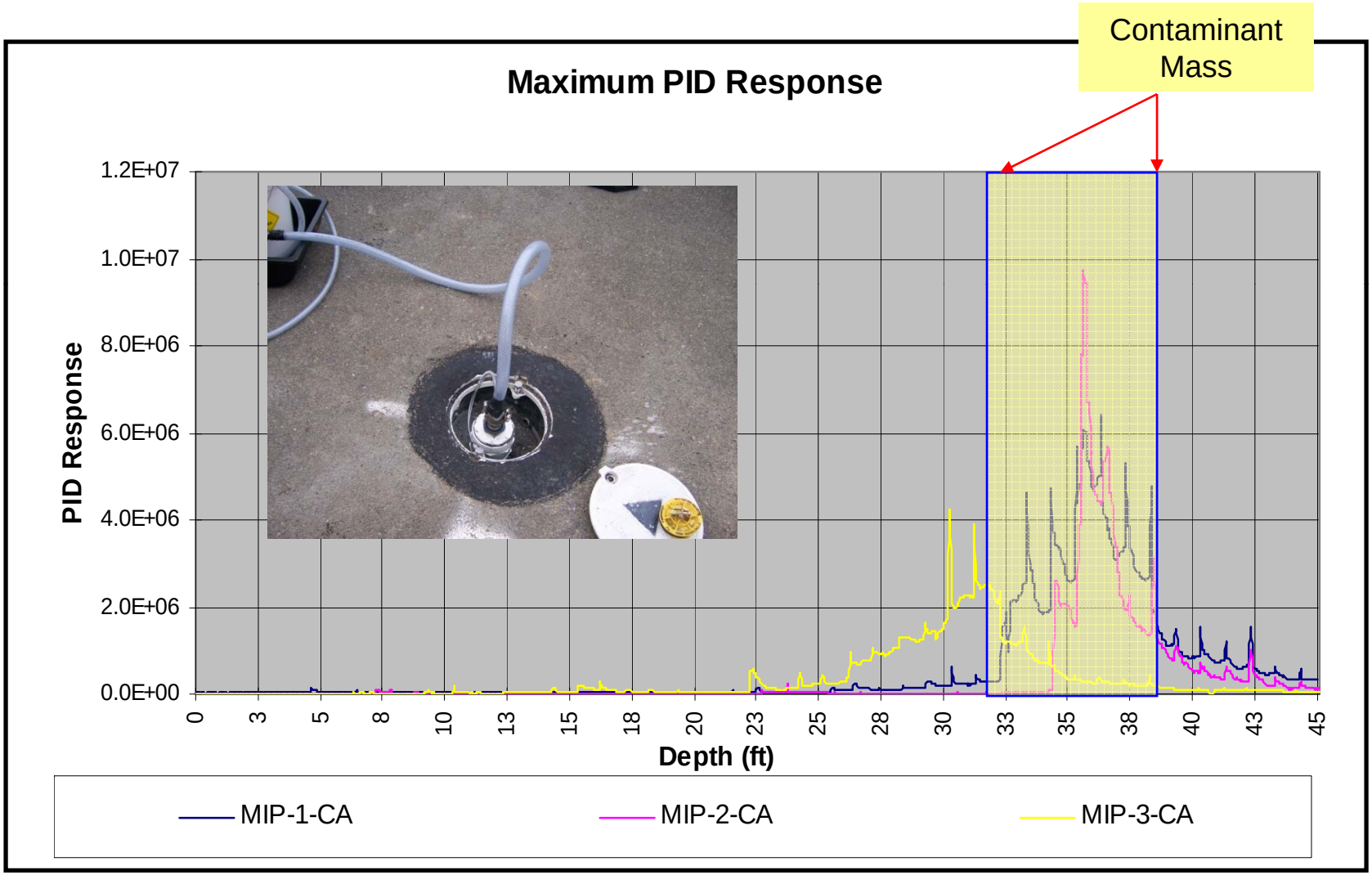
- Advanced Site Characterization Tools can be used after the remediation event to:

  -Trouble Shoot

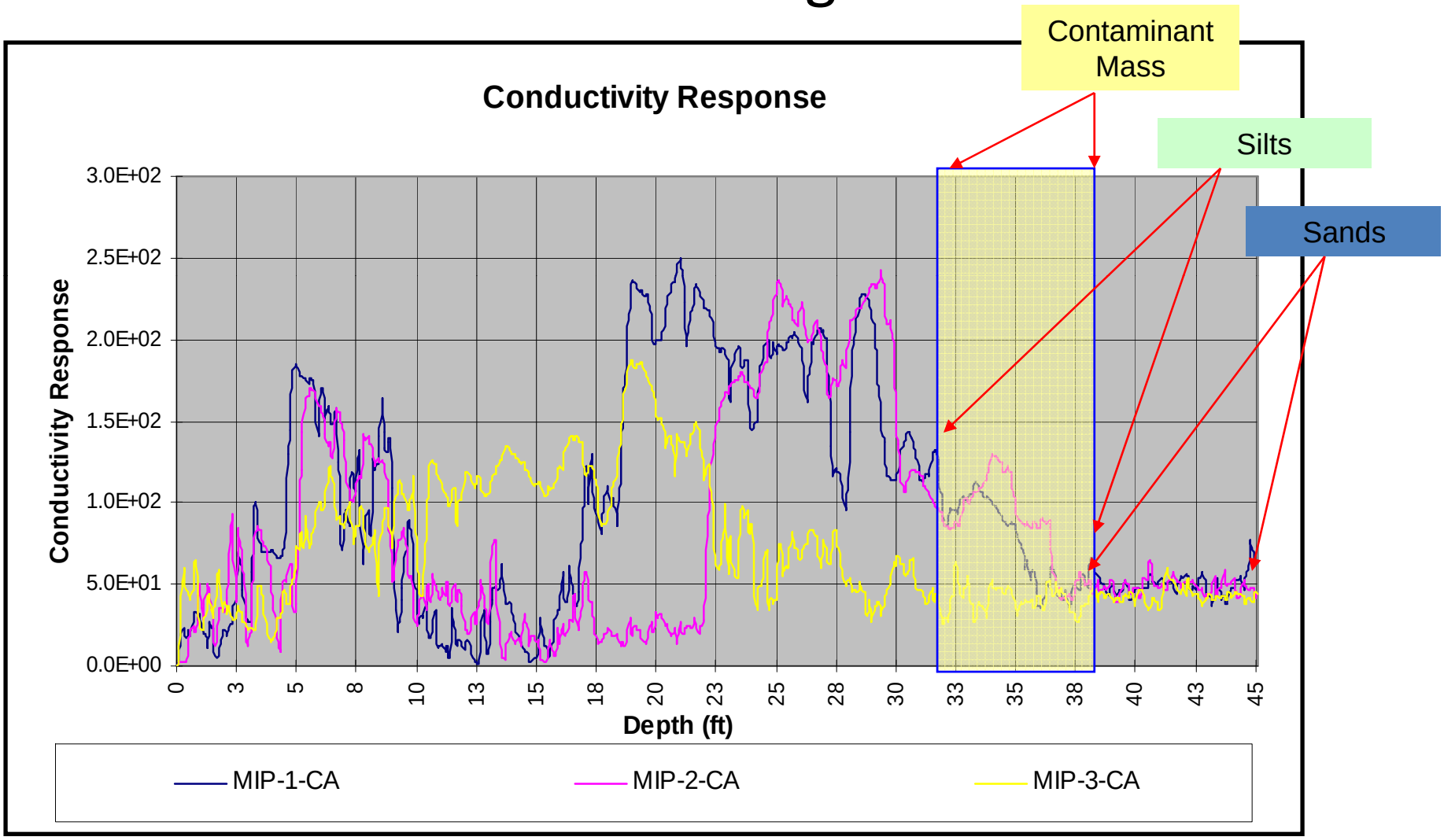
  -Confirm Influence

  -Confirm Remediation

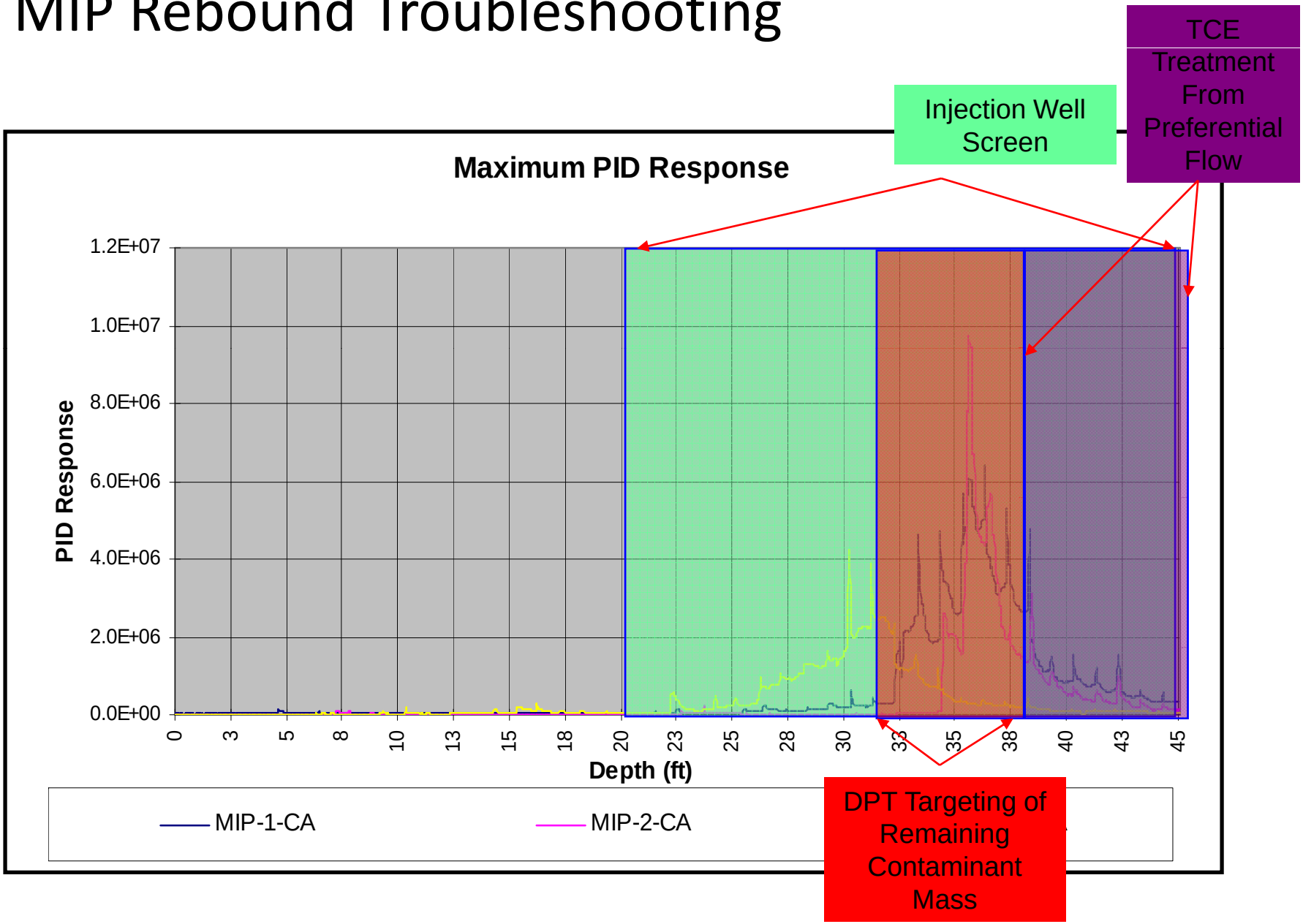
MIP Rebound Troubleshooting



MIP Rebound Troubleshooting

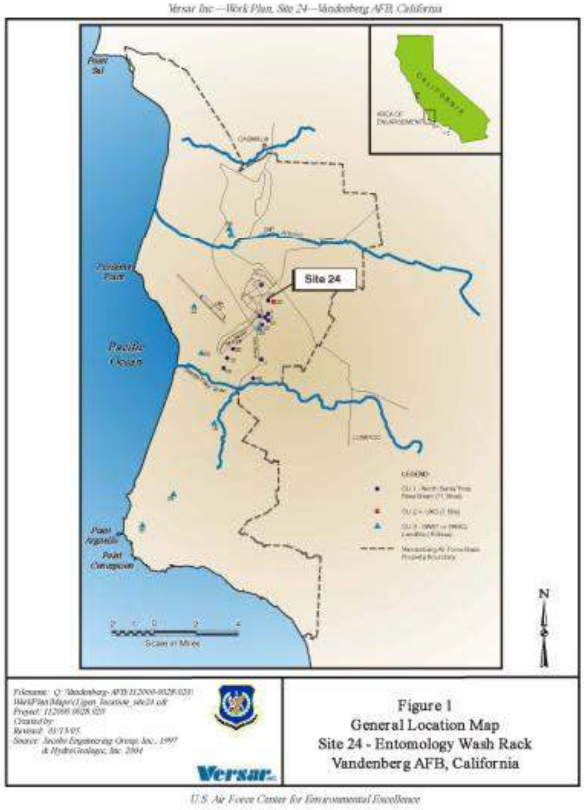


