Portsmouth/Paducah Project Office

Paducah TCE Fate & Transport Project

Data Quality Objectives Process

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Presented by

Steve Hampson, Associate Director

Kentucky Research Consortium for Energy and the Environment

University of Kentucky

and

Hope Lee, North Wind Environmental

Background
PGDP Site & Plumes

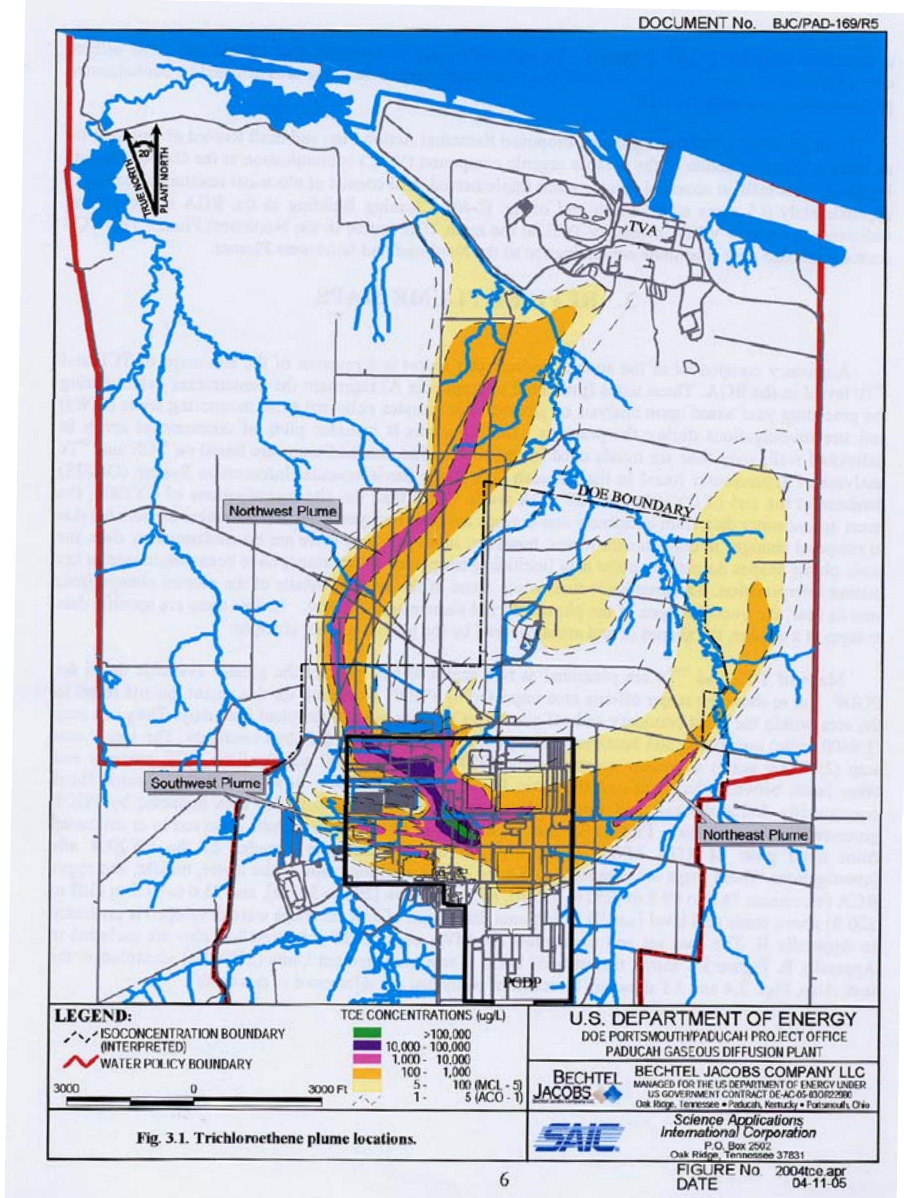


Fig. 3.1. Trichloroethene plume locations.

