

Lessons Learned from Multiple ERH Implementations Design Considerations and Challenges

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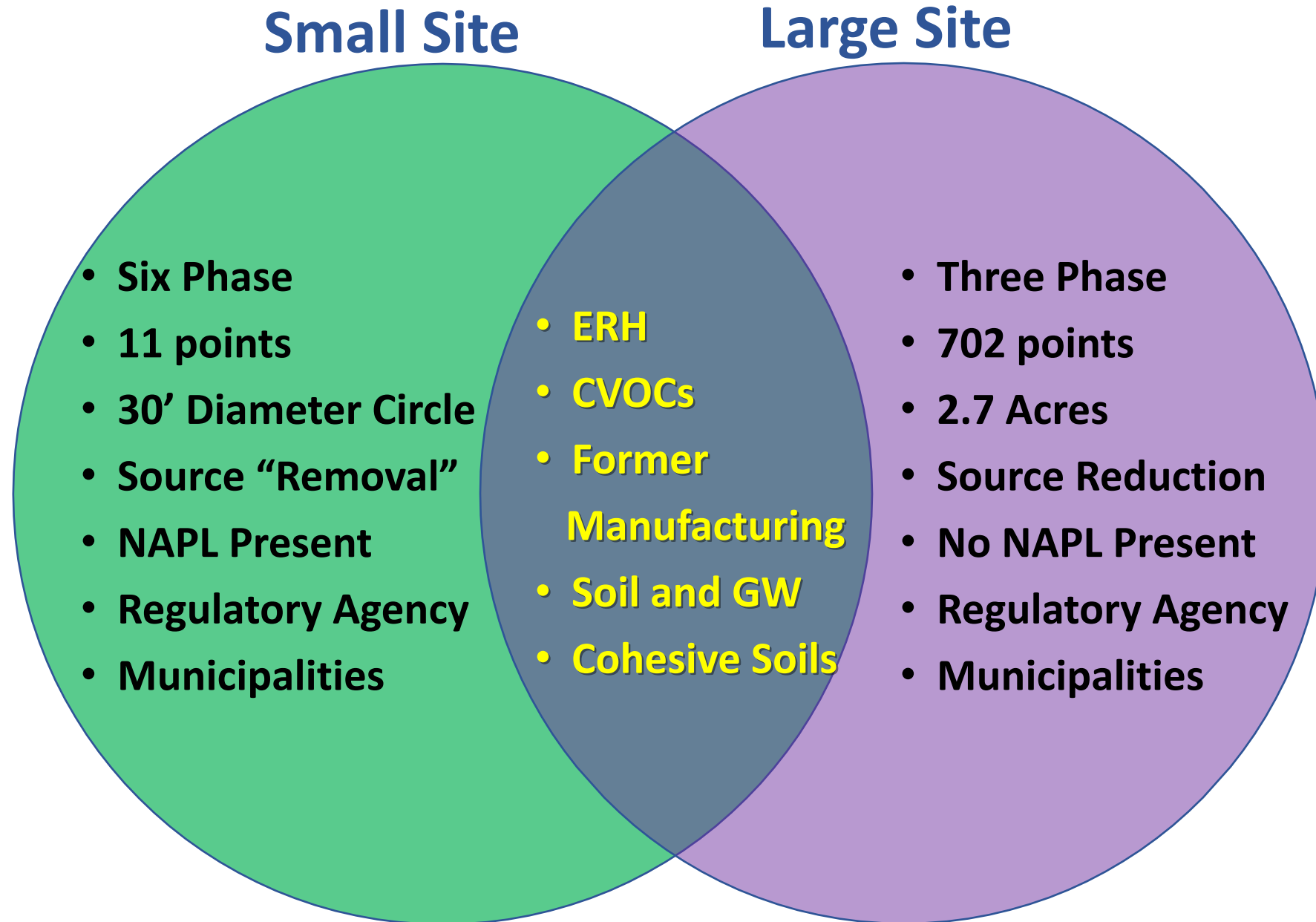


- Overview
 - Technology
 - Case Studies
- Design/Implementation
 - Hurdles
 - Goals
- Operation
 - Heatup
 - Mass removal
 - Hydraulic Control
 - Soil Cooldown
- Lessons Learned

In-situ Thermal Treatment (ISTT)

- Electrical Resistive Heating (ERH)
- Vigorously Heat the Subsurface
 - Enhanced volatilization
 - Boil off VOC impacts
 - Steam Formation/Partitioning
- Limited Specialty Vendors
- Relatively High Cost
- Best for:
 - Low Cleanup Goals
 - Low Permeability Zones





Large Site

Small Site



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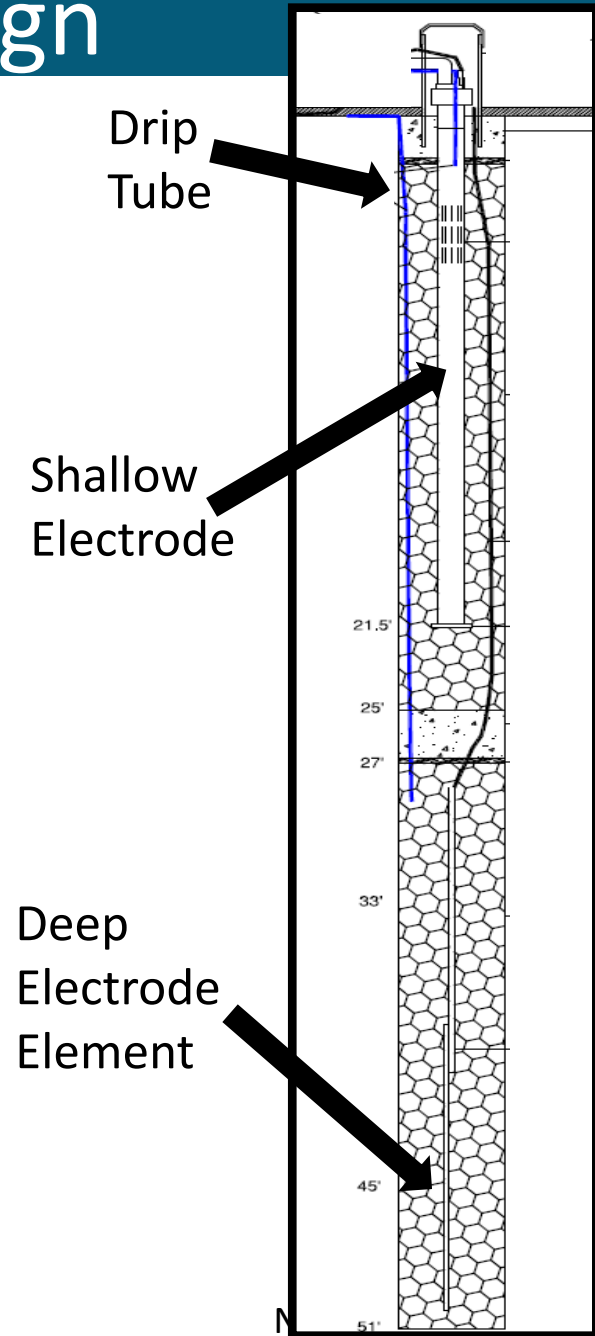
Small Site



