Used Fuel Disposition Campaign

DOE MANAGED HLW AND SNF DISPOSAL PRELIMINARY ANALYSIS OF THE EFFECT OF DECAY HEAT IN THE NEAR FIELD

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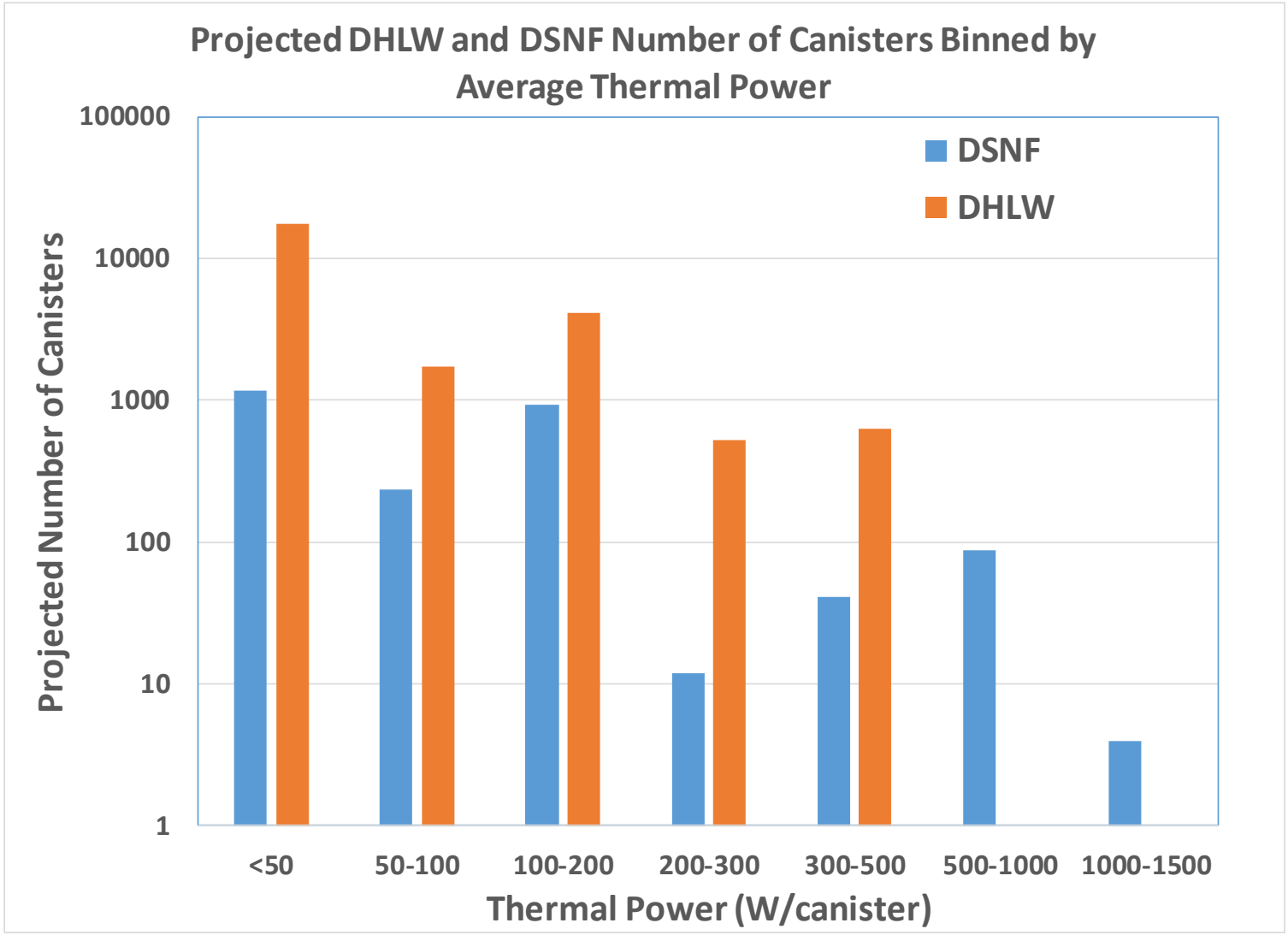
Used Fuel Disposition

