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NSZD RATES FROM TEMPERATURE DATA

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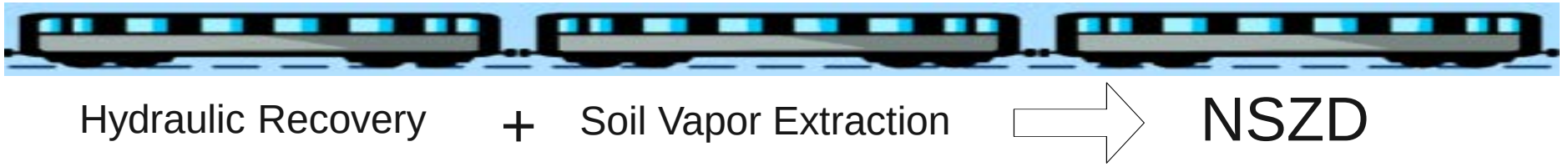
What is NSZD?
Why Evaluate it?

Photo Courtesy of M. Lyverse

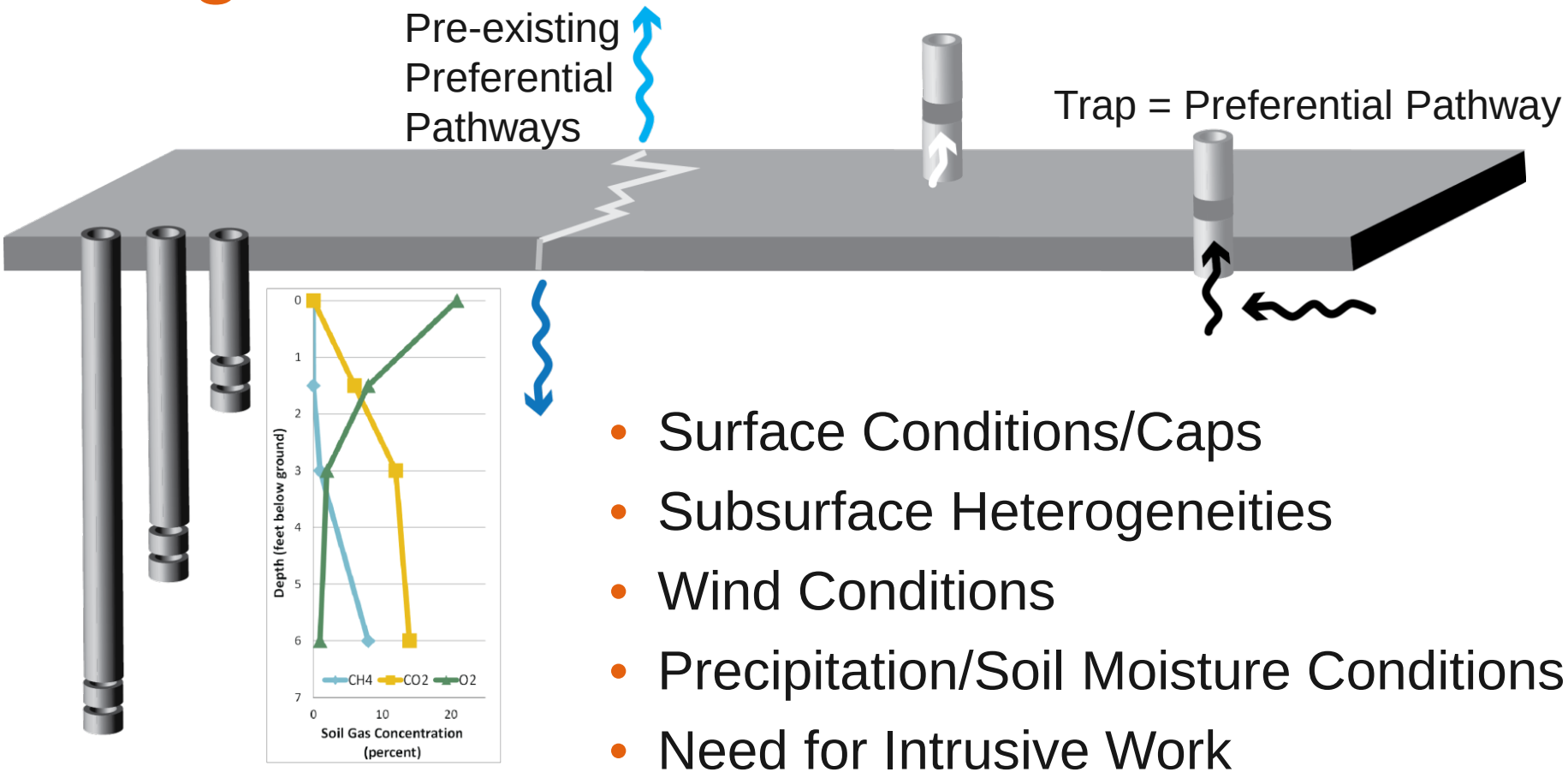
- Mass Reduction by Natural Processes
  - Volatilization
  - Dissolution
  - Biodegradation
- LNAPL Stability Line of Evidence
- Remedy Cost-Benefit
  - NSZD = Baseline mass removal rate
  - NSZD nearly always the final remedial step
    - Rarely, if ever, remove all LNAPL
    - Position for transition to NSZD



