Large Dilute Plumes: Use of Molecular Tools for reaching acceptable end states

HOPE LEE

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Definitions

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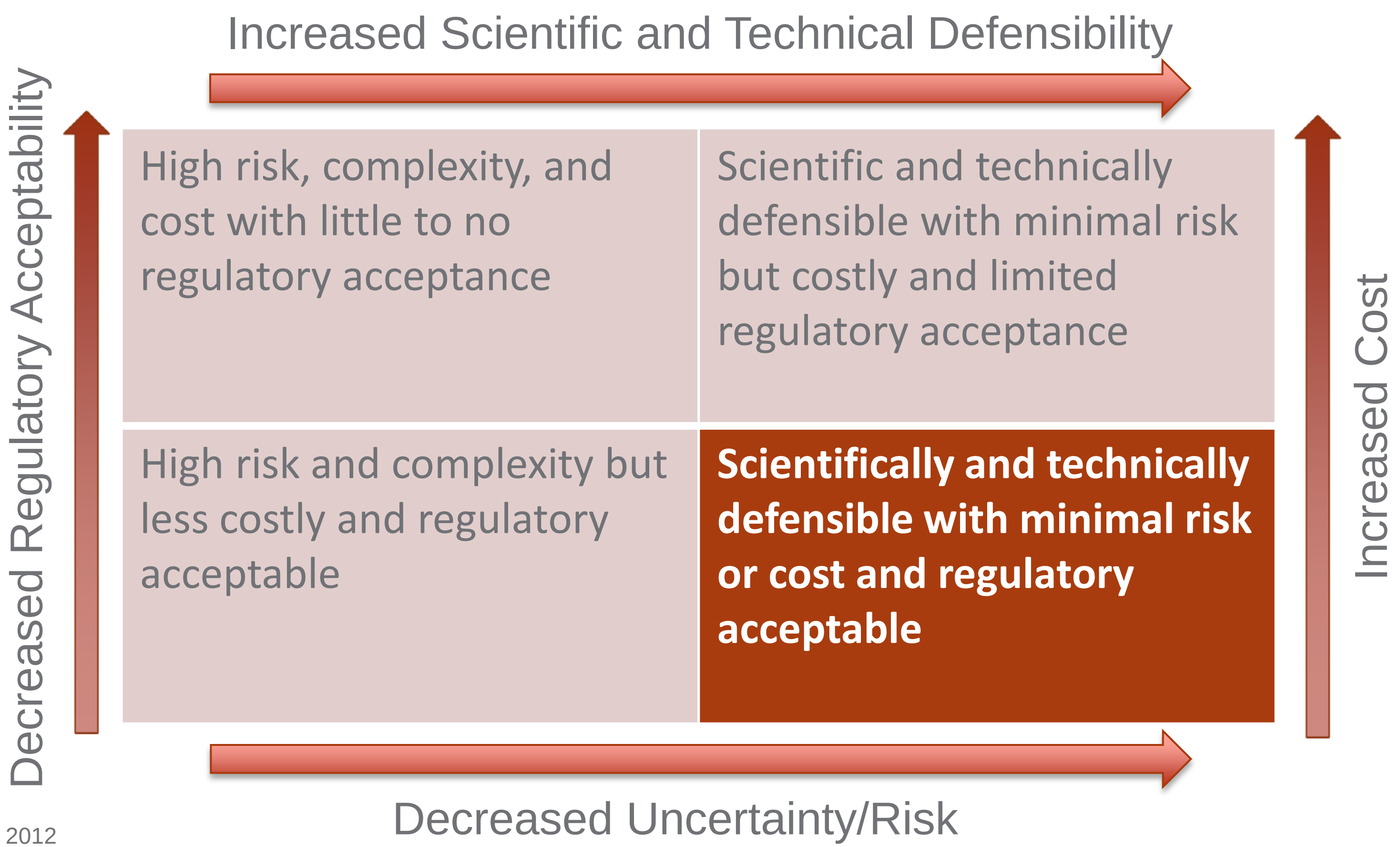
End States – final remedial goals that are permitted by regulations and are protective of human health and the environment

Risk-based – decision process based on analysis of the potential of a contaminant to cause immediate and long-term harm to a receptor resulting from exposure and the likelihood of occurrence

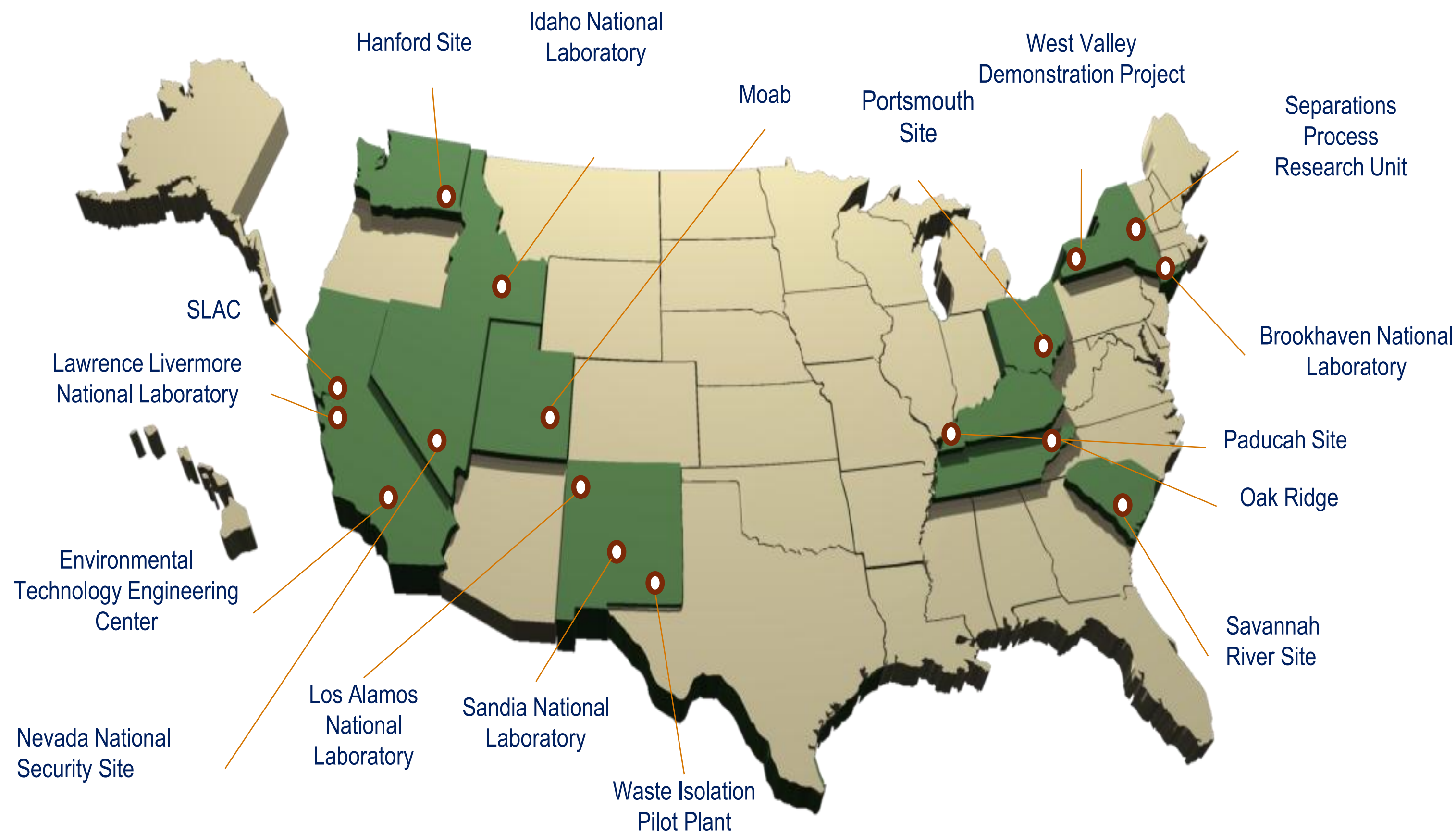
Scientifically based/ technically defensible – systematic, objective understanding of a problem based on, objective approaches and independently reproducible results that provide a sound understanding and justification for decision making.

