NEWMOA In-Situ Chemical Oxidation Workshop

March 15, 2011 – Westford, MA

March 16, 2011 – Danielson, CT

IMPLEMENTATION AND SYSTEM OPERATION

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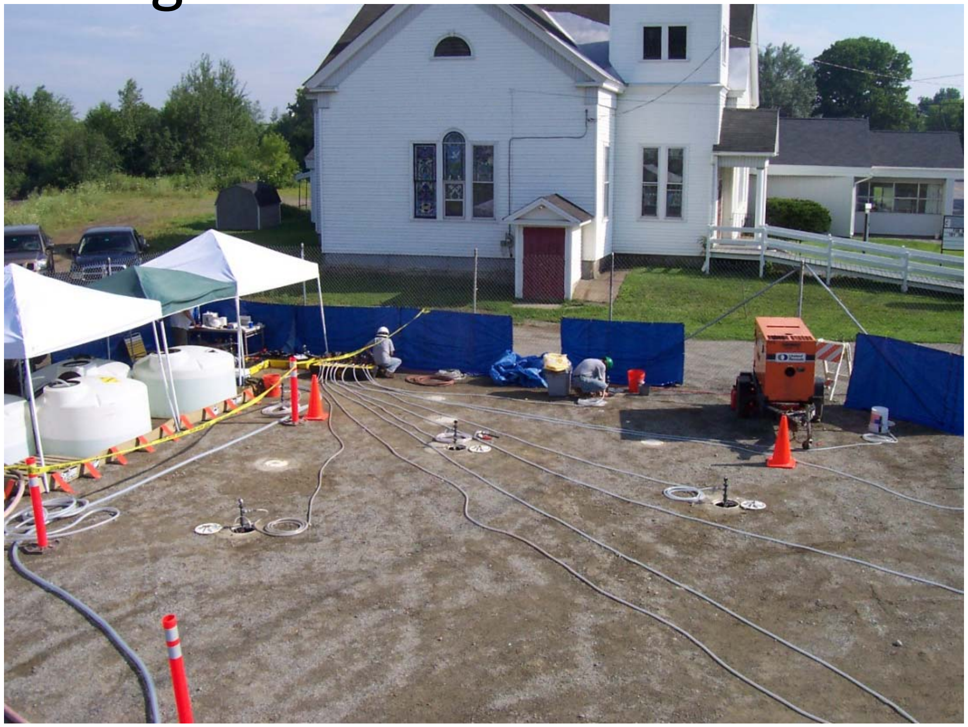
- Mobilization and Logistics
- Health and Safety
- Monitoring
- Troubleshooting
- Reaction Daughter Products
- Rebound

Mobilization

- Establish adequate staging and management area
- Utilities (electricity and lighting)
  - Equipment selection
    - Pumps, manifolds, valves, gauges, tubing, tanks, packers
    - Cost versus longevity
    - Chemical compatibility
  - Injection layout
    - Injection line distances
    - Access and safety

Logistics

- Oxidant delivery and trucking schedules
- Site and design-specific logistics



- Mixing/batching requirements
- Disposal of unused chemicals

Health and Safety

A safe and successful ISCO program requires more than good data and system design

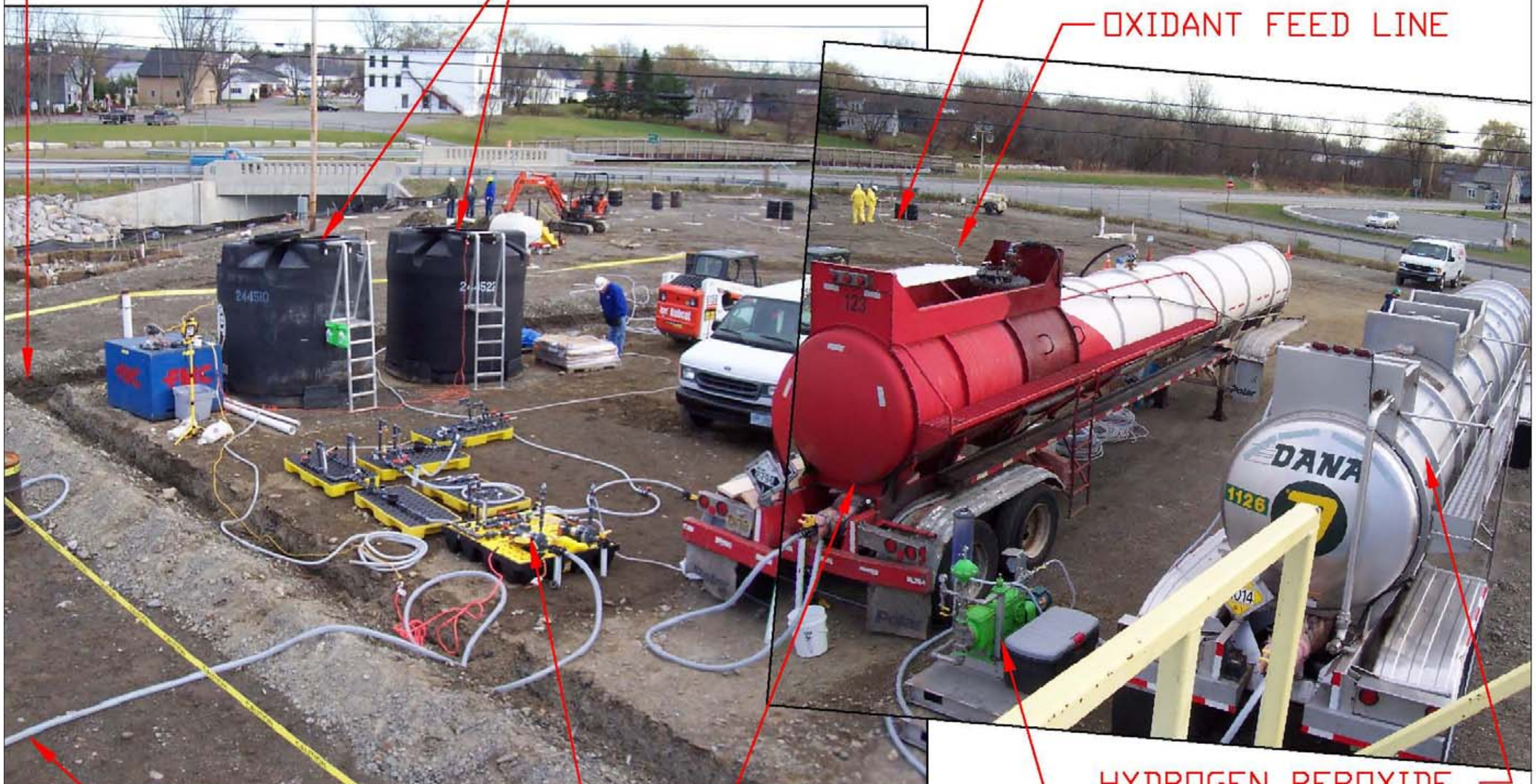
- Equipment staging
- Spill prevention and chemical handling
- PPE
- Site security
- Hydraulic controls for chemical injection