NSZD Methods

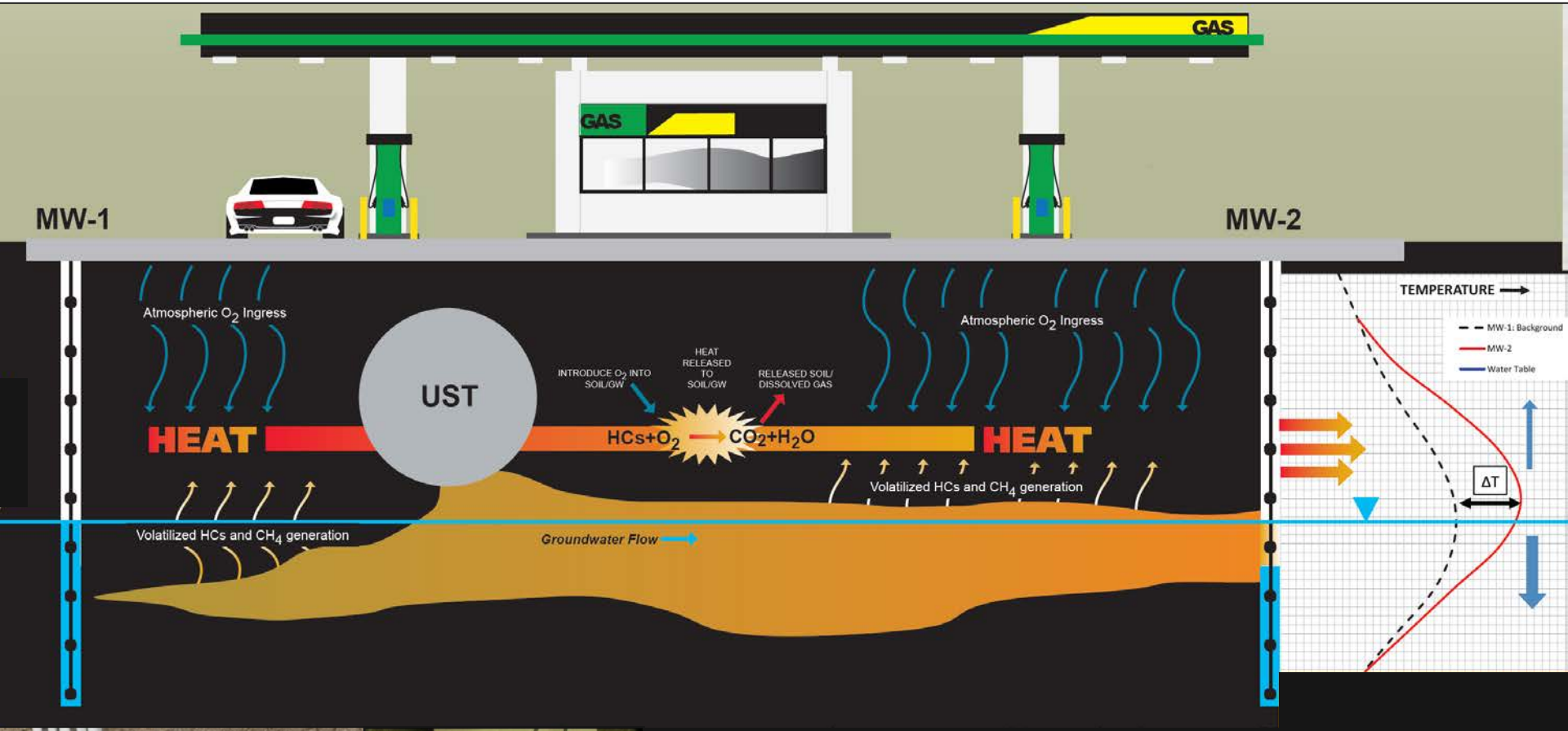
Temperature

Things to Consider



- Surface Conditions/Caps
- Subsurface Heterogeneities
- Wind Conditions
- Precipitation/Soil Moisture Conditions
- Need for Intrusive Work

