# PGDP Ground Water Model -Sensitivity Analyses


Presented by

Dr.Chandramouli Viswanathan

**Project Team :**

**Dr. Chandramouli Viswanathan**

**Dr. Srinivasa Lingireddy**

**Dr. Lindell Ormsbee**

**Steve Hampson**

# Overview

1. Objectives
2. Ground Water Model Setup and Inputs
3. Sensitivity Studies
    - Physical Parameters
    - Hydraulic Parameters
    - Transport Parameters
4. Remedial Alternatives
5. Conclusions
6. Recommendations

# 1. OBJECTIVES

- Evaluate the sensitivity of the current PGDP flow and transport models to various
  - physical
  - hydrologic
  - hydrogeologic
  - and transport input parameters
- Identify the need for collection of additional field data to improve the model accuracy
- Evaluate the effectiveness of the current models to
  - Predict temporal and spatial extents of future contamination
  - Characterize future contamination extent resulting from implementation of remedial schemes

# 1. OBJECTIVES

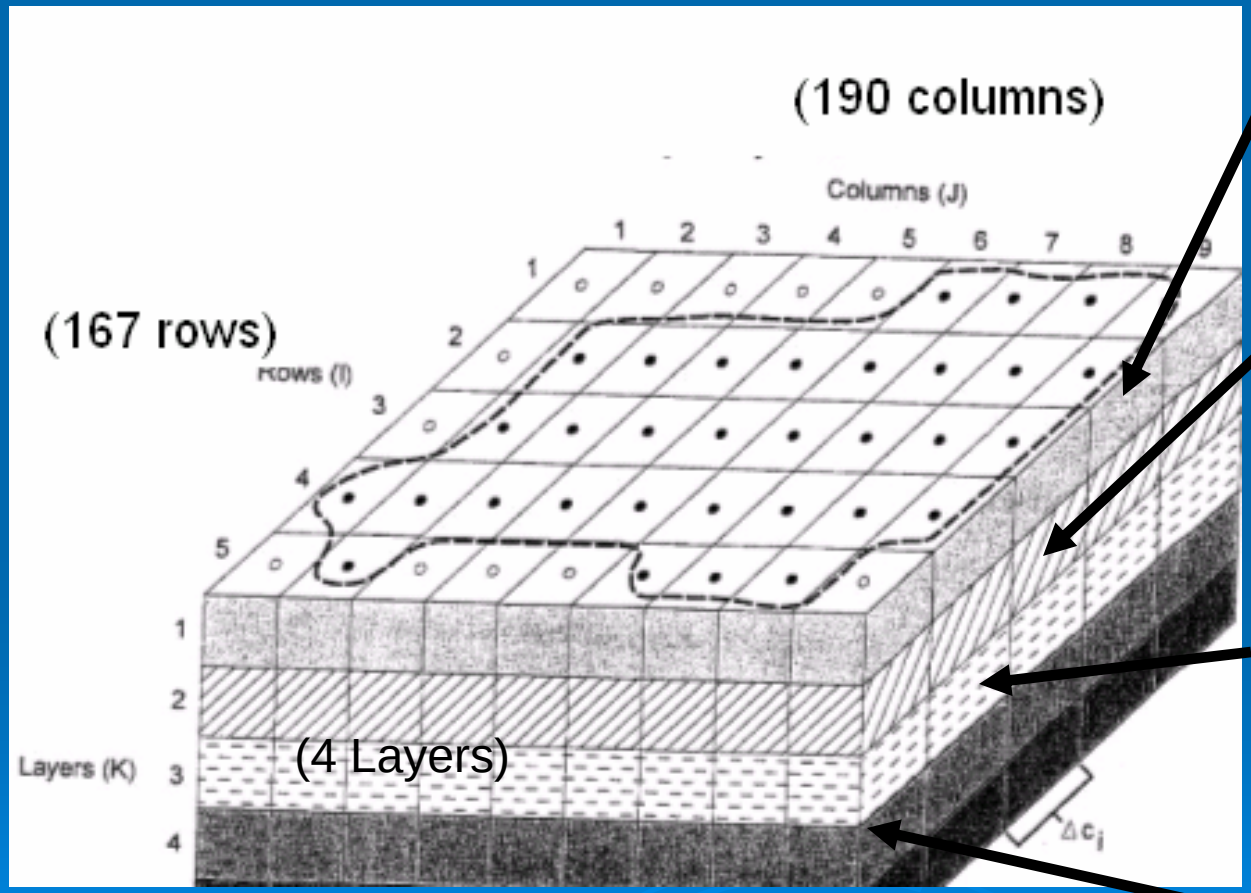
- Independent verification of past model results
- Set the stage for new modeling efforts
- Allow freedom to conduct “what if” model runs for modeling work not covered by DOE site contracts

# 2. Ground Water Flow and Transport Model Details

- Model Interface : **GW Vista version 4.0**
- Flow Model : **MODFLOW**
- Transport Model : **MODFLOWT**

# 2. Ground Water Flow and Transport Model Details

## Conceptual Model



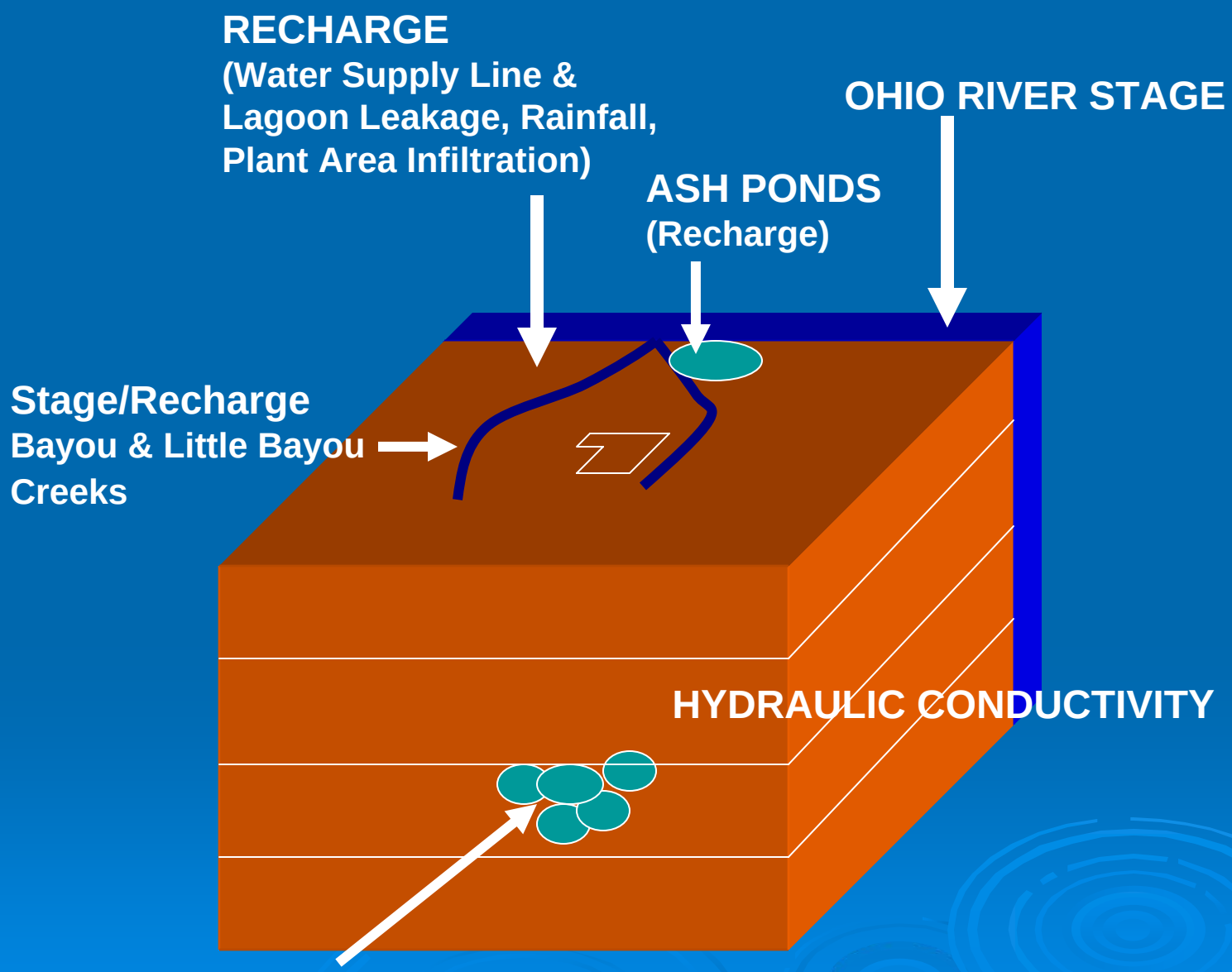

**Layer 1 – Loess (Hydrogeologic Unit 1) and the sands/silty sands of the Upper Continental Deposits = Hydrogeologic Unit 2 (HU2A)**

**Layer 2 - Silts & clays of lower portion of the Upper Continental Deposits Hydrogeologic Units HU2B and HU3**

**Layer 3 - Simulates the sands and gravels of the Lower Continental Deposits = Regional Gravel Aquifer = Hydrogeologic Units HU4 and HU5**