Background

Historical TCE Attenuation Activities/Information

- **PGDP Groundwater Flow & Transport Models**
  - MODFLOW & MODFLOWT
  - Development 1990 – 1999
  - Original models applied no degradation or "half-life" to TCE in aquifer
- ***Evaluation of Natural Attenuation Processes for TCE and Tc-99 in the Northwest and Northeast Plumes*** (Lockheed Martin Energy Systems,1997)
  - Evaluated RGA Geochemistry
  - Evaluated Biological and Abiotic Processes based on existing site monitoring data
  - Estimated TCE half-life range from 9.4 to 26.7 years
  - Applied TCE half-life of 26.7 years to sources and all dissolved phase plume concentrations in MODFLOW & MODFLOWT Models
- ***Chlorine Isotope Investigation of Natural Attenuation in an Aerobic Aquifer*** (Sturchio, Claussen, et.al.,1999)
  - Re-evaluation of parameters in Lockheed Martin Energy Systems,1997
- ***Groundwater Operable Unit Feasibility Study*** (DOE, 2001)
- ***Southwest Plume Site Investigation*** (DOE, 2004)
  - 1^{st} Order Decay Calculations revisited
  - Used ^{99}Tc to estimate TCE half-life range from 3.2 to 11.3 years in aerobic aquifer

Background

- Regulators and technical community concerned degradation rates for TCE attenuation/degradation developed thru 2005 not well supported
- Need for site to identify & quantify TCE Fate & Transport parameters in order to proceed with assessment of:
  - Long term environmental impacts
  - Long term risks
  - Remedial options
- KRCEE asked by DOE-Portsmouth/Paducah Project Office (PPPO) to assemble a Project Team to address TCE Fate and Transport
  - Project team started Summer 2006
  - Application of DQO Process
  - Degradation rate of TCE in the RGA is only one of several parameters affecting fate and transport being addressed

