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Thermal Removal of Tritium from Concrete and Soil to Reduce Groundwater Impacts

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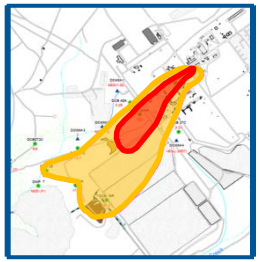


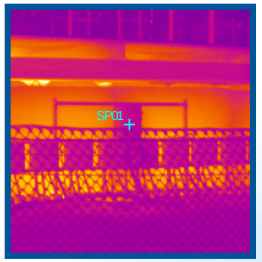

Presented at the Tritium Focus Group Meeting
April 22 - 24, 2014 Aiken, South Carolina

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Savannah River Site & D-Area Heavy Water Processing

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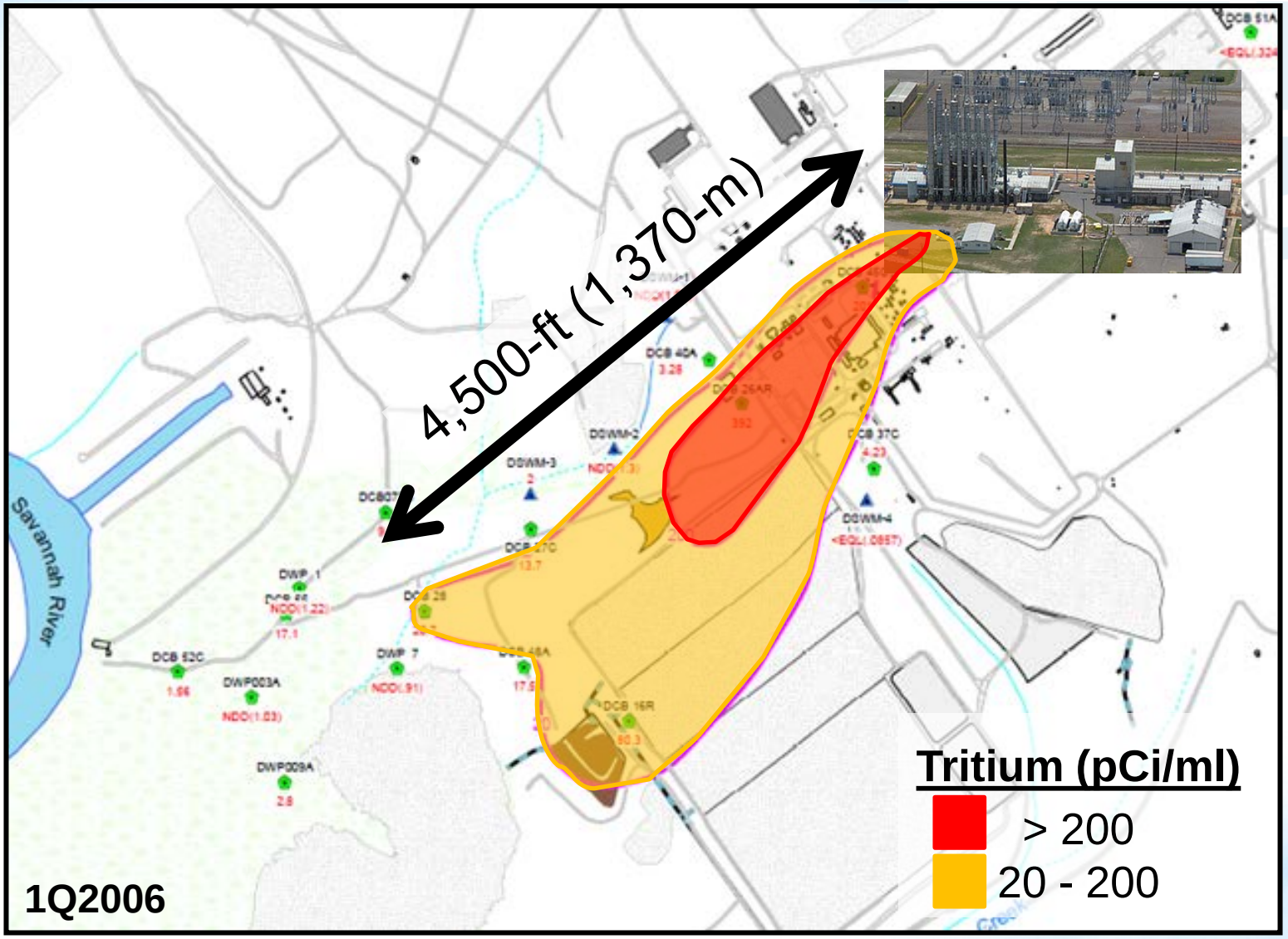
Moderator Processing Subunit & Impacts to Groundwater



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Synopsis of Tritium at Moderator Processing Subunit:

- **Tritium is present in Concrete & Vadose Zone Soils:**

  Concrete: 1,680,000 pCi/g (WSRC, 2006a)