**Layer 4 - Simulates the Silty sand and sandy silt of the McNairy Formation flow system (HU6)**

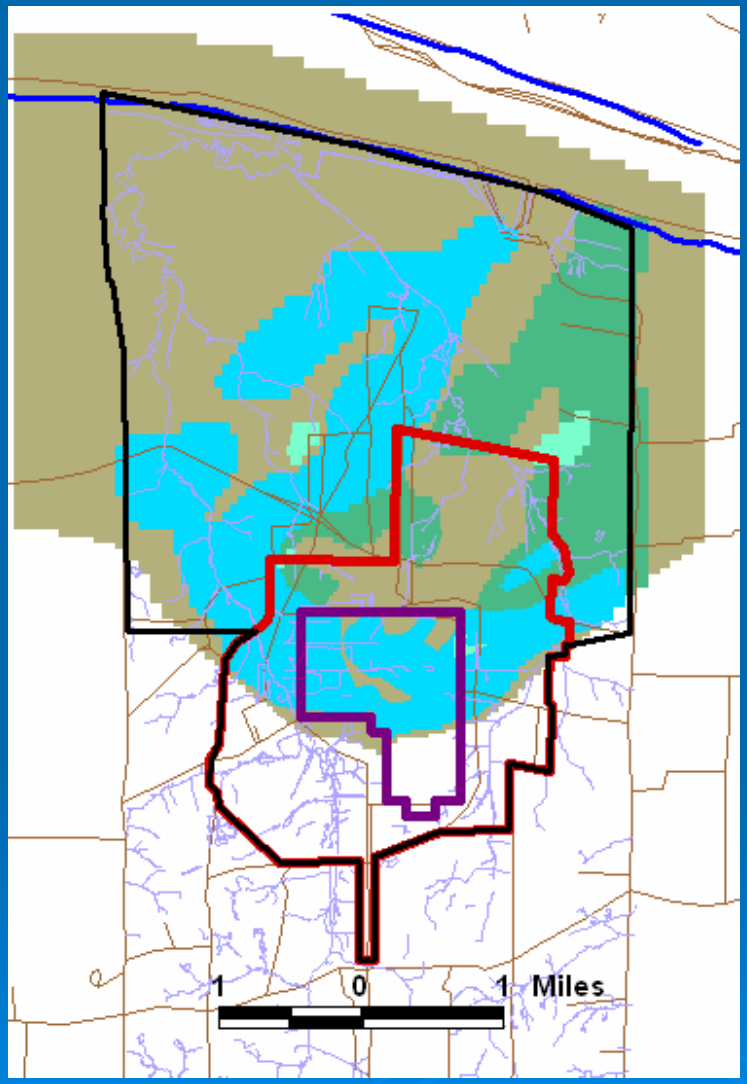
# 3. SENSITIVITY STUDIES



# Results

- Model was sensitive to:
  - Hydraulic conductivity in the RGA
  - TCE degradation half-life.
  - Plant shut down (i.e. creek stage)
  - Lineal features
- Model is relatively insensitive to:
  - Ohio River Stage
  - Rainfall recharge
  - Pipeline leakage
  - Lagoon stage

# Hydraulic Conductivity Zones for Layer 3




Hydraulic Cond. Kx (ft/day)
1
75
200
500
1500

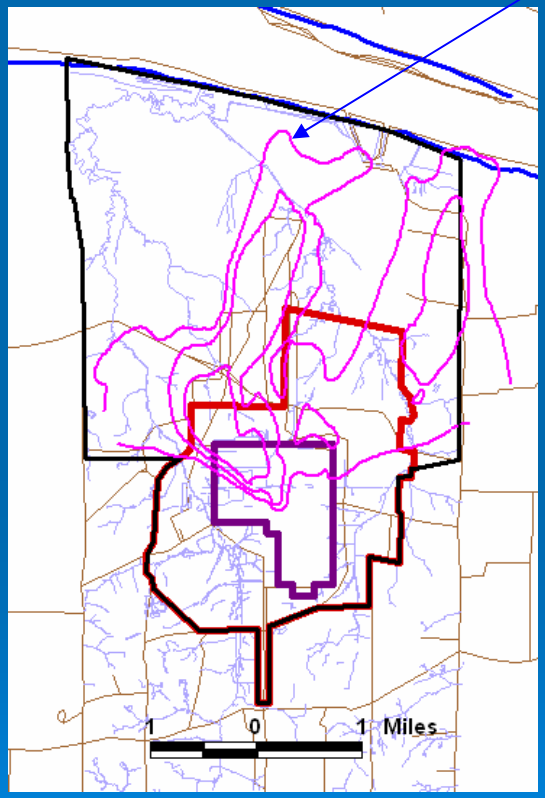
# Ground Water Plume contours after 30 year results

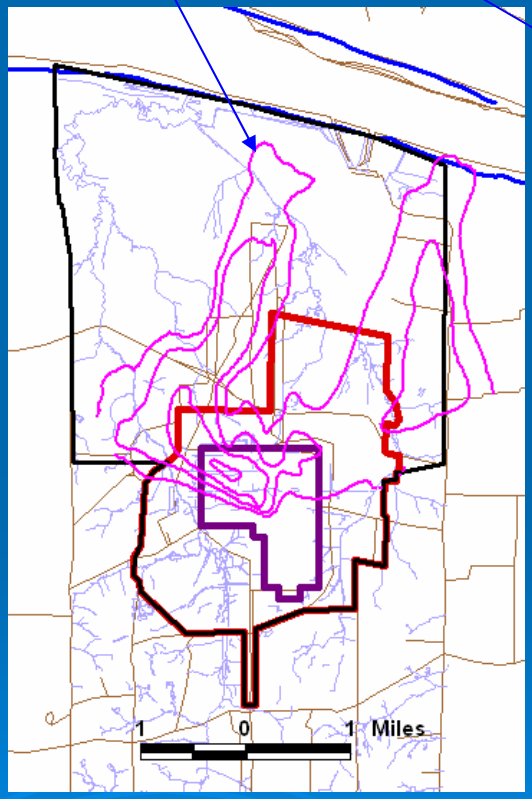
**Baseline**

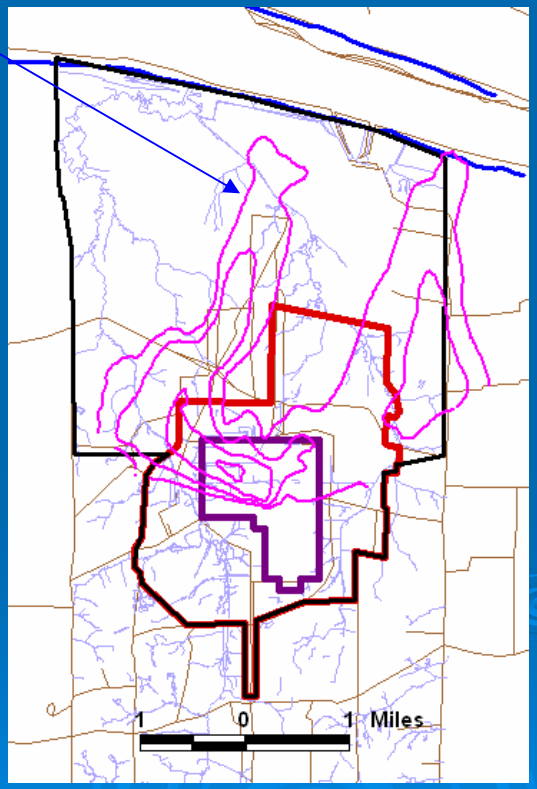
**Model with 20 % reduction in K**

**Model with 30 % reduction in K**

TCE Contour 5 µg/l



# 3.2 Sensitivity Studies - Plant Shutdown Analysis

- Bayou and Little Bayou Creeks were modeled as “River Boundaries” in baseline model
  - Uniform depth of 2.5 ft. for all river cells
- Sensitivity Analyses assumed reduced plant inflows to **both Bayou and Little Bayou** Creeks
  - Reflected in lower stage levels to both creeks
- Assumed increases in the recharge rate within plant fence into layer 1 of the model
  - D&D expected to remove impervious infrastructure

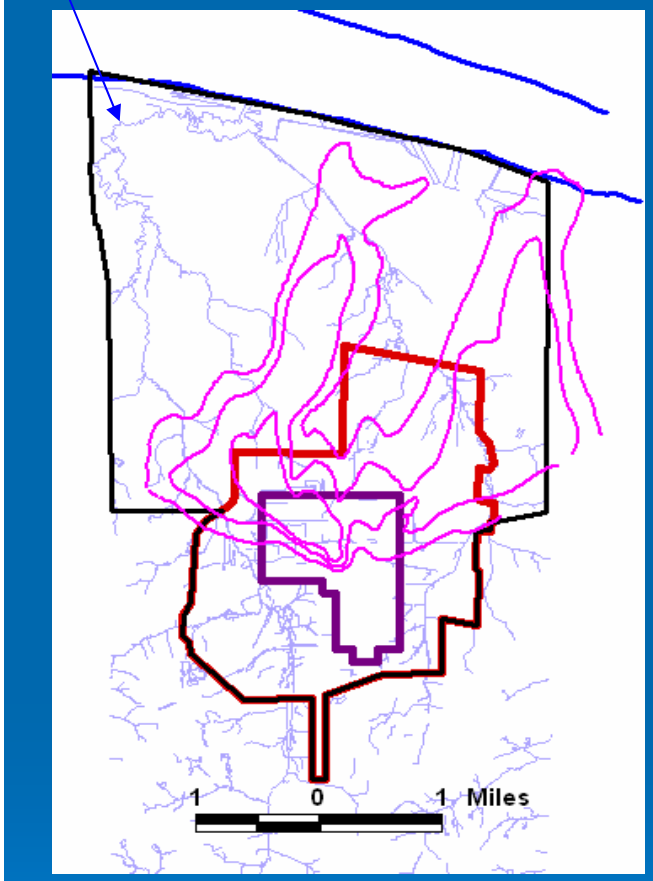
# 3.2 Sensitivity Studies - Plant Shutdown Analysis

1. **Vary water depths in Big Bayou (BBC) and Little Bayou (LBC) Creeks**
2. **Vary recharge in plant due to D&D of infrastructure**
3. **All other parameters are maintained as per the baseline model**