What is an acceptable End State?

- Tradeoffs must be carefully considered among the competing influences of cost, scientific defensibility, and the amount of acceptable uncertainty in meeting remediation decision objectives



U.S. DOE Environmental Management Sites



- **Remediating ~ 1,800 million m^3 of contaminated groundwater**
- **75 million m^3 of contaminated soil**

What are EMs primary contaminants?

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Site	Metals & Rads	Organics	Fuels	Other
Hanford	Strontium, Chromium, Uranium, Technetium, Iodine	Carbon Tetrachloride, TCE, Cis-1,2-DCE	Diesel	Tritium, Sulfate, Nitrate
Savannah River	Strontium, Uranium, Lead, Iodine, Technetium, Cadmium, Mercury	PCE, TCE, DCE, VC, Carbon Tetrachloride		Tritium
Oak Ridge	Mercury, Technetium, Cadmium, Chromium, Uranium, Strontium, Cobalt	DCE, TCE, VC, PCE		Nitrate, Tritium
Paducah	Technetium	TCE		
Portsmouth	Technetium	TCE		
West Valley	Strontium, Cesium			Tritium
Moab	Uranium			Ammonia
Los Alamos	Chromium			Nitrate, Tritium, Explosives, Perchlorate
Idaho	Chromium, Strontium, Technetium, Iodine, Cesium	Carbon tetrachloride, TCE, PCE, DCE		Nitrate
Sandia	Chromium	Chloroform, Carbon Tetrachloride, TCE	Diesel	Explosives, Nitrate, Perchlorate

EM goals for subsurface …

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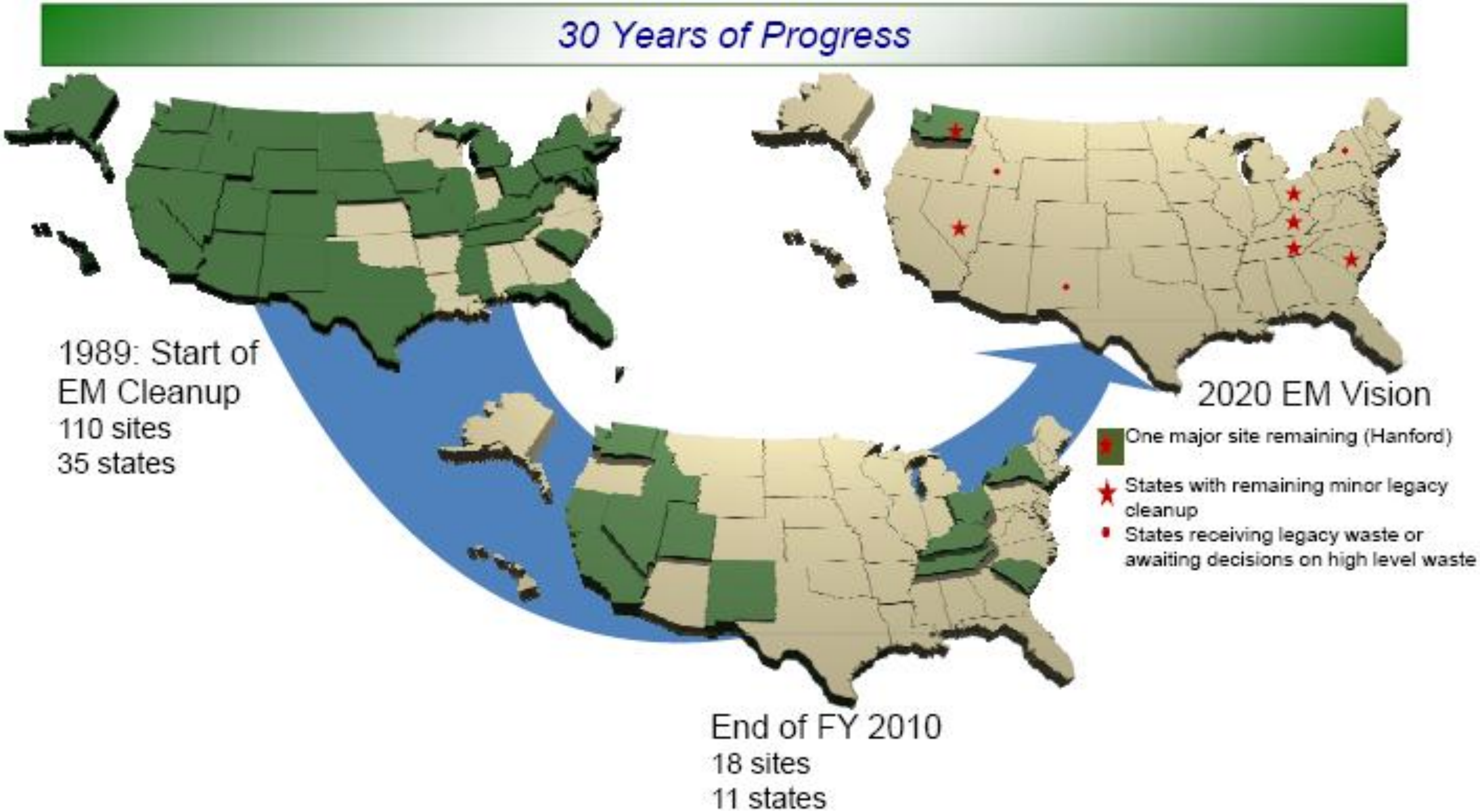

- **Reduce the life-cycle costs and accelerate the cleanup of the Cold War environmental legacy**
- **Reduce the EM legacy footprint by 40 percent by the end of 2011, leading to approximately 90 percent reduction by 2015**

How do we achieve these goals?