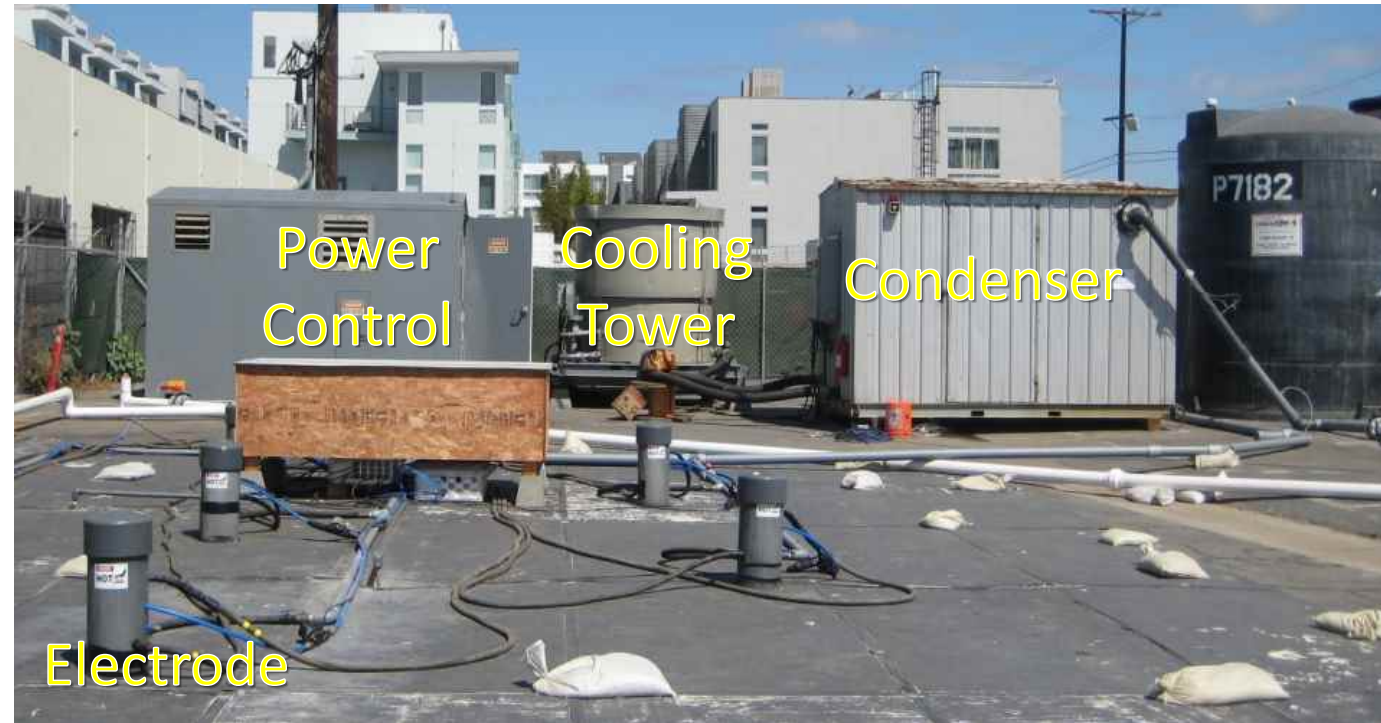
Large Site



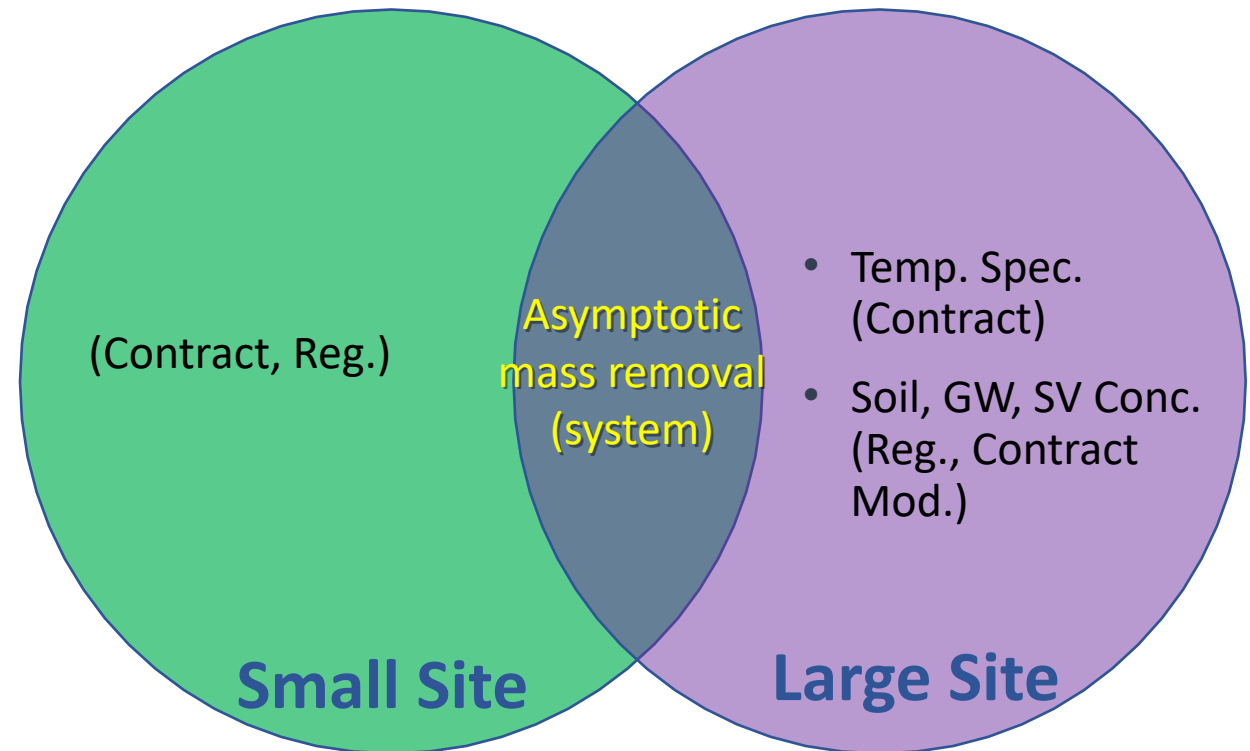
- Power Drop/Electrical Permit
- Air permit
- Injection Permit
- POTW permit