**(CRSV = Creek and River Stage Variation)**

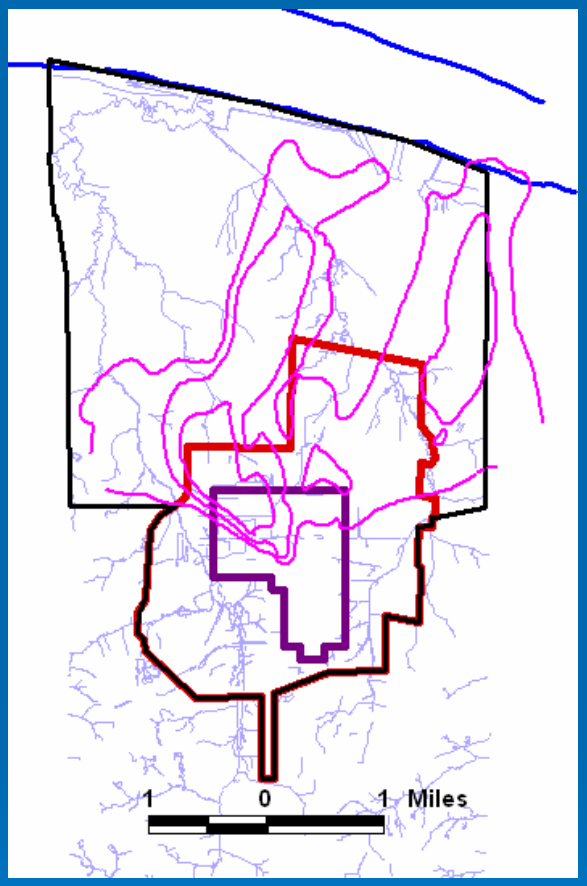
| Simulation | BBC Stage (% Reduction from baseline condition) | LBC Stage (% Reduction from baseline condition) |
|---|---|---|
| Baseline Model | 2.50 ft | 2.50 ft |
| CRSV 1 | 1.25 ft (50 %) | 2.50 ft ( 0 %) |
| CRSV 2 | 2.50 ft ( 0 %) | 1.25 ft (50 %) |
| CRSV 3 | 1.25 ft (50 %) | 0.50 ft (80 %) |
| CRSV 4 | 0.50 ft (80 %) | 0.50 ft (80 %) |

# Simulation Results after 30 years



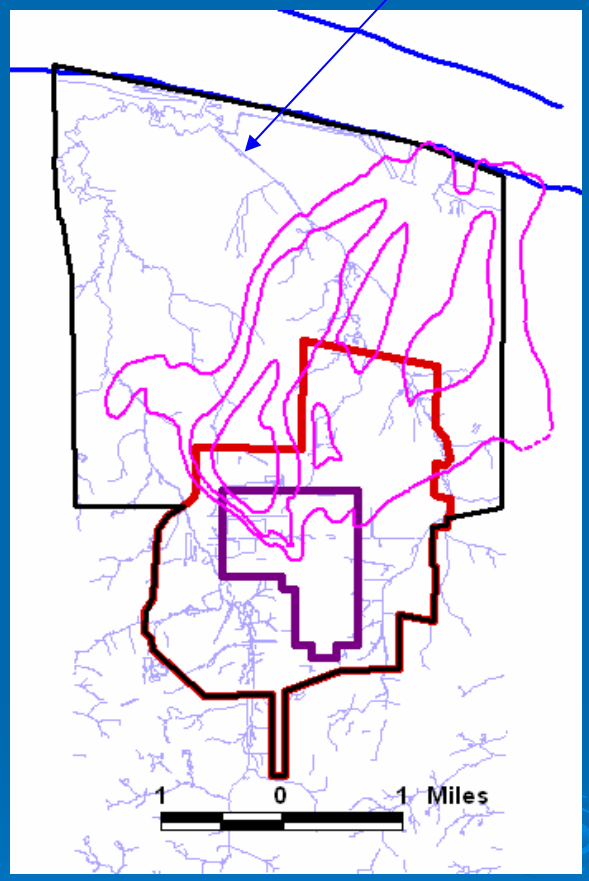

Baseline Model

Bayou creek
– 2.50 ft stage
Little Bayou creek
– 2.50 ft stage




Model CRSV 2

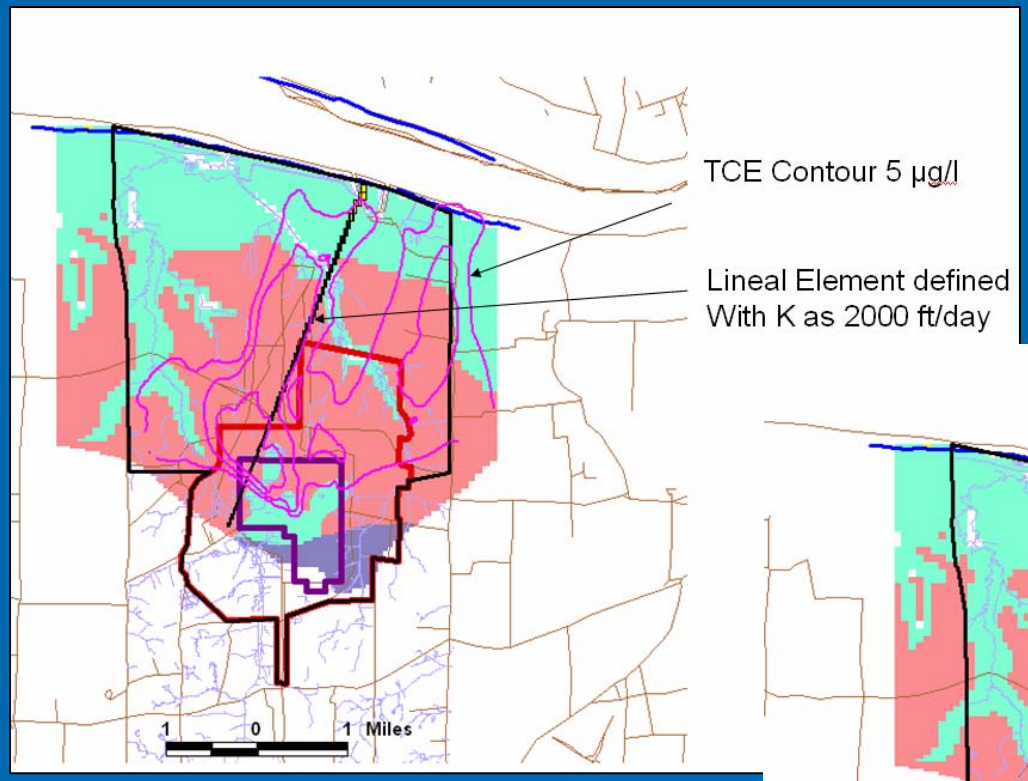
Bayou creek
– 1.25 ft stage
Little Bayou creek
– 2.50 ft stage