Health and Safety

Emergency response planning and coordination

- Local response agencies
- MSDS
- Spill response/evacuation plan

IN-SITU CHEMICAL OXIDATION PILOT STUDY - NOVEMBER 2004



Monitoring

Monitoring consists of field monitoring and measurements, and laboratory analysis.

- Pre-ISCO Baseline – Establishes baseline characteristics/conditions
- Process Monitoring – oxidant distribution, surfacing/mounding, used for post-ISCO optimization
- Post-ISCO Performance Assessment – evaluate mass reduction and potential rebound

Monitoring – Process Monitoring

Process Monitoring program is based on:

- Site characterization data (e.g. aquifer geochemistry)
- Bench testing data
- Oxidant selection and design aspects
- Field observations from pilot studies/prior injections

Monitoring - Field

Field monitoring depends on oxidant/chemicals used

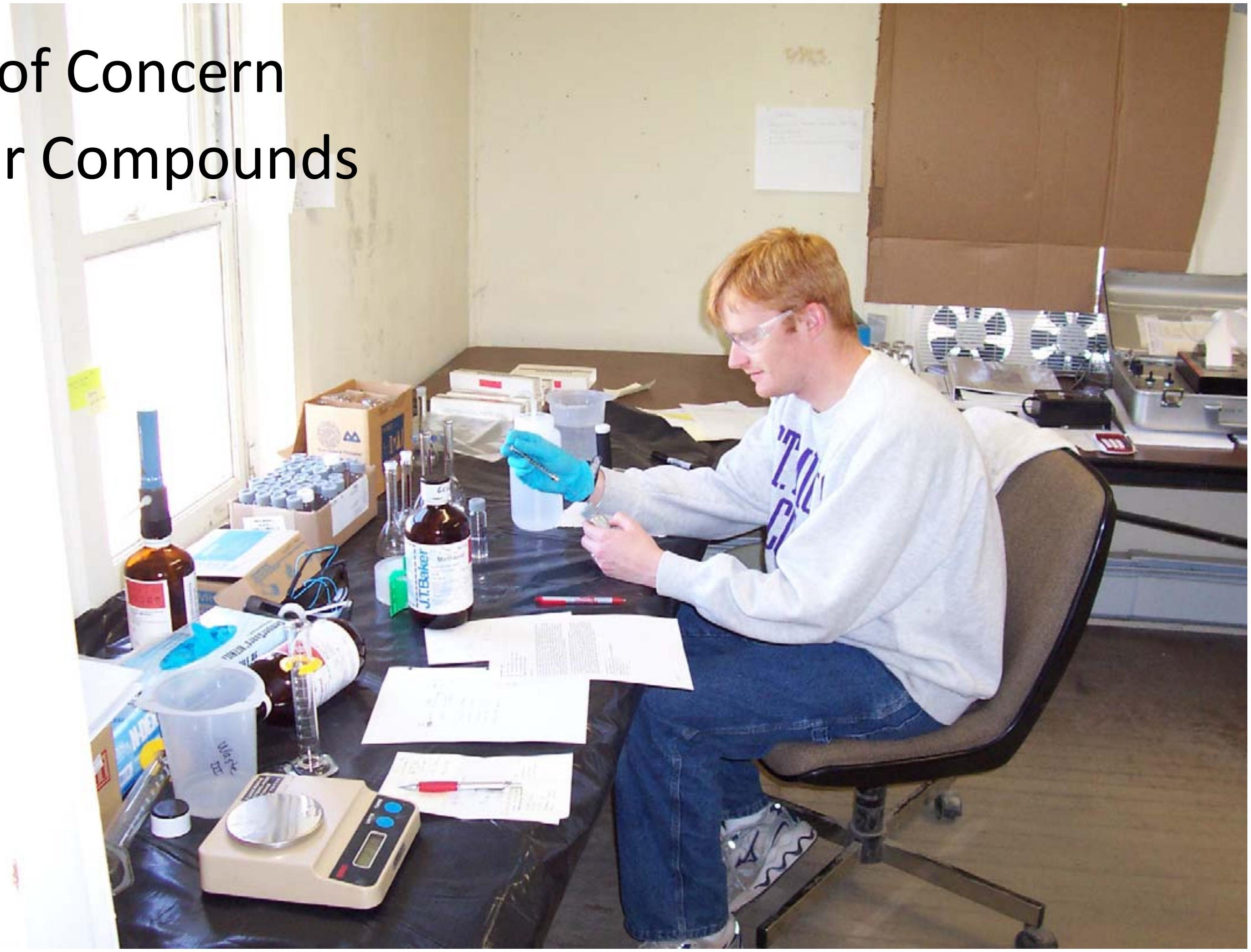
- Specific Conductivity
- Dissolved Oxygen
- Oxidation-Reduction Potential
- pH
- Temperature
- Pressure
- Groundwater Level
- Oxidant concentrations