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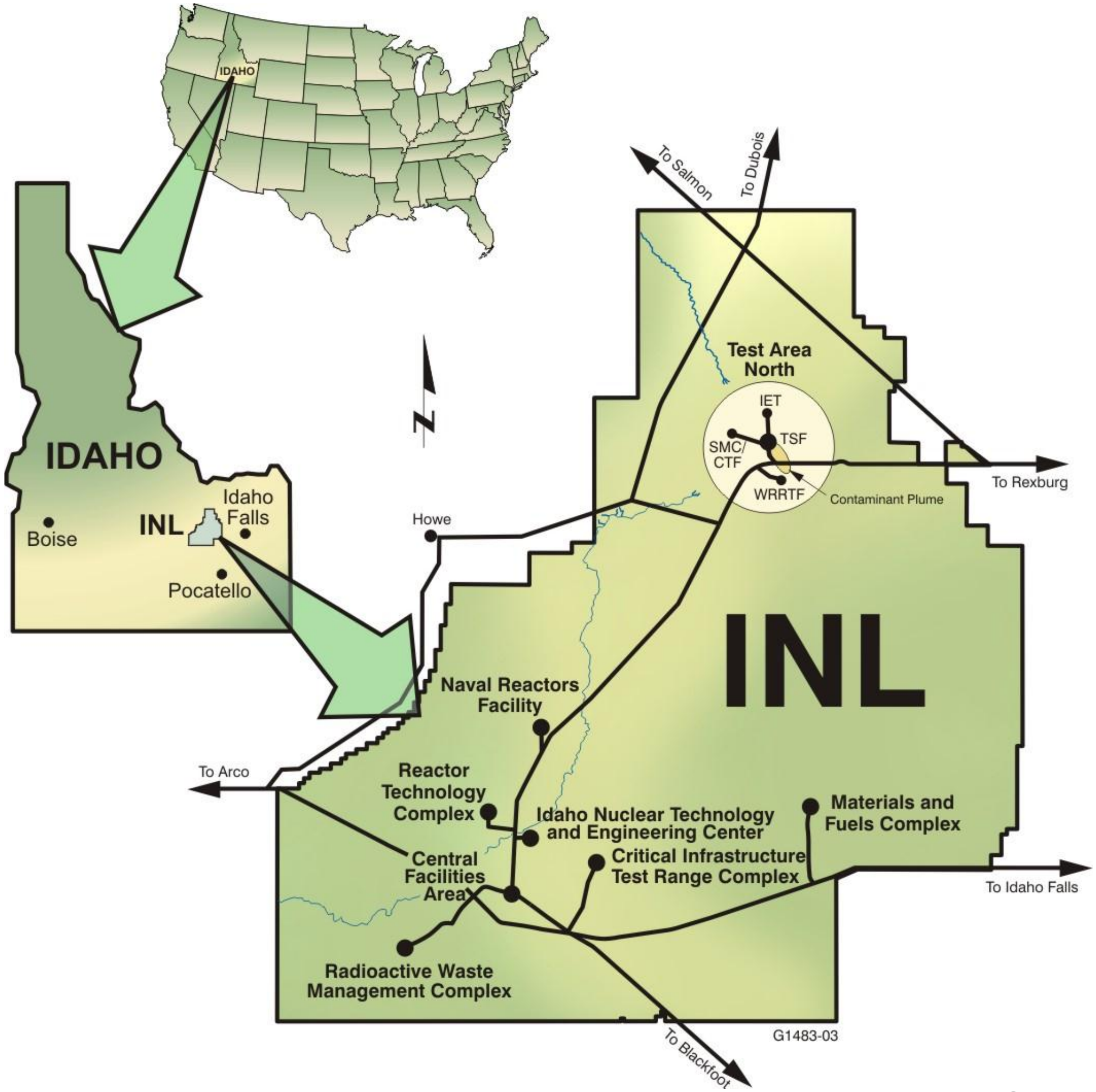
DoD ALSO has set ambitious goals…

Air Force:
90% of BRAC sites "achieve accelerated site completion" by 2015.
DoD:
95% of IRP and MMRP sites achieve Remedy Complete by 2021.

- **What has been done at other sites**
- **Interagency collaboration**
- **Lessons Learned**
- **Technology/expertise transfer**
- **Regulatory and stakeholder engagement**
- **Risk-informed understanding and defensibility**
- **Robust long-term management of residual contamination**

Test Area North

- Direct injection of industrial wastewater into the aquifer from 1953-1972.
- Primary contaminant of concern is TCE.
- TCE plume is nearly 2 miles long.
- Contaminated aquifer is 200-400 ft deep.
- Aquifer is comprised of fractured basalt.



History of Decisions

1995 Record of Decision

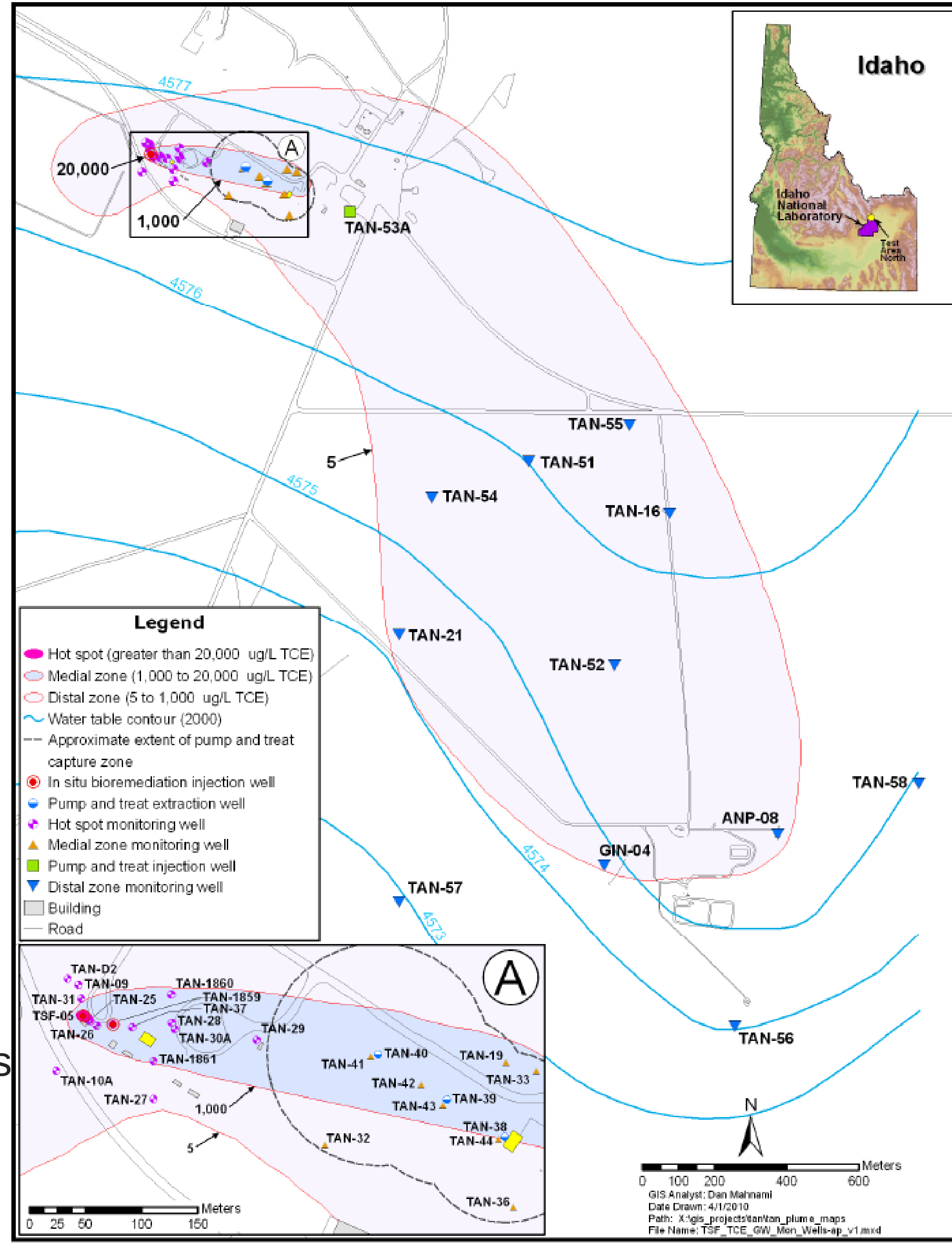
- Pump and treat default remedy
- Alternative technology evaluations
- 100 year restoration timeframe (2095) established