Small Site



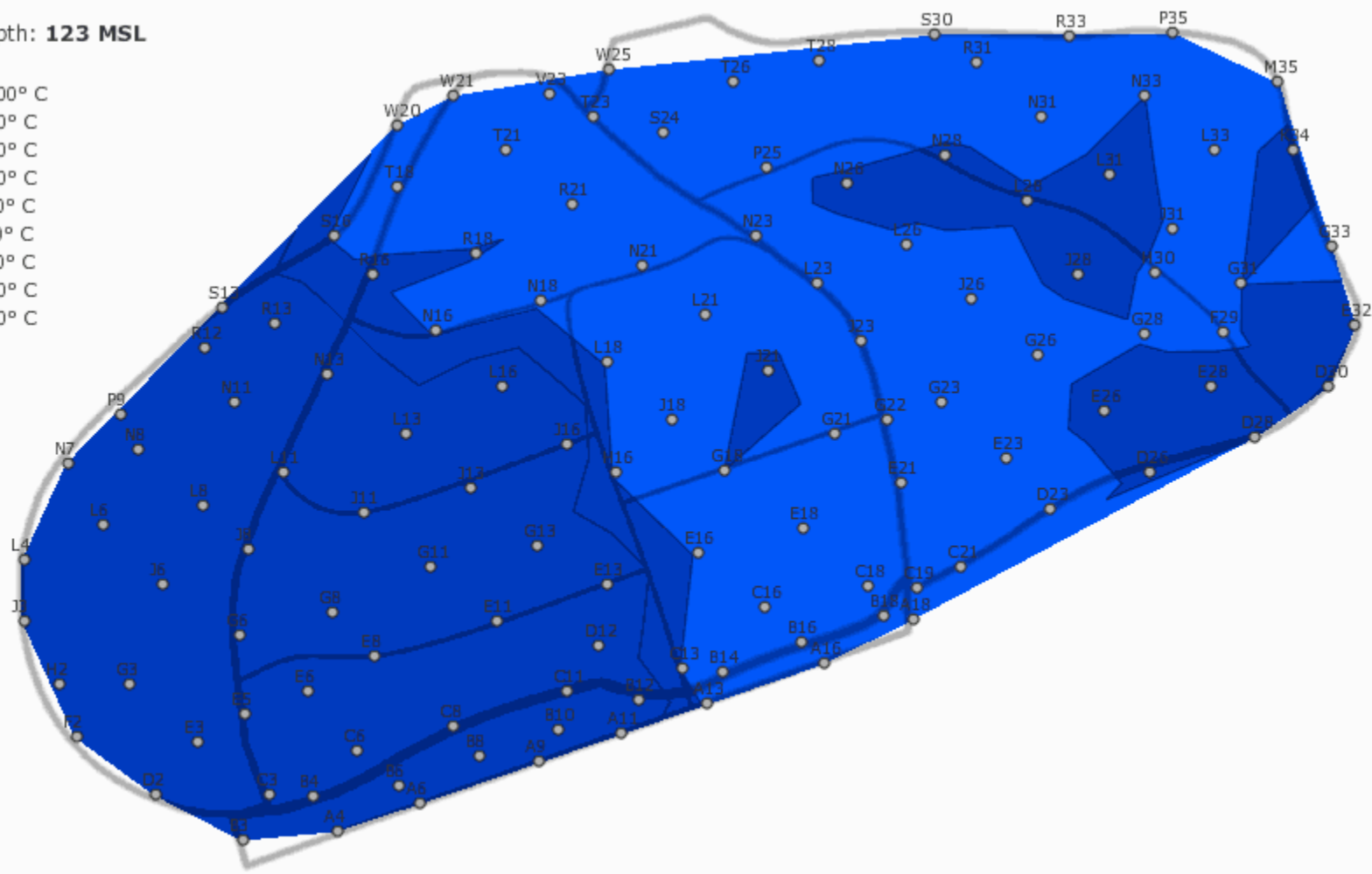
- System vs. Contractual vs. Regulatory
- Specific vs. Conceptual (e.g. “source mass reduction”)
- Asymptotic mass removal (from influent stream)
- Soil, Groundwater, Soil Vapor – below threshold
- Temperature Specification
- Mass reduction in subsurface



