



Phytoremediation as a Technology for Both Risk Management and Remediation at a Former Herbicides Production Site

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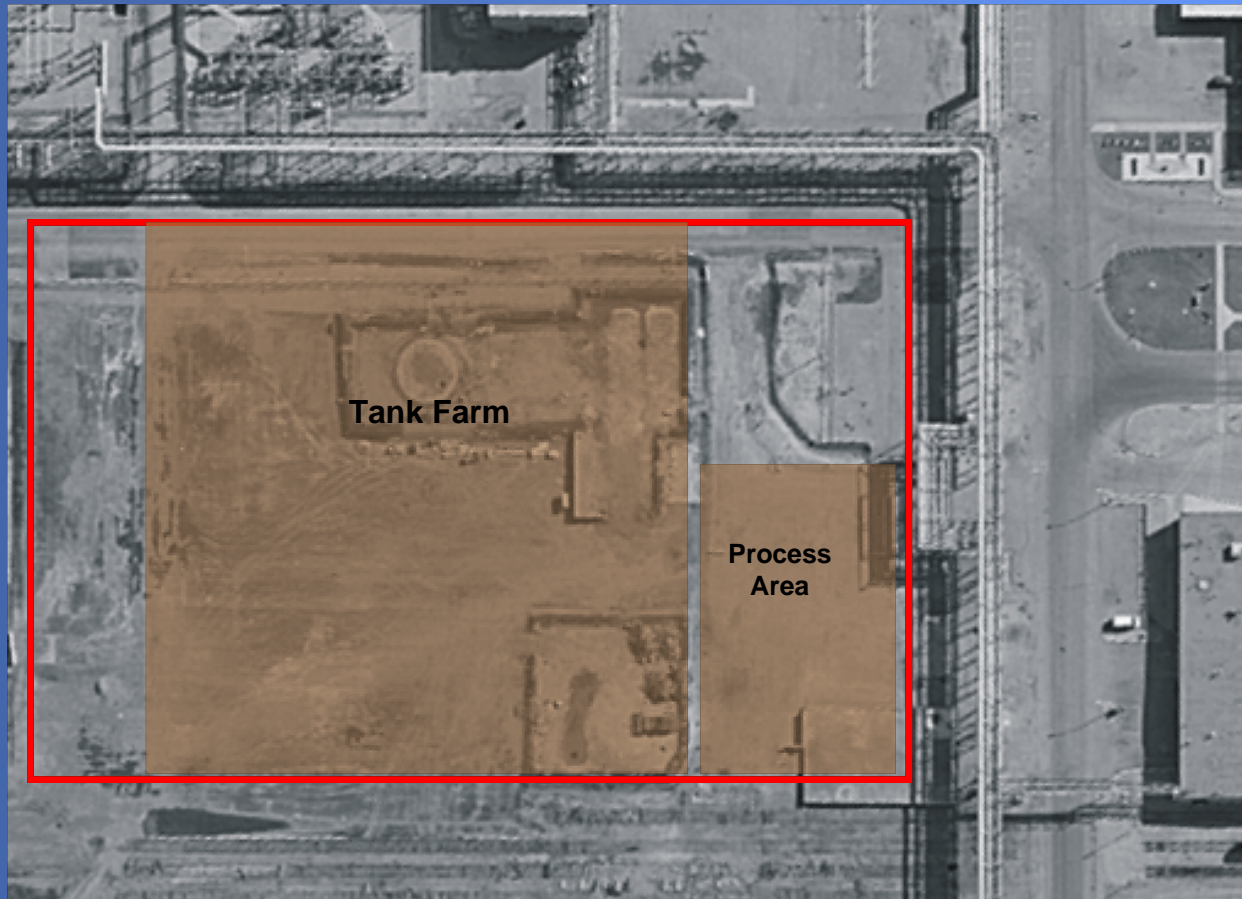
Remediation Leader, Dow Chemical Canada, Inc.