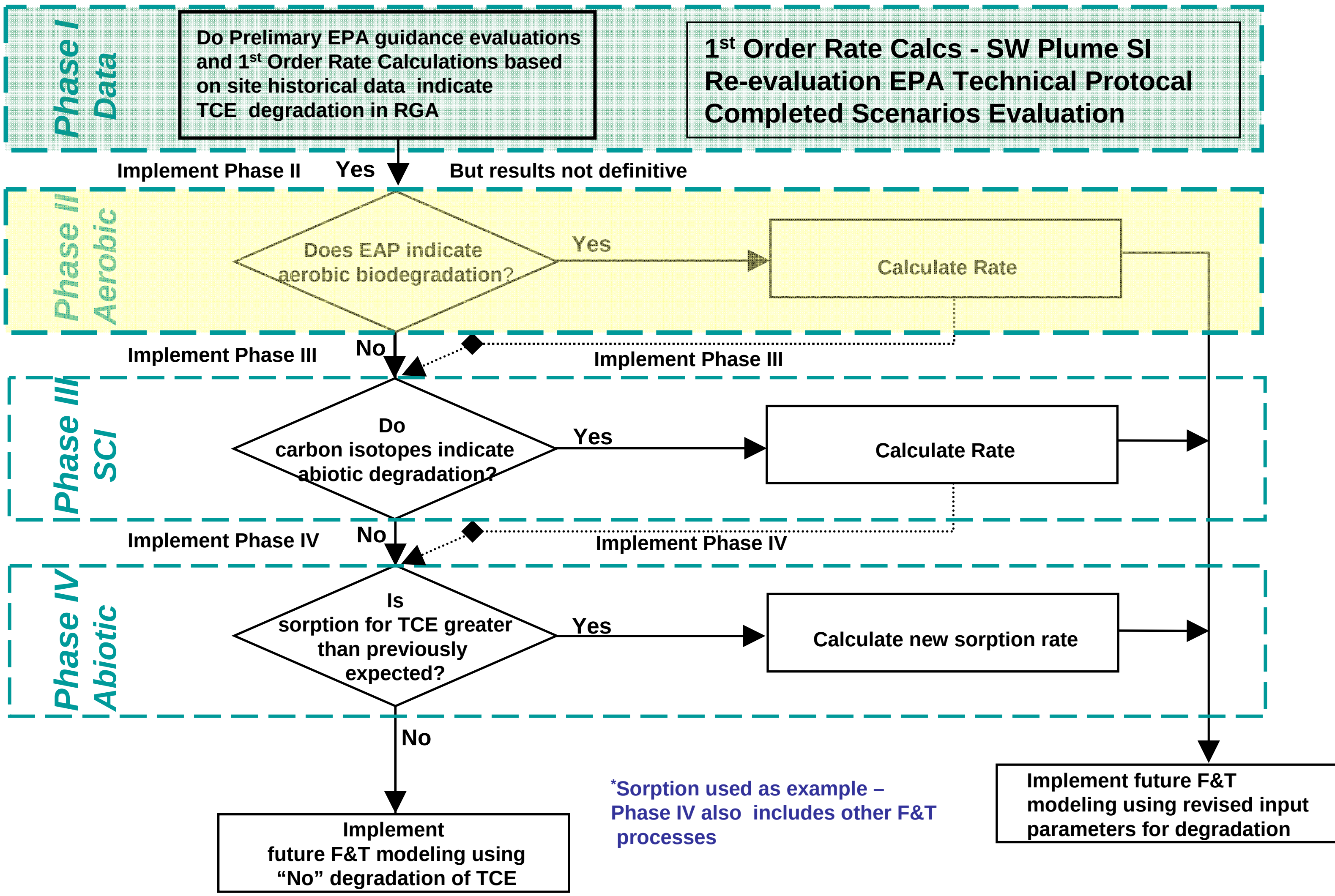
TCE Fate & Transport Project

PROJECT TEAM

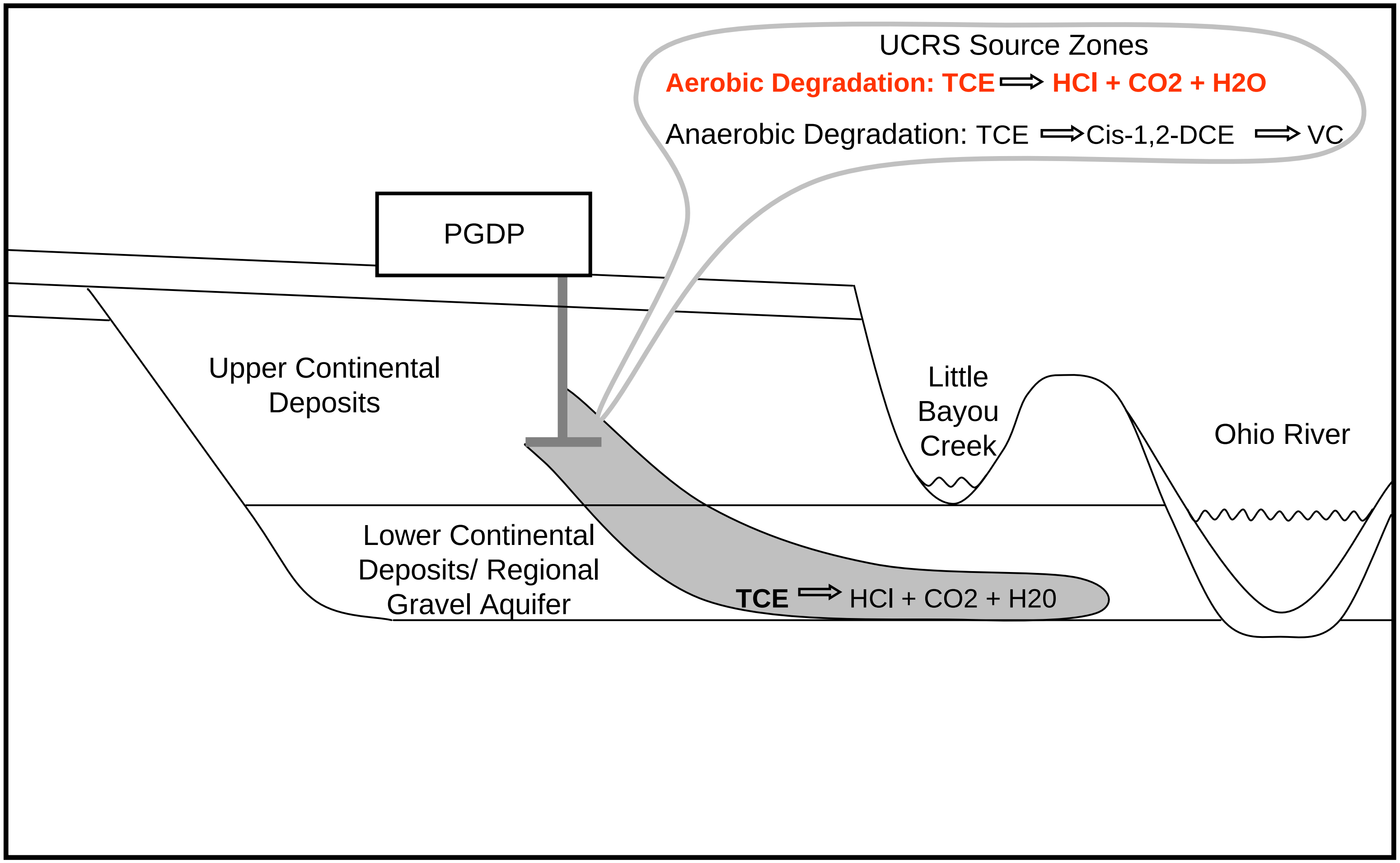
Organization	Representatives
DOE-PPPO	Rich Bonczek (PPPO Tech Lead) Dave Dollins (PGDP GWOU PM)
KRCEE	Steve Hampson, John Volpe
USEPA Region IV	David Williams
Kentucky Division of Waste Mgmt	Ed Winner, Todd Mullins
DOE-EM	Beth Moore
Savannah River National Laboratory	Brian Looney
North Wind Environmental	Hope Lee
Paducah Remediation Services	Bryan Clayton, Ken Davis
Navarro Engineering	Bruce Phillips, Tracey Fitzgerald

TCE Fate & Transport Project

4 Phased Project Approach



Background
GW Conceptual Model - Biodegradation



Trichloroethene Migration (Primary Source and Dissolved-Phase Plume)

Regional Gravel Aquifer: Aerobic Environment

TCE Fate & Transport Project
Phase I

Project Team Activities (Data Assessment/Research)

- ***Decision-Making Framework Guide for the Evaluation and Selection of Monitored Natural Attenuation Remedies at Department of Energy Sites***
- ***Assessing Aerobic Natural Attenuation of Trichloroethene at Four DOE Sites*** (Bob Starr et.al., 2005 WM '05 Conference)
  - Assessment of site conditions in RGA at PGDP
- ***Technical Protocol for Evaluating Natural Attenuation of Chlorinated Solvents in Ground Water***
  - Re-evaluation indicated that anaerobic TCE degradation processes not likely to be widespread in RGA
  - Recalculate 1st order rate constant (SW Plume SI)
- **Scenarios Evaluation (SRNL, 2006)**
  - Scenarios development
    - Assess site contaminant, physical, geochemical conditions
  - Scenarios evaluation
    - Identify likely degradation processes – Aerobic Cometabolism

TCE Fate & Transport Project
Phase II - Aerobic Degradation

Natural Attenuation

- Increasingly accepted as a remedial alternative for organic compounds in GW
- Relies on processes such as dispersion, dilution, and biological degradation to reduce contaminants
- Focus of most regulatory documents is anaerobic reductive dechlorination, however due to large size and aerobic conditions of many contaminated aquifers in DOE and DoD complexes, other biological mechanisms are receiving reater attention