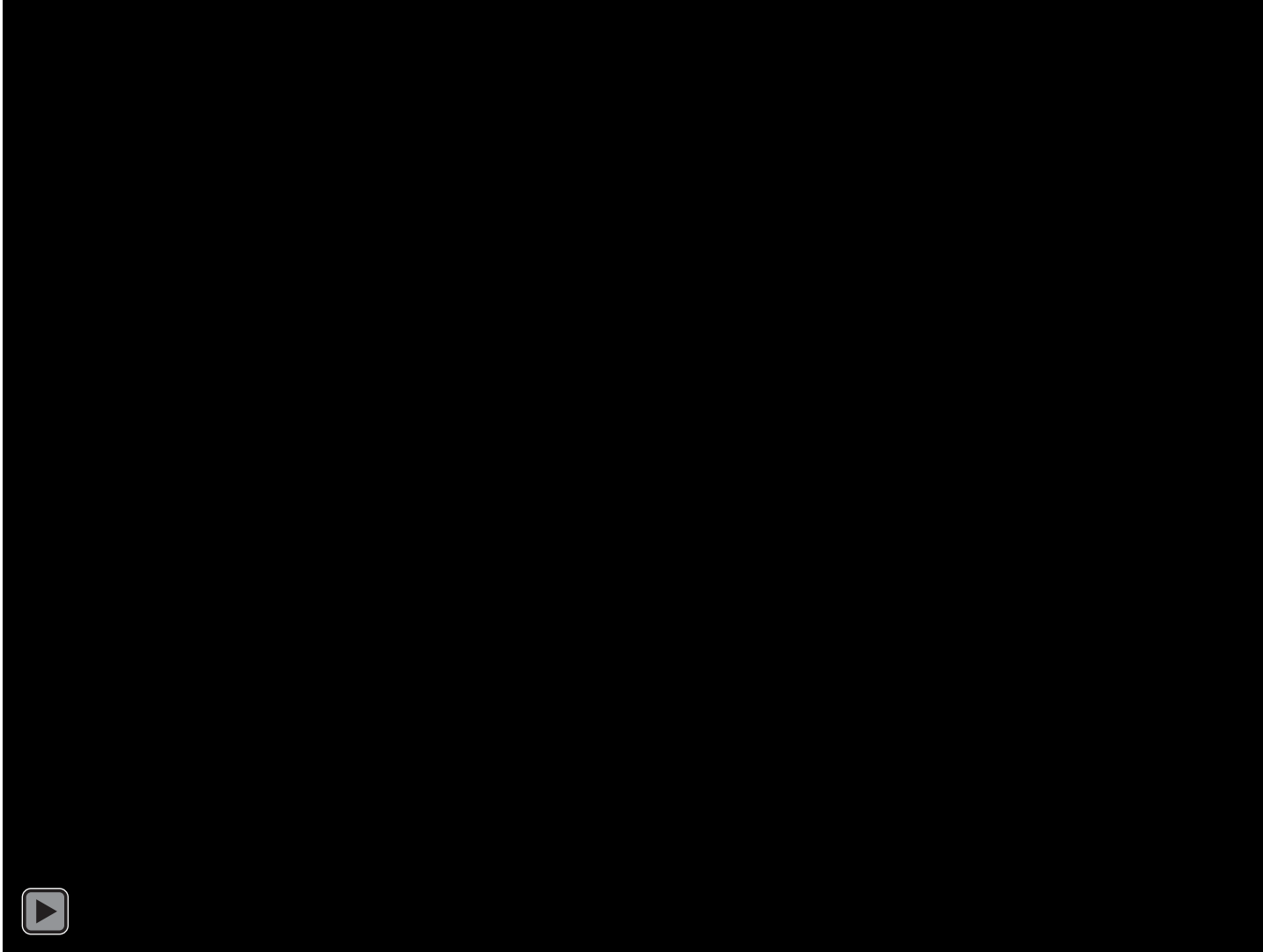
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Large Site Heating (Zones 2-6)

Current Depth: **123 MSL**

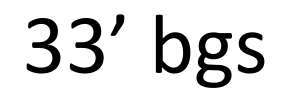


Large Site Heating (Zones 2-6)