History of Herbicide Production Area



- Start-up of herbicide operations in 1961
 - 2,4-D
 - chlorophenols
- Shut-down of herbicide operations in 1980
- Demolition of equipment
 - early 1980s
 - asphalt cover

Former Herbicides Plant Post equipment demolition



Key Issues

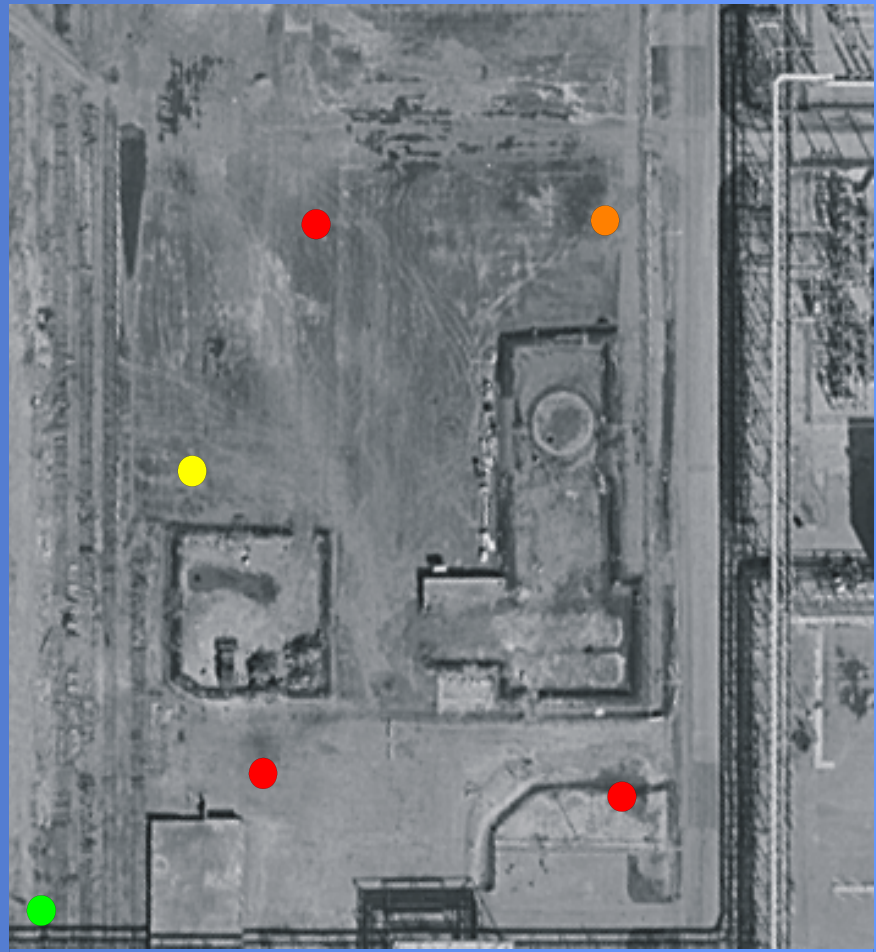


- Soil contamination
 - Groundwater contamination
 - Asphalt cover
- 2,4-D
 - Phenols
 - Chlorinated Organics

Groundwater Analytical Data - 2,4-D

ppb

■	400	to	1,900
■	40	to	400
■	8	to	40
■	4	to	8
■	<4		



Soil and Groundwater Management Strategy



- Understand Risks
 - Characterization
 - Fate and Transport
 - Risk Assessment
- Apply Risk Management Systems
 - Mitigate contaminated groundwater movement
 - Manage exposure to personnel
- Remediation (cleanup) of contaminants in groundwater and soil

Phytoremediation- Risk Management *and* Remediation



- Cost effective and efficient control of groundwater movement
- Biodegradation by plants and their associated root-zone microbial populations
- Addition of oxygen to degrade site contaminants
- Manage contamination in-situ
 - no waste generation
 - no energy use
 - sustainable

Phytoremediation Pilot Study

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- Hydraulic Control
- Contaminant Reduction
- Phytoremediation Technology Research

Phytoremediation Pilot Chronology



- Initial Plant Viability Test (2002)
 - Two plots with a total of 16 trees and grasses
 - 6 species of trees, 4 of grasses
- Phyto Pilot Study (June 2005)
 - 475 trees, 6 species
 - 100+ monitoring installations
 - designed research studies
 - monitoring program
 - analytes, tree health, water level data