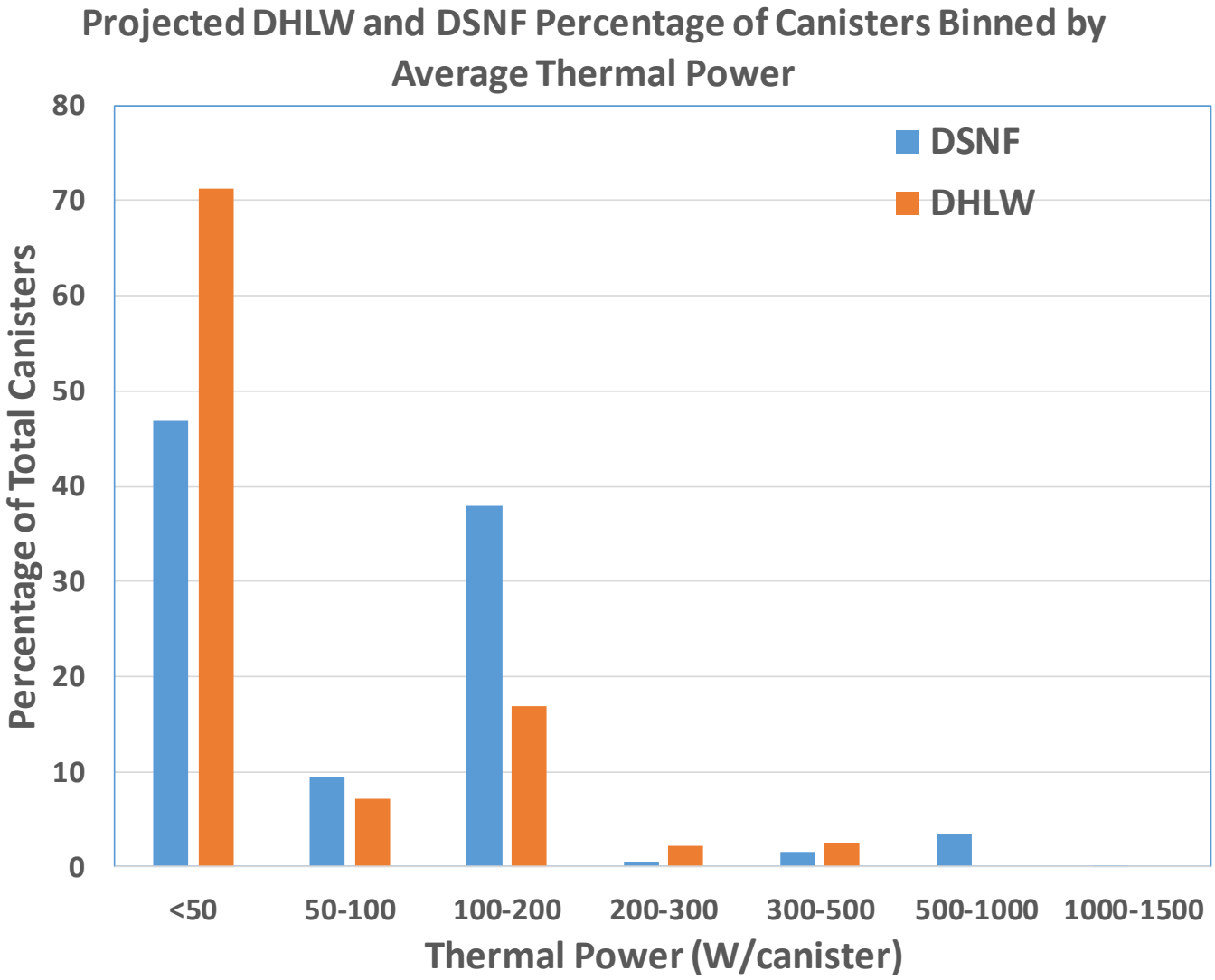
Thermal Analysis of DOE Managed HLW and SNF

- Detailed thermal analysis for various disposal concepts
- Disposal in crystalline and salt host rocks
- Single-pack and multi-pack packaging
- Thermal-only Semi-analytical methods and Thermal-Hydrology numerical simulations
- Thermal decay data from Wilson (2016)