MIP Rebound Troubleshooting

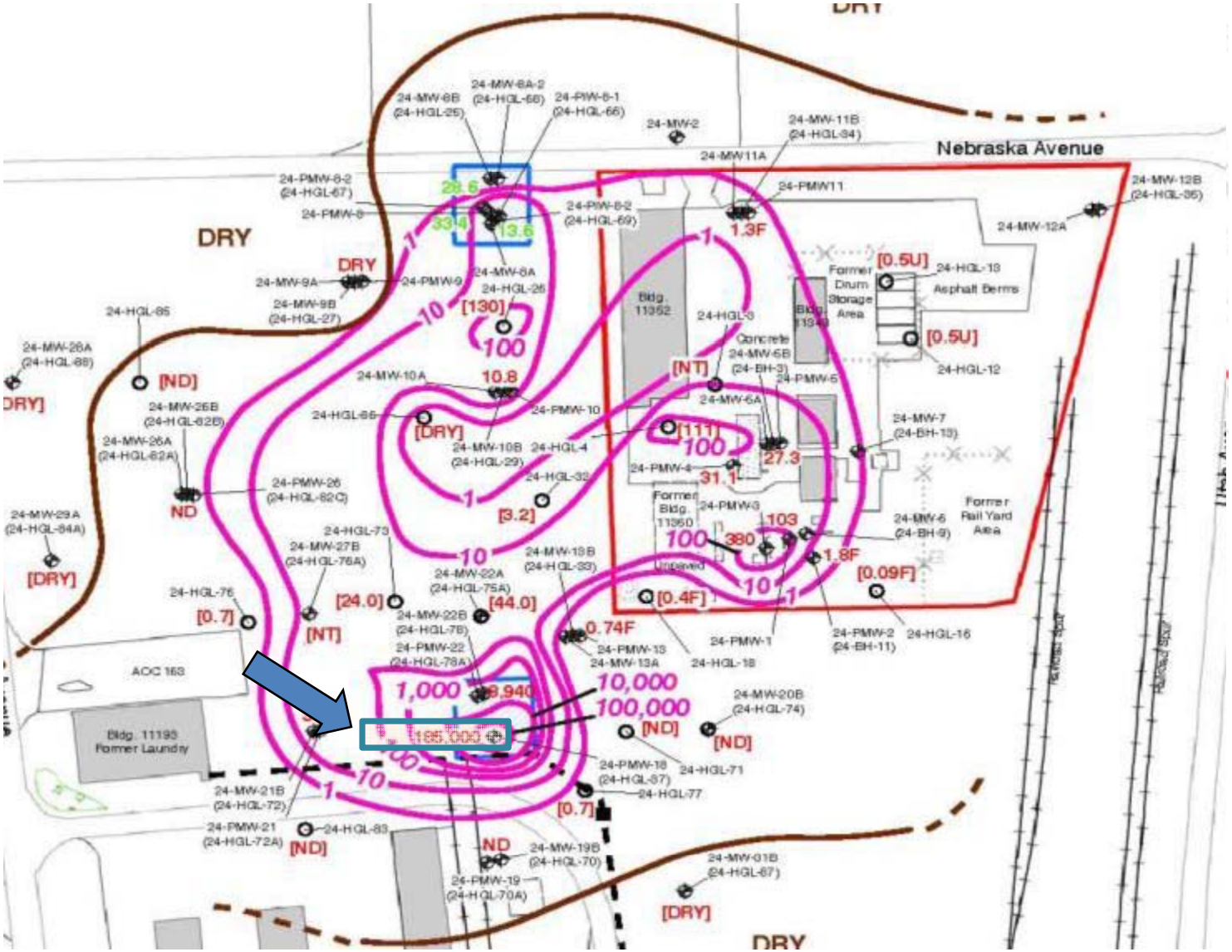


Search and Destroy™ Case Study

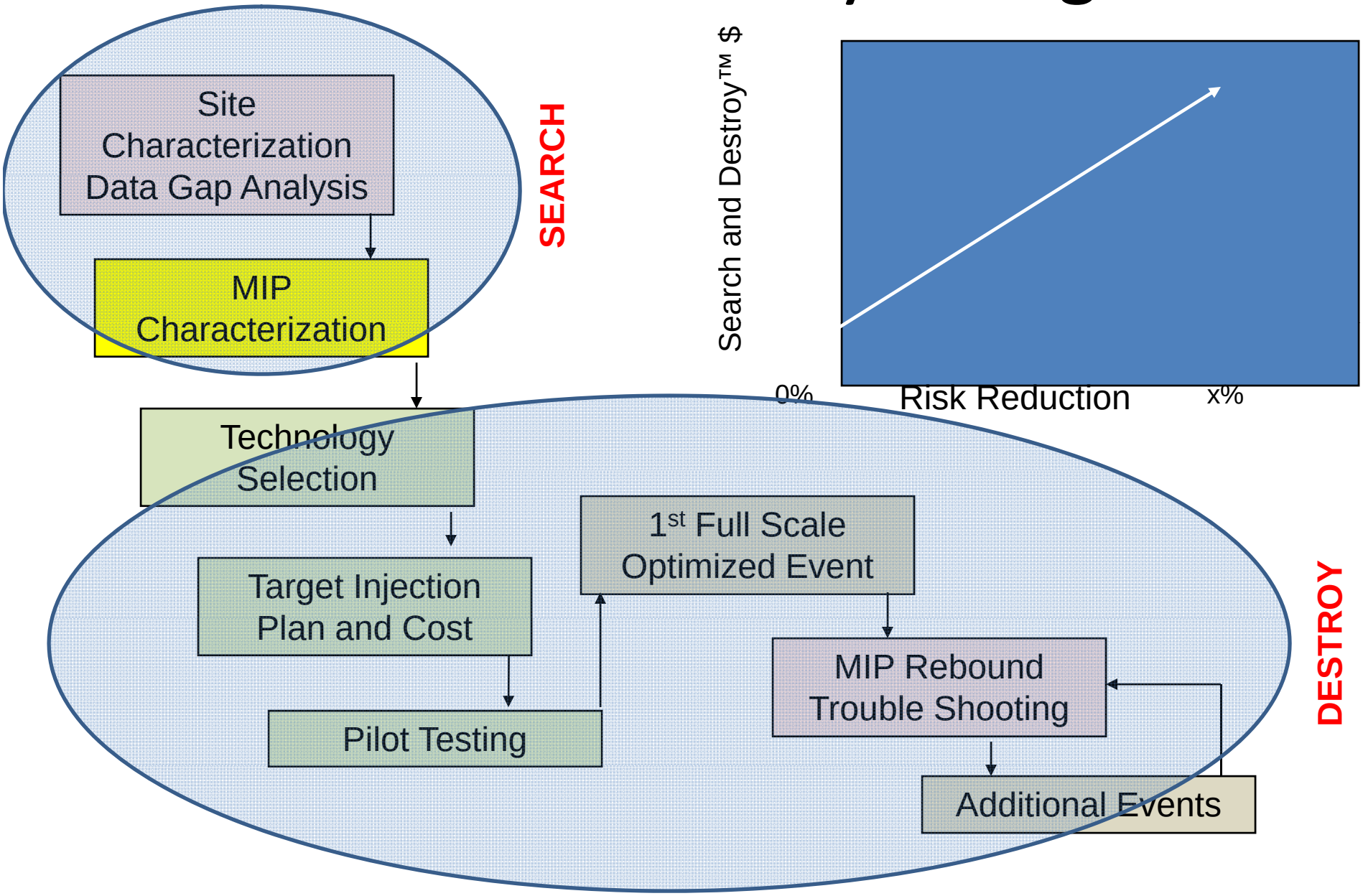
Vandenberg AFB, CA
Site 24
PCE Source Area
Versar / Irvine, CA