Temperature-Based NSZD Concept

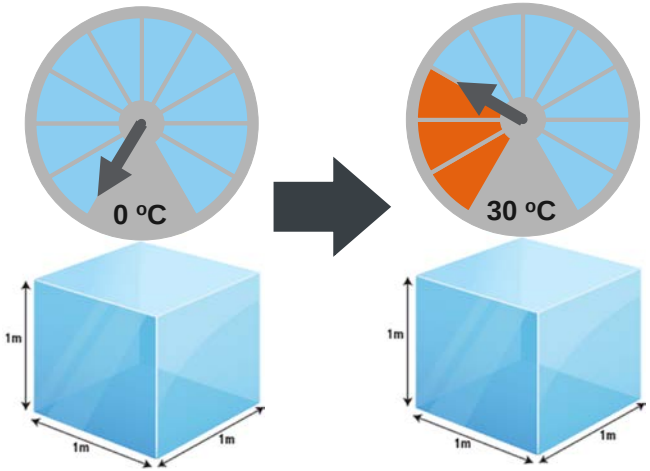


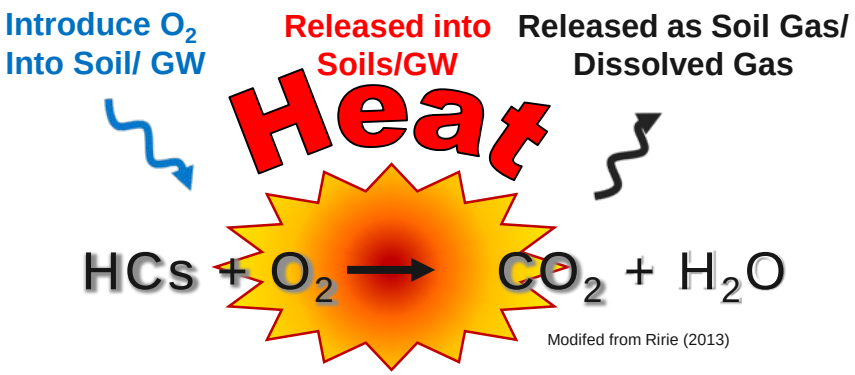
Source: Ririe (2013)

- Thermal Anomalies Identified by Measuring Temperature Distribution Down Existing Wells
  - "Snapshot" Data by Lowering Thermocouple / Temperature Probe, or
  - Over Longer Time Periods Using Data Loggers Placed at Different Depths

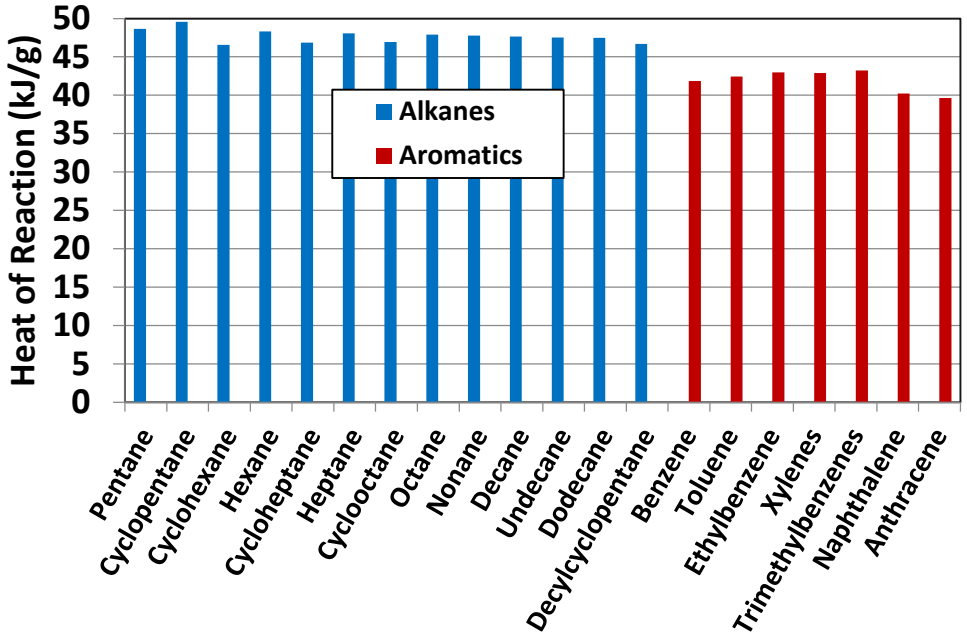
Temperature to NSZD Rates

- Aerobic Biodegradation = Exothermic
- Releases ~ 30,900 kcal/gal-NAPL
  - About 120 SNICKERS
  - 1 m^3 of ice-water to pool temperature