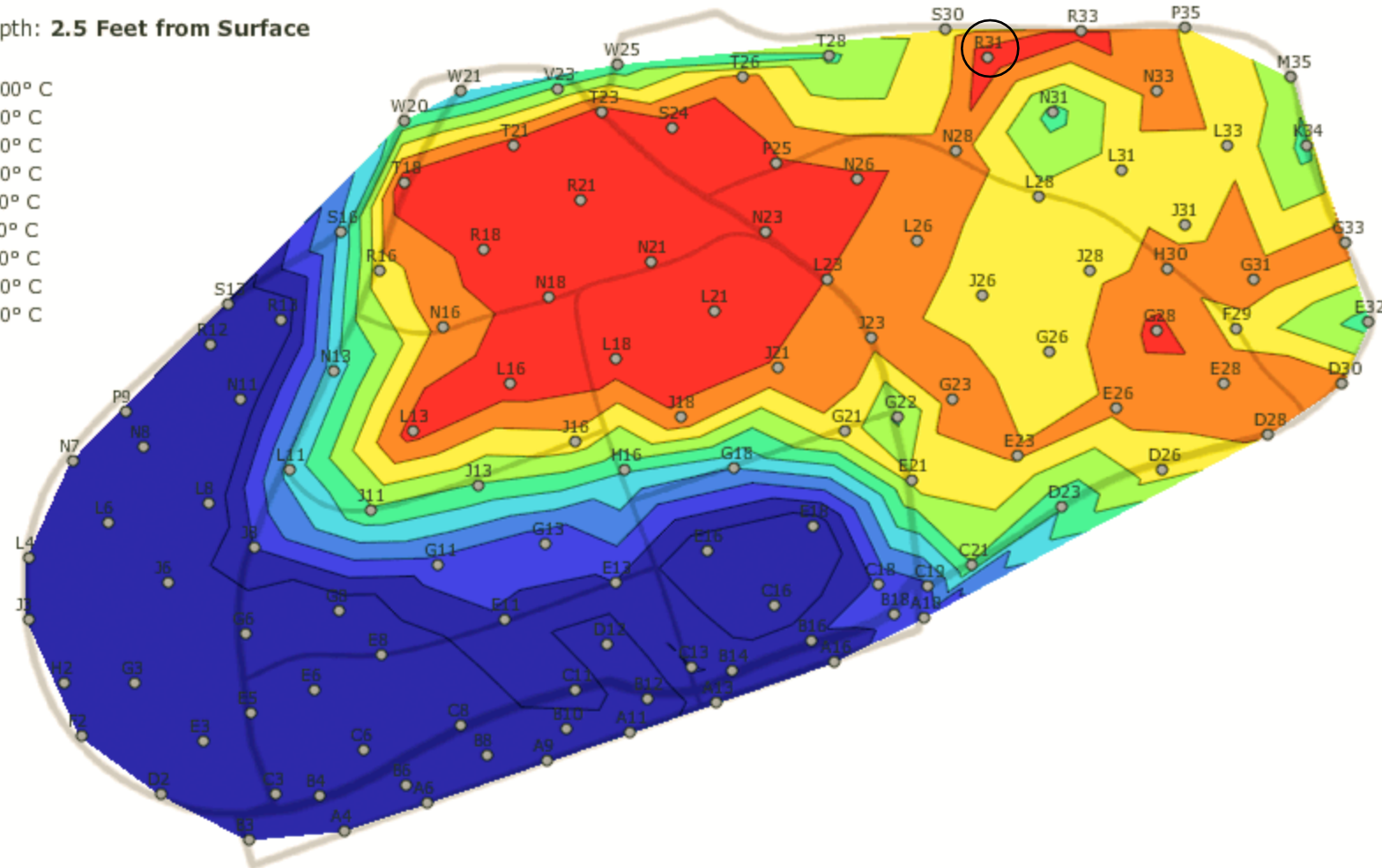
33' bgs

GEOTECHNICAL ENVIRONMENTAL ECOLOGICAL WATER CONSTRUCTION MANAGEMENT



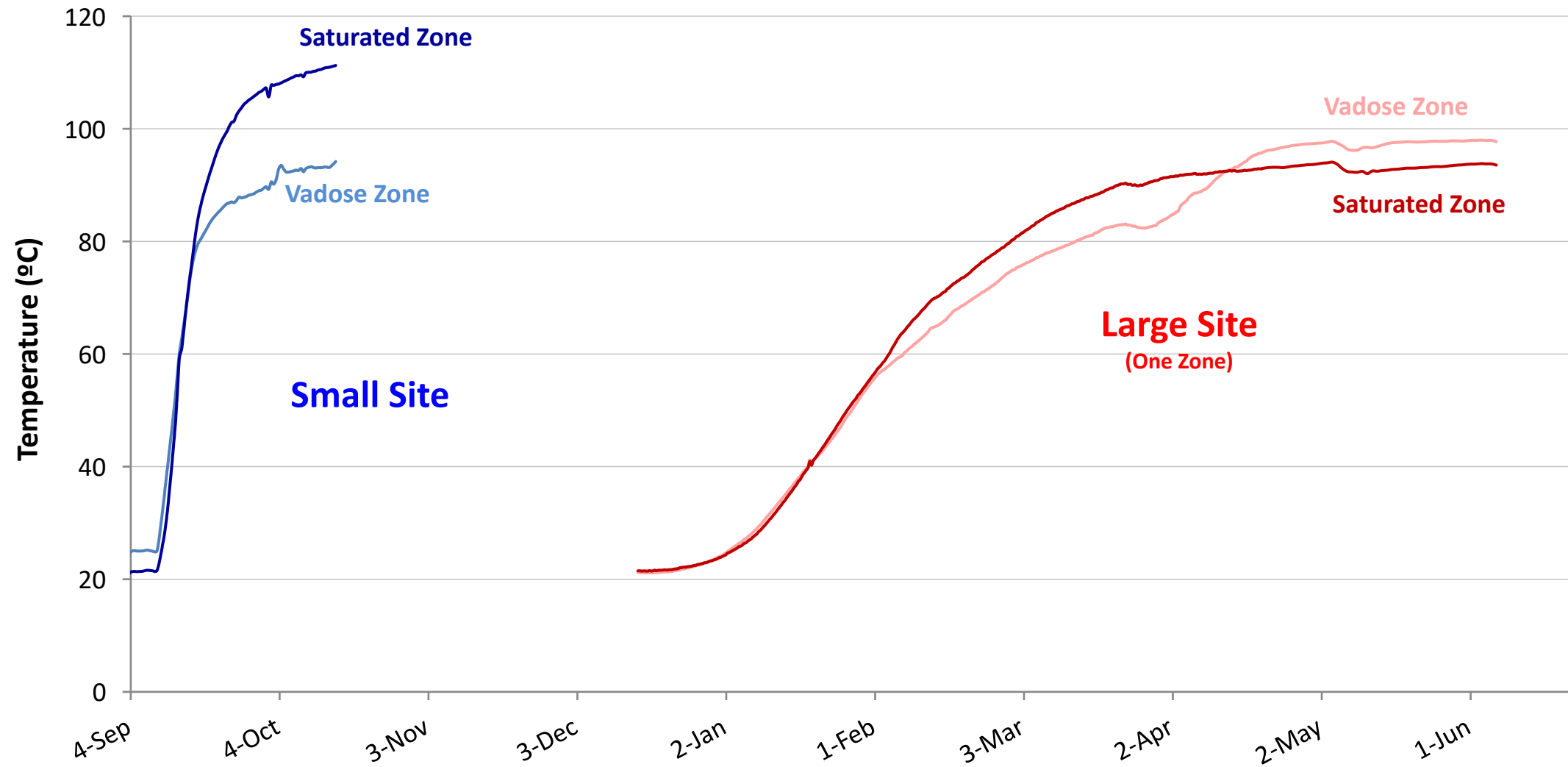
Large Site Shallow Heating (Zones 2-6)