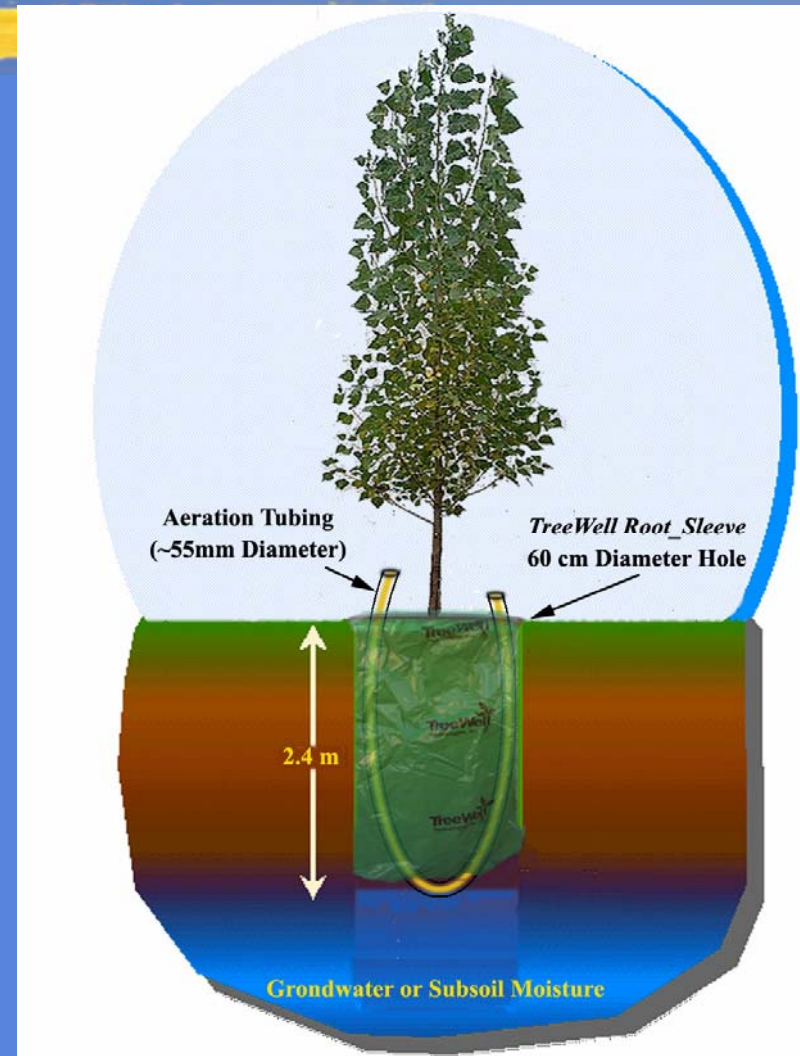
Phytoremediation Pilot Design Parameters



- Sufficient quantity of trees to create drawdown
- Direct trees to deeper groundwater extraction
- Protect Tree roots from high herbicide concentrations
 - *TreeMediation*[®] System
- Mixed tree variety to evaluate viability
- Three experimental designs

Specific Planting Technology

- Patented phytoremediation technology Treemediation®
- Water flows upward through media in TreeWell® Root_Sleeve
- Biodegradation prior to tree root uptake
- Targets deeper groundwater



Tree Planting Locations

- Strategic grid system
- Higher concentrations
- 4.5 meter centres





June 17, 2005

Asphalt was jack hammered and soil augered.



All tree locations & in-well monitoring
installed



Planting process underway.