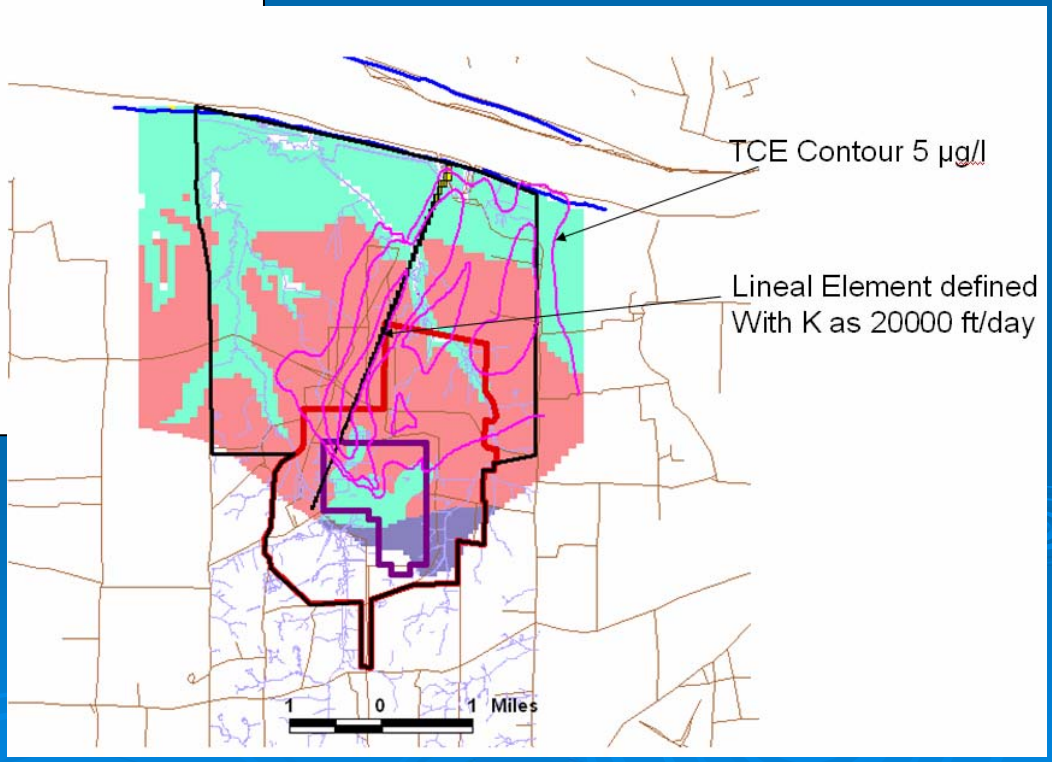



Model CRSV 3

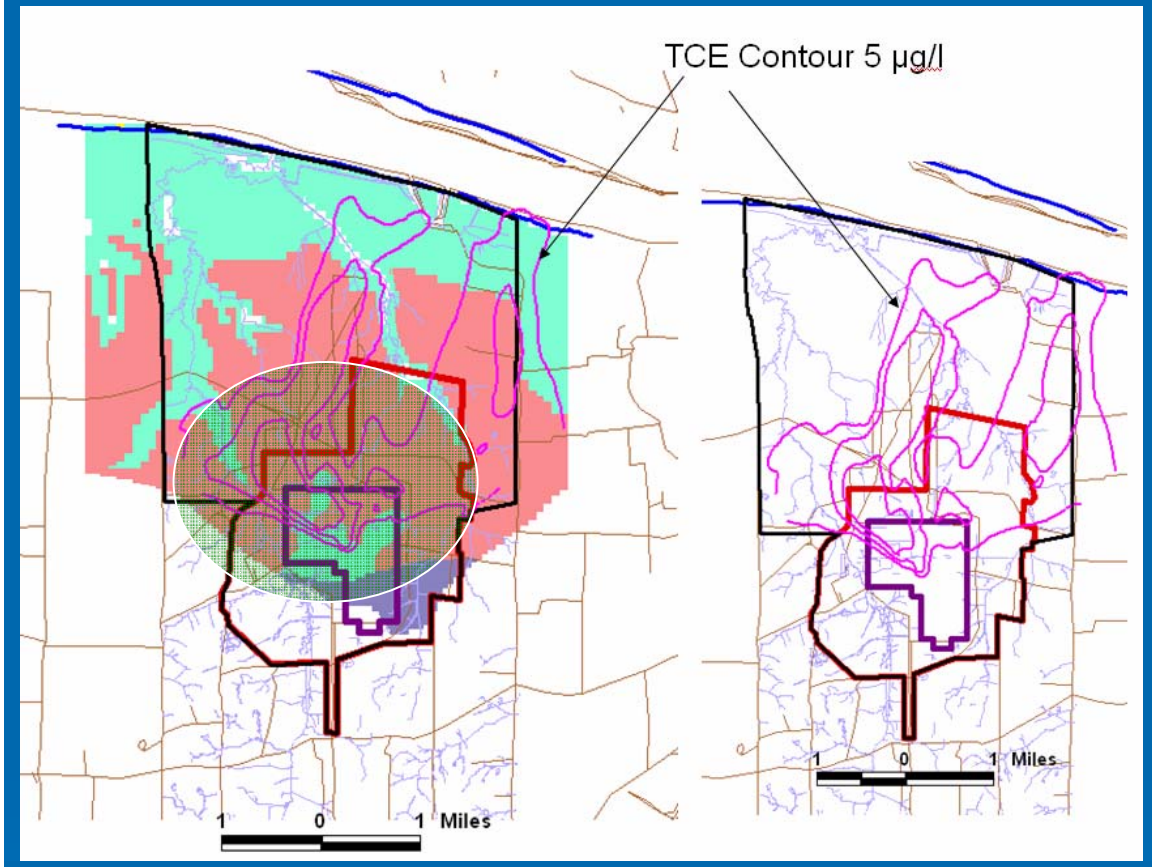
Bayou creek
– 1.25 ft stage
Little Bayou creek
– 0.50 ft stage