Current Depth: **2.5 Feet from Surface**

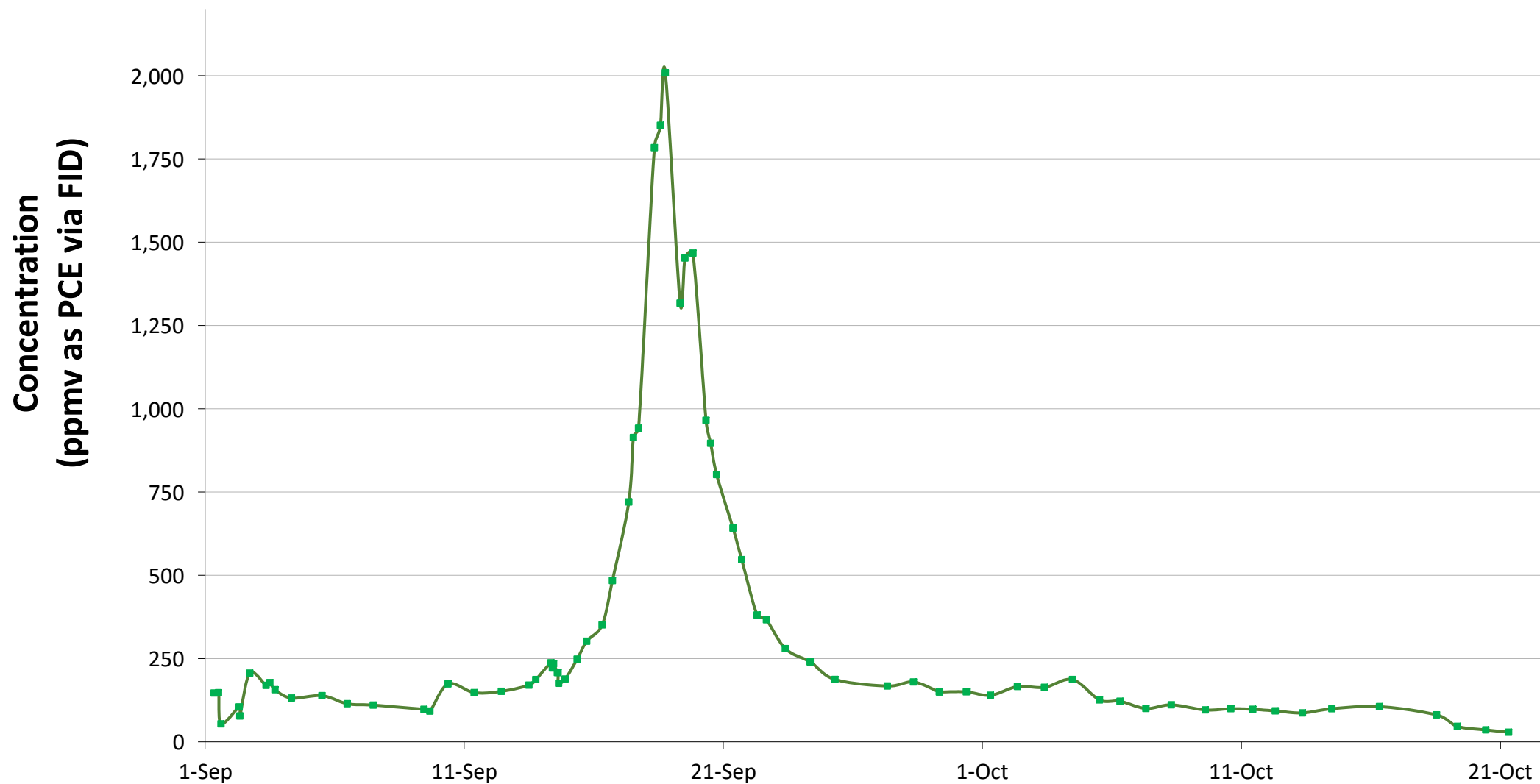


2.5' bgs

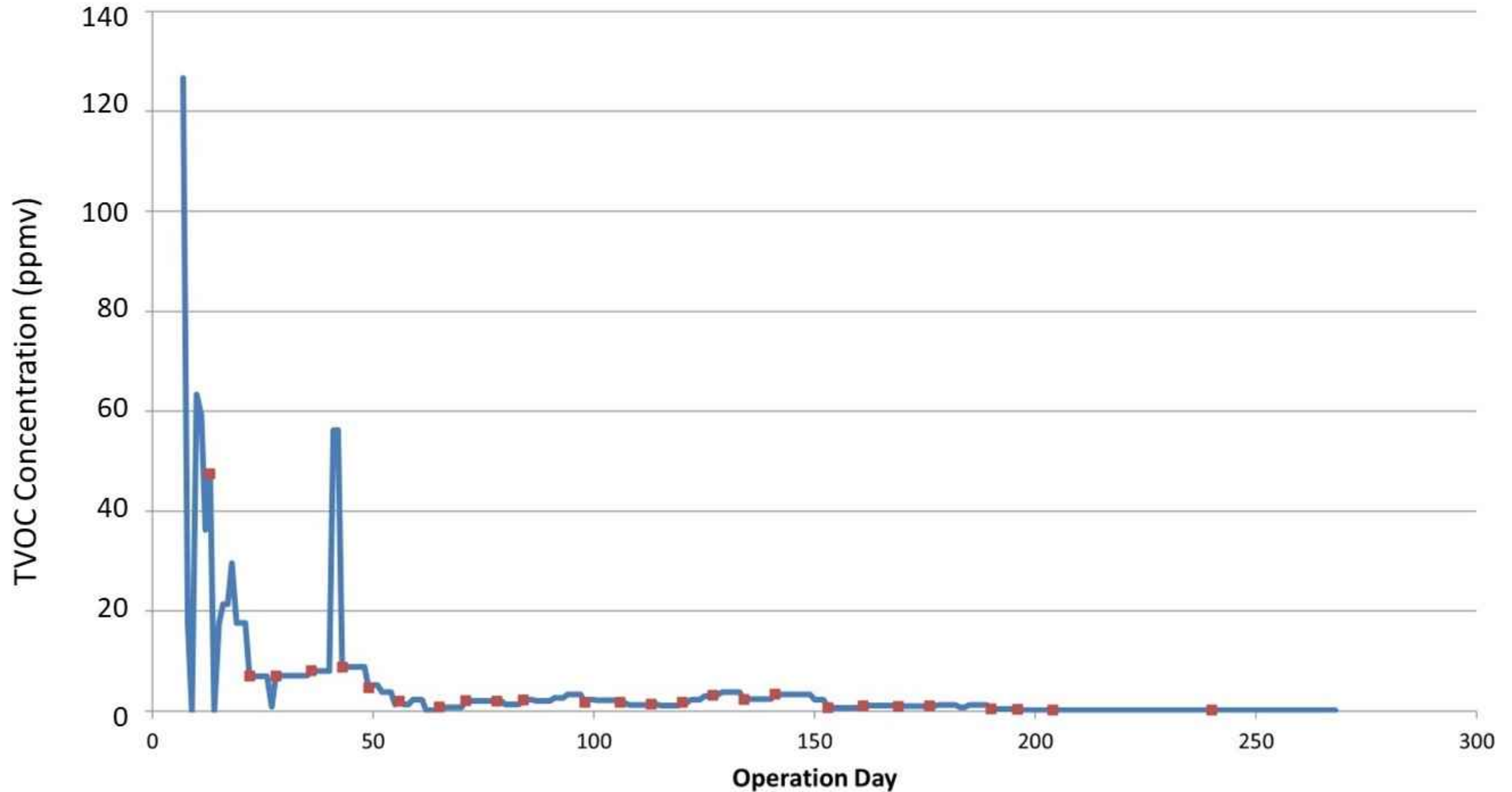
Heatup Evaluation



ERH Operational Data – Small Site



ERH Operational Data – Large Site