Phytoremediation Research Plots



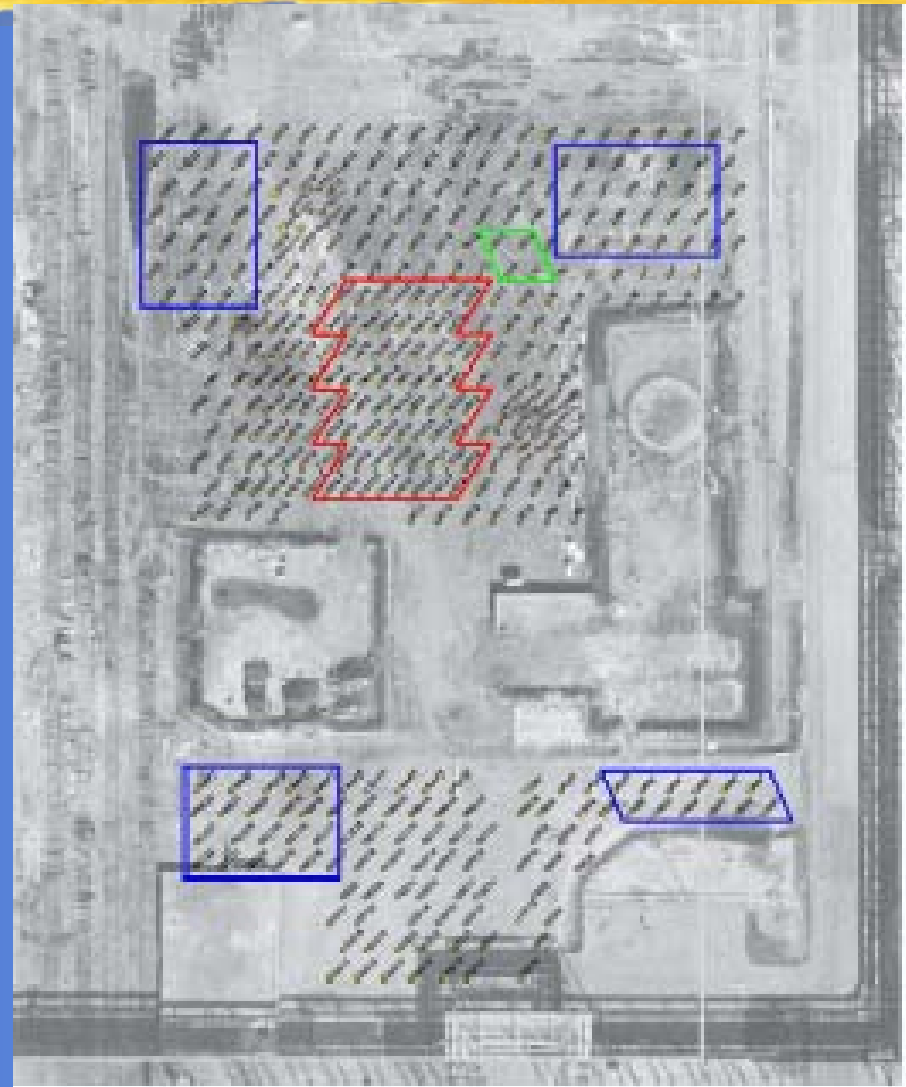
- Species Study
 - 4 plots, 6 species with 4 replicates of each type
- Area of Influence Study
 - 4 willows, 4 monitoring wells with each willow
- Treatment Effectiveness Study
 - varying soil mixture, w or w/o air tube, w or w/o sleeve