# Lineal Element Presence : with different K values



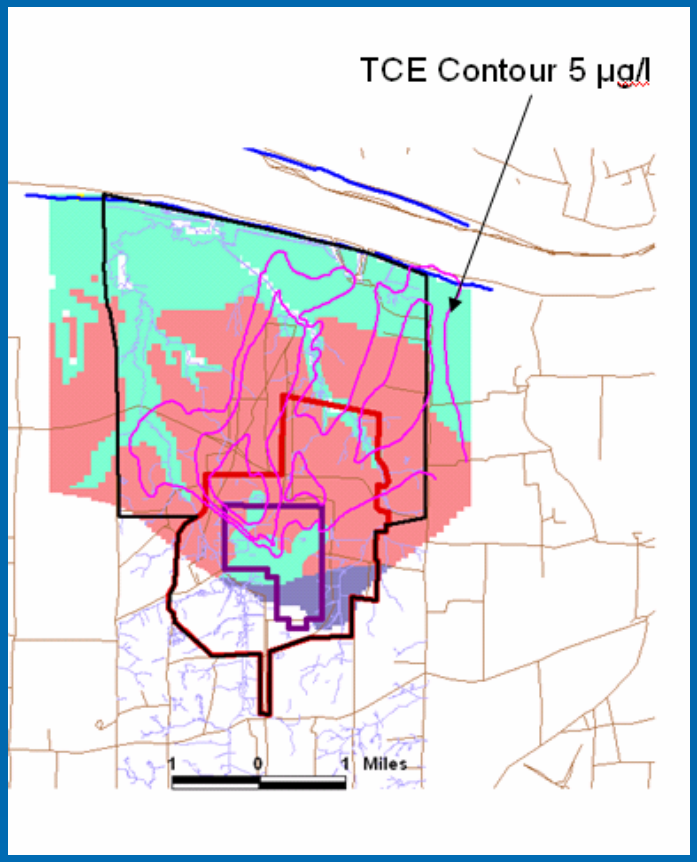



# 3.4 Sensitivity Studies -Recharge due to Rainfall



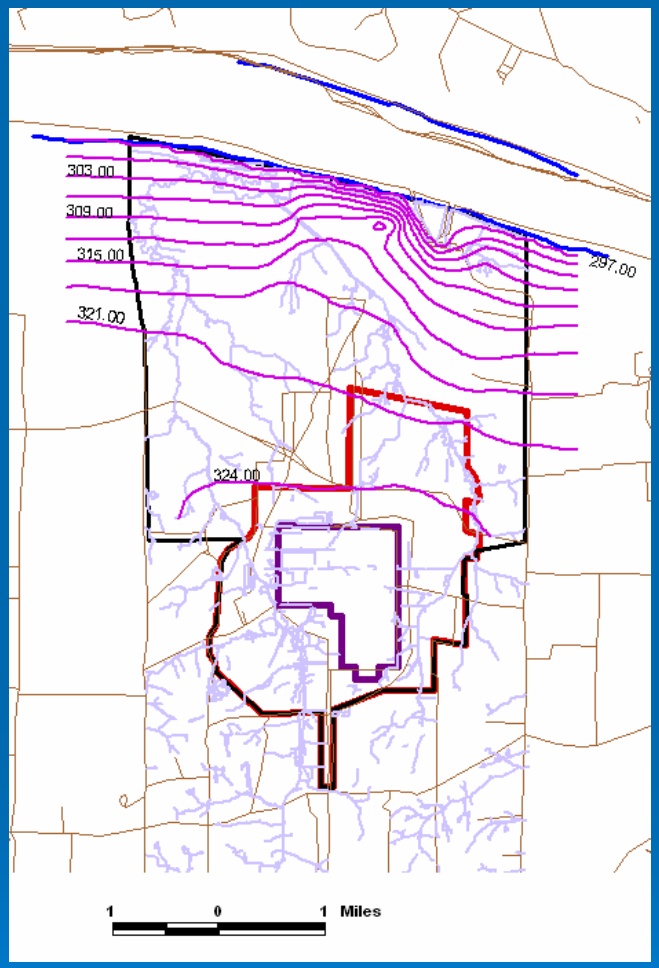

**With 25 % Increase in Rainfall Recharge**

**Baseline Model**

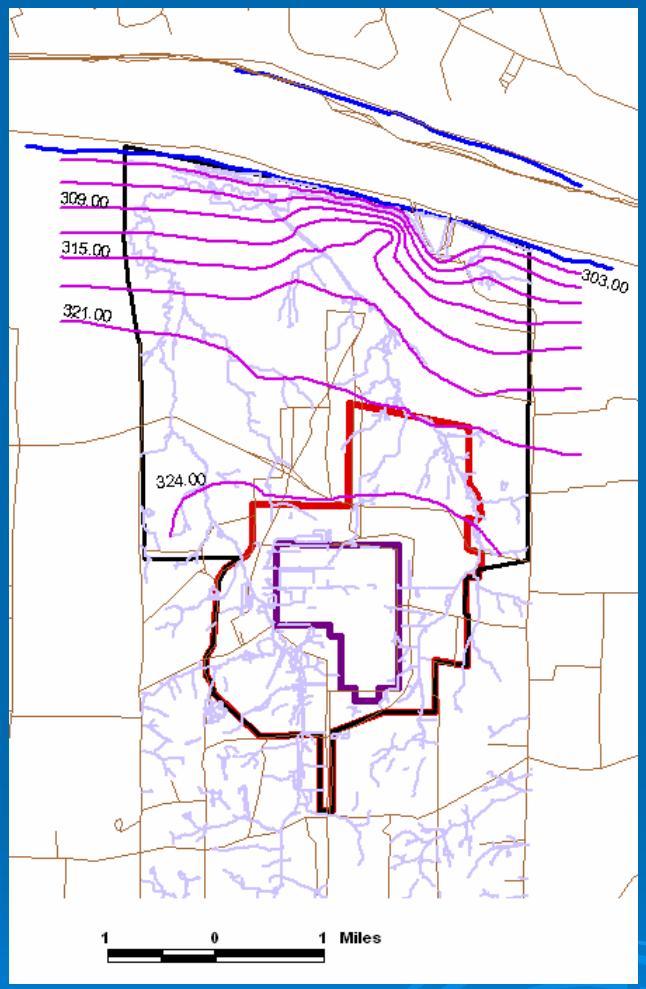



With 25 % Reduction in Rainfall Recharge

# 3.5 Sensitivity Studies - Ohio River Stage HGL Contours after 30 Years

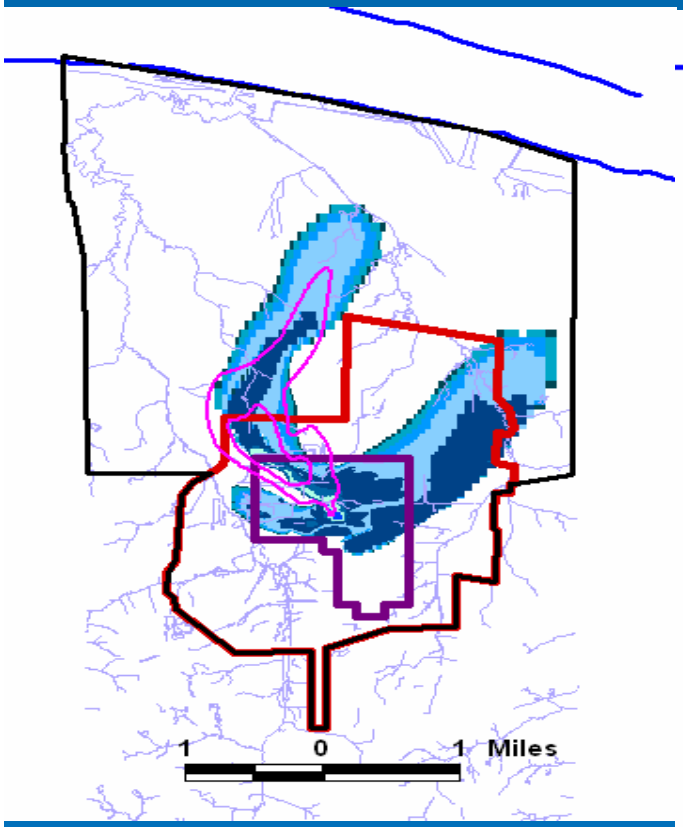



**Simulation 1 : with 295.4 ft for Stress period 1 and 2**

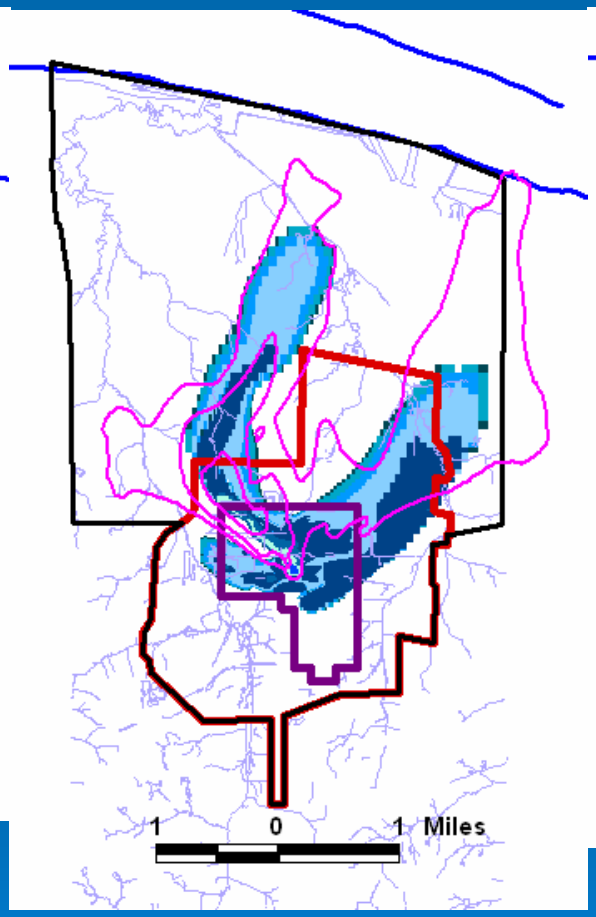



**Simulation 2 : with 300.4 ft for Stress period 1 and 2**

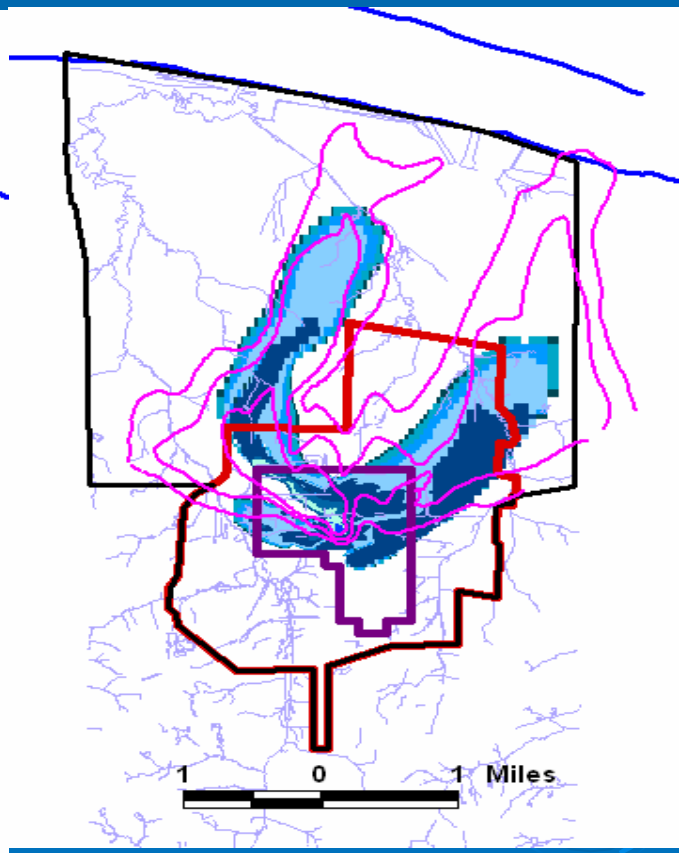
# 3.6 Sensitivity Studies - Half-Life Period
# 30 Years