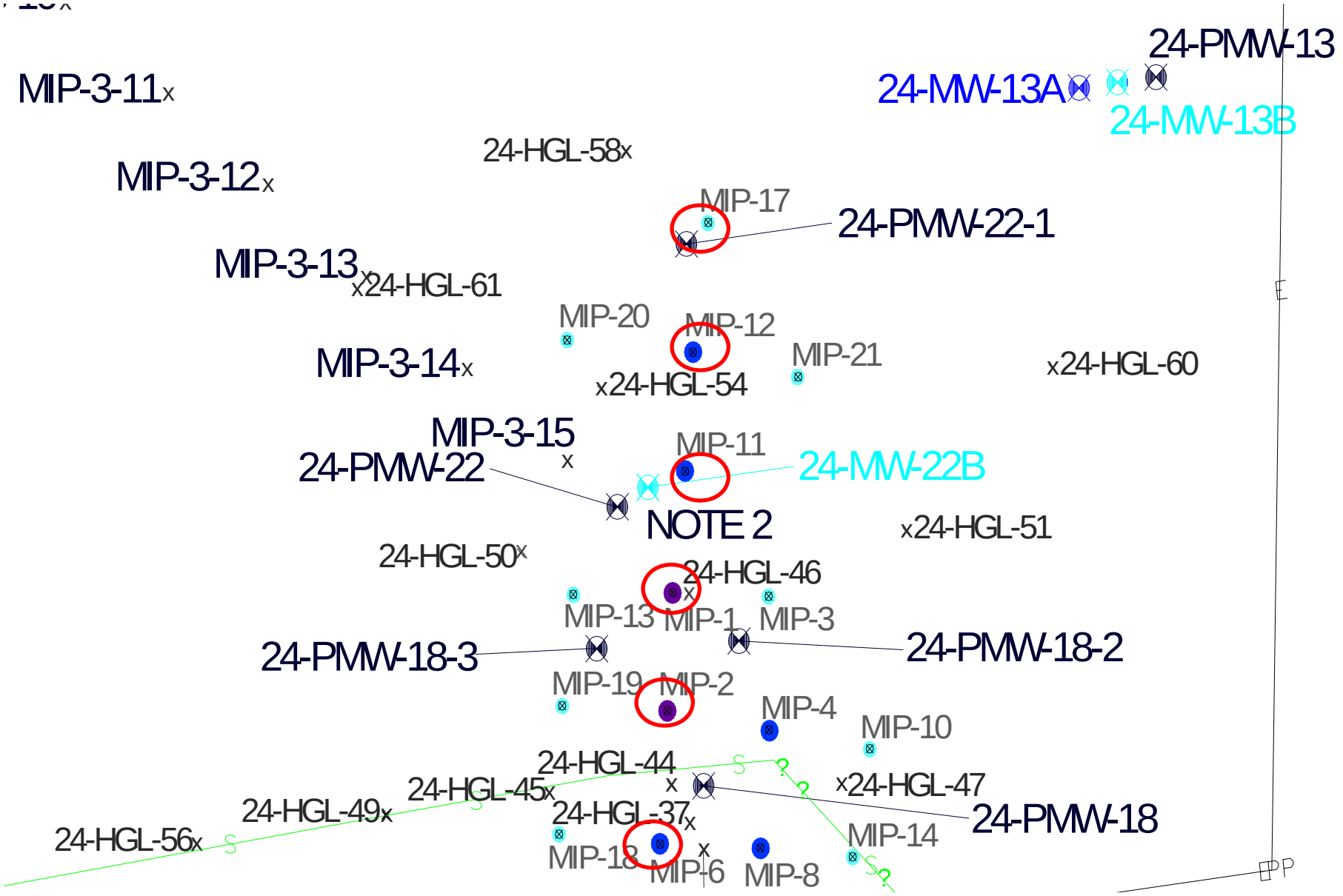
Site 24 – Vandenberg AFB



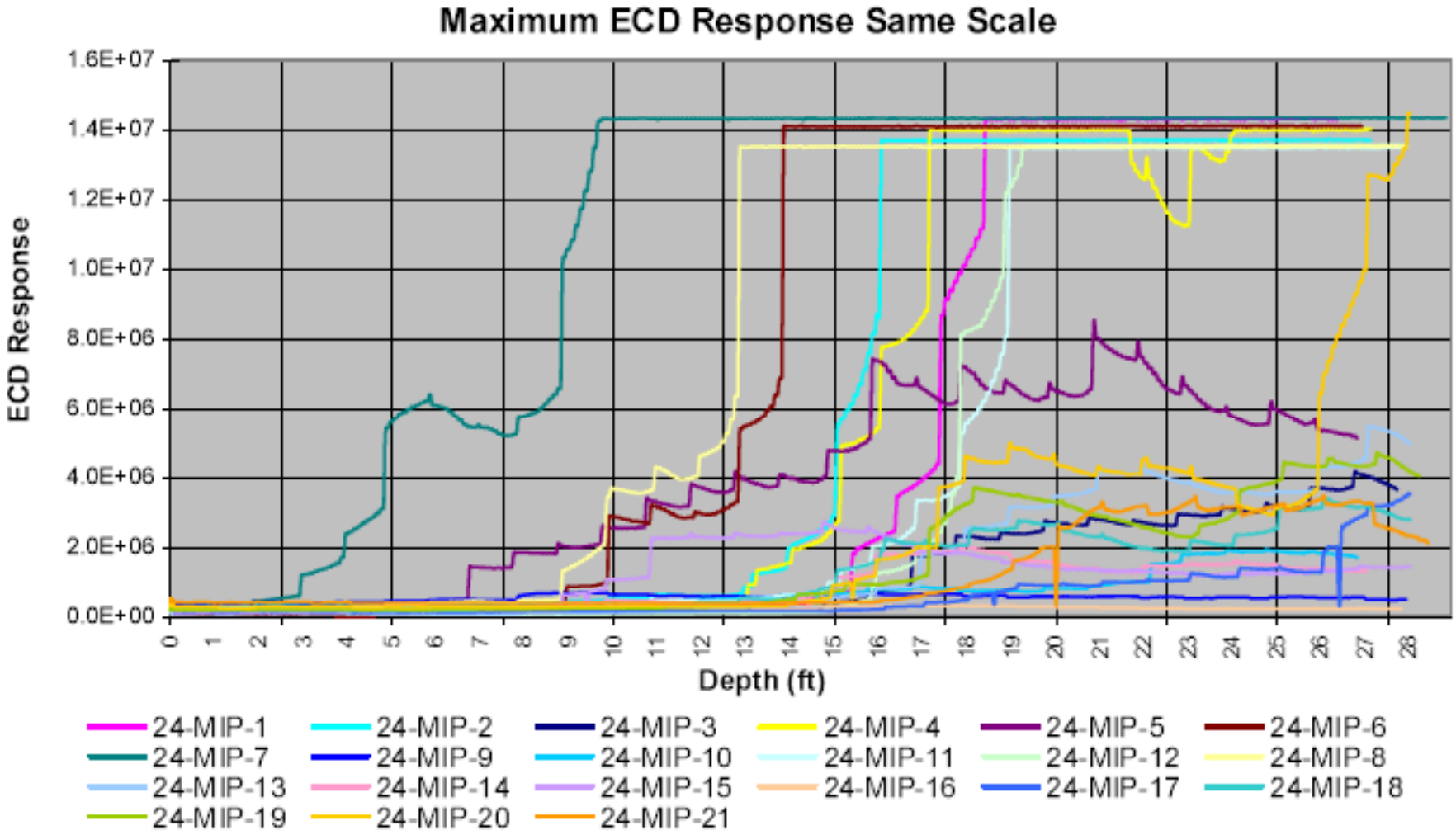
Search and Destroy™ Stages



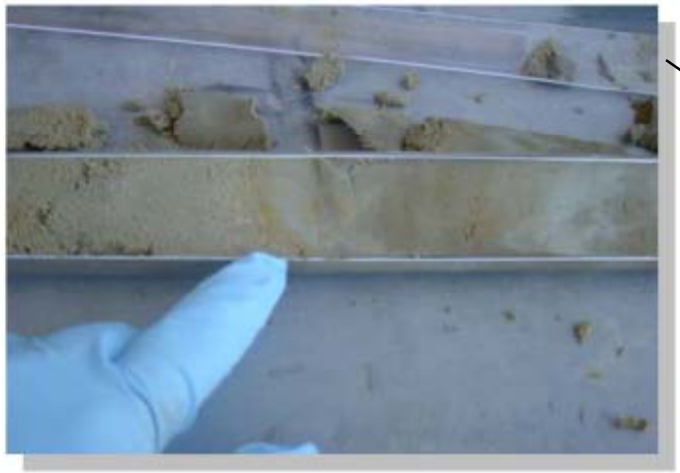
Search - MIP


24-PMW-13
MIP-3-11
24-MW-13A
24-MW-13B
24-HGL-58
MIP-3-12
MIP-17
24-PMW-22-1
MIP-3-13
24-HGL-61
MIP-20
MIP-12
MIP-3-14
MIP-21
24-HGL-60
24-HGL-54
MIP-3-15
MIP-11
24-PMW-22
24-MW-22B
NOTE 2
24-HGL-51
24-HGL-50
24-HGL-46
MIP-13
MIP-1
MIP-3
24-PMW-18-3
24-PMW-18-2
MIP-19
MIP-2
MIP-4
MIP-10
24-HGL-44
24-HGL-45
24-HGL-47
24-HGL-49
24-HGL-37
24-PMW-18
24-HGL-56
MIP-14
MIP-18
MIP-6
MIP-8