  Soil: 251,000 pCi/g (WSRC, 2008a)

- **1,650 yd^3 of contaminated material is present**
- **Shallow water table (< 3 m) impacted by Tritium**
- **Source control needed to prevent future releases**
- **Contaminant Migration Levels:**

  Concrete < 68,000 pCi/g **Soil < 120 pCi/g**

- **Governed by EPA and SCDHEC under CERCLA**

Basis of Thermal Removal of Tritium:

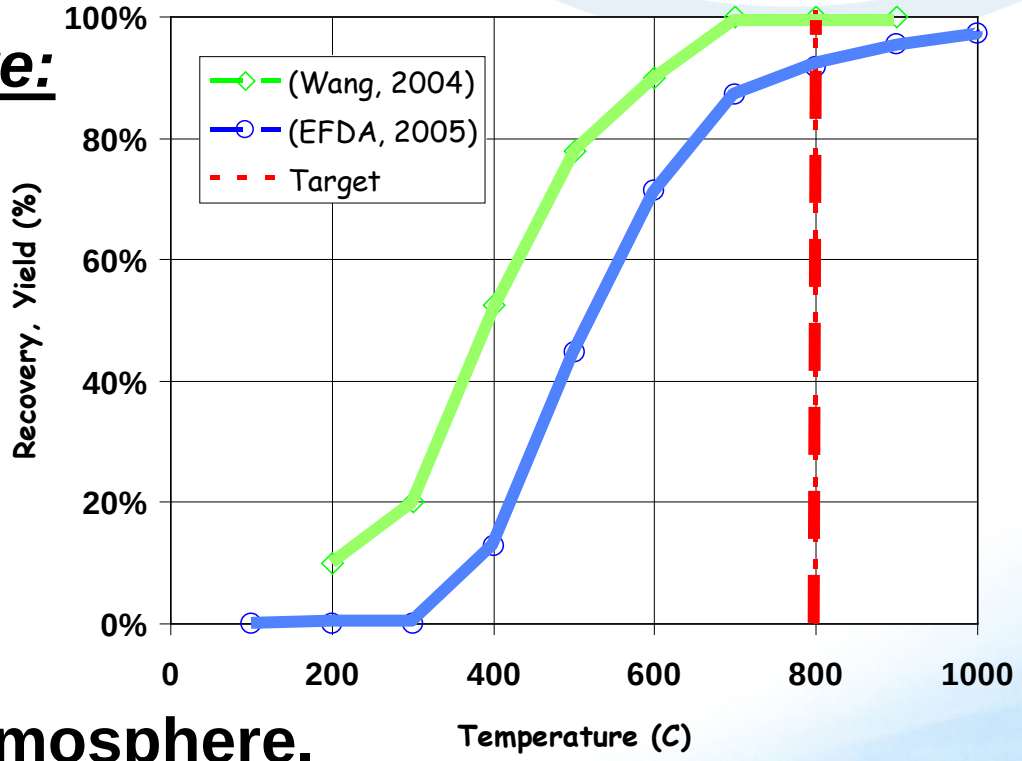
- ***Removal from Soil:***

  Drying, T > 212°F (100°C).

- ***Removal from Concrete:***
  - **Drying Pore Water:**

    T = 212°F (100°C)
  - **Dehydration Paste:**

    T > 1500°F (815°C)