ISCO Process Monitoring

- Parameters monitored: temperature, pH, ORP, conductivity, dissolved oxygen, total/dissolved iron, persulfate, CO_2, O_2
- 360 samples collected from 30 locations to monitor the ISCO injection

Monitoring - Laboratory

- Contaminants of Concern
- Metals or other Compounds
- Alkalinity
- Chloride
- Sodium
- Sulfate



Monitoring - Considerations

- For short-lived ISCO reactions (Fenton’s, catalyzed persulfate) monitoring data needs to be collected rapidly
- Poses a challenge for larger sites/injection areas
- Data needs have to be balanced with collection and assessment cost
- Data and monitoring needs can change between injection events
- Be aware that pH changes in groundwater can mobilize metals even if you are dealing with an organic source area

Monitoring - Results

Process monitoring results for both field measurements and laboratory data are important in determining future injection design

- Indicate hydrologic flow conditions
- Determine where residual source remains

Post-ISCO Monitoring
Evaluating Treatment Success

The goal is contaminant mass destruction

- Mass estimates
- Site heterogeneities
- Dilution effects
- Residual versus dissolved mass?
- Daughter product formation (TCOC vs. TVOC)
- Rebound

Troubleshooting/Lessons Learned

- Some infrastructure sensitive to heat or reactions
- Utility trenches or other buried infrastructure can affect distribution or act as preferential pathways
- Surfacing and mounding (hydraulic controls)

Troubleshooting/Lessons Learned

Recognize nearby potential receptors

- Water supplies
- Surface water bodies
- Other sensitive environments

Situational awareness

- Facility and municipal coordination
- Public perception

Not St. Patrick's Day…

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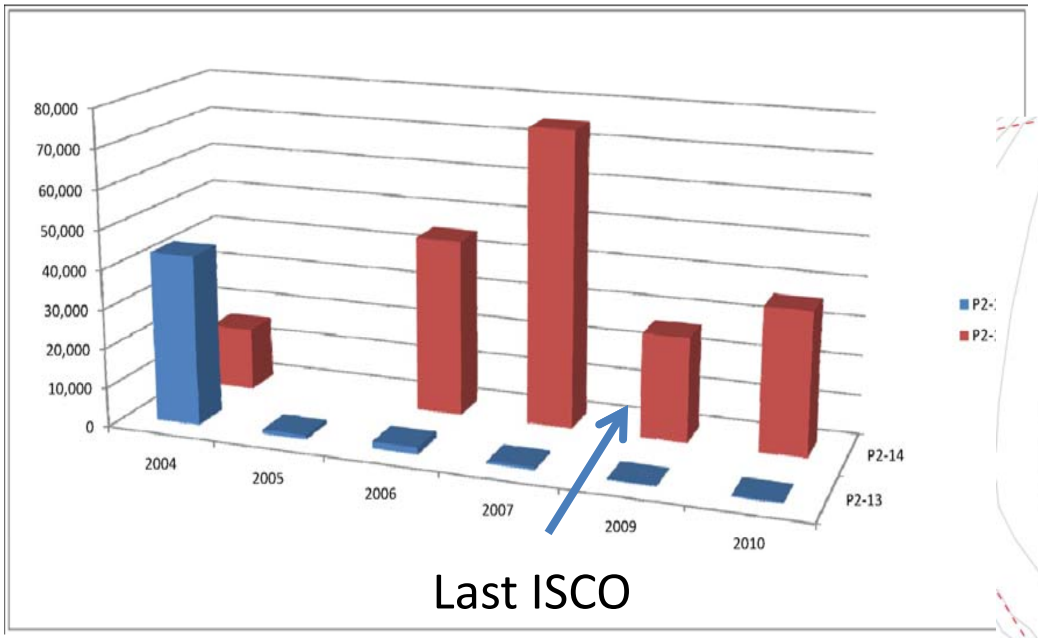
Troubleshooting/Lessons Learned

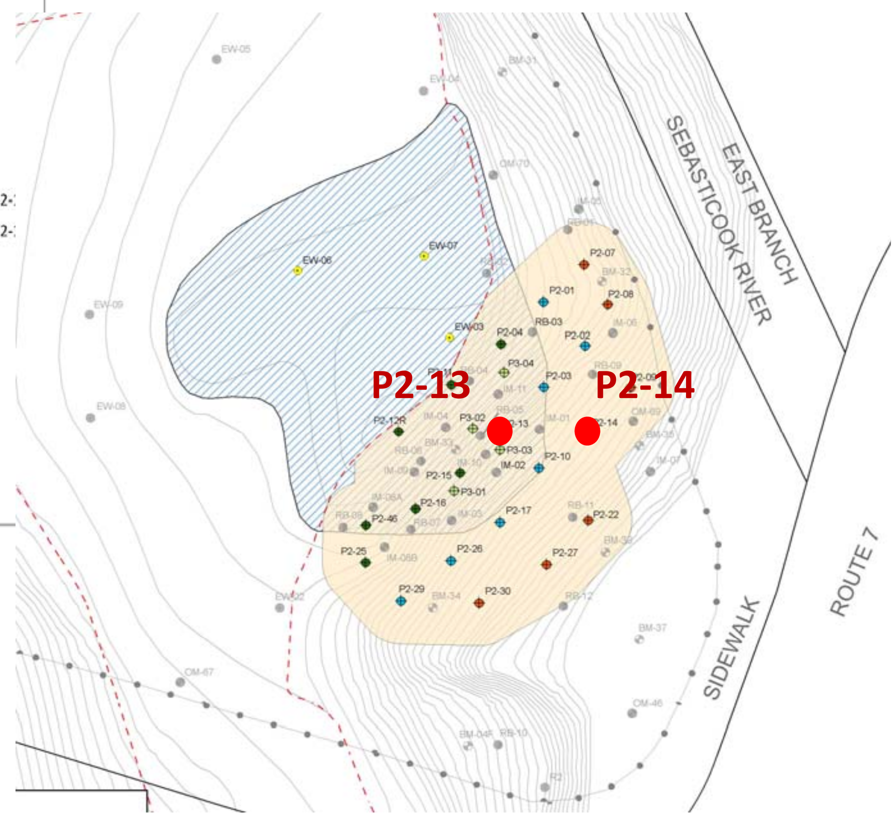
Based on field monitoring, adjustments to application may be required