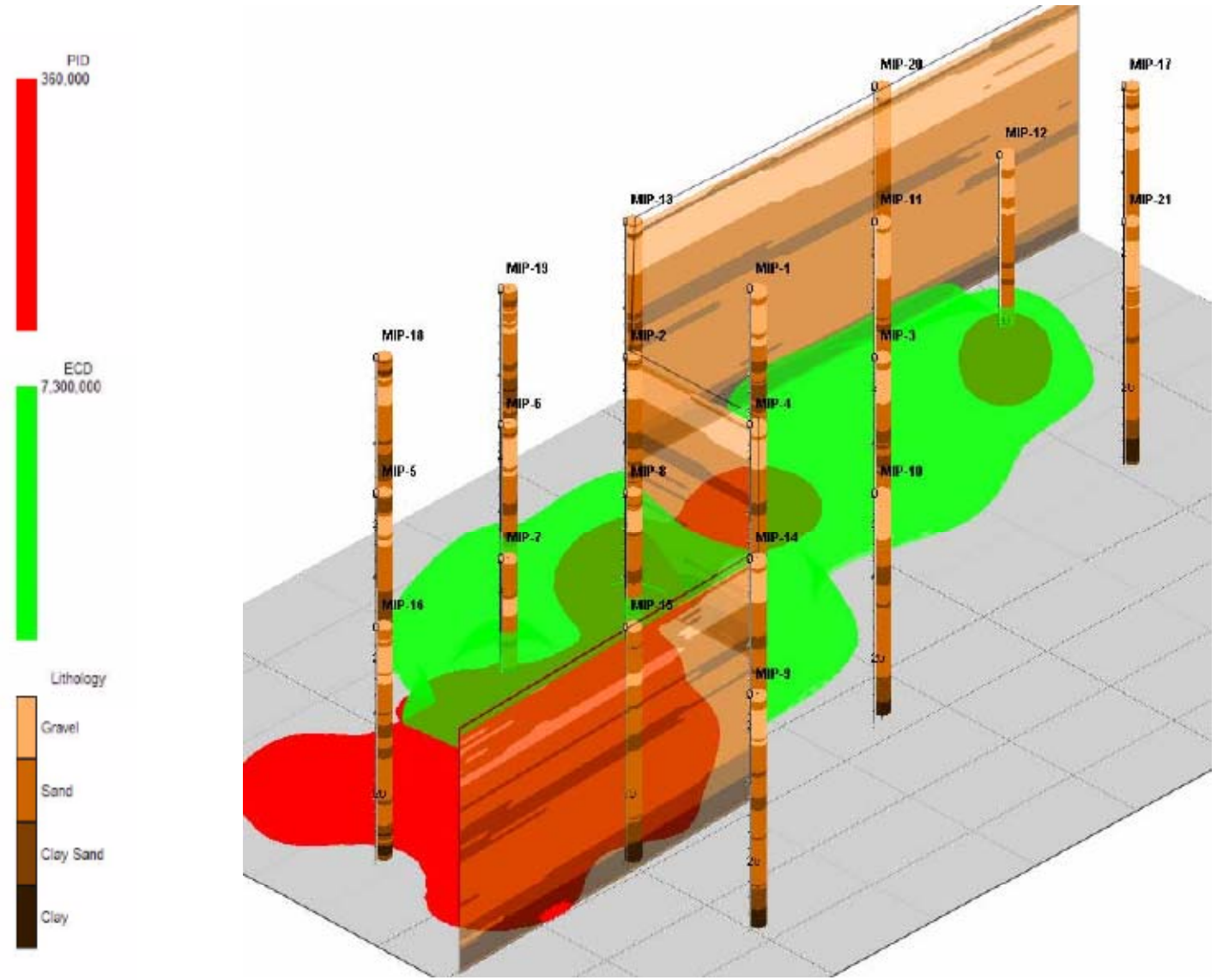
ECD Response



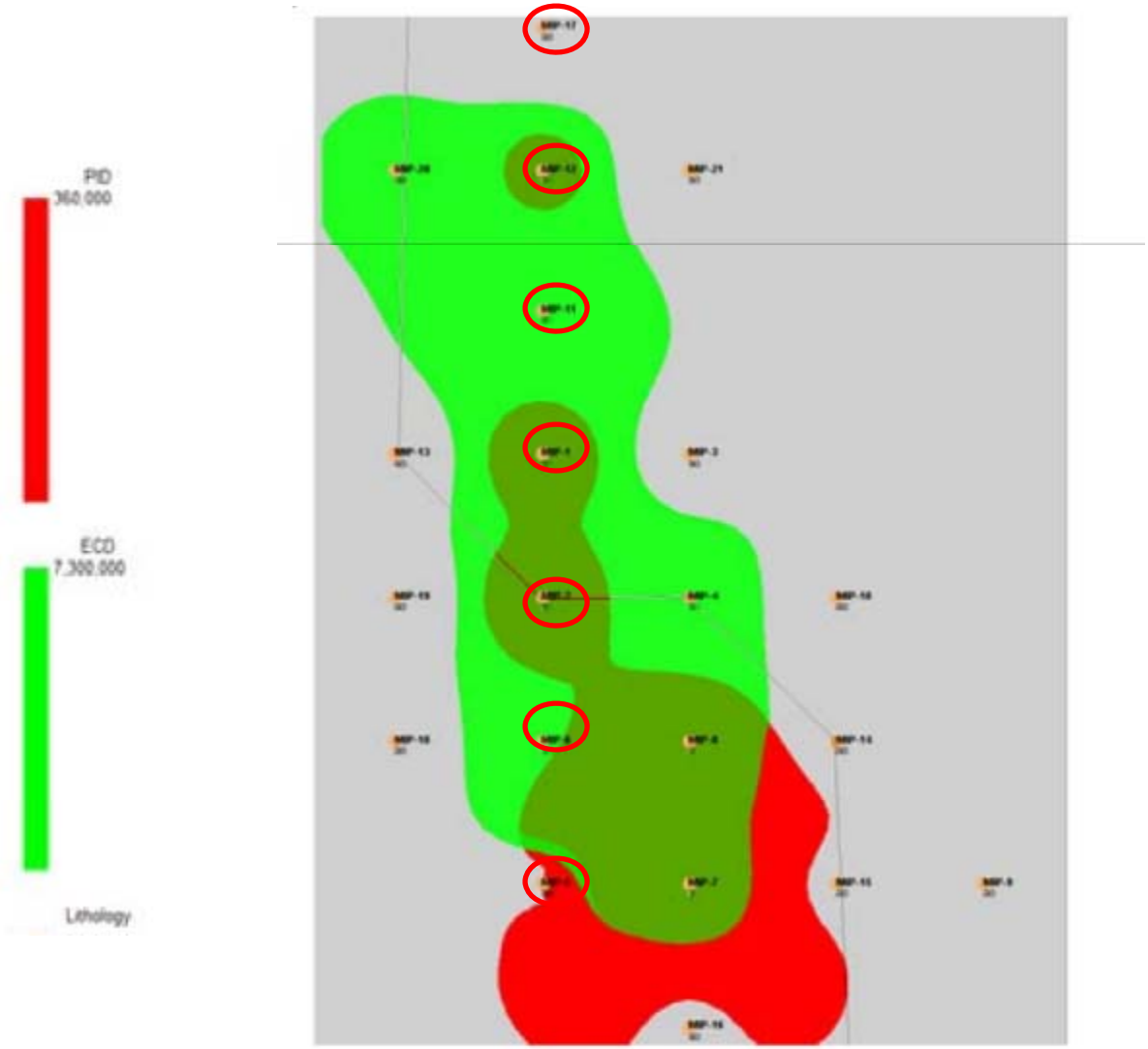
Conductivity Response