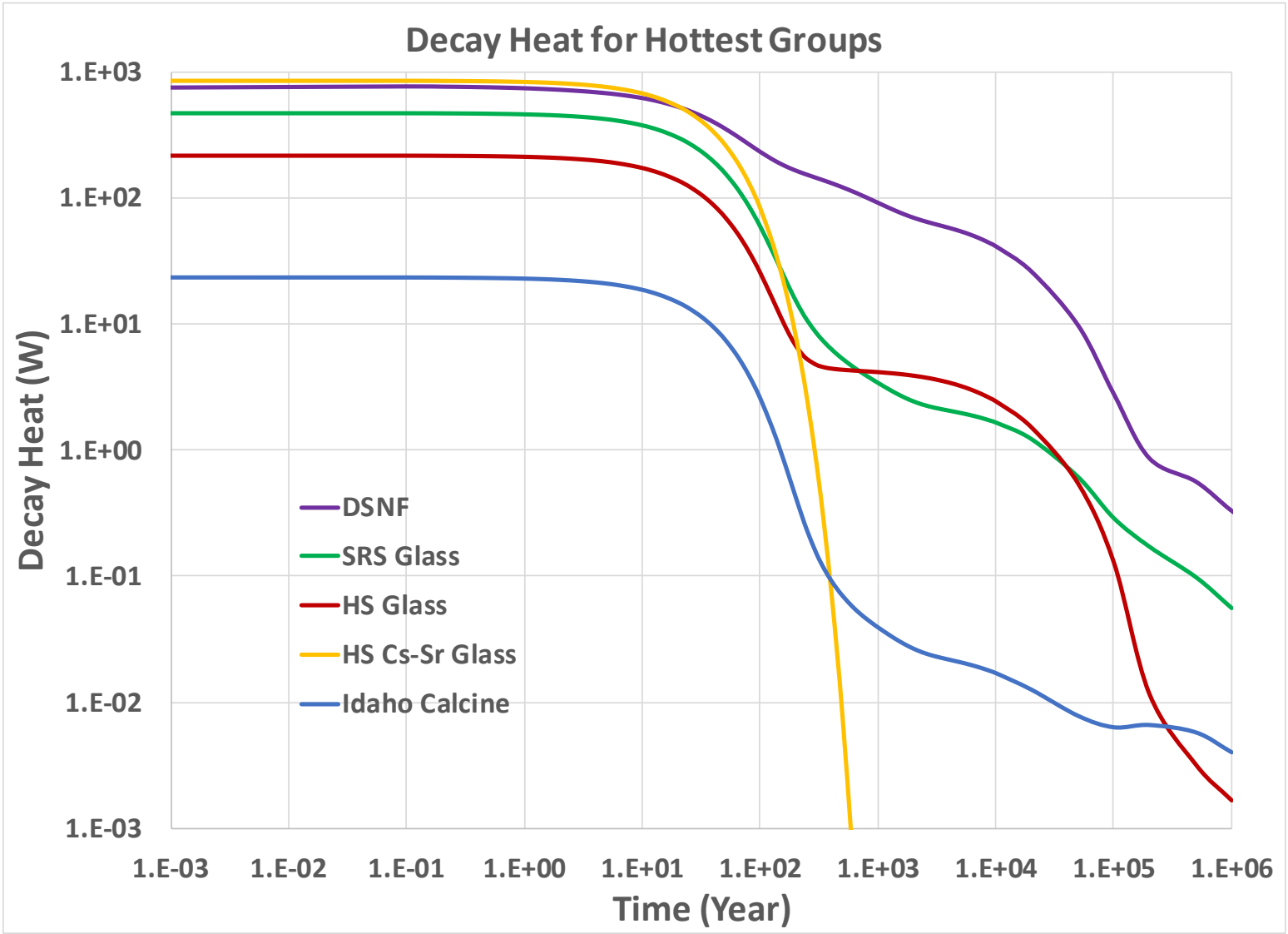
Thermal Decay Data of DHLW and DSNF



Thermal Decay Data for DHLW and DSNF, Contd.