- High temperature/pressure indicative of aggressive reaction
- Mounding of groundwater table/daylighting
- Injection well "short-circuiting"

Troubleshooting/Lessons Learned

- Oxidant distribution difficulties/heterogeneity





P2-13 vs P2-14

Approx. 15 feet apart

Reaction Daughter Products

Complex chain reactions occur during ISCO

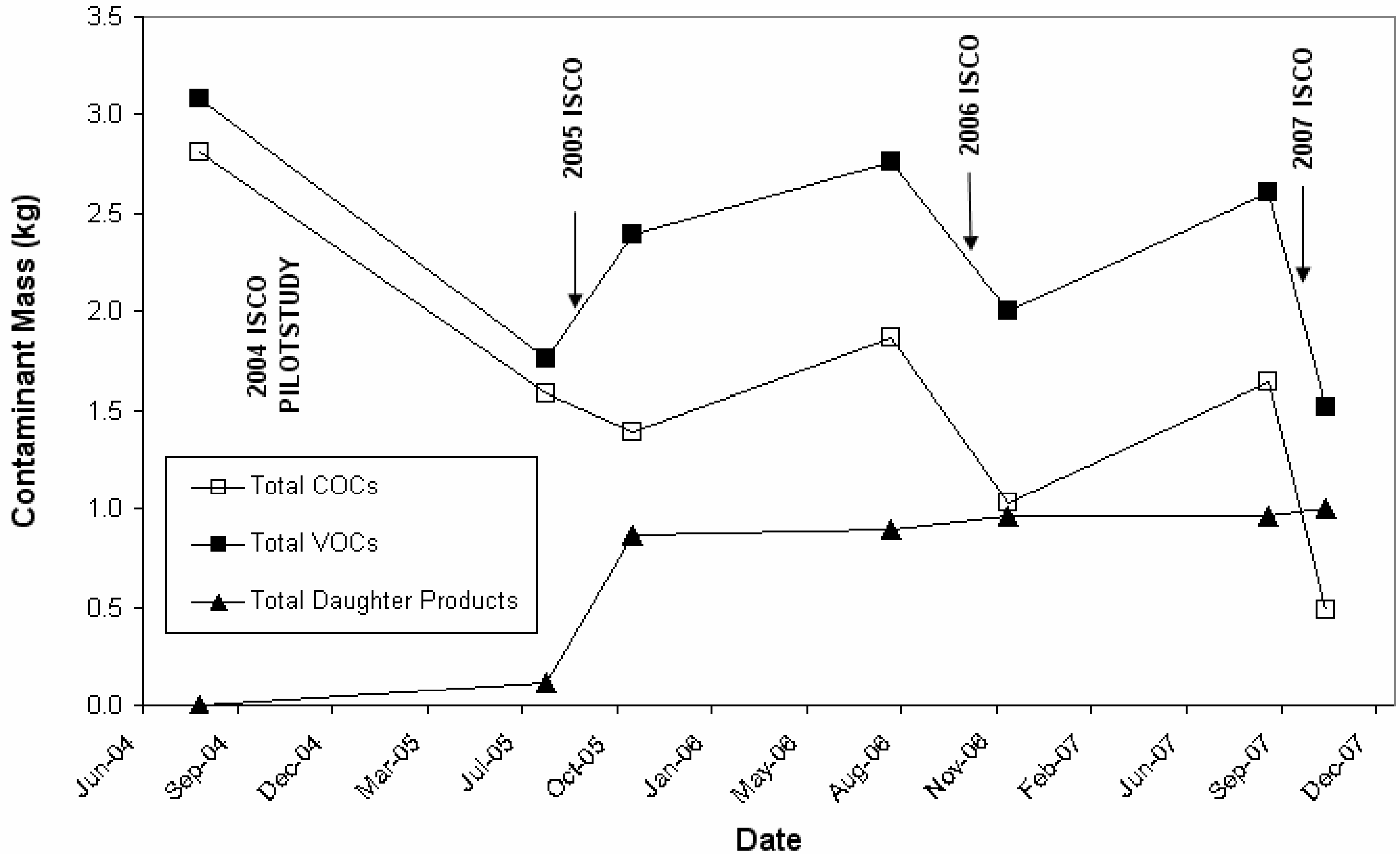
- Incomplete reaction pathways can result in the formation and accumulation of daughter products
- Anticipate and Prepare - Chemical properties and regulatory standards for these compounds can be different than the COCs