Phytoremediation Research Plots

Treatment Effectiveness Study

Species Study

Area of Influence Study



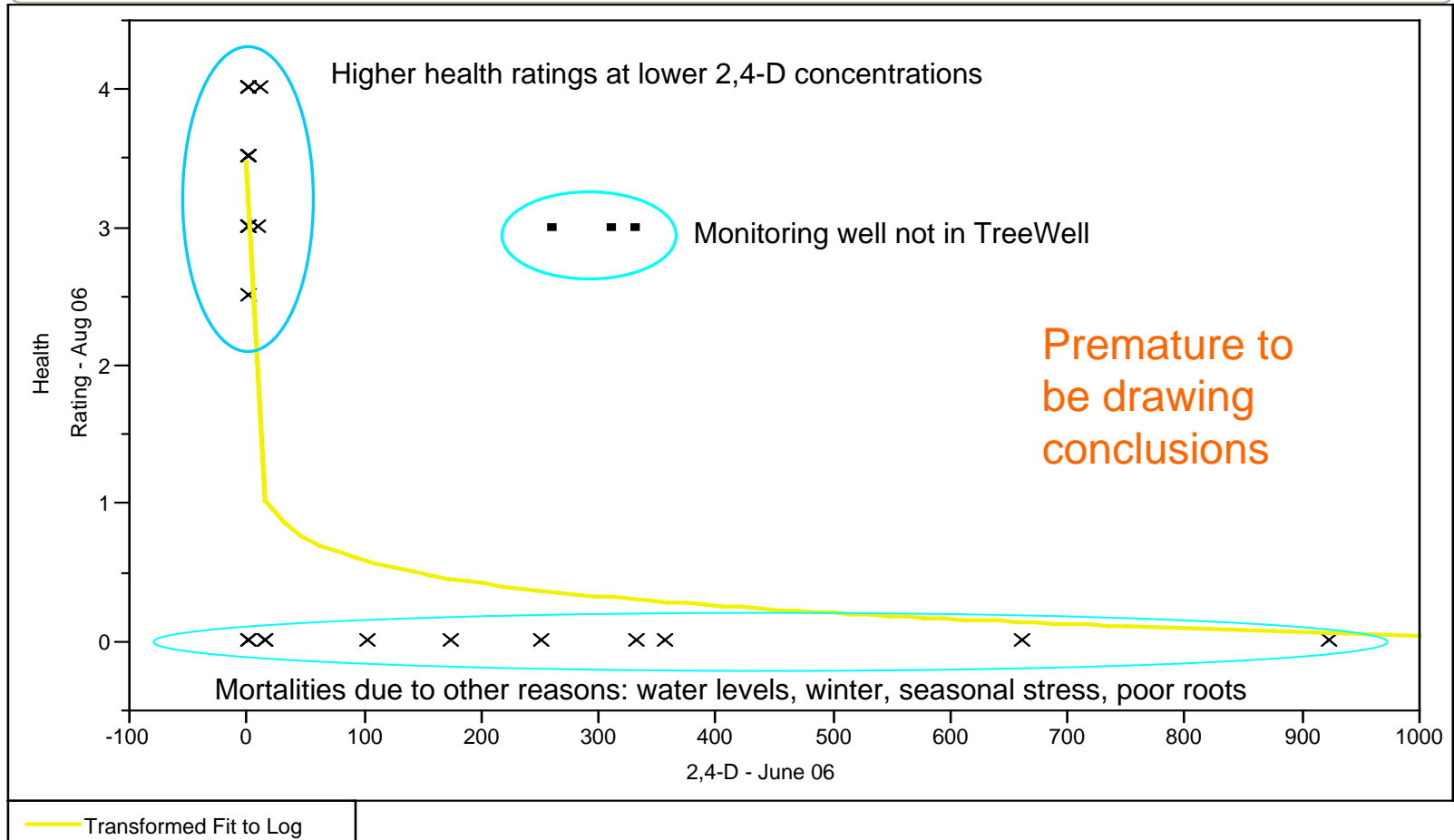
Phytoremediation Research Results



- Species Study – Tree Viability, overall mortality 34%
 - Green ash – zero mortality, good viability results/lower water use
 - Aspen – acceptable viability results/medium water use
 - Willow and poplar – low to moderate viability results/robust water use
 - High water levels confound results for willow & poplar
 - Evidence of high concentration effects for willow
 - Birch & hackberry – low vigor rating, low survival rate
 - Russian olive (2002) – promising species