Thermal Decay History for DHLW and DSNF Hottest Groups (Bins)



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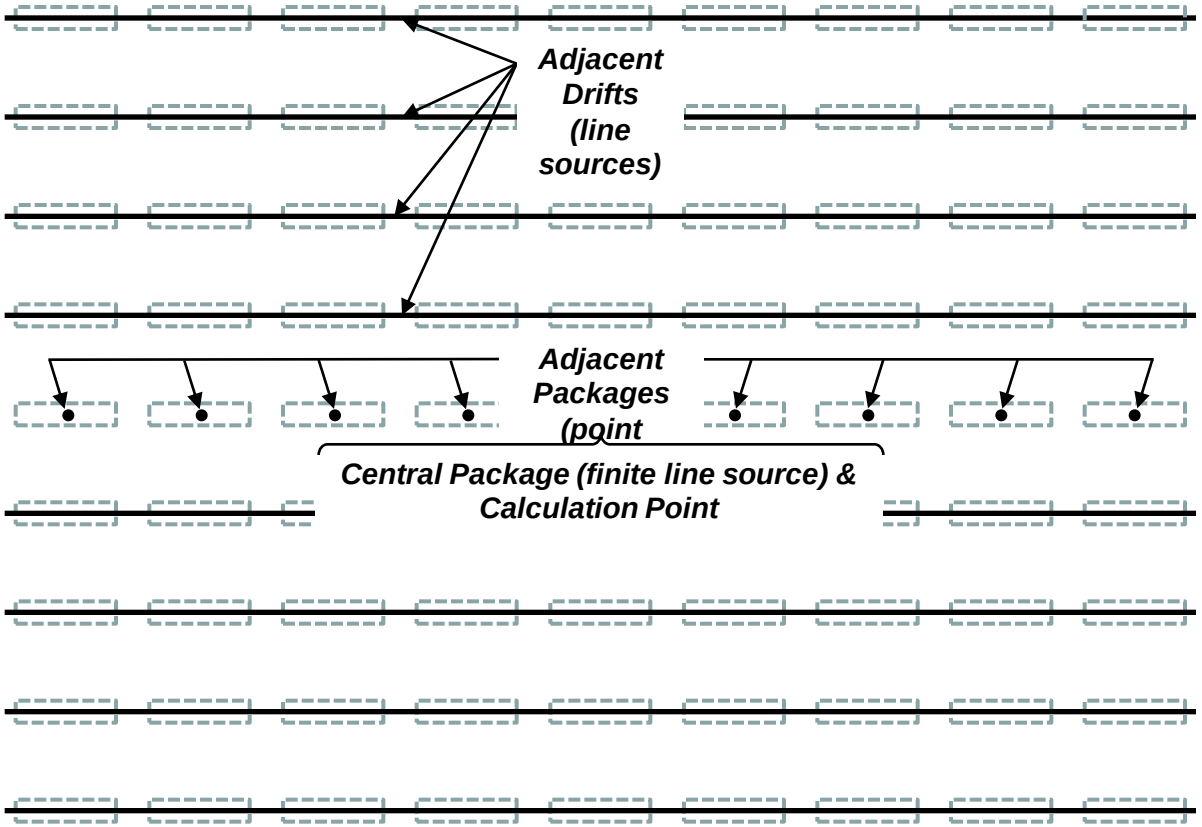
Thermal Analysis (MathCAD) Repository Layout

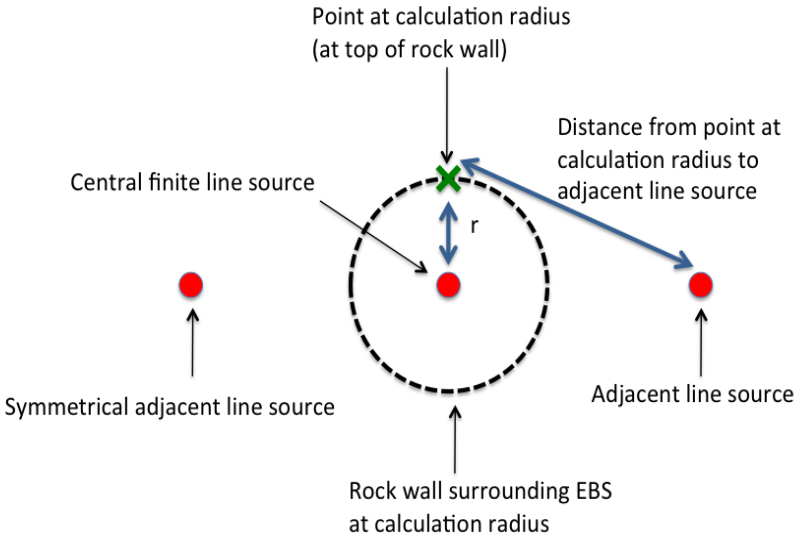
- Thermal-only analysis based on semi-analytical solution
- Based on method of superposition