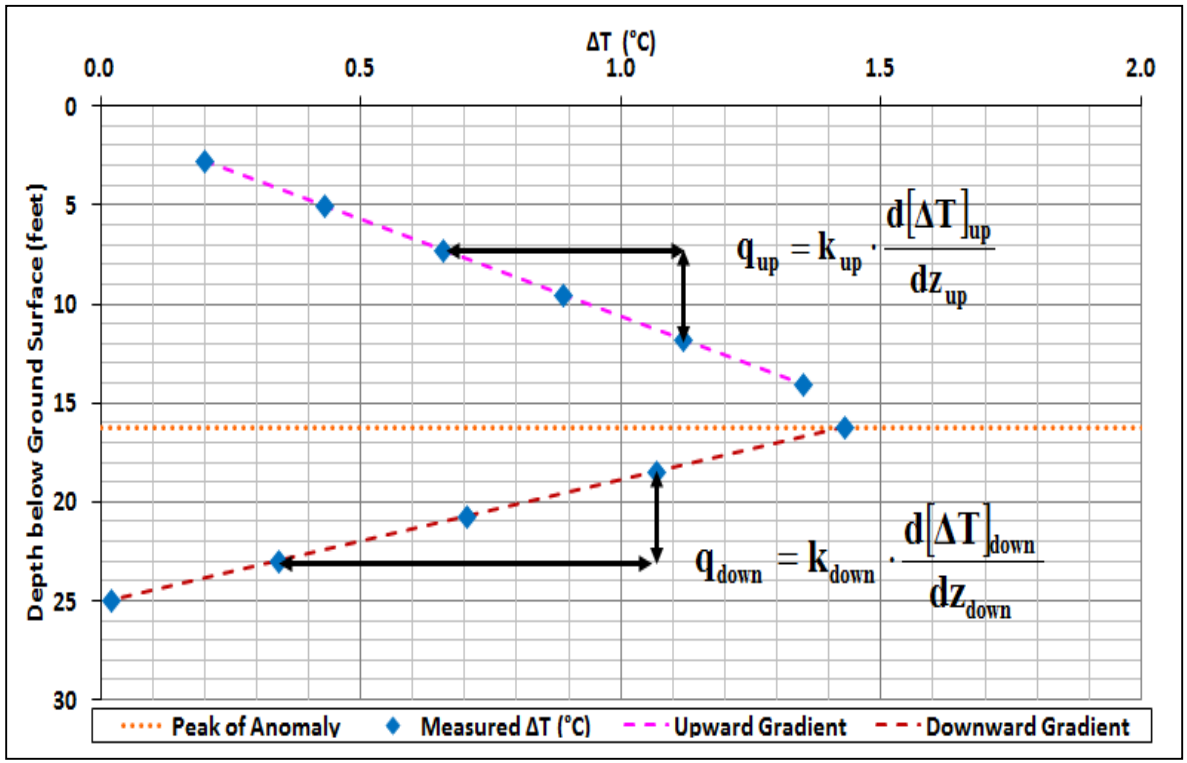




Modifed from Ririe (2013)