Tree viability

Bivariate Fit of Health Rating - Aug 06 By 2,4-D - June 06



Panoramic View Phyto Pilot Project – Year 2



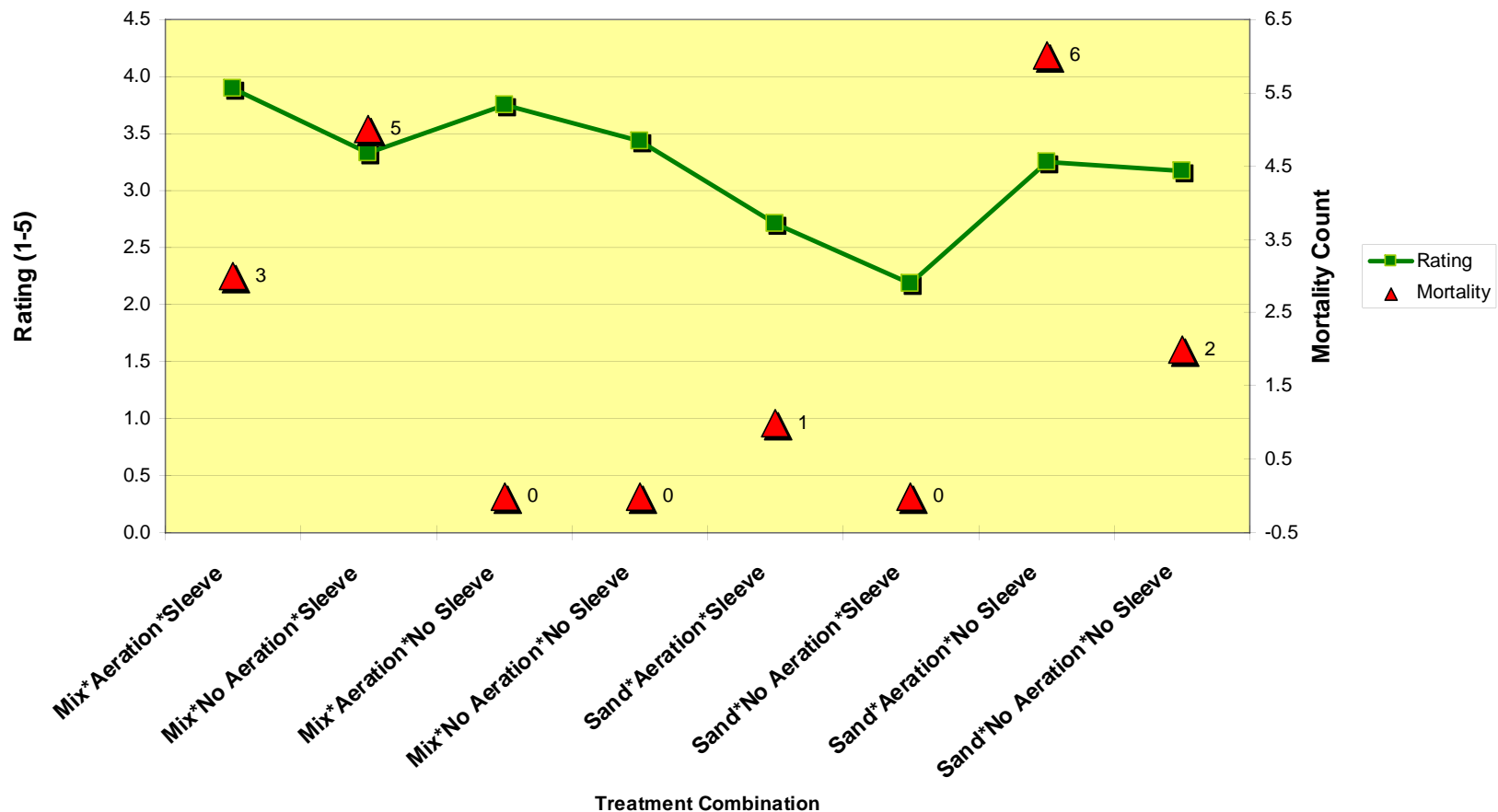
Phytoremediation Research Results



- Area of Influence Study
 - Willow mortality- 100%
 - Likely due to high 2,4-D concentrations
 - No conclusions - artificially high water table is confounding results

Phytoremediation Pilot Treatment Effectiveness Study

Treatment Effectiveness Study
August, 2006



Phytoremediation Pilot Hydraulic Control Study



- Hydraulic drawdown due to tree uptake - no conclusions yet
- Artificially high water table confounding results
 - Average depth to groundwater in 2002 = $2\text{ m} \pm$
 - Actual encountered in 2005 & 2006 = $0.5\text{ m} \pm$
- Tree establishment and viability is inhibited

2002 Phyto Demonstration



- Limited planting to show if plants viable in these site conditions
- Water table levels low in 2002
- Mortality high, but a few are thriving