5 Year Half Life




10 Year Half Life

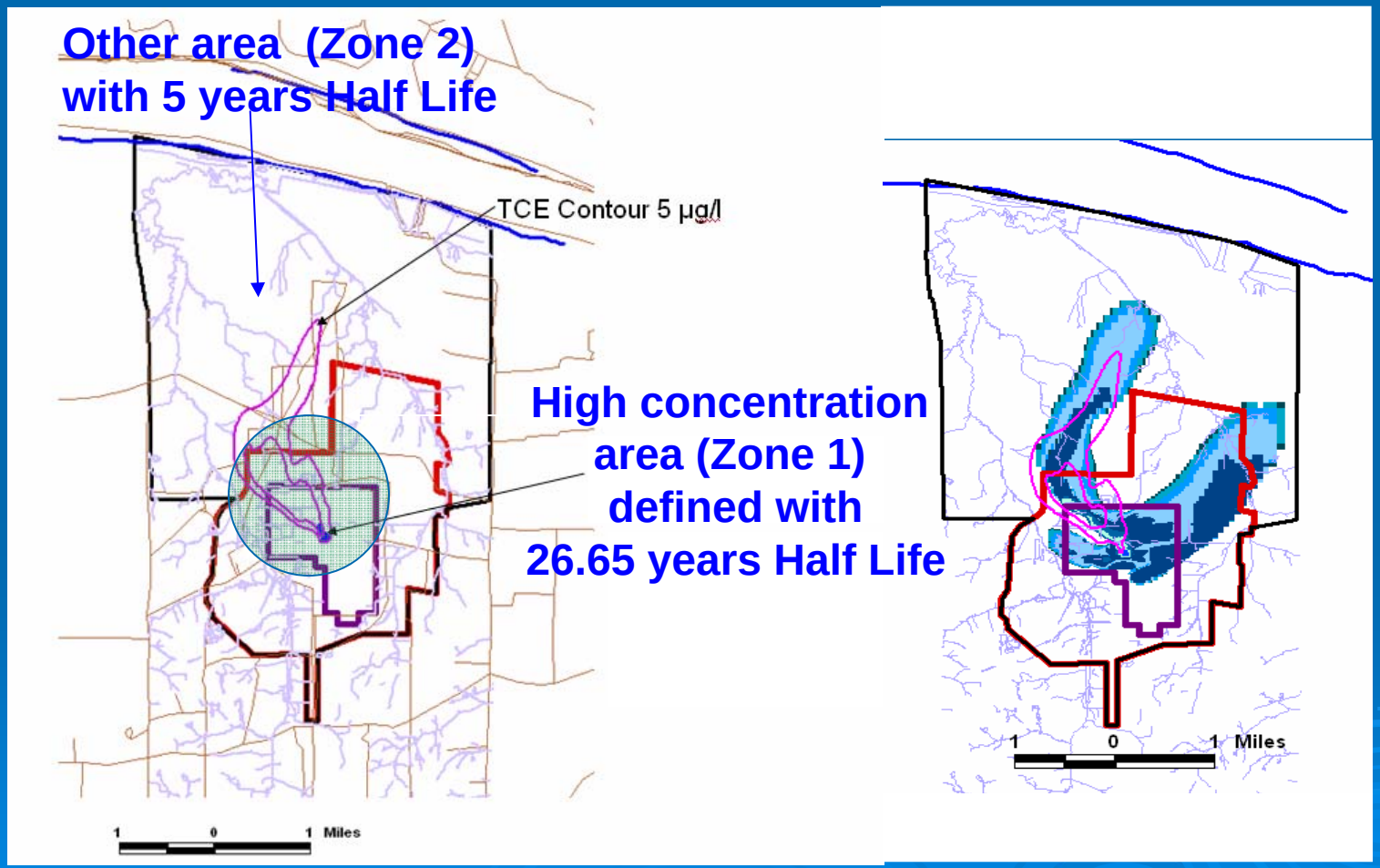



26.65 Year Half Life
Baseline Model

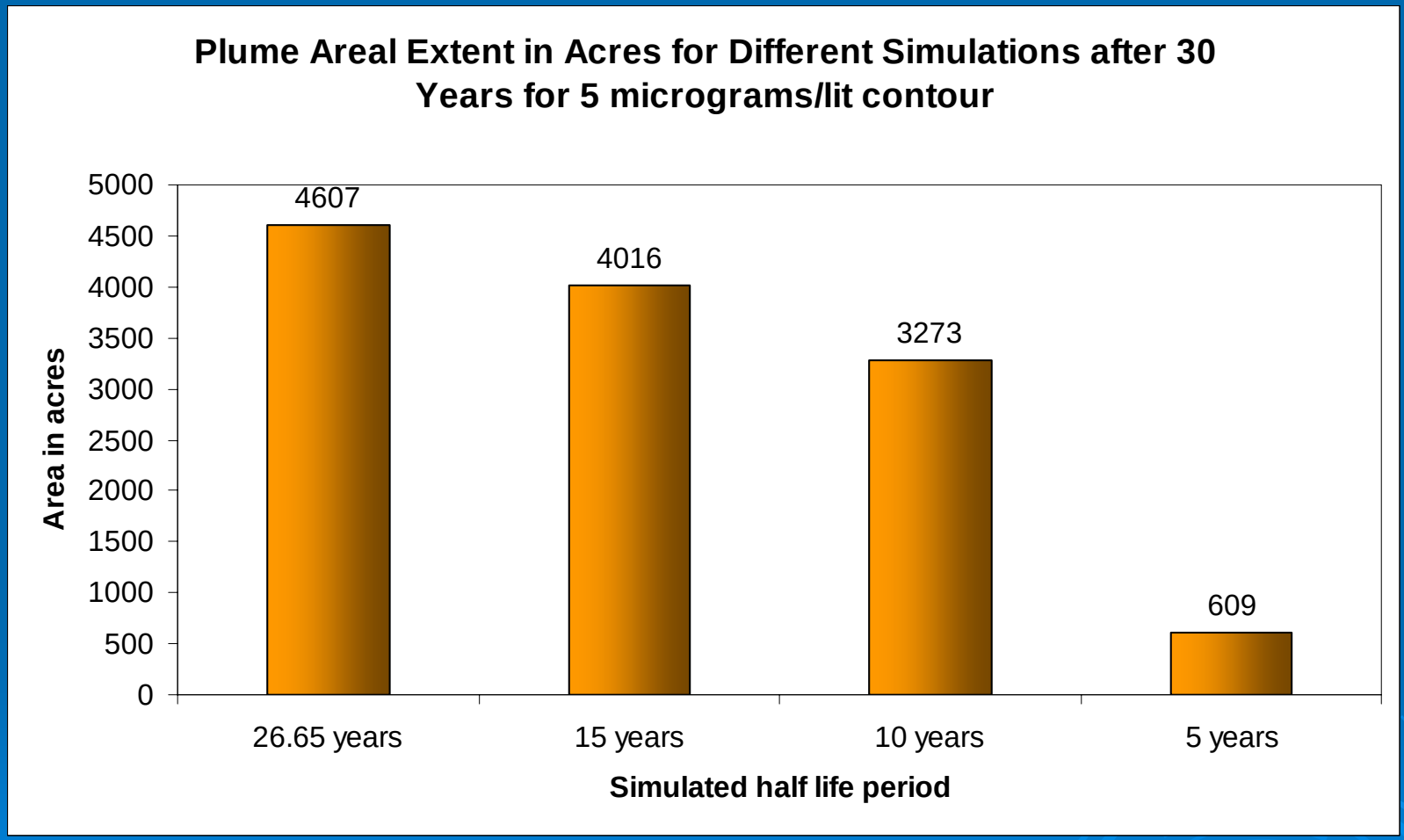
# After 30 years of Simulation

**Model Run with Two Half Life Zones:**
**(5 YEARS & 26.65 years)**

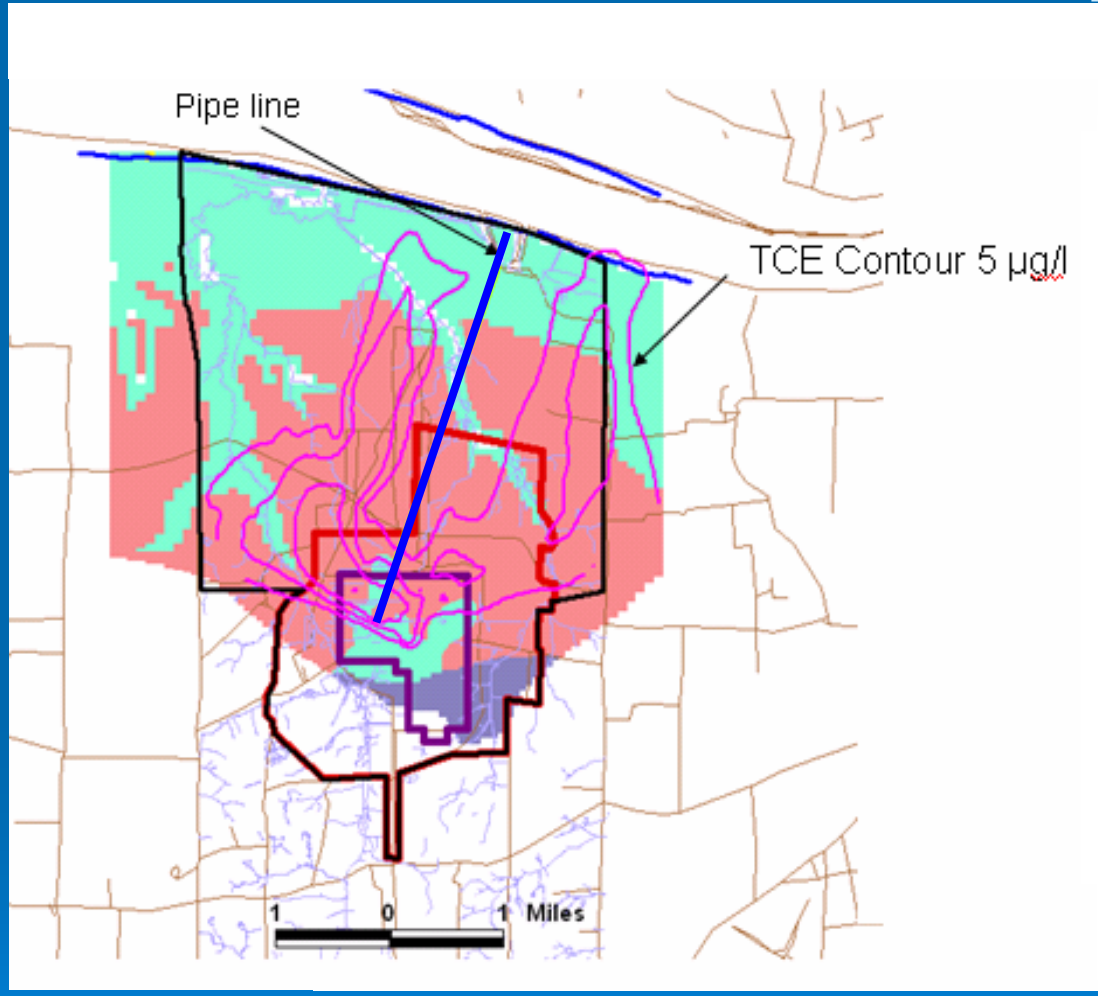
**Model Run with One**
**5 Year Half Life Zone**