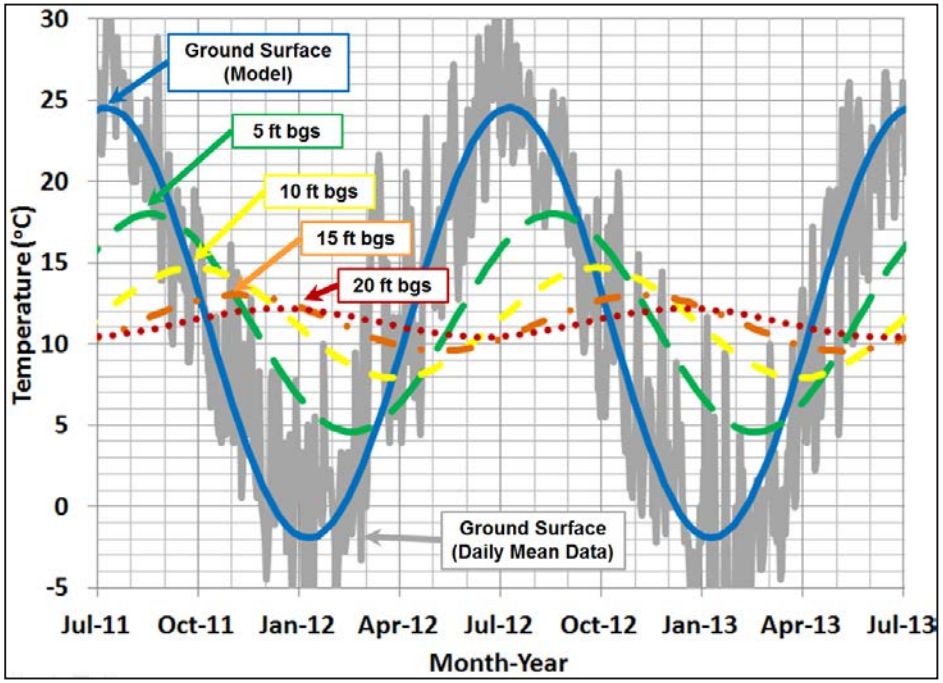
Converting to NSZD Rates

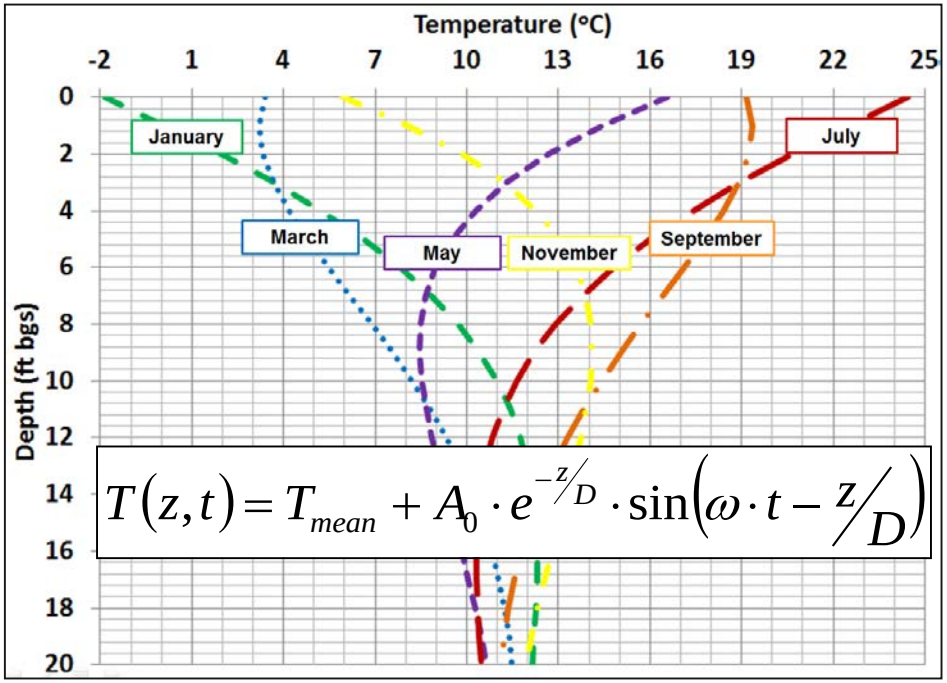


- Measure Temperature Profiles to Resolve Thermal Anomaly
  - Source Area and Background Locations
- Calculate Gradients (Up & Down) from Peak of Anomaly
- Steady Heat Flux ($q_{up} + q_{down}$) = Rate of Heat Production
- Convert to Equivalent LNAPL Loss Rate