1997 Explanation of Significant Differences

- Defined three plume zones
- Performed alternative technology evaluations

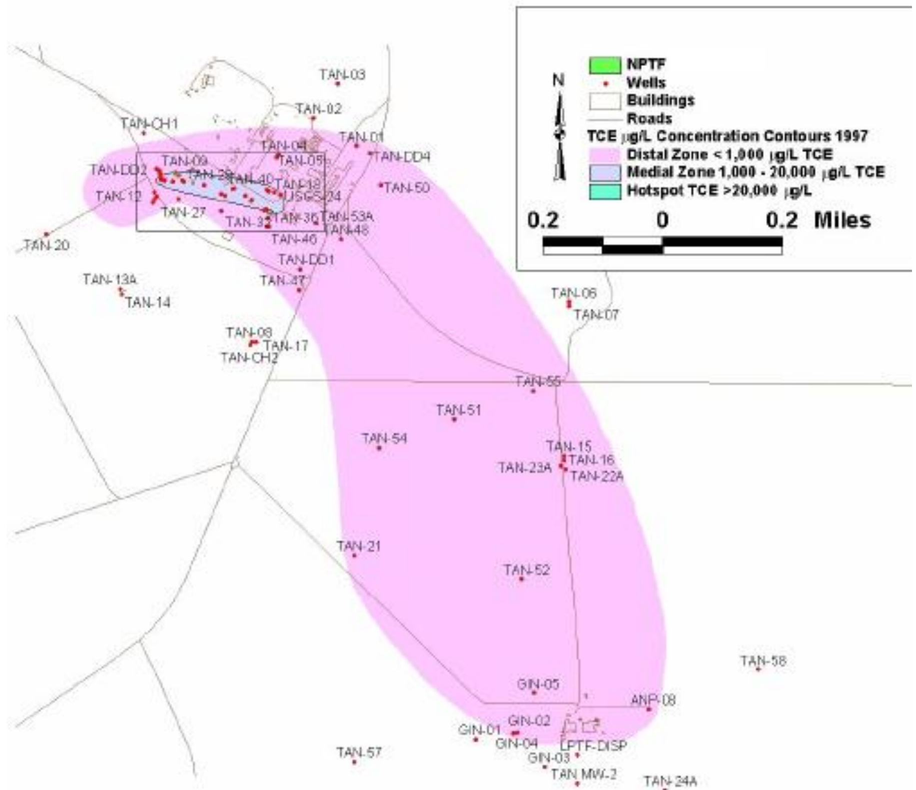
2001 ROD Amendment

- Identified alternative remedies for two of the three plume zones



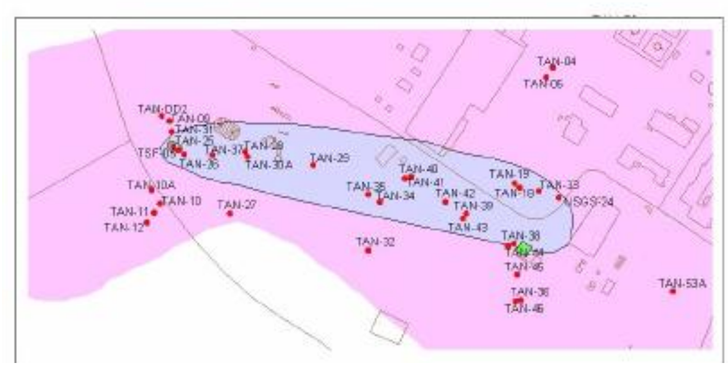
Three component strategy

- Source Area > 10,000 µg/L: In situ bioremediation
- Medial Zone > 1000 µg/L: Pump and Treat
- Distal Zone < 1000 µg/L: Monitored Natural Attenuation



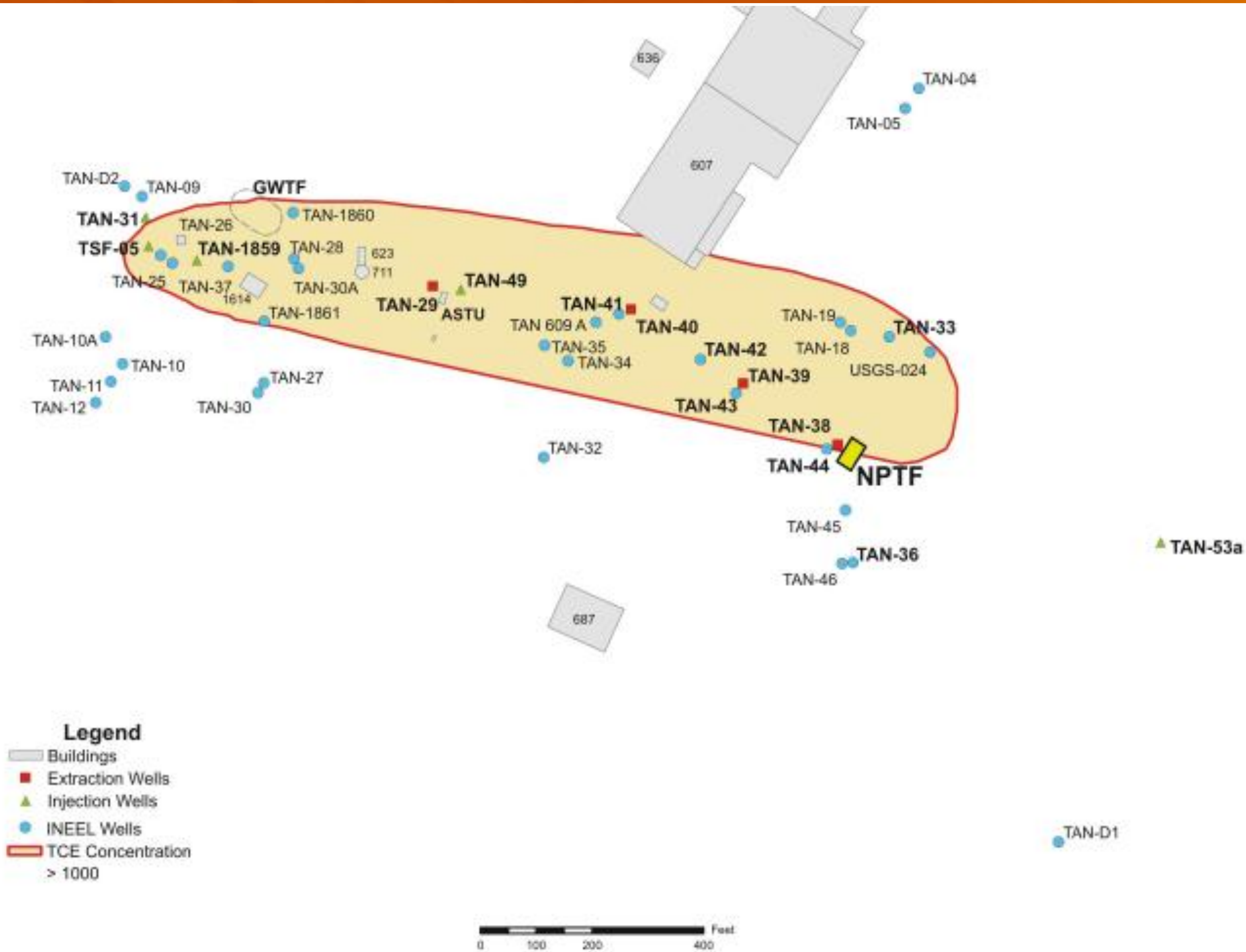
Source Area:

- Removal of Sludge
- Injections of Lactate
- Injections of Whey Powder

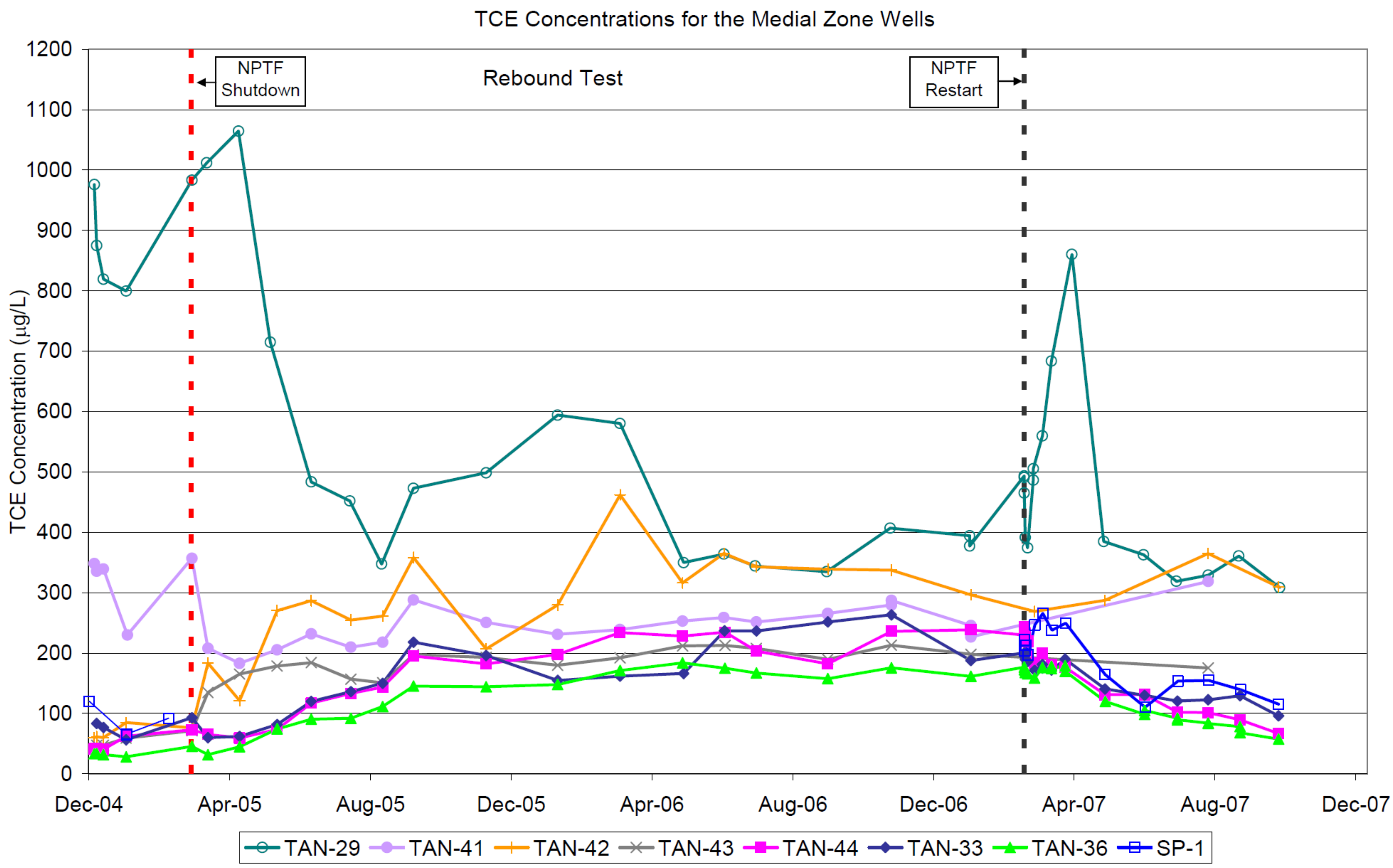


Performance based optimizations of ARD and injection strategies

Medial Zone


636
607
TAN-04
TAN-05
TAN-D2
TAN-09
GWTF
TAN-31
TAN-26
TAN-1860
TSF-05
TAN-1859
TAN-28
623
711
TAN-25
TAN-37
1614
TAN-30A
TAN-49
TAN-29
ASTU
TAN-1861
TAN-41
TAN 609 A
TAN-40
TAN-19
TAN-33
TAN-10A
TAN-35
TAN-34
TAN-42
TAN-18
USGS-024
TAN-10
TAN-11
TAN-12
TAN-27
TAN-30
TAN-39
TAN-43
TAN-38
TAN-32
TAN-44
NPTF
TAN-45
TAN-53a
TAN-36
TAN-46
687
Legend
Buildings
Extraction Wells
Injection Wells
INEEL Wells
TCE Concentration
> 1000
TAN-D1
0
100
200
400
Feet