- **Tritium Released to Atmosphere.**

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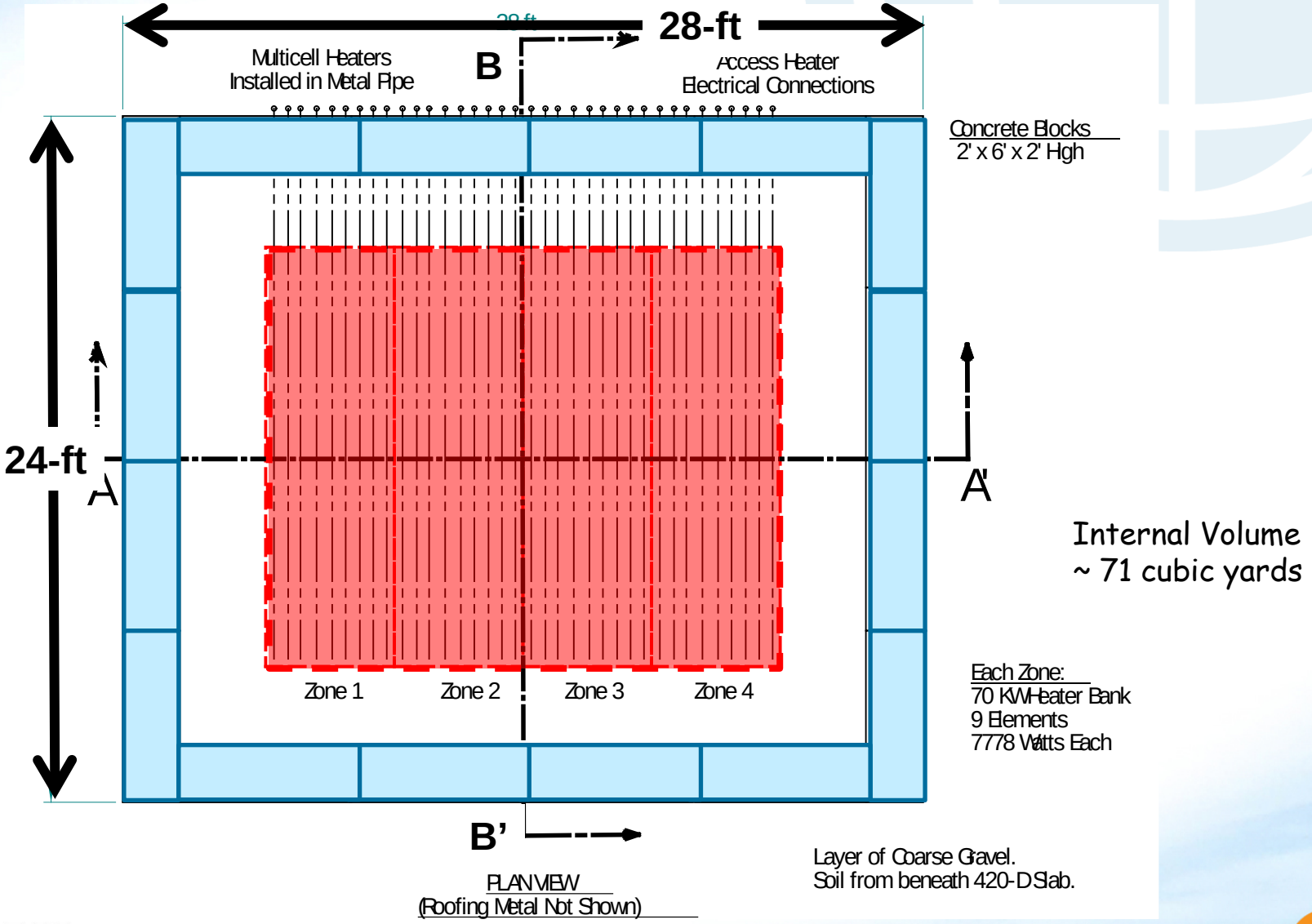
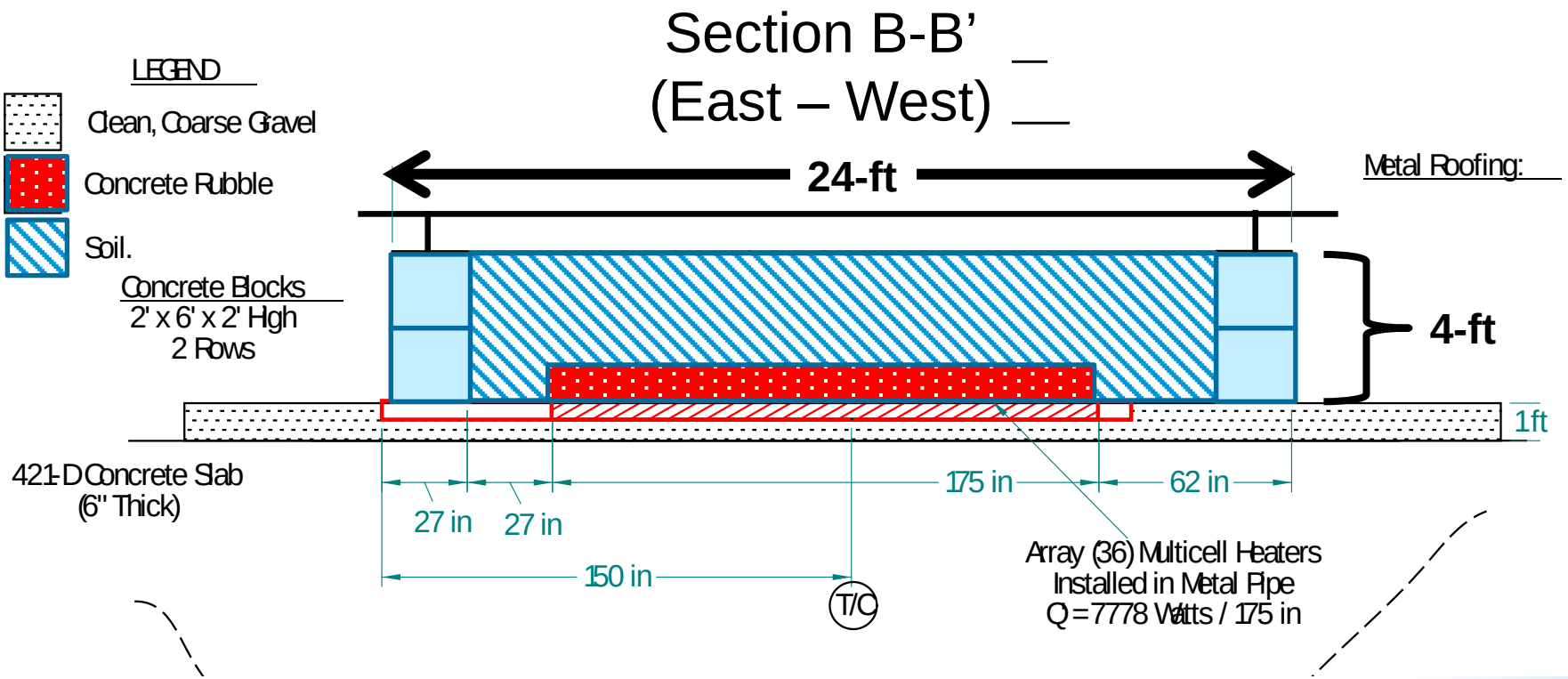
Design of Thermal Treatment Cell (Plan View):