Background Temperature

Seasonal Variation

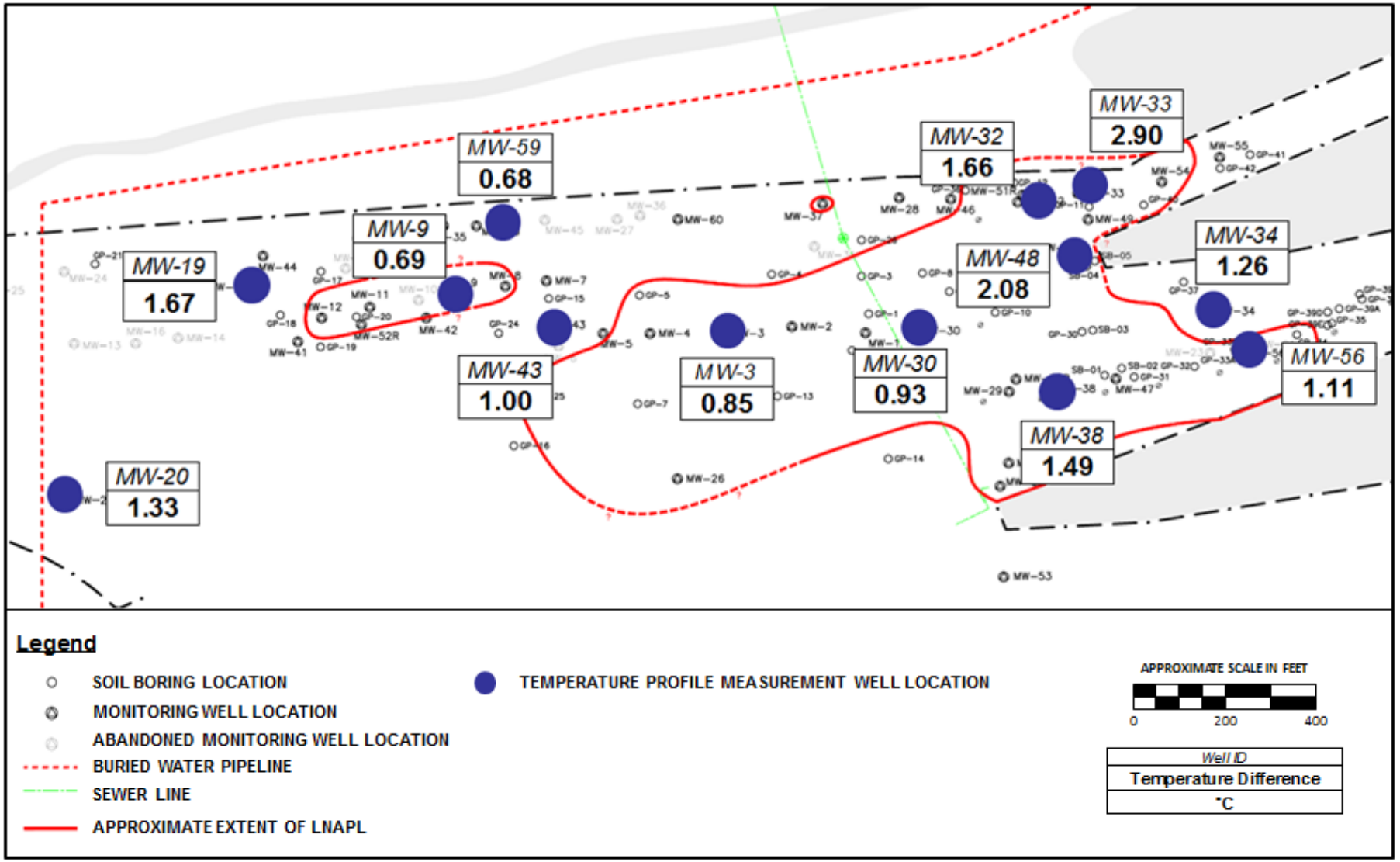




- Background Temperature Model
  - Developed from Air Temperature Data at/near Site
  - Amplitude Attenuates with Depth,
  - Phase Shift (Time Lag) with Depth
- Calibrate Model to Field Results
  - Determine Soil Heat Transfer Properties