Reaction Daughter Products

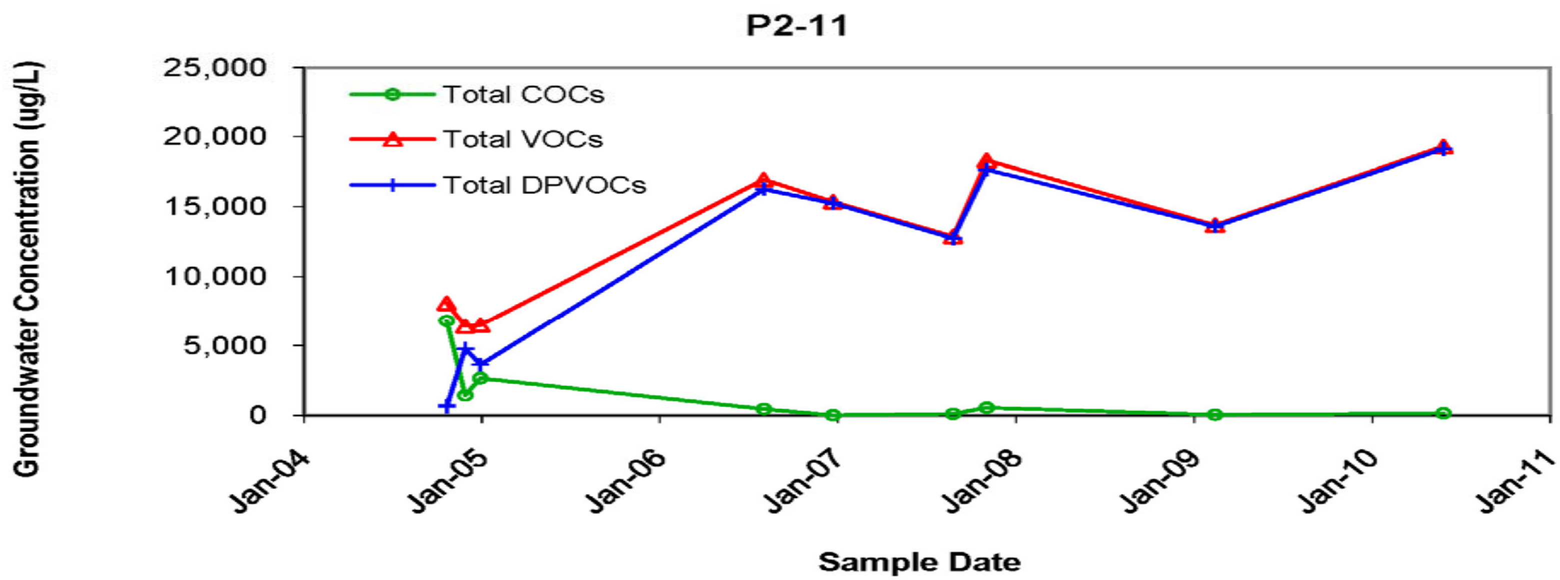
- Pilot study design and evaluation - what products might be formed and how will they be managed?
- You can be successful at treating a COC but may end up with another problem.
- chlorinated benzenes + ICP = chloromethane

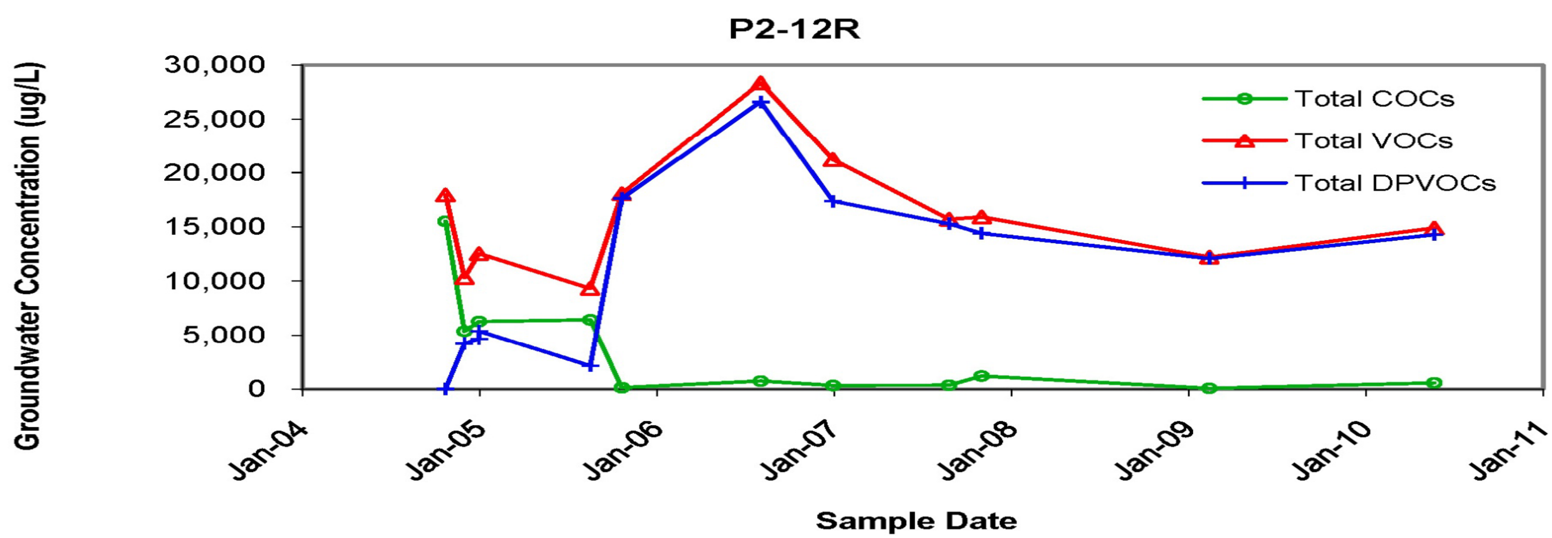
Daughter Products

Eastland Woolen Mill Site - Historical Summary of Area 1
Overburden Groundwater Contaminant Mass Estimates