Cometabolism

- Fortuitous degradation of a compound that is not the organisms primary energy-yielding substrate
- Reactions are catalyzed by microbial enzymes and yield no carbon or energy to the cells
- Chlorinated solvents can be oxidized by a wide range of oxygenases

There are few field sites where MNA has been evaluated or implemented where cometabolic or aerobic processes have been considered

TCE Fate & Transport Project
Phase II - Aerobic Degradation DQOs

Problem Statement
(Aerobic Biodegradation)

- The Paducah site has contaminated groundwater. The purpose of the proposed work is to demonstrate whether sustainable trichloroethene (TCE) biodegradation occurs within the RGA under aerobic aquifer conditions. Biodegradation needs to be characterized and assessed, and the resources necessary to evaluate this process need to be identified.

TCE Fate & Transport Project
Phase II - Aerobic Degradation DQOs

Range of Decision / Estimation Statements Developed

- **#1 Based on the use of "oxygenase" specific enzyme activity probes, determine whether bacteria capable of aerobically biodegrading TCE are present in the RGA.**

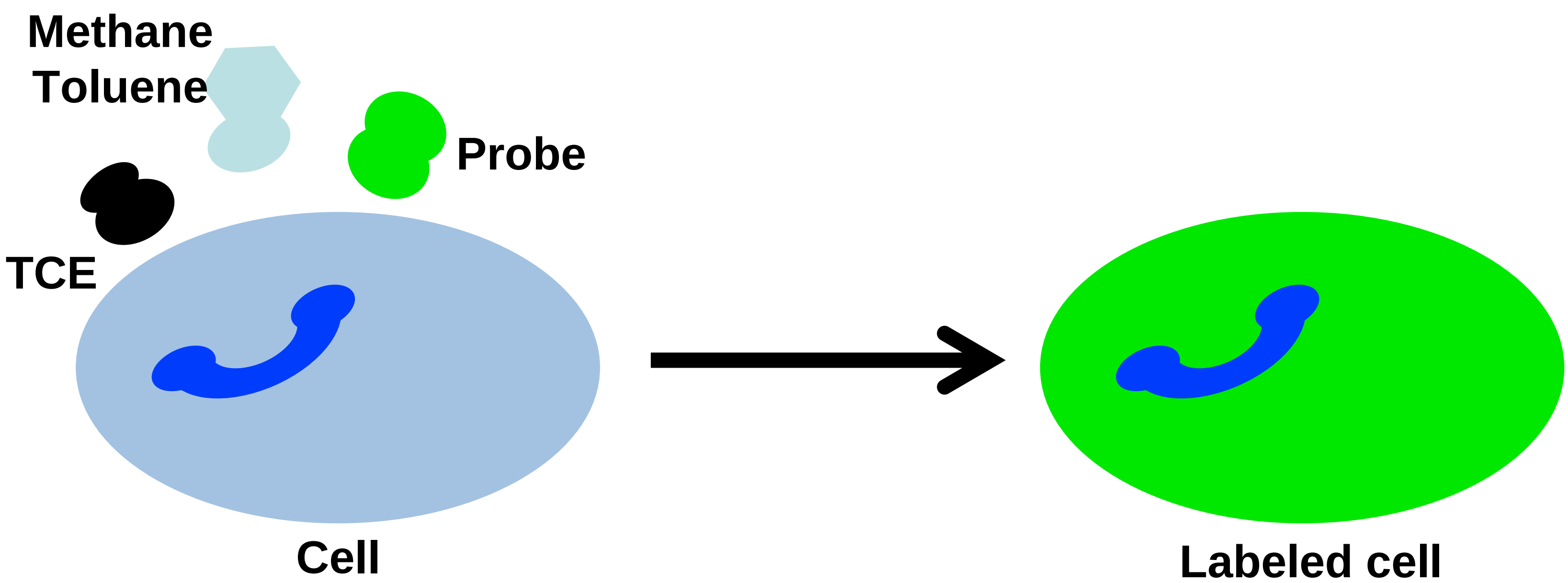
- **#2 Based on the use of stable carbon isotope (SCI) fractionation tests, determine whether SCI supports the occurrence of aerobic degradation and/or other biotic/abiotic degradation processes.**