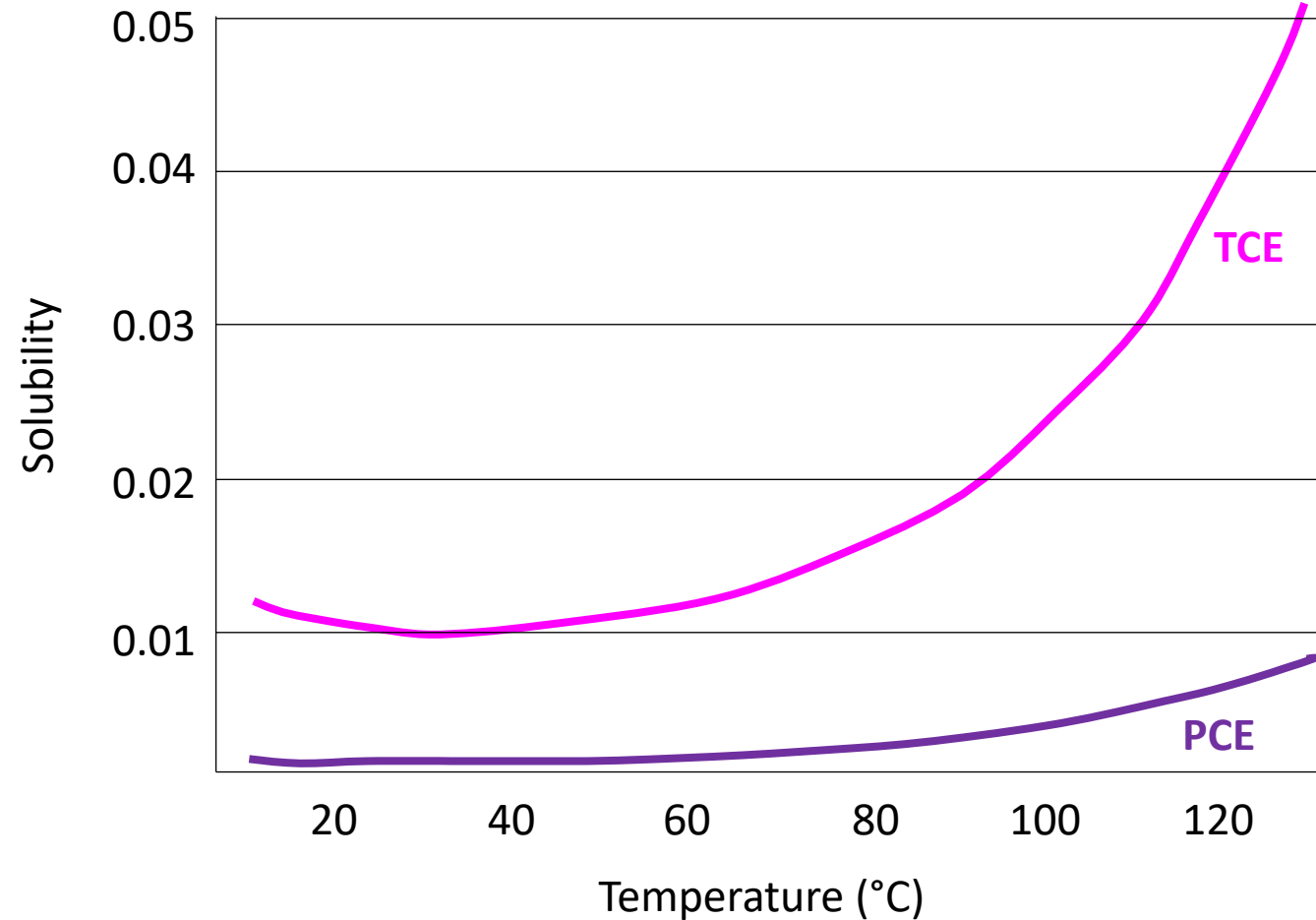
Small Site

- 1,000 lb in 5.5 WEEKS
- Max Conc – 2,000 ppm-v
- 400 KW ➡ 285 KW-hr/CY

Large Site

- 1,000 lb in 5.5 MONTHS
- Max Conc – 114 ppm-v
- 5,000 KW ➡ 127 KW-hr/CY

Why is Hydraulic Control Important?