NPTF rebound data



NPTF Optimization Summary

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Construction
Mar 2000

Full-Time Operations
Oct 2001

Rebound Test
Mar 2005

Pulse-Pumping Ops
Restart
Mar 2007

Standby
Nov 2007

Pulse pumping
2008-2010

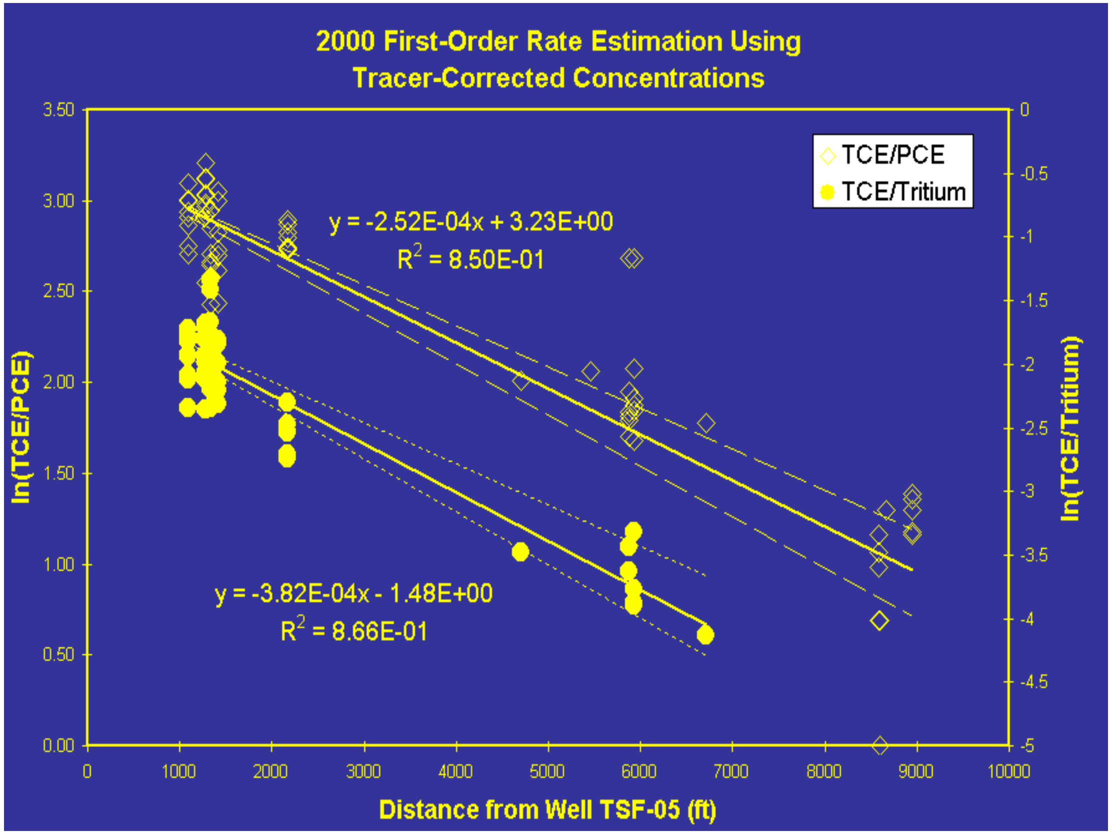
Cold
March 2012

Natural Attenuation : Distal Plume

- TCE concentrations decrease with distance from the source area in relation to PCE and tritium with a half-life of 9-21 years.

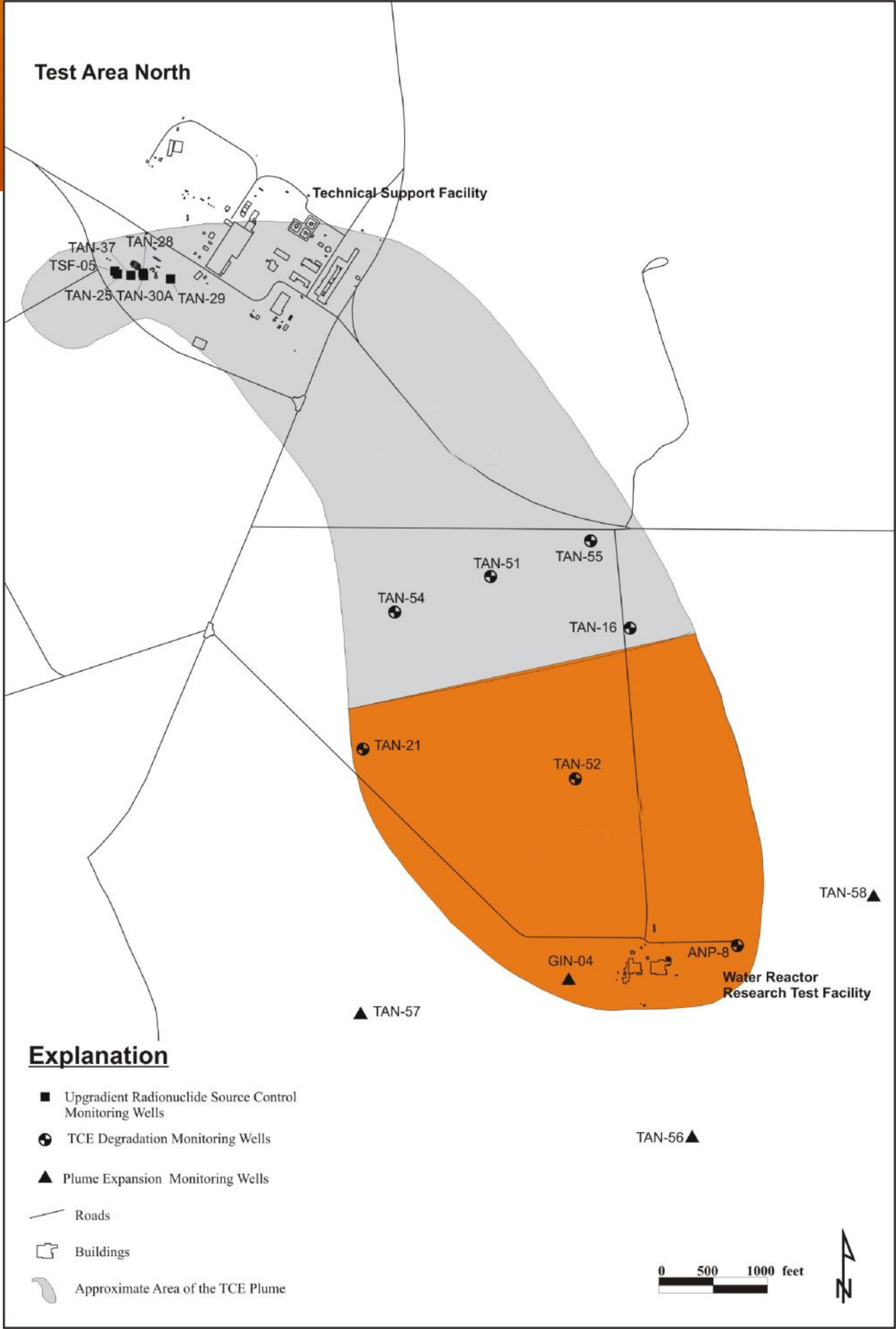
- A numerical model generates a plume that more closely matches field data when the model incorporates a TCE degradation term.

- Laboratory studies have shown that organisms capable of aerobic cometabolic oxidation of TCE are native to TAN.



Plume Stability

- Plume was stable (although changing) 1997-2009
- 2010 - concentrations in MW at leading edge of plume showed decreasing trend
- 2011 - plume is shrinking (shown by MW data < MCLs at leading edge of plume)