2002 Plantation Areas

Between-Tree Monitoring Well # 2

Between-Tree Monitoring Well # 1

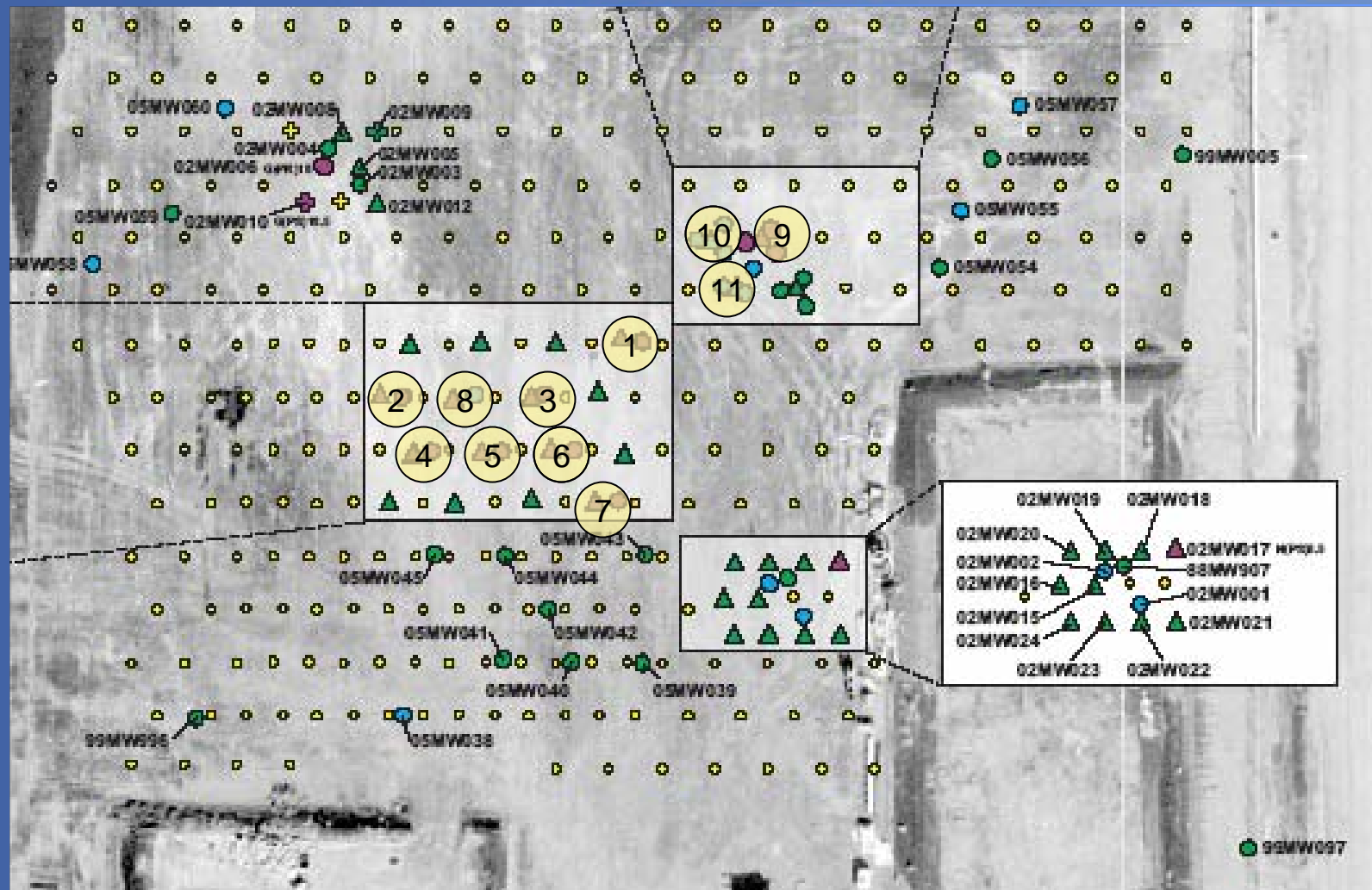


Phytoremediation Results

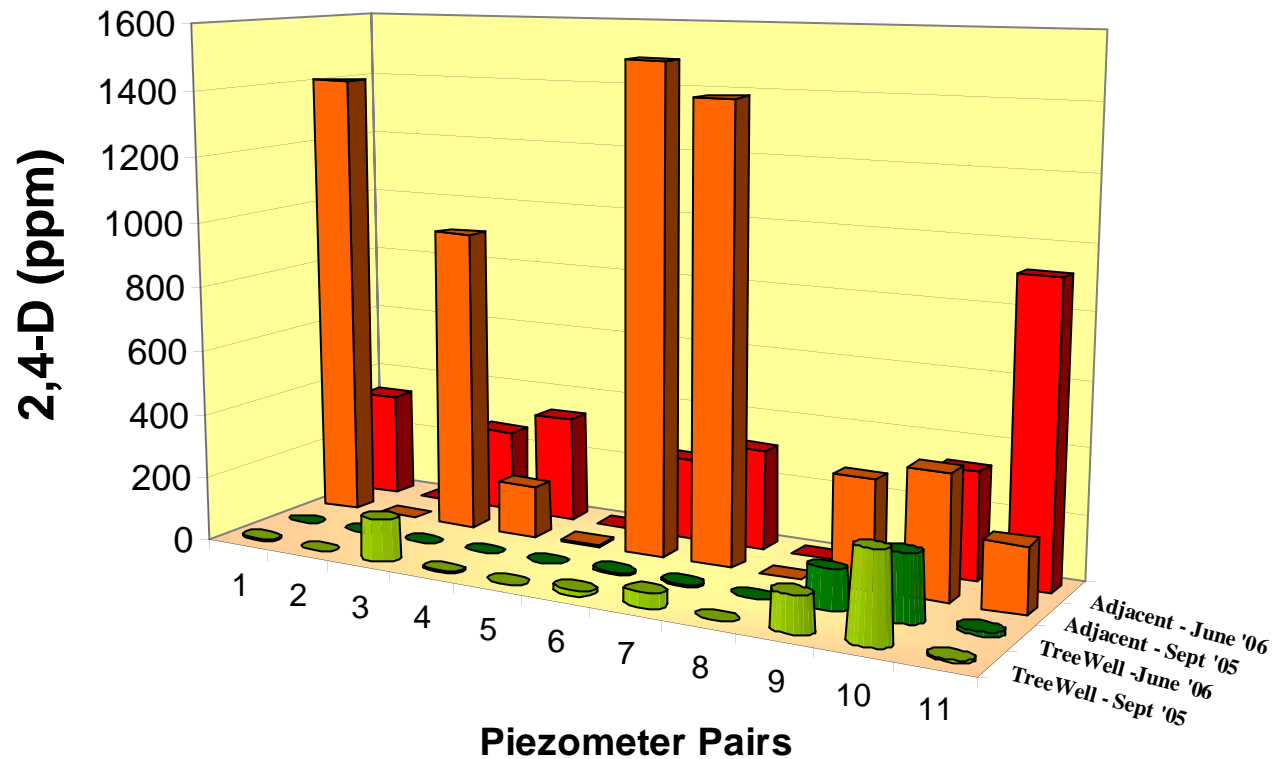
Groundwater Data



	Between Trees Monitoring Well # 1 mg/L			Between Trees Monitoring Well #2 Mg/L		
	07/24/2002	09/14/2005	06/06/2006	07/24/2002	09/14/2005	06/06/2006
2,4 – D	300	0.009	0.0058	290	0.13	1.3
3 & 4 - Chlorophenol	130	1.5	0.4	52	7.6	3.7



2,4-D Comparison of Paired Piezometers
TreeWell Piezometer vs Adjacent Piezometer
2m spacing (0.5m for Pairs 9-11)



■ TreeWell - Sept '05

■ TreeWell - June '06

■ Adjacent - Sept '05

■ Adjacent - June '06

Monitoring Plan



- Tree health assessment
 - 3 times/year
- Groundwater levels
 - 8 times/year
- Groundwater sample collection and analysis
 - 2 times/year
 - VOC's, chlorophenols, herbicides
 - Field parameters (pH, temp, ORP, conductivity, D.O.)

Next Steps in Pilot Study



1. Collect soil data to compare with 2002 data
2. Collect representative leaf and stem samples for nutrients and herbicides analysis
3. Replant dead areas in spring 2007 (perhaps 2 tree varieties/hole)
4. Plant control area for species evaluation (spring 2007)
5. Harvest representative number of trees in fall 2007 to evaluate root growth

Expectations



- Phytoremediation can be an effective risk management system
- Phytoremediation is a remediation technology
- Site conditions are a challenge but not insurmountable

Contributors to Project



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Questions?

Phytoremediation Pilot Project

Work in Progress



Trees have been planted here to study the long-term improvement of the soil and groundwater through the use of this innovative remedial technique.

RESTRICTED ACCESS
DO NOT ENTER

WEST WOODS ESTATES