Background Interference

Geologic/Anthropogenic Heat Sources/Sinks



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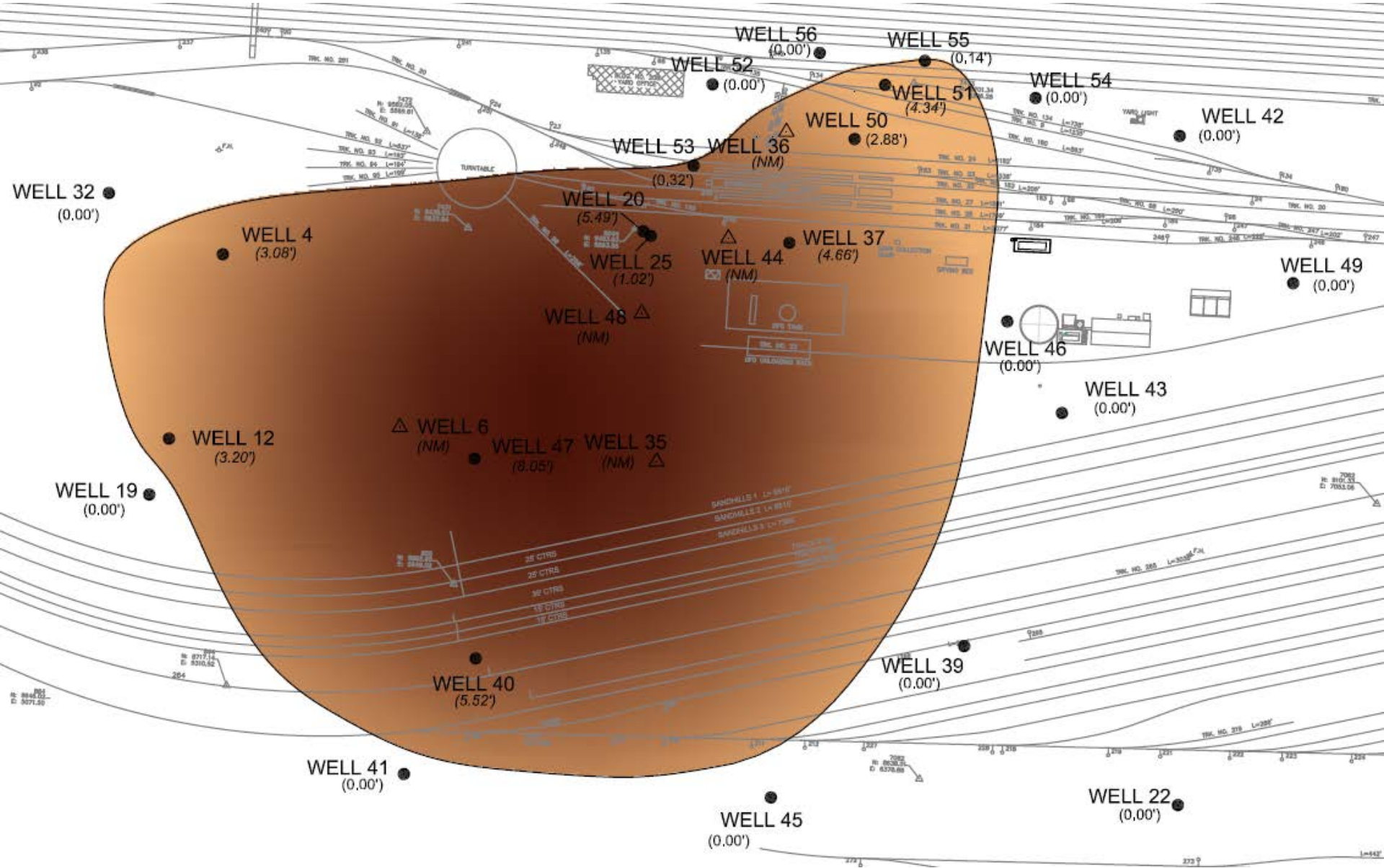
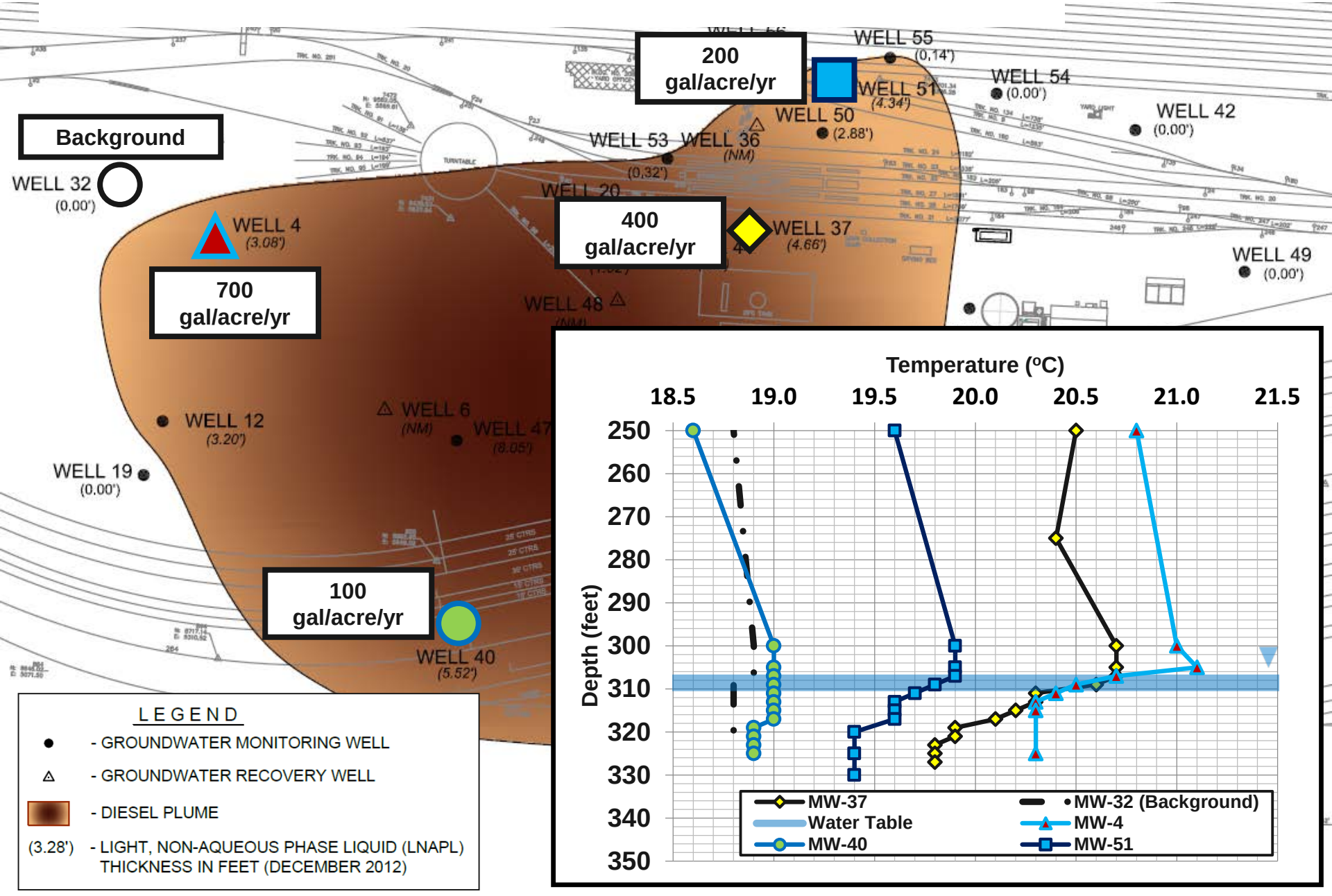
Case Study Site