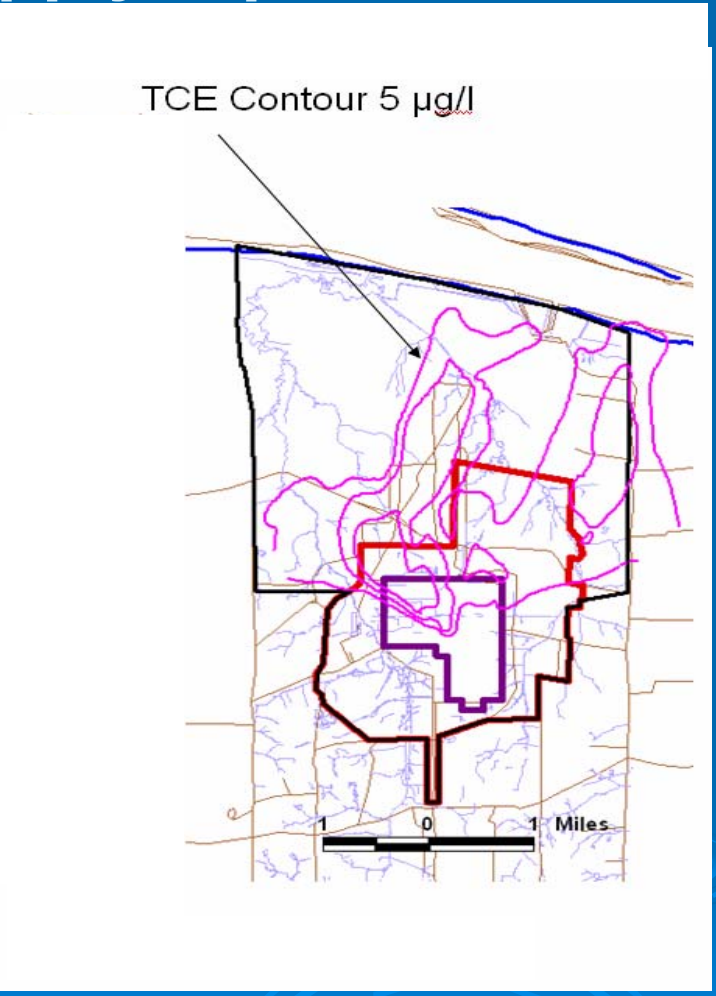


# 3.6 Sensitivity Studies - Half-Life Period



# 3.7. Sensitivity Studies – Simulating Leakage from the PGDP Water Supply Pipeline




**Model run with 20 % uniform pipe line Leakage**

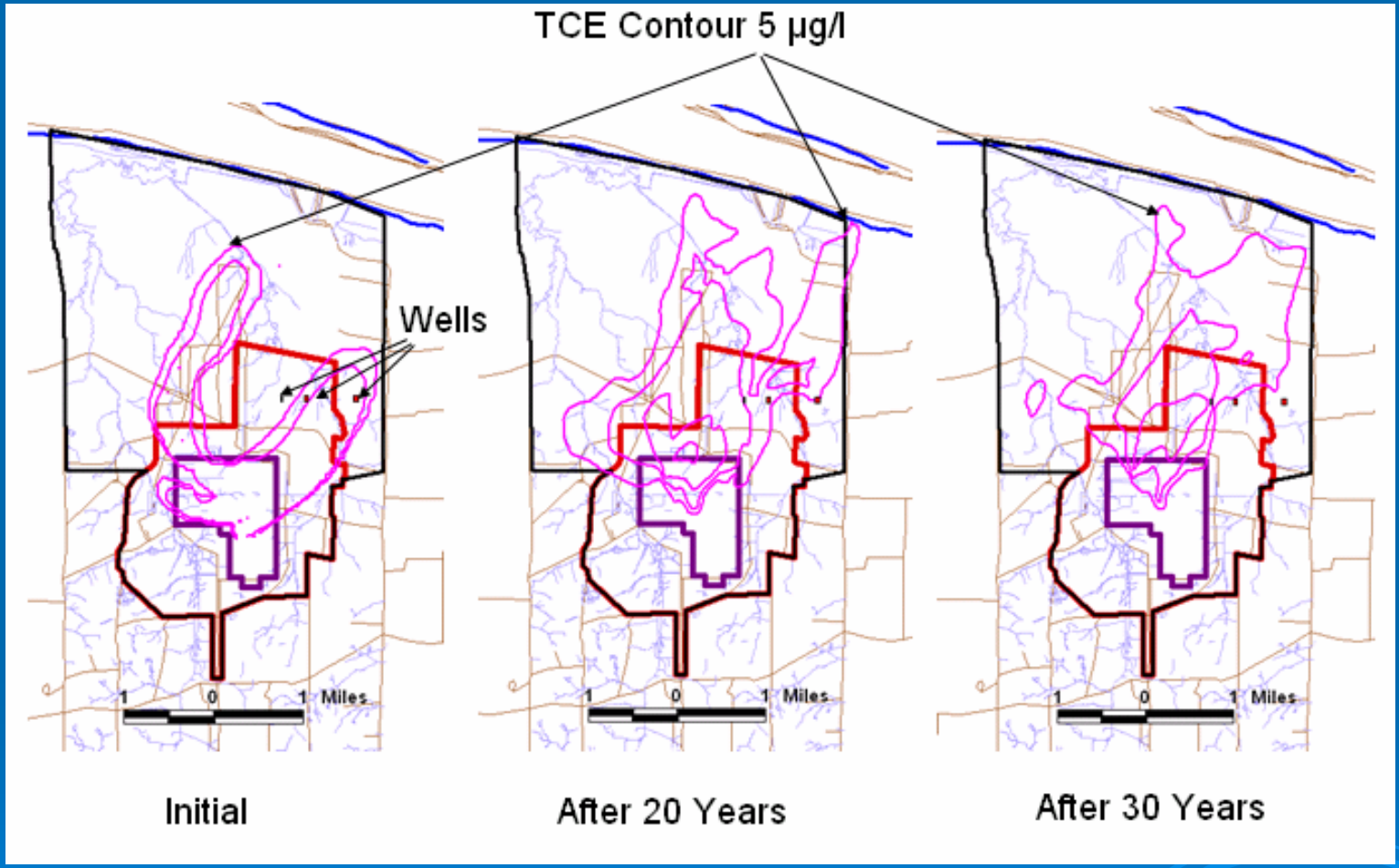
**Baseline Model**

# 4. Remedial Alternatives

- 4.1 Pump and Treat Trials
  - Three wells with huge pumping potential
  - Recharge and pumping wells together
- 4.2 Permeable Reactive Barriers
  - East- West Barrier
  - L Shaped Barrier

# 4.1 Remedial Alternatives – Pump and Treat

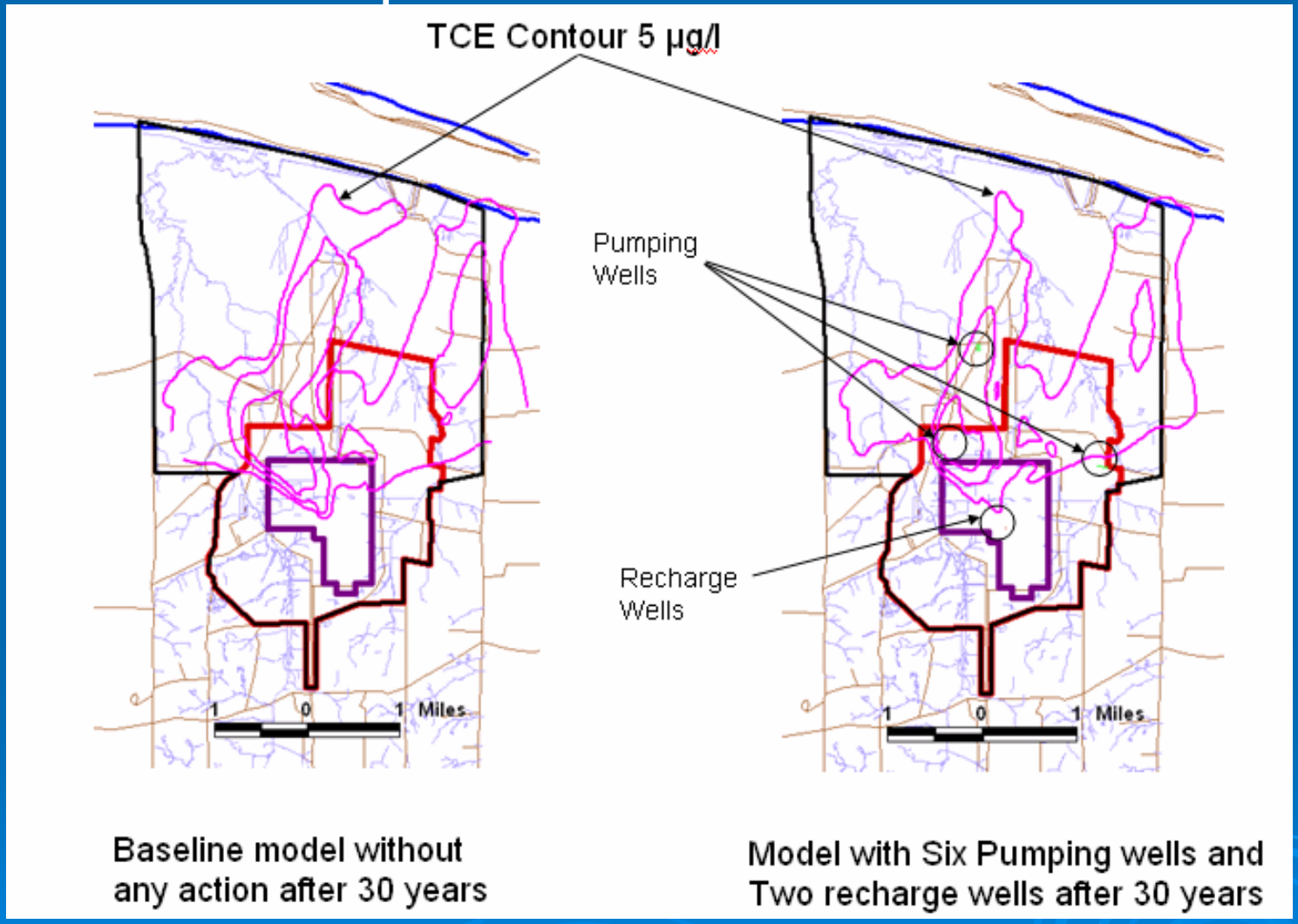
## Pump and Treat Scenario - 1




Demonstrates the theoretical potential for remediation of the contaminated aquifer with large scale pump and treat operation (i.e. 700 gpm or 21 wells)