Design of Thermal Treatment Cell (Section View):



Internal Volume = 71 cubic yards
Tritium Content = 48 curies.

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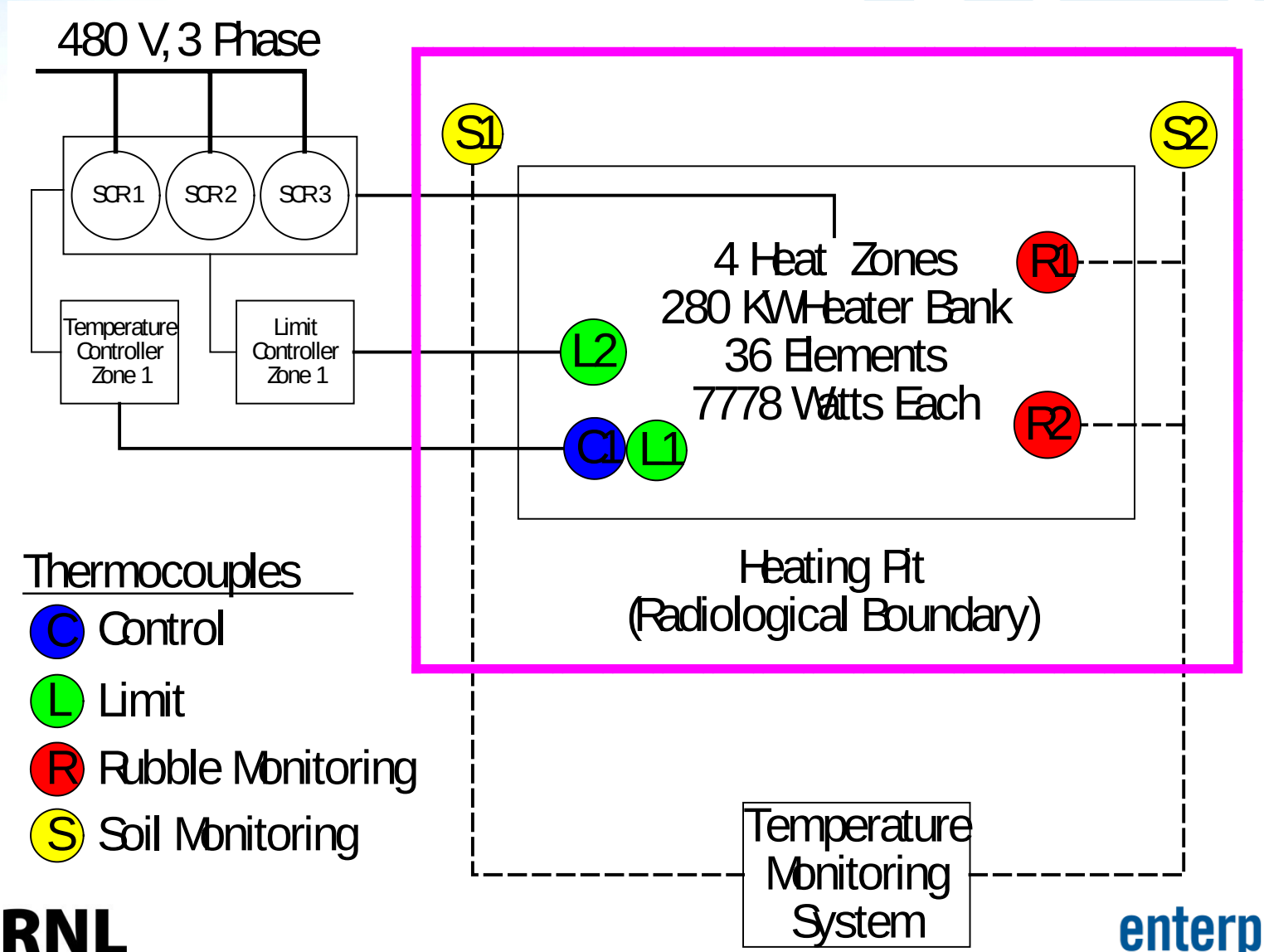
Simplified Control Scheme for Thermal Treatment:



Construction - Assembly of Block Walls:

Construction: Wiring for Heating Elements

Construction: Installation of Roof

Thermal Detritiation Concrete & Soils Heating Timeline:

Mar-09: Begin Heating, Raise Temperature 300°F/day.