Remedial Objectives	Performance Metrics
Verify Stability / Reduce Long-term Risk	Dissolved Phase Plume Stability
Reduce Mobility / Recover to Maximum Extent Practicable	LNAPL Transmissivity Compare NSZD Rates to Active Recovery Rates

Temperature Screening Results



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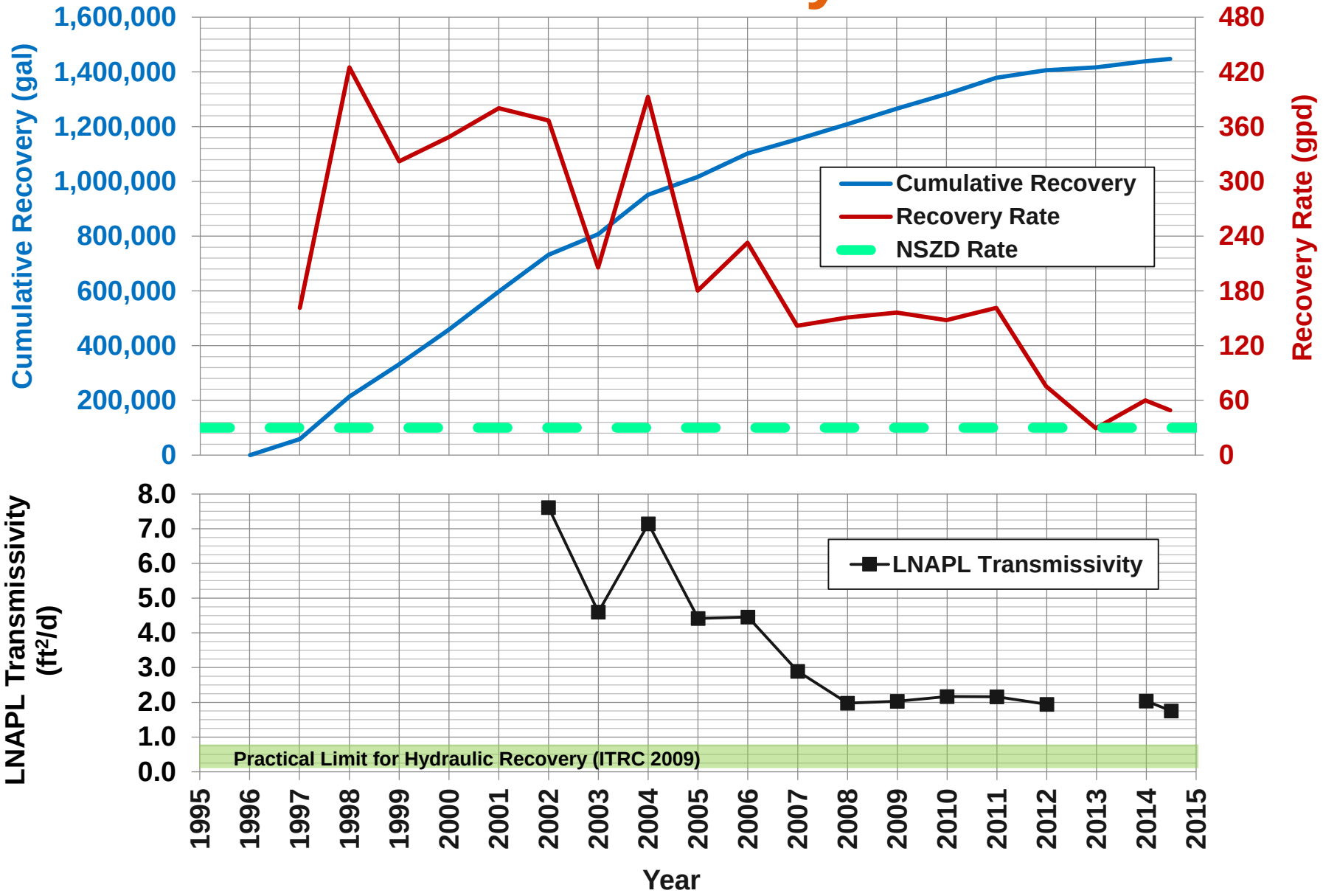
NSZD vs. Active Recovery



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Questions/Discussion