Hydraulic Control

Small Site

Chemox to Address
Dissolved-Phase Impacts



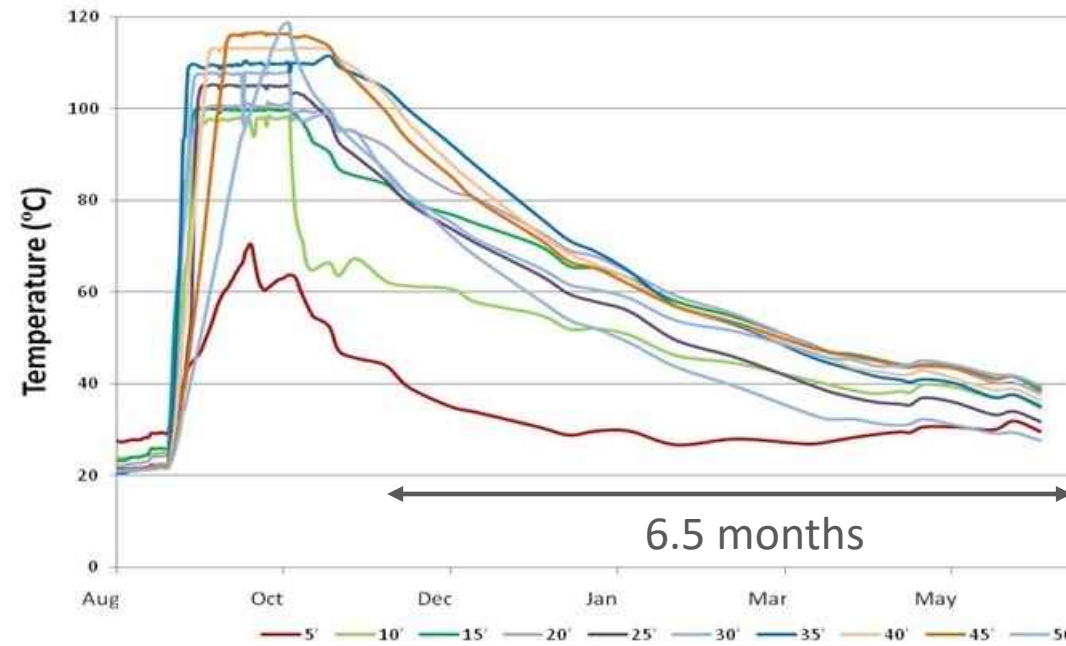
Large Site

Install Hydraulic Control
System prior to Operation

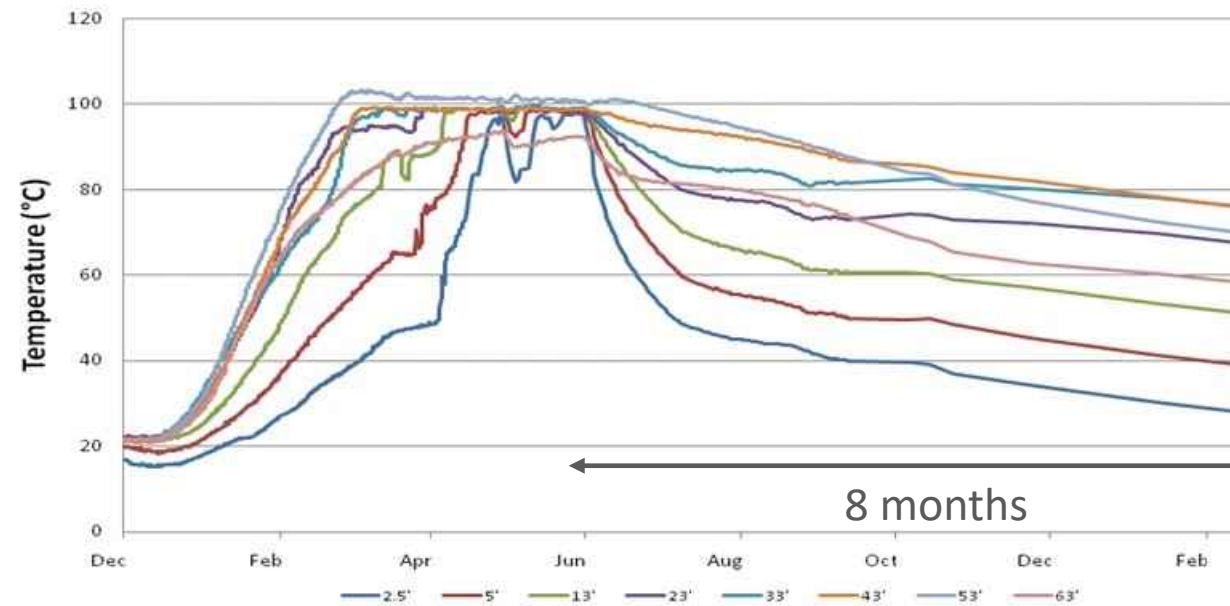


Soil Cooling

Small Site



Large Site



Hot Soil Sampling



- Who does the work?
- Cost vs. conventional sampling
- Three-Phase Partitioning & Conservation of Mass
- Risk Assessment

Hot Soil Vapor Sampling



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Regulatory Acceptance!

Small Site

- Asymptotic mass removal
- Increased downgradient concentrations
- Additional polishing required

Large Site

- ~~Temperature Specification~~
- Small spot excavations
- Acceptable soil and soil vapor concentrations

Design Criteria

- Electrodes Spacing
- Presence of NAPL
- Vapor Control
- Remediation Area Geometry



- Hydraulic Control
- Efficacy of Remediation
- Achievement of Boiling Point
- Remedial Timeframe



- “Minimal pressures generated in the subsurface”
- “Saturated zone will likely be dewatered”
- “Once power to the field is turned off – steam generation will stop”

- **High pressures observed**
- **No substantial decrease in groundwater level**
- **Residual subsurface pressures existing for weeks**

The Solution ??

- Tight electrode spacing
- Conservative hydraulic control system
- Increase vapor recovery
- Record temperatures and pressures outside the ISTT zone

Design Considerations

Design Consideration	Effect on Operation/Goals	Result
Tight Electrode Spacing	Improve heating Achievement of boiling point	Increase in power/drilling Cost Increase
Supplemental Vapor Recovery	Provide shallow subsurface vacuum Cooling Effect	Increase in power/drilling Cost Increase
Water Balance	Limit hot GW migration Cooling Effect	Increase in power/infrastructure Cost Increase
TMP Locations	Record temperatures outside the ISTT zone Evaluate efficacy of hydraulic control	Recognize potential for increasing downgradient groundwater concentrations. Cost Increase

Final Takeaways

- Keep the end in mind (Goals! Goals! Goals!)
 - Temperature specification
 - Hot media sampling
 - Asymptotic mass removal
- Balancing design with cost
 - Electrode/heater spacing
 - Vapor Recovery
 - Hydraulic Control
- Beware of hot groundwater migration
- Do your homework





Questions?