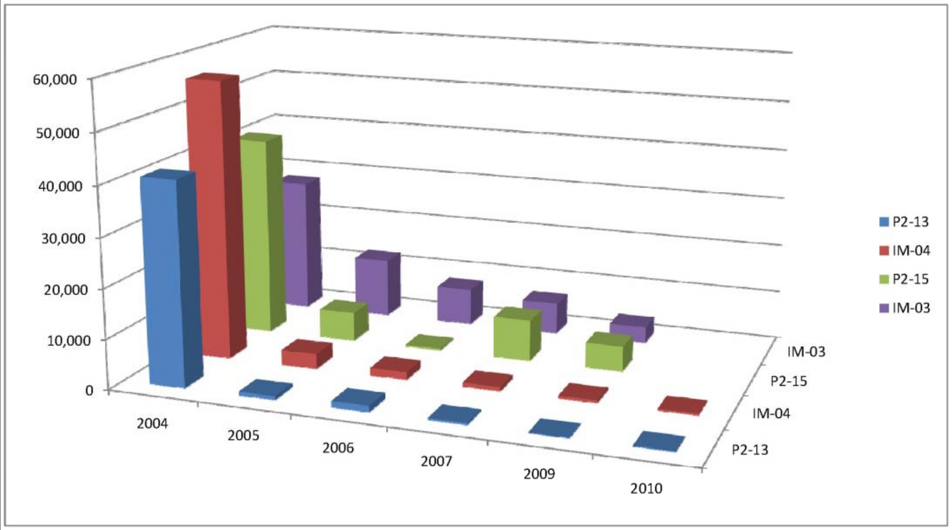


Daughter Products

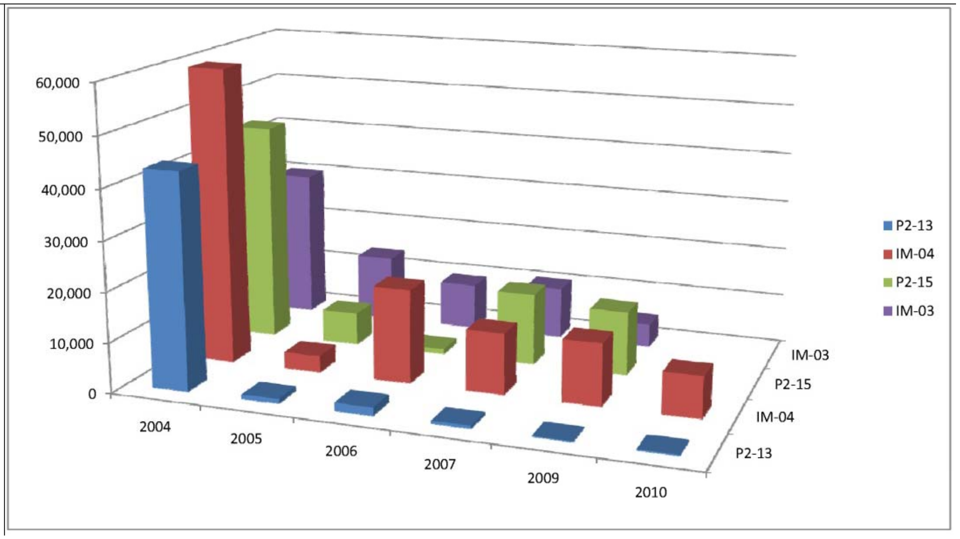




Daughter Products



Total COCs



Total VOCs

Rebound

Rebound is the observed increase in contaminants after ISCO has been conducted

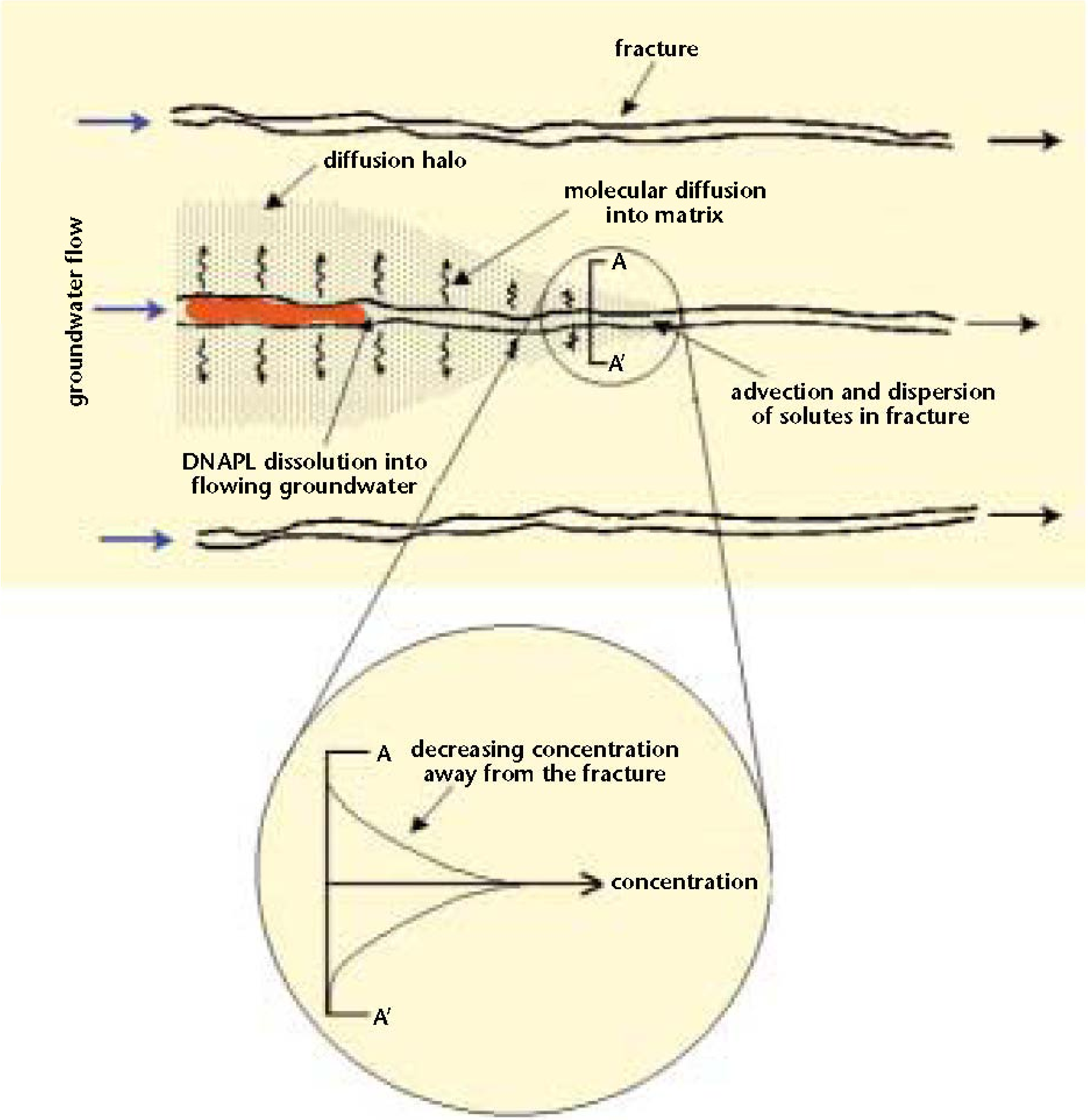
Initial reductions followed by a upward trend towards baseline conditions