End States at TAN

Holistic Systems Based Approach

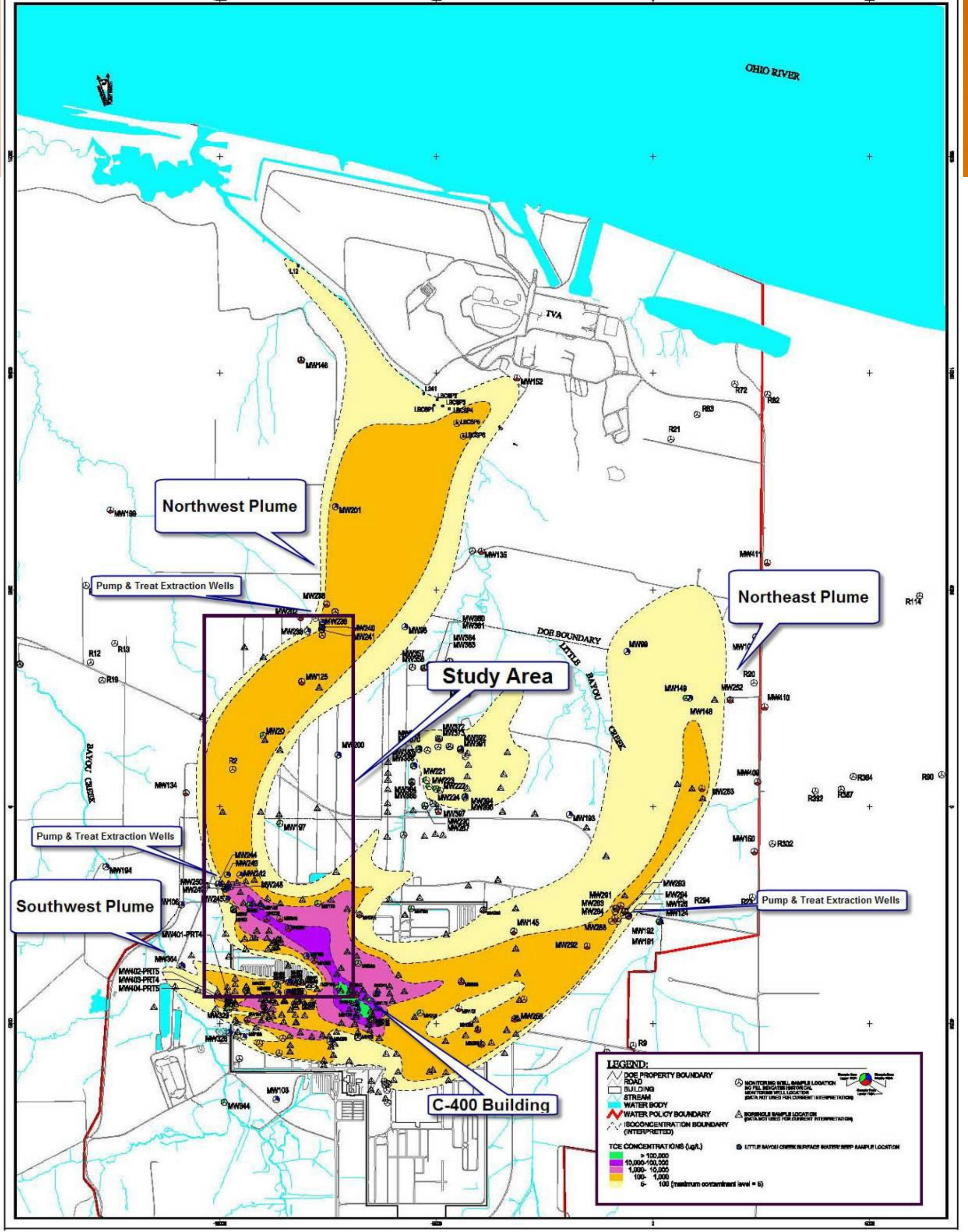
Interagency Project team consisted of EPA, DOE, IDEQ, and public

Scientifically defensible strategy - reevaluated when new technologies or approaches were applicable and available (mass flux, revise SCM, molecular tools)

Optimized strategies throughout plume ($$ and performance)
e.g. PNT rebound study and shut down (estimated cost savings of 3 component strategy 8 million over PNT for lifetime of plume)

Monitoring program modified (reduced) on year to year basis based on defensible data (concentration, risk)

Paducah Gaseous Diffusion Plant



Source Area Remedy & Results

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ROD for an interim action was signed in August 2005: *C-400 Cleaning Building at the Paducah Gaseous Diffusion Plant,* elected **electrical resistance heating** (ERH) to address the source area comprised of VOCs

- March-December 2010
- Upper aquifer < 70 ft was heated to target temperatures
- Groundwater concentrations in the SW decreased from average 38,000 µg/L to 315 µg/L (99%); East 123,000 to 29,000 µg/L (76%)
- Soil TCE concentrations were reduced by an average of 99% SW and 95% in East