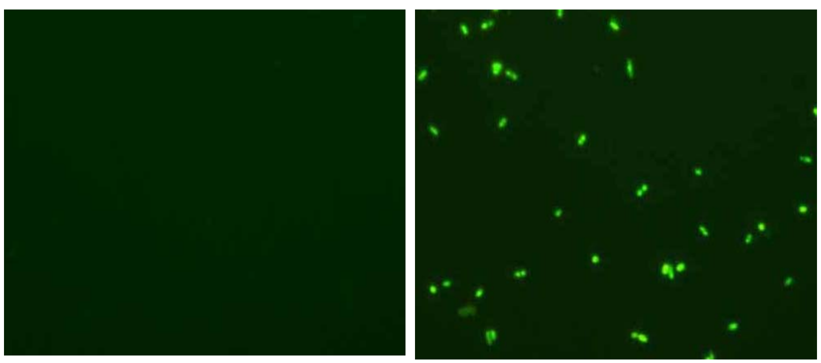
- **#3 Estimate whether the distribution and number of bacteria are sufficient to significantly biodegrade the plumes**

- **#4 Determine whether conditions (e.g., bioavailable and sustainable substrates) in the RGA are conducive for ongoing and sustainable aerobic biodegradation of TCE**

- **#5 Based upon a comparison of the calculated biodegradation rate, or rate range, to values in literature, either accept the calculated rate for future modeling or assess the team's confidence in the unsupported results**

What is an Enzyme Activity Probe?





- Alternate substrates for TCE enzymes
- Non-fluorescent substrate = fluorescent product
- Quantifiable product, direct evidence of activity
- Measure activity in situ

TCE Fate & Transport Project
Phase II – Aerobic Degradation DQOs

Decision Rules

- The bacterial cell count per well must be greater than 10^3/ml. If the cell count in any well is less than 10^3/ml, the well is considered to have no aerobic bacteria activity capable of TCE degradation.

- Greater than or equal to half (50%) of the wells in the plume must contain bacteria having an "oxygenase" enzyme capable of aerobically degrading TCE in order to conclude that aerobic processes are occurring throughout the plume.

- If greater than 50% of the EAP analyses indicate bacteria having an "oxygenase" enzyme capable of degrading TCE, then the spatial relationship between the monitoring wells with positive results will be examined to estimate the impact of biodegradation on the plume.

- If the 50% level is not reached, it will be assumed that aerobic bacteria are not appreciably contributing to degradation in the plume from which the samples were collected (does not mean that biodegradation is not occurring, but biodegradation alone is insignificant in **its** impact on the areal extent of the **plume).**