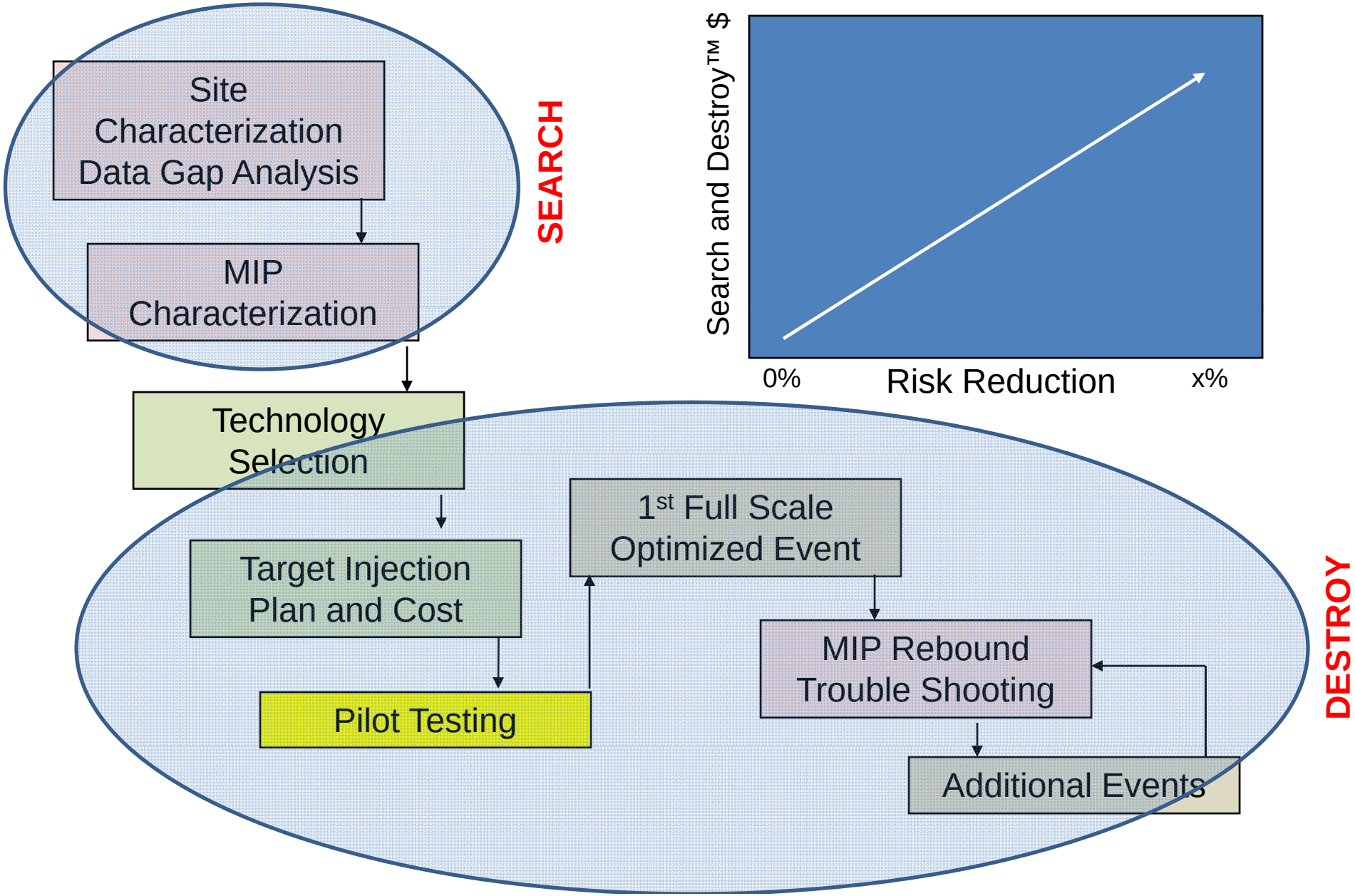
South East ECD Greater than 7.6+E6, PID Greater than 3.6+E5