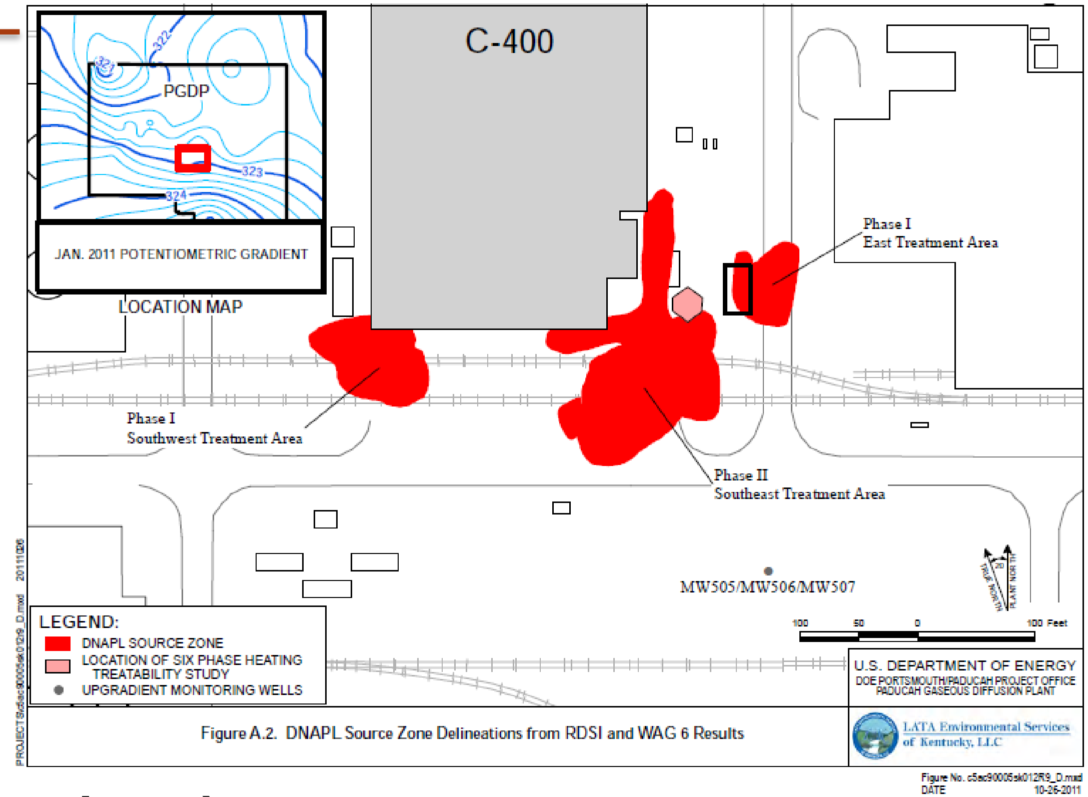


Figure A.2. DNAPL Source Zone Delineations from RDSI and WAG 6 Results

2012 -

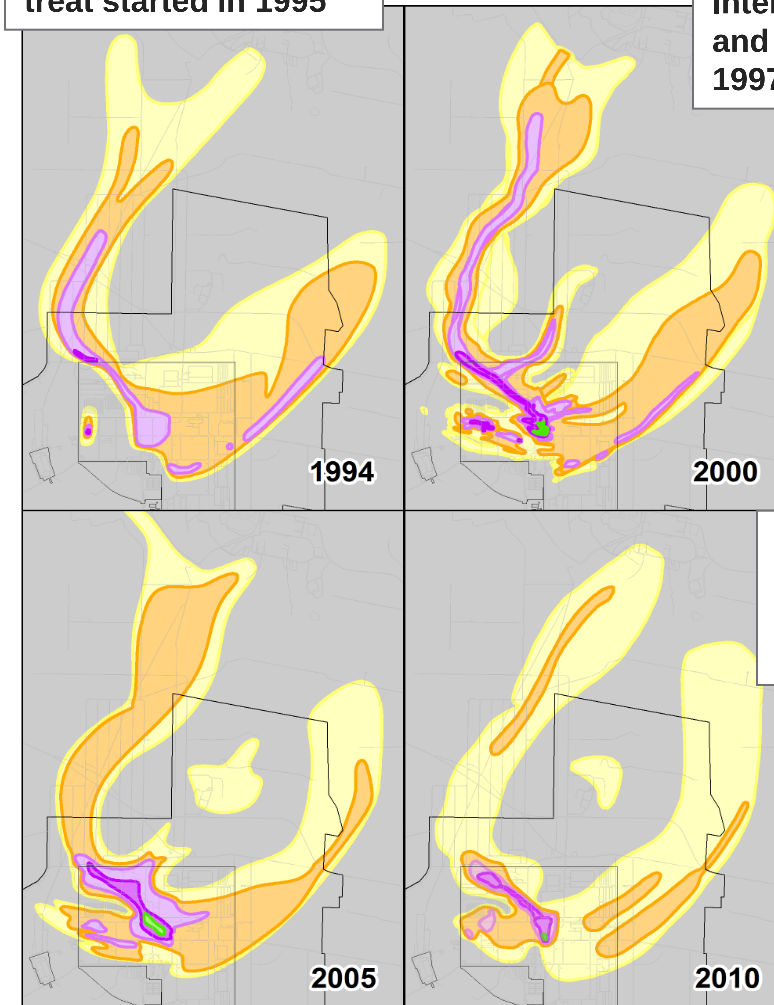
- **Lessons Learned (heating, removal, etc.)**
- **Remedial alternatives ISCO, ERH steam**
- **MW data and revised site Conceptual Model**

Remedial Action Summary

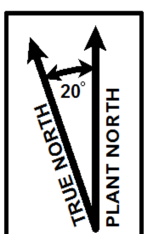
- Interim Actions intended to intercept dissolved-phase mass greater than 1,000 µg/L
  - 2000 Plume Mass
    - Approx. Mass = 85,000 lbs
  - 2005 Plume Mass
    - Approx. Mass = 87,000 lbs
  - 2010 Plume Mass
    - Approx. Mass = 27,000 lbs
- Dissolved-phase mass removed via pump and treat = 35,000 lbs
- Source-based mass removed via interim actions/treatability studies = 33,000 lbs

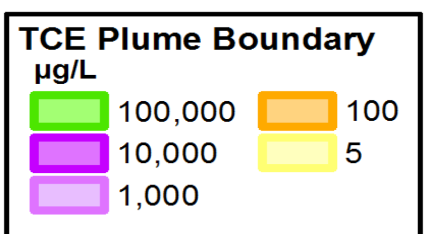
NW Plume Interim Action pump and treat started in 1995

Northeast Plume Interim Action pump and treat started in 1997



Optimization of Northwest Plume system - August 2010





Paducah: MNA

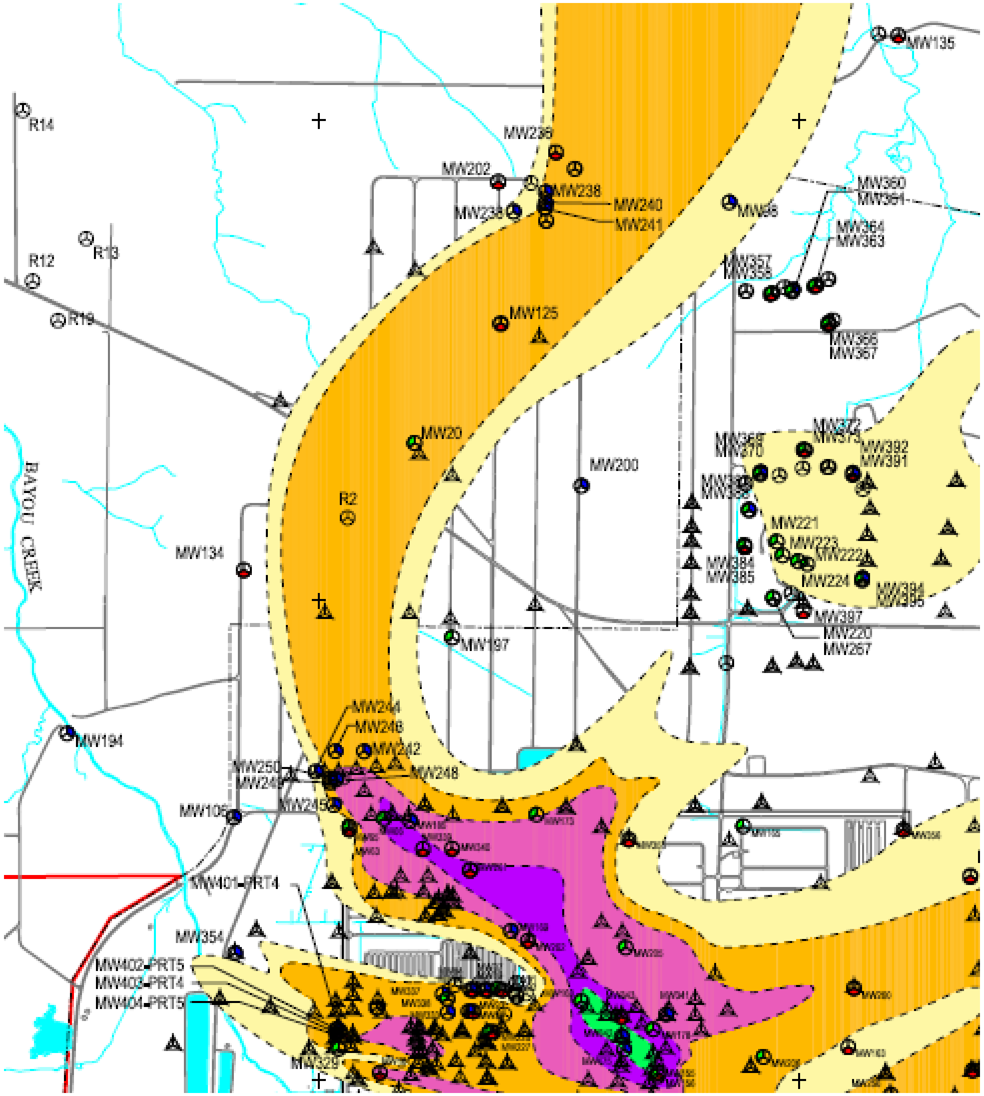
Lines of Evidence:

First-order degradation rate calculations indicate that TCE is being attenuated along NWP flowpaths at a rate faster than its co-contaminant 99Tc.

Molecular analyses provide evidence that microbes capable of cometabolism of TCE are present and actively in the aquifer.

Geochemical conditions suggest that organic carbon is available in the aquifer in sufficient concentrations to support the identified microbial populations.

SCIA well-pair data indicate aerobic co-metabolic degradation of TCE is occurring in the RGA within the study area.



End States at Paducah

Interagency Project Teams

Optimized Strategies:

- Revision of SCM
- Installation of suite of MWs to delineate sources
- Application of new technologies, new tools

Lessons Learned

- Target temperatures were not attained in middle and lower RGA
- The density of vapor extraction points should be increased
- The vapor treatment technology should be changed

Remedial Action Review

- Thermal, PNT performance and optimization (new wells)

Opportunities ….

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TAN

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