Rebound

Occurs due to multiple processes:

- Dissolution of residual NAPL into dissolved phase
- Desorption of sorbed soil sources into dissolved phase
- Back-diffusion from low-K matrices to high-K matrices
- Advection of contamination from outside injection areas

Example of Matrix Diffusion



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Rebound

- Indicates remaining source but difficult to quantify how much remains
- Soil data collected from post-injection boring programs is a better indicator of residual mass than groundwater alone
- Rebound more likely to occur in heterogeneous, low-permeability environments as a result of back-diffusion from low-K matrix blocks into high-K areas (fractures/pathways where flow is preferential)

Addressing Rebound

- If heterogeneity issues are identified during site characterization, use of an oxidant with longer half-life may be effective in addressing some amount of rebound (longer contact time)
- Since rebound indicates residual source, another way to address it is additional injections

Rebound

- Observations of where rebound is occurring and at what magnitude can be useful in evaluating where residual source areas exist
- Can be used to determine where additional injections need to be applied

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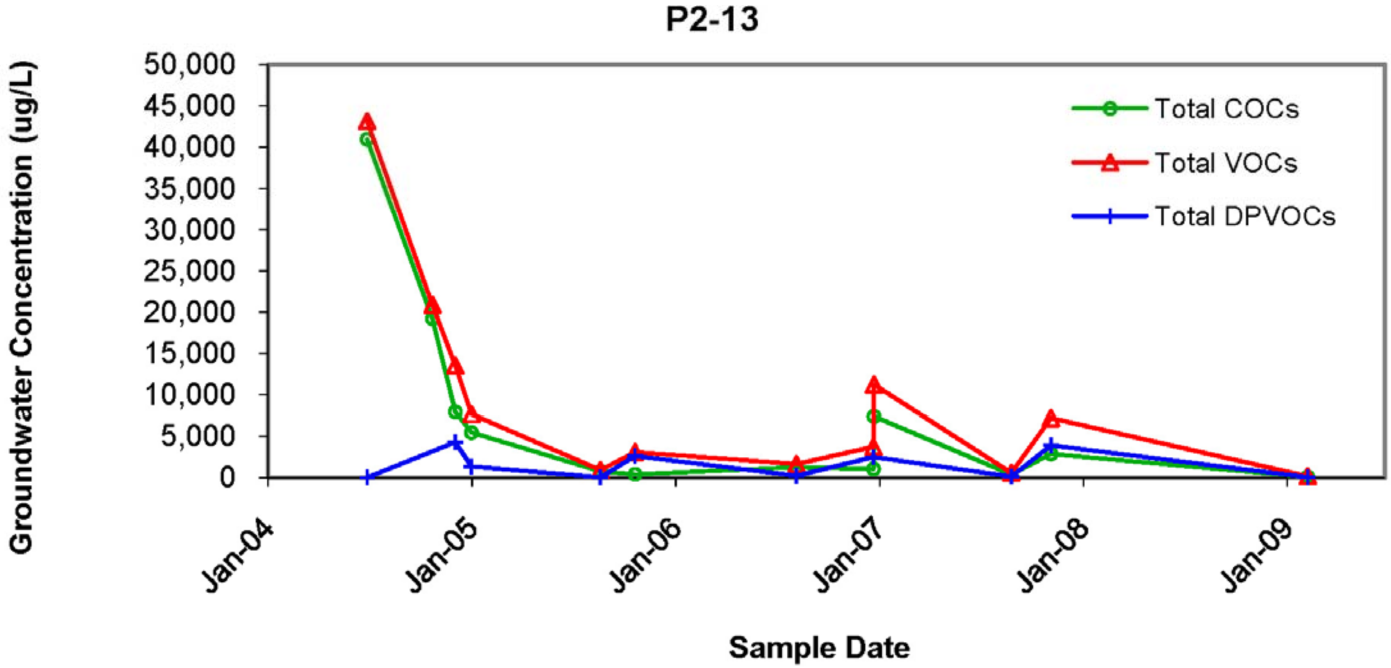
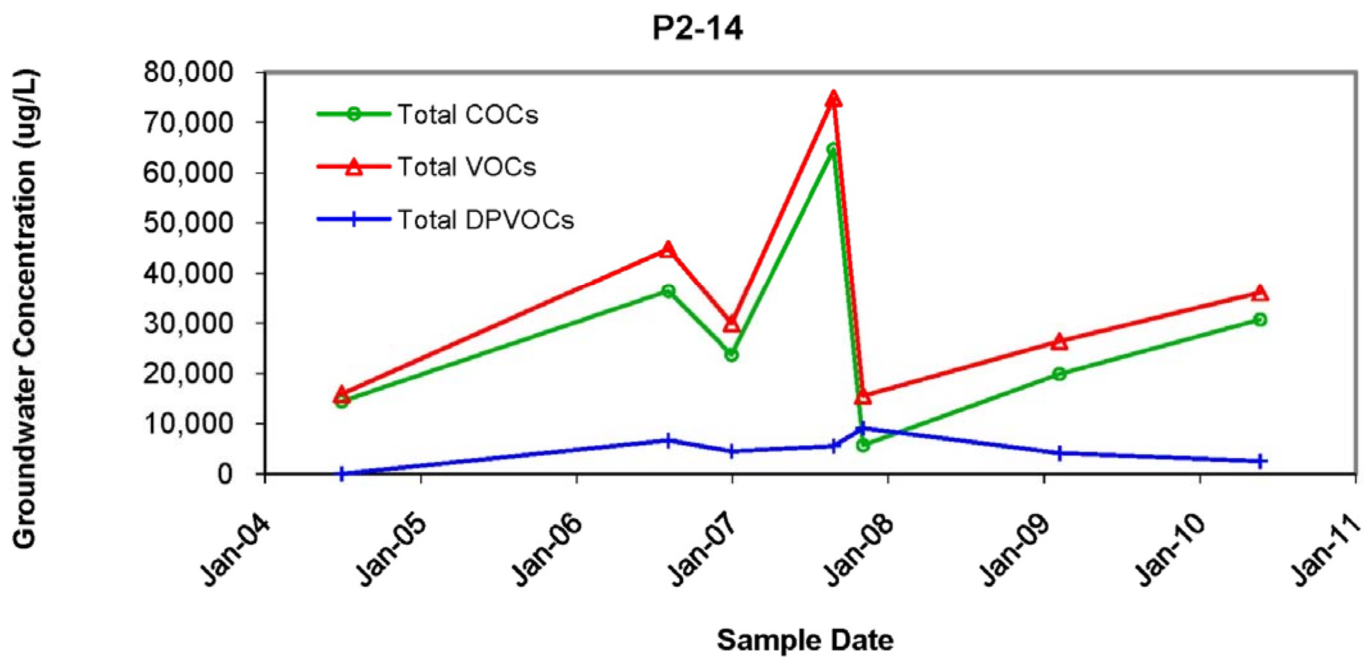
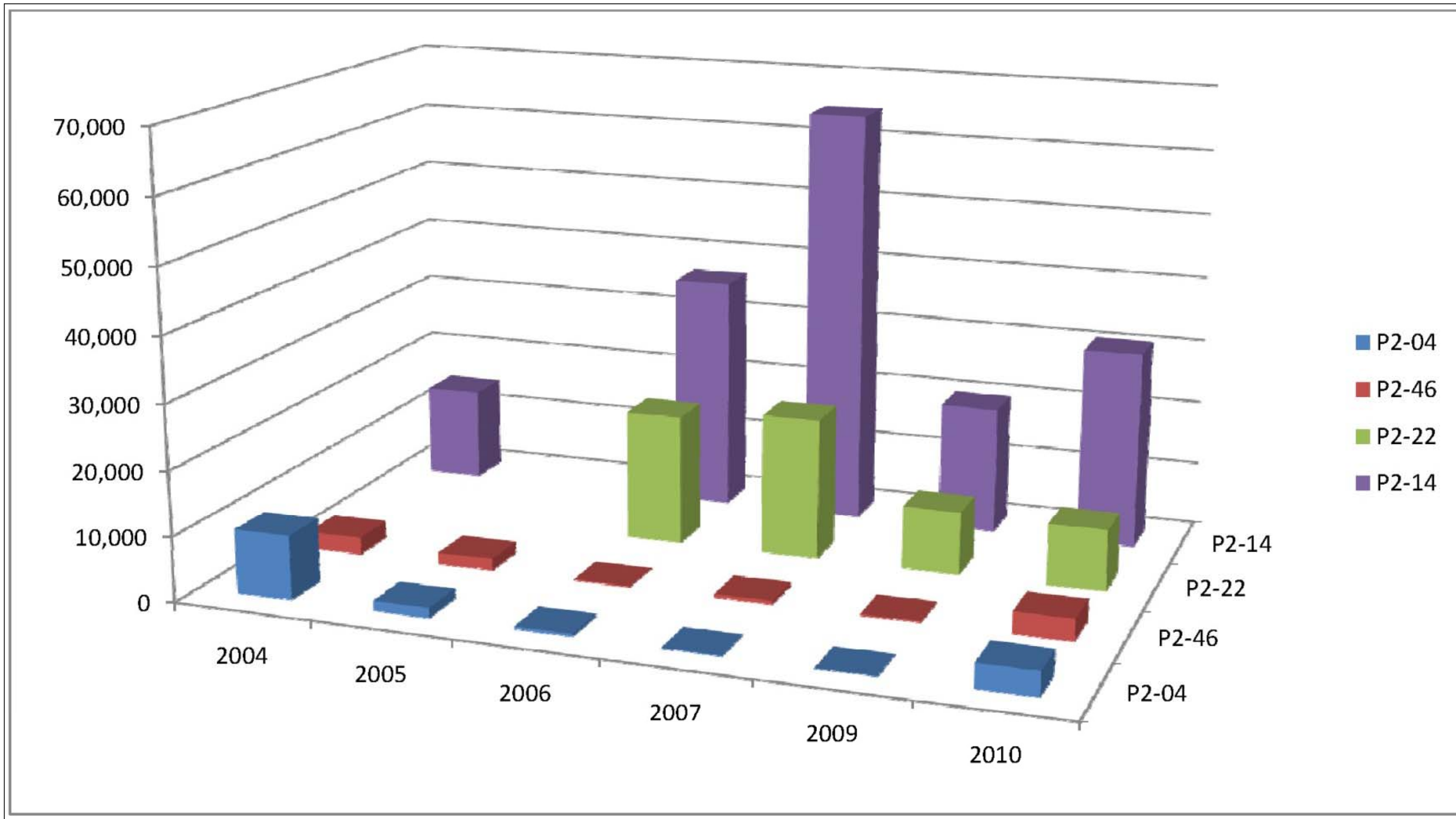
No Rebound



Rebound



Rebound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2009
2010
P2-14
P2-22
P2-46
P2-04
P2-04
P2-46
P2-22
P2-14

Rebound

- May ultimately reach a point where ISCO is no longer cost effective
- ISCO reactions can interrupt naturally-occurring bioattenuation processes
- Bioremediation as a polishing step may assist in treating residual contamination

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References

Some materials presented were taken from:

"An Illustrated Handbook of DNAPL Transport and Fate in the Subsurface", Environment Agency, 2003