Mar-13: Element Temperatures reached 1500°F.

Apr-03: Soil Temperature Reached 212°F,

Began Increasing Elements above 1500°F.

Apr-14: Element Temperature > 1700°F.

Soil Temperature Increase over 212°F.

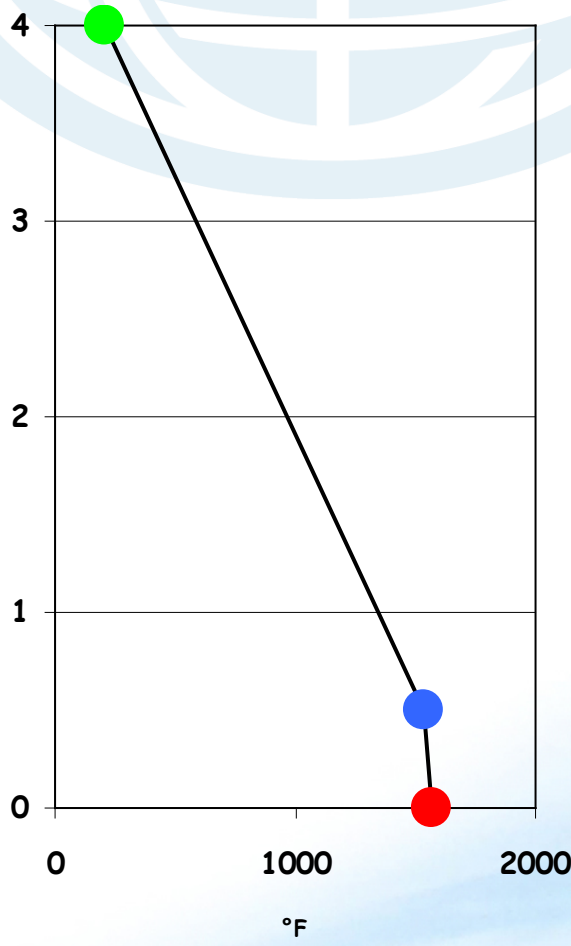
Heat Transfer Indicates Rubble > 1500°F.

May-04: Soil temperatures > 212°F for 30 days.

Rubble temperatures > 1500°F for +14 days.

Setpoint reduced to 150°F.

Jun-17: System (Power) Turned OFF to empty cell.



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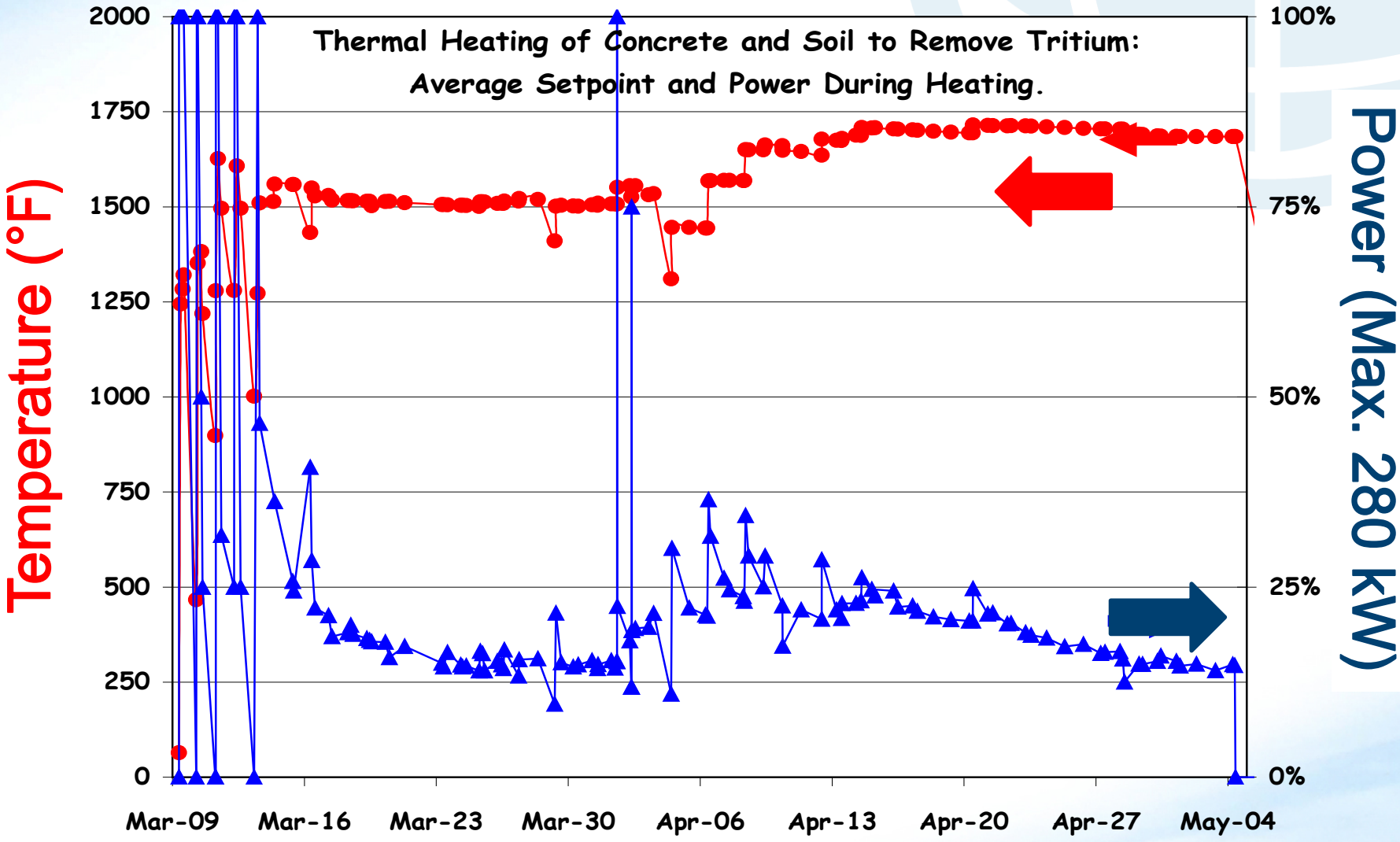
Operations – Rubble Temperature & Power:



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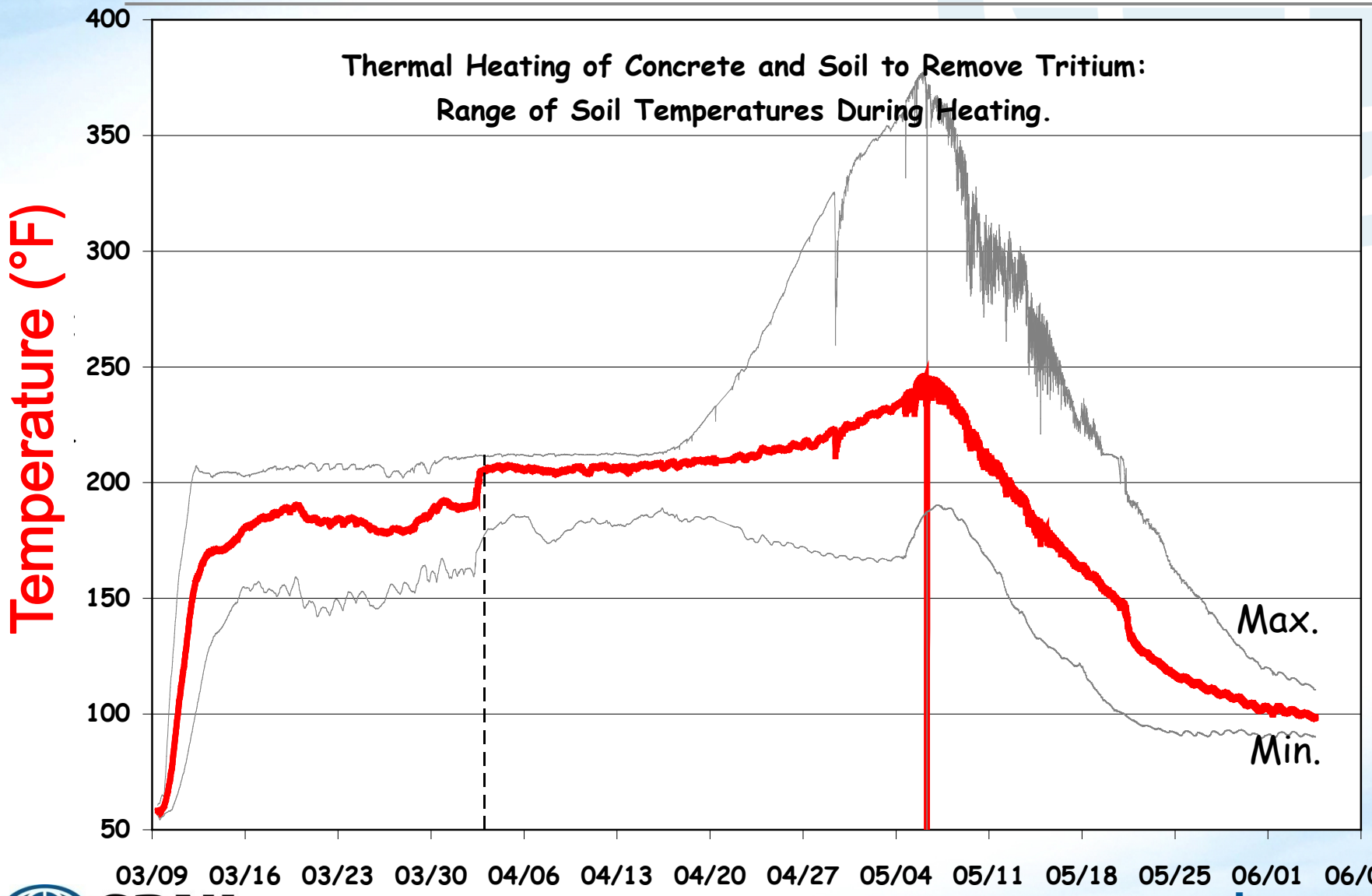
Soil Temperatures During Treatability Study:



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Effectiveness of CERCLA Treatability Study:

- **Pre-Treatment**

  Concrete: 1,680,000 pCi/g (WSRC, 2006a)

  Soil: 251,000 pCi/g (WSRC, 2008a)

- **Post-Treatment:**

  Concrete (n=8 of 10 below MDL of 0.5 pCi/g):

  Average = **25.4 pCi/g**

  Contaminant Migration Level = 68,000 pCi/g.

  Soil (n=4):

  Average = **24.4 pCi/g**, Maximum of 34.9 pCi/g,

  Contaminant Migration Level = 120 pCi/g.

Full-Scale Implementation: 4 Treatment Cells (722 yd^3)

Removal Action Performance Summary

Cell	Size (ft)	Vol. (yd^3)	Campaigns
1	24 x 20 x 4 / 6	71 / 82	1 / 5
2	48 x 20 x 6	213.3	5
3	48 x 20 x 6	213.3	3
4	48 x 20 x 6	213.3	3
Concrete Migration Level (Target)		< 68,000 pCi/g	
Post Treatment Concrete (n=32)		**x = 93.9 (0.43 – 724) pCi/g**	
Soil Migration Level (Target)		< 120 pCi/g	
Post Treatment Soil (n=76)		**x = 36.6 (4.4 – 133) pCi/g**	
Total Project Cost		$3,980,000	
Total Volume Excavated		1,650 yd^3	
Unit Treatment Cost		**$2,412.12 yd^3**	

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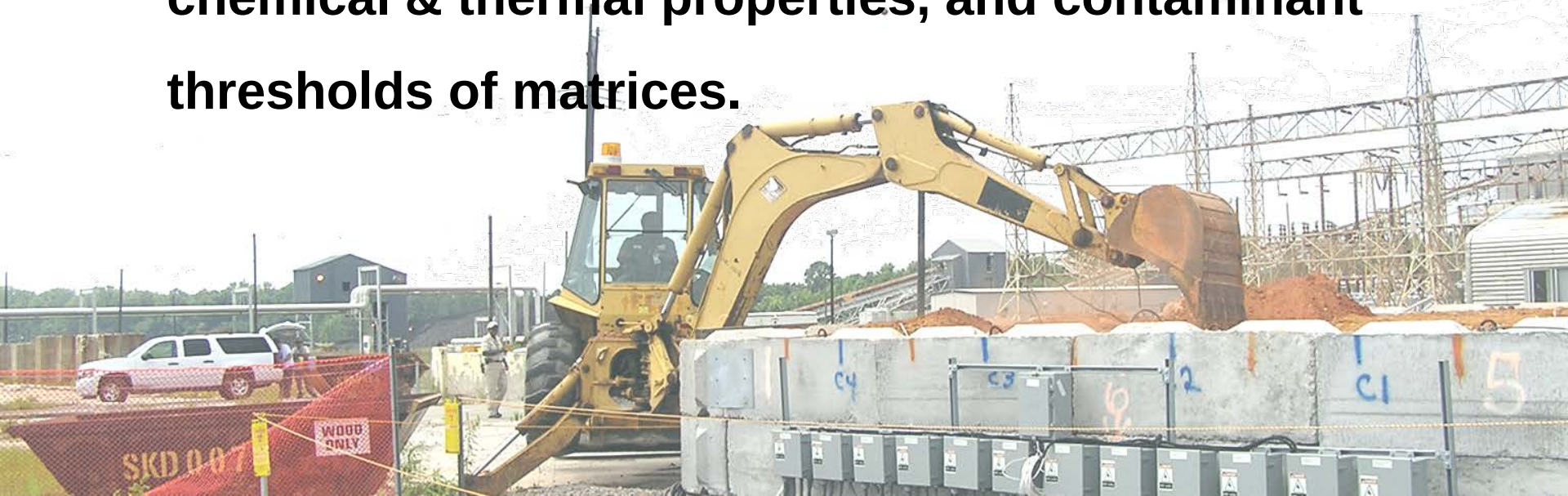
Summary & Conclusions:

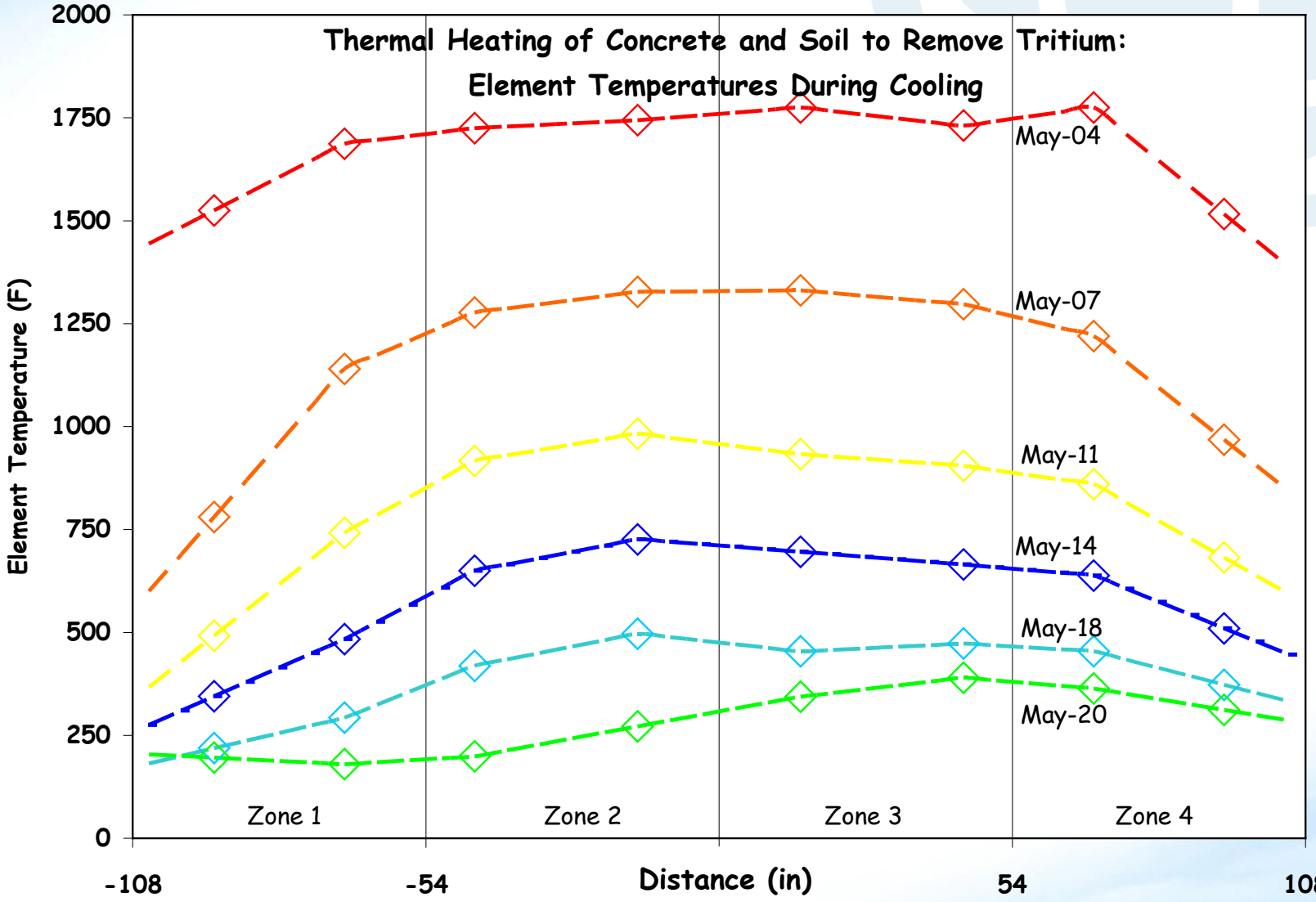
- **Thermal Heating is an effective method for removing tritium from concrete and soil.**
- **Treatment Costs on Order of $2,500 per cubic yard.**
- **Successful deployment considers geometry, chemical & thermal properties, and contaminant thresholds of matrices.**



Tritiated Debris Remediation Project

2011 E-Star Environmental Sustainability Award from DOE Office of Environmental Management.

Element Temperature Profiles (Cooling):



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Water Removal from Concrete:

- **Free Water Removal by Drying 212°F (100°C) ,**
- **Dehydration of Cement Paste:**
  - 752°F (400°C) - Dehydration of $Ca(OH)_2$
  - Dehydration of Silicate Hydrates is complicated,
  - 1472°F (800°C) - Complete dehydration of Paste.
- **Carbonate Aggregates – Decompose with Heat:**
  - 1220 – 1795°F (660 – 979°C): $CaCO_3 \rightarrow CaO + CO_2$
  - 1365 – 1540°F (741 – 838°C): $MgCO_3 \rightarrow MgO + CO_2$
  - Calcined Material becomes better insulator.
- **Siliceous Aggregates – Don't decompose with Q:**
  - While stable, Volume changes at 1063°F (573°C).