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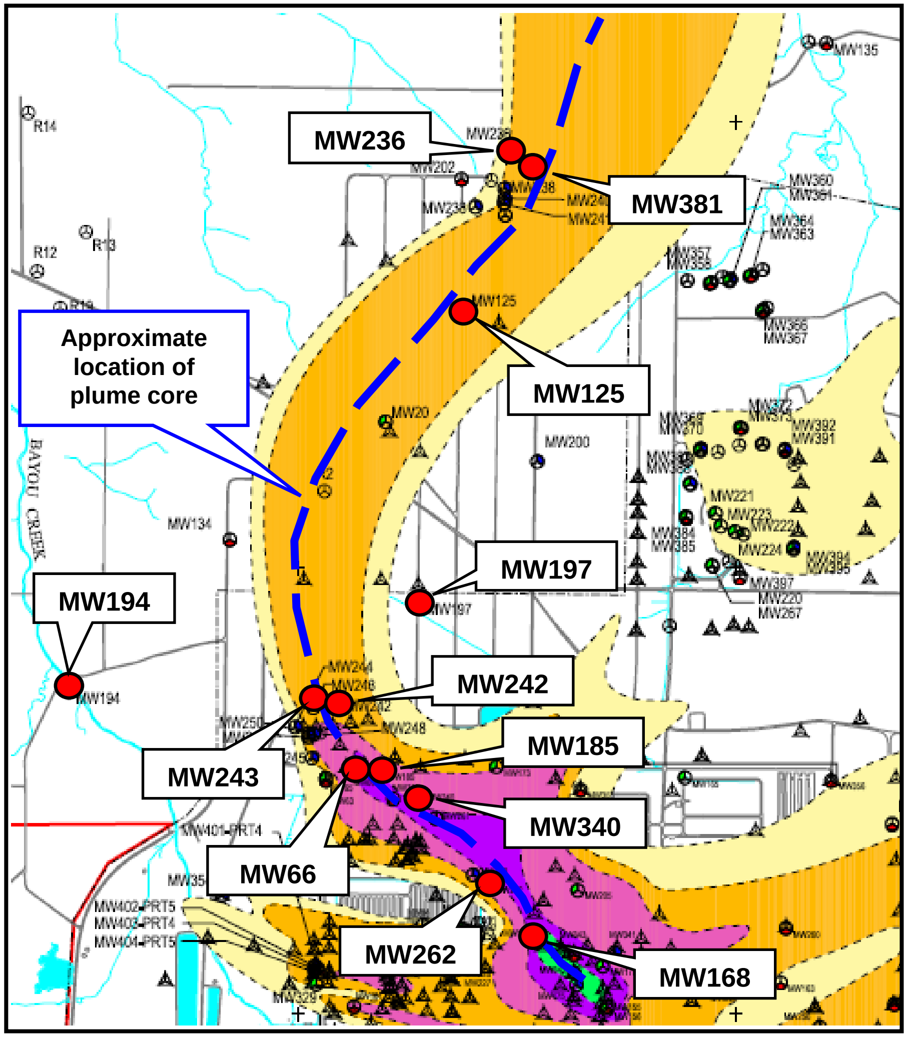
Phase II – Aerobic Degradation DQOs

Monitoring Wells Proposed for Sampling



TCE Fate & Transport Project
Phase II – Aerobic Degradation DQOs

Activities Schedule

- ***<u>Phase II - Aerobic Degradation Investigation</u>***
  - **Collect samples (May - June)**
  - **Run analyses (May - September)**
    - **Preliminary information on presence (June - September)**
    - **Microcosm study (August - September)**
  - **Reporting (October - December)**
- ***<u>Phase III - Stable Carbon Isotope Evaluation</u>***
  - **Finalize DQOs and Scoping (May - June)**
  - **Sample collection (May – June)**
- ***<u>Phase IV – Abiotic Degradation Evaluation</u>***
  - **Finalize DQOs and Scoping (May - June)**
  - **Conduct project activities (Planning)**
  - **Complete Abiotic Degradation Evaluation (Planning)**

Contact Information

- Steve Hampson, Associate Director
  University of Kentucky - KRCEE
  (859) 533-0633; Steve.Hampson@ky.gov

- Brian Looney, Ph.D.
  SRNL
  (803) 725-3692; Brian02.looney@srnl.doe.gov

- Beth Moore, FRTR Contact
  DOE – EM
  (202) 586 - 6334; Beth.Moore@em.doe.gov

- Hope Lee, Ph.D.
  North Wind Inc.
  (208) 557-7820; hlee@northwind-inc.com

- Richard Bonczek, Ph.D.
  DOE-PPPO
  (859) 219 – 4051; Rich.Bonczek@lex.doe.gov