# 4.1 Remedial Alternatives – Pump and Treat

## Pump and Treat Scenario - 2

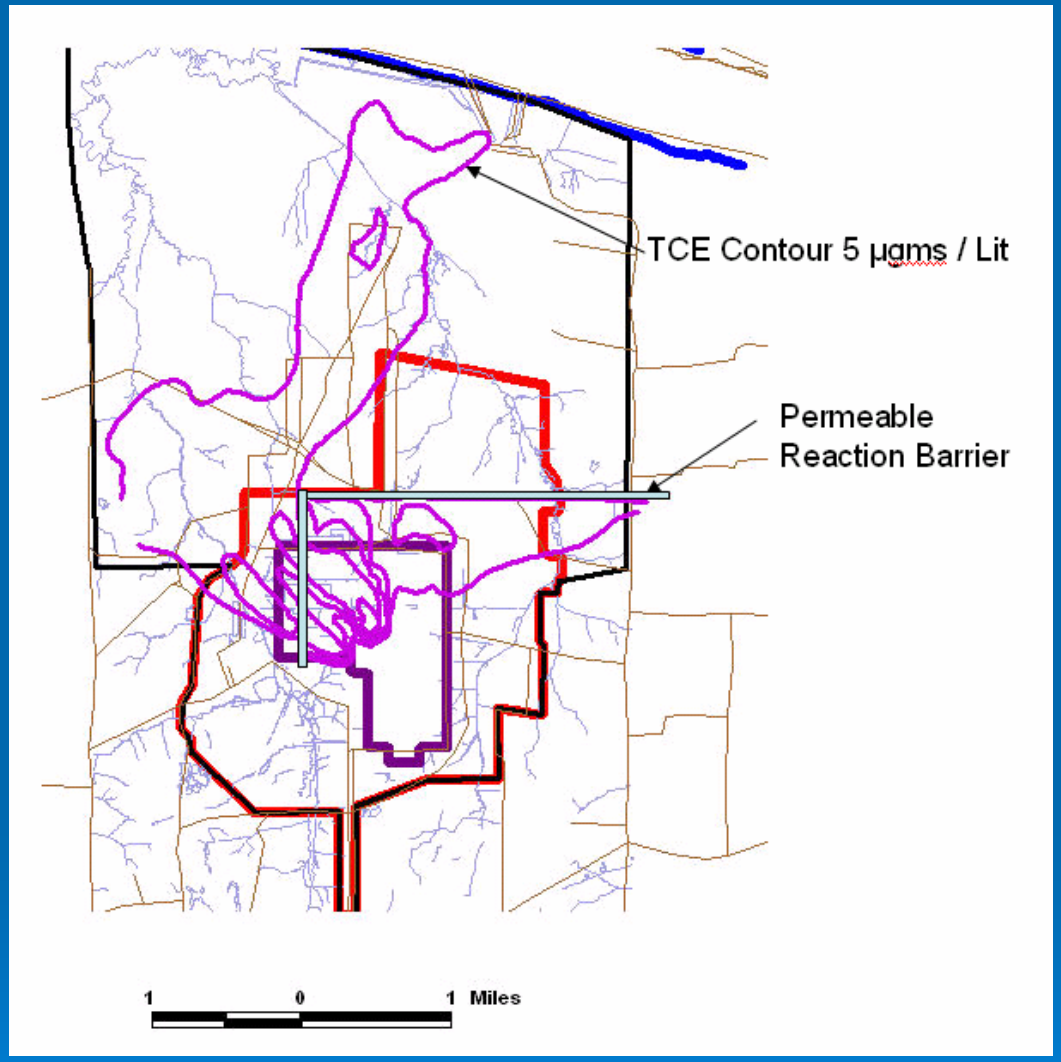



Baseline model without any action after 30 years

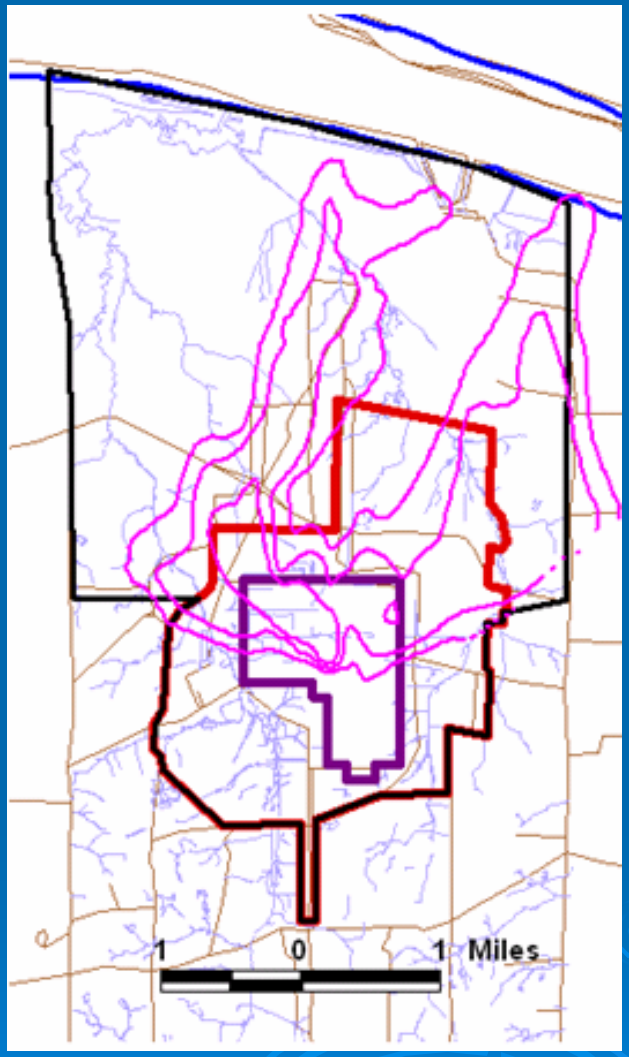
Model with Six Pumping wells and Two recharge wells after 30 years

**This pumping scheme appears to have minimized the extents of both southeast and northwest plumes. The pumping rate considered for different wells are not very high and are practicable.**

# 4.2 Remedial Alternatives – Permeable Barriers

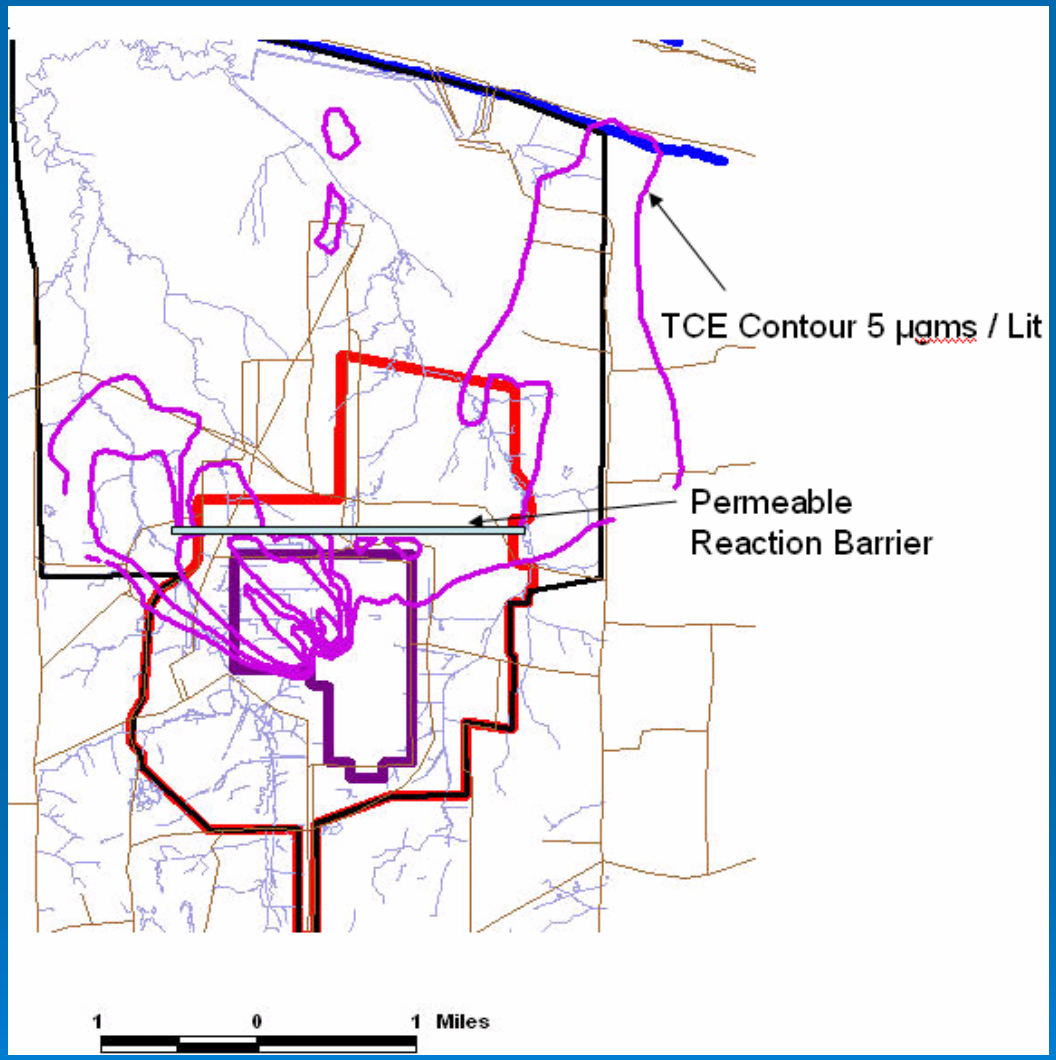



Model Run with Permeable Barrier – Position 1 after 30 years

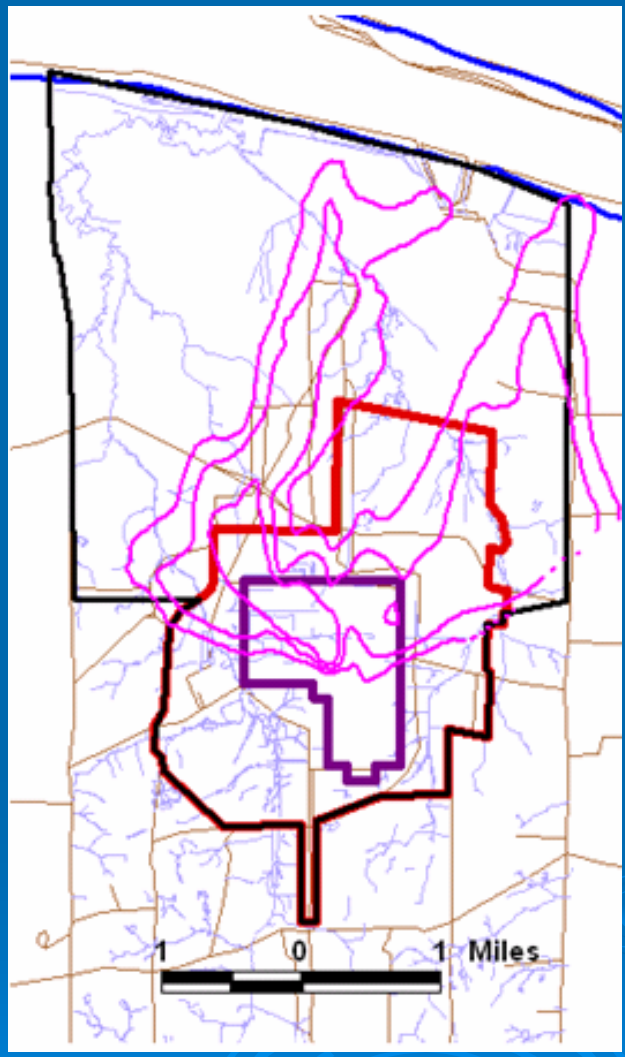



Baseline Model after 30 years

# 4.2 Remedial Alternatives – Permeable Barriers




Model Run with Permeable Barrier – Position 2 after 30 years




Baseline Model after 30 years

# General Conclusions

- Model was sensitive to:
  - Hydraulic conductivity in the RGA
  - TCE degradation half-life.
  - Plant shut down (i.e. creek stage)
  - Lineal features
- Model is relatively insensitive to:
  - Ohio River Stage
  - Rainfall recharge
  - Pipeline leakage
  - Lagoon stage

# Recommendations

- Refine aquifer conceptualization
  - Lateral and vertical discretization
- Refine surface water boundary conditions
  - Little Bayou Creek
- Determine and implement aquifer/contaminant specific degradation terms
- Conduct calibration of transport model