Top View ECD Greater than 7.6+E6, PID Greater than 3.6+E5

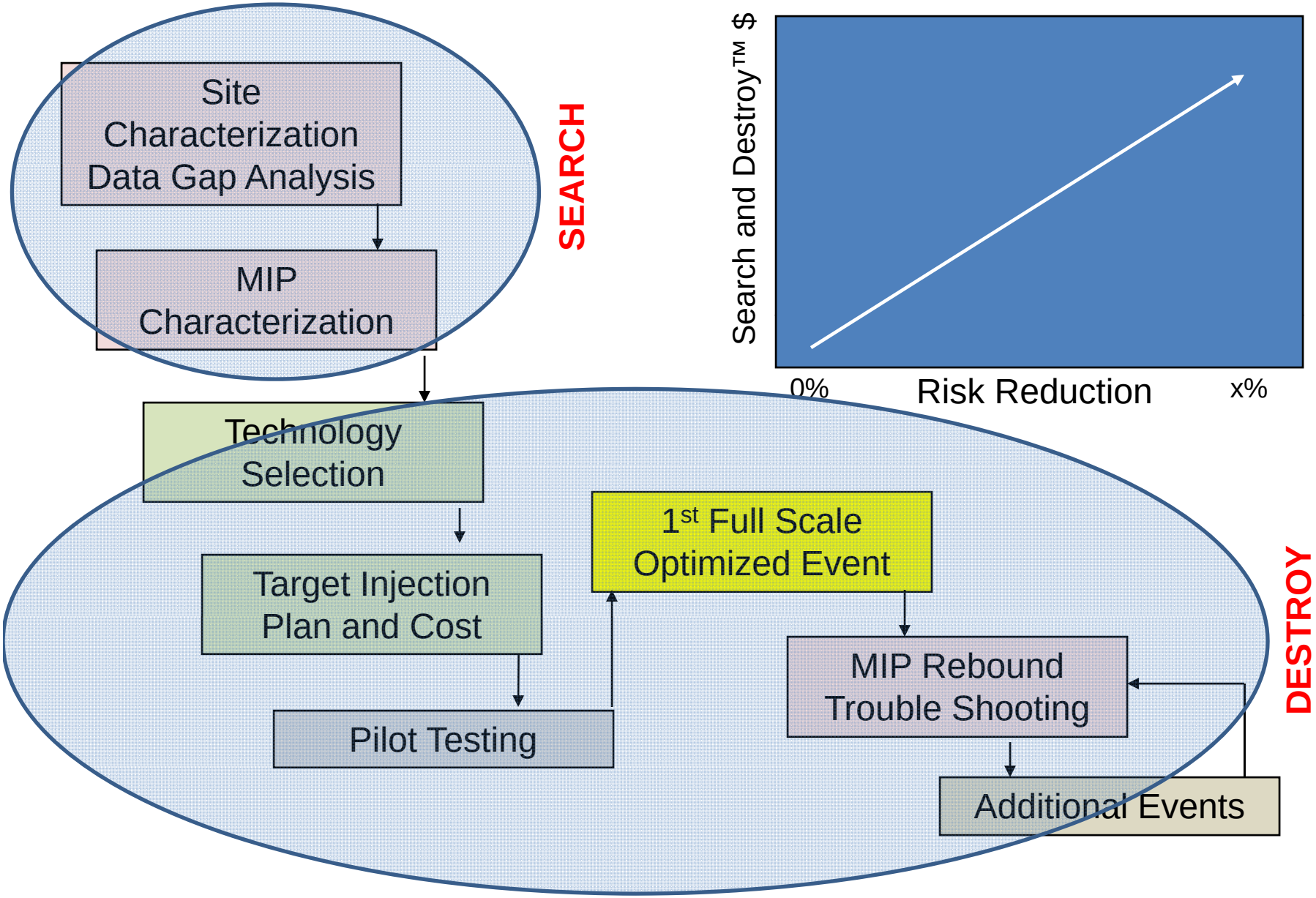


Search and Destroy™ Stages



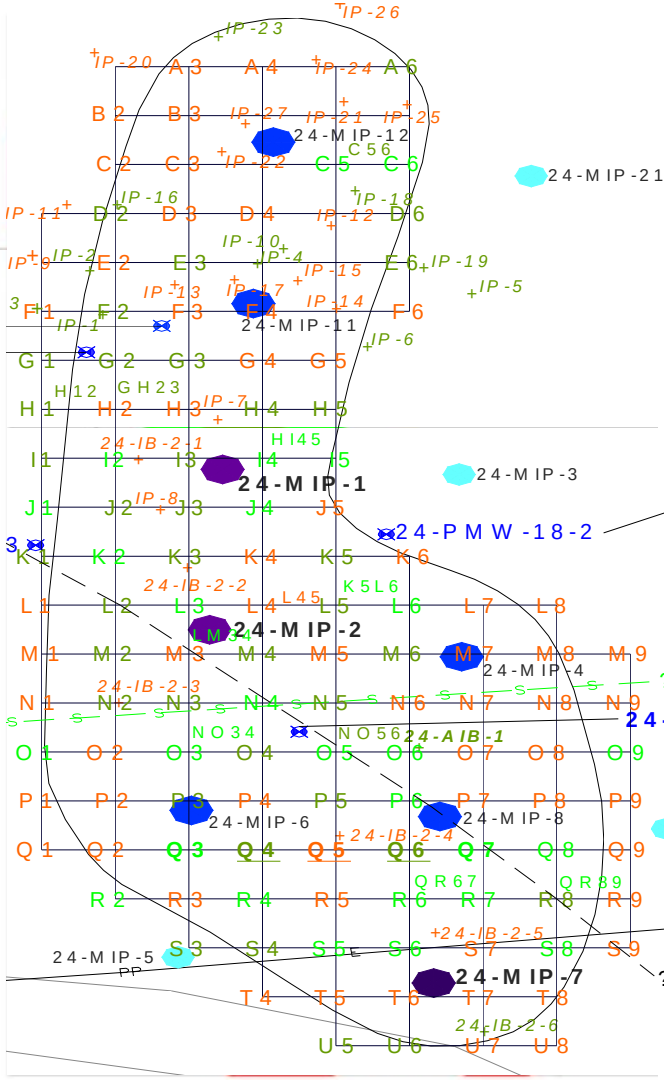
Pilot Testing

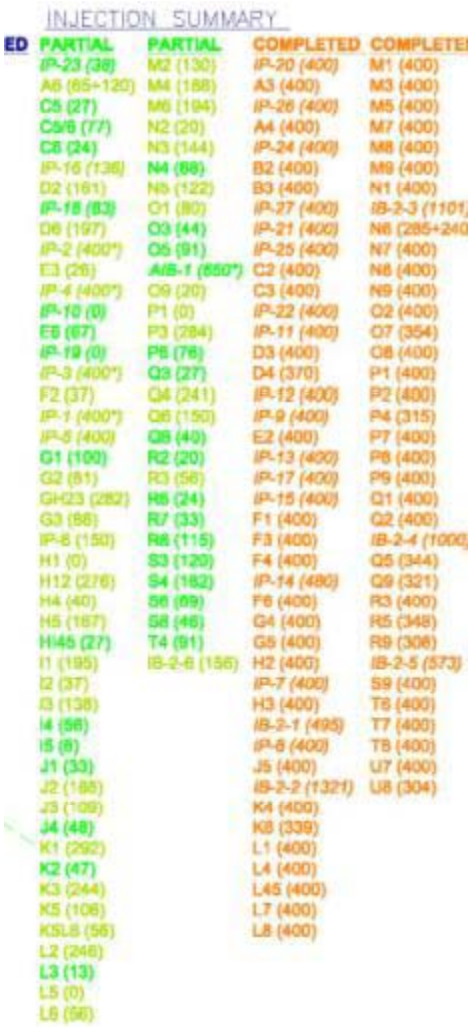
Search and Destroy™ Stages



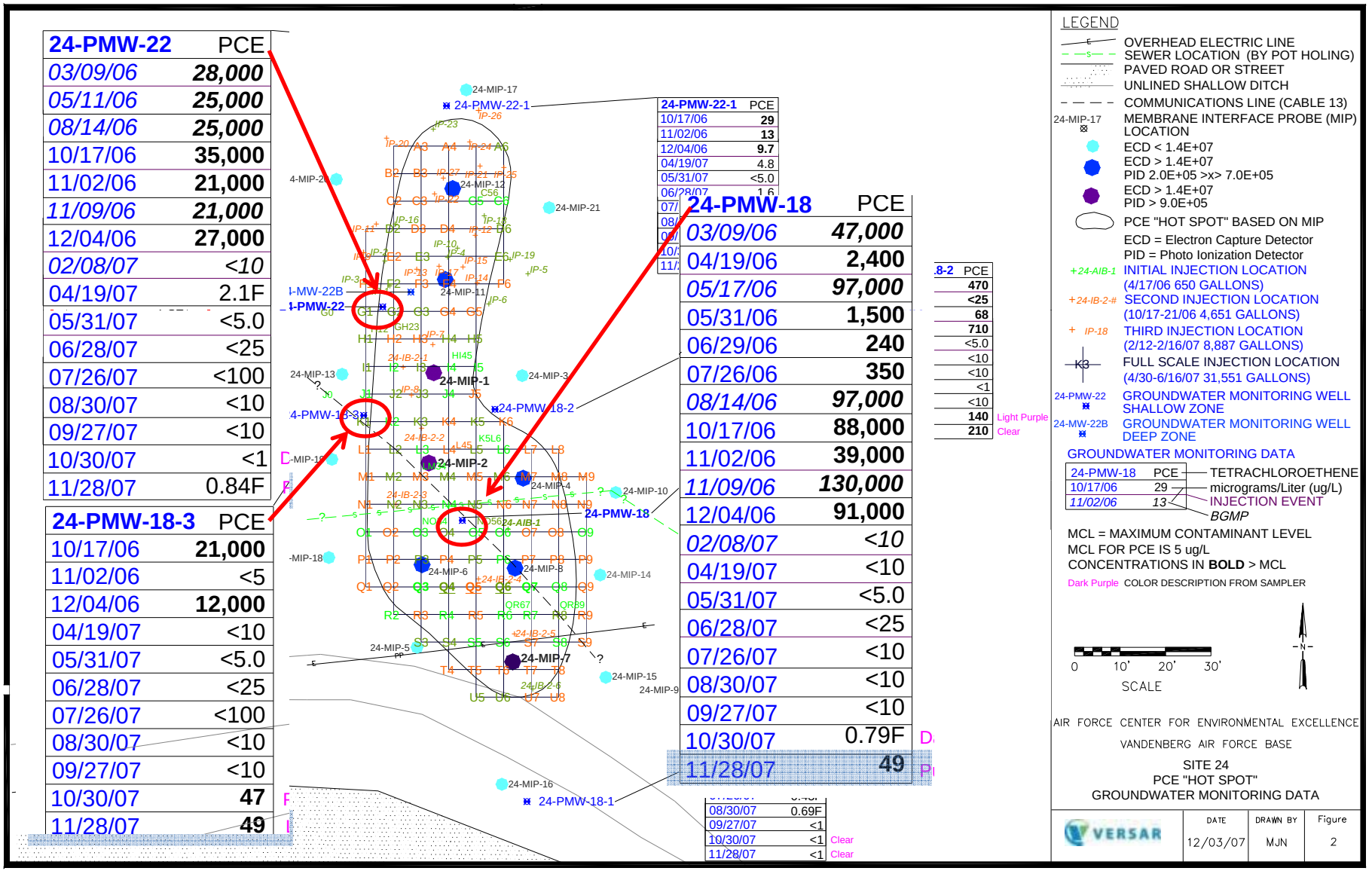
Destroy Full Scale Injection

Injection Data:
02/12/07 (pilot) 8,887 gals
04/30-06/04/07 (full scale – 28,334 gals
3% $KMnO_4$





Post Injection Results



Search and Destroy™ In Practice

- MWH – Denver, CO MIP/Pmag/TCE
- ADEQ - Holbrook AZ MIP/Persulfate / BTEX, DCA
- Mactec – Lowry AFB,CO MIP/Persulfate/ Carbon Tet
- Malcolm Pirnie – Kauffman Minteer Superfund, NJ MIP/Pmag/TCE
- URS – Dover AFB,DE MIP/EVO/TCE
- Tetra Tech – Denver, CO MIP/Pmag/TCE
- Battelle, North Island NAS MIP/Soybean Oil/TCE
- Arcadis, Sarasota FL – MIP/Persulfate / TCE


Questions
Mike Mazzarese
410-504-2546
mmazzarese@vironex.com