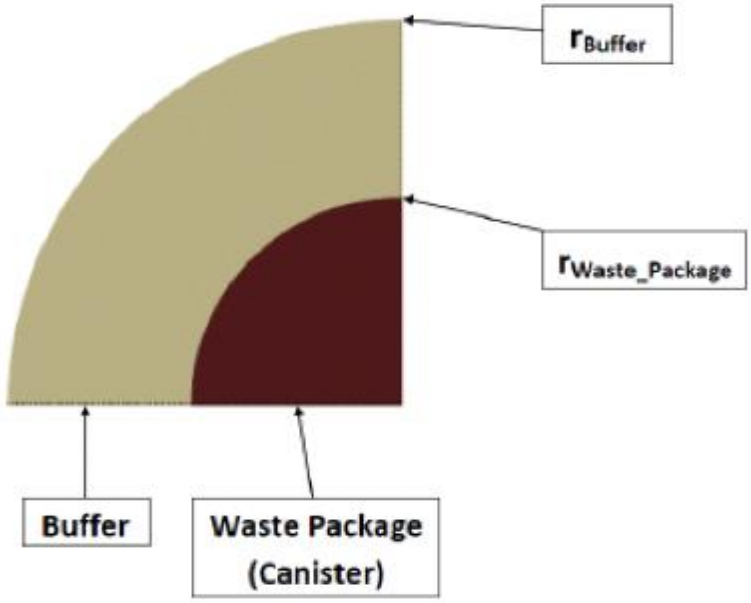


Hardin et al. (2012)

Thermal Analysis (MathCAD), Contd. Repository Layout and EBS Representation

Graphical representation of EBS





Hardin et al. (2012)

Input for Thermal-Only Analysis Crystalline Host Rock

- Drift Diameter – 4.5 m
- Drift Spacing – 20 m, 10 m
- Waste package Spacing – 5 m, 1 m
- Buffer thermal conductivity: 0.6, 1.43 W/m K
- Storage time – 10, 50 ,100 years

Sizes of Single Pack Canisters

Waste Type	Diameter (in)	Length (in)
DSNF	24	180
SRC Glass	24	120
Idaho Calcine	24	120
HS Glass	24	180
HS Cs/Sr Container	26	60

Size of Multi Pack Waste Package (contains 5 glass canisters):

Diameter = 83.7 in Length = 209 in

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Thermal-Only Calculation Results Single Pack (Canisters) – Crystalline Host Rock

Waste Type	Drift Spacing	WP Spacing	Buffer Kth	Tmax WP	Tmax DW
SRS Glass					
468 W at t=0	10	5	0.6	105	57
	20	1	0.6	132.3	97.6
	20	5	0.6	98.3	44.8
	20	5	1.43	63.8	44.8
HS Glass					
218 W at t=0	10	5	0.6	54.9	41
	20	1	0.6	69.4	59.5
	20	5	0.6	50.8	35.4
	20	5	1.43	40.8	35.4
Calcine Glass					
23.8 W at t=0	10	5	0.6	31.4	29
	20	1	0.6	40	32.7
	20	5	0.6	31.1	28.4
	20	5	1.43	29.3	28.4
DSNF					
634 W at t=0	10	5	0.6	133.1	83.7
	20	1	0.6	208.2	175.3
	20	5	0.6	113.5	62.1
	20	5	1.43	79.8	62.1
Cs/SR Glass					
849 W at t=0	10	5	0.6	264	79.6
	20	1	0.6	297	149.5
	20	5	0.6	259.3	57.9
	20	5	1.43	133.4	57.9

10 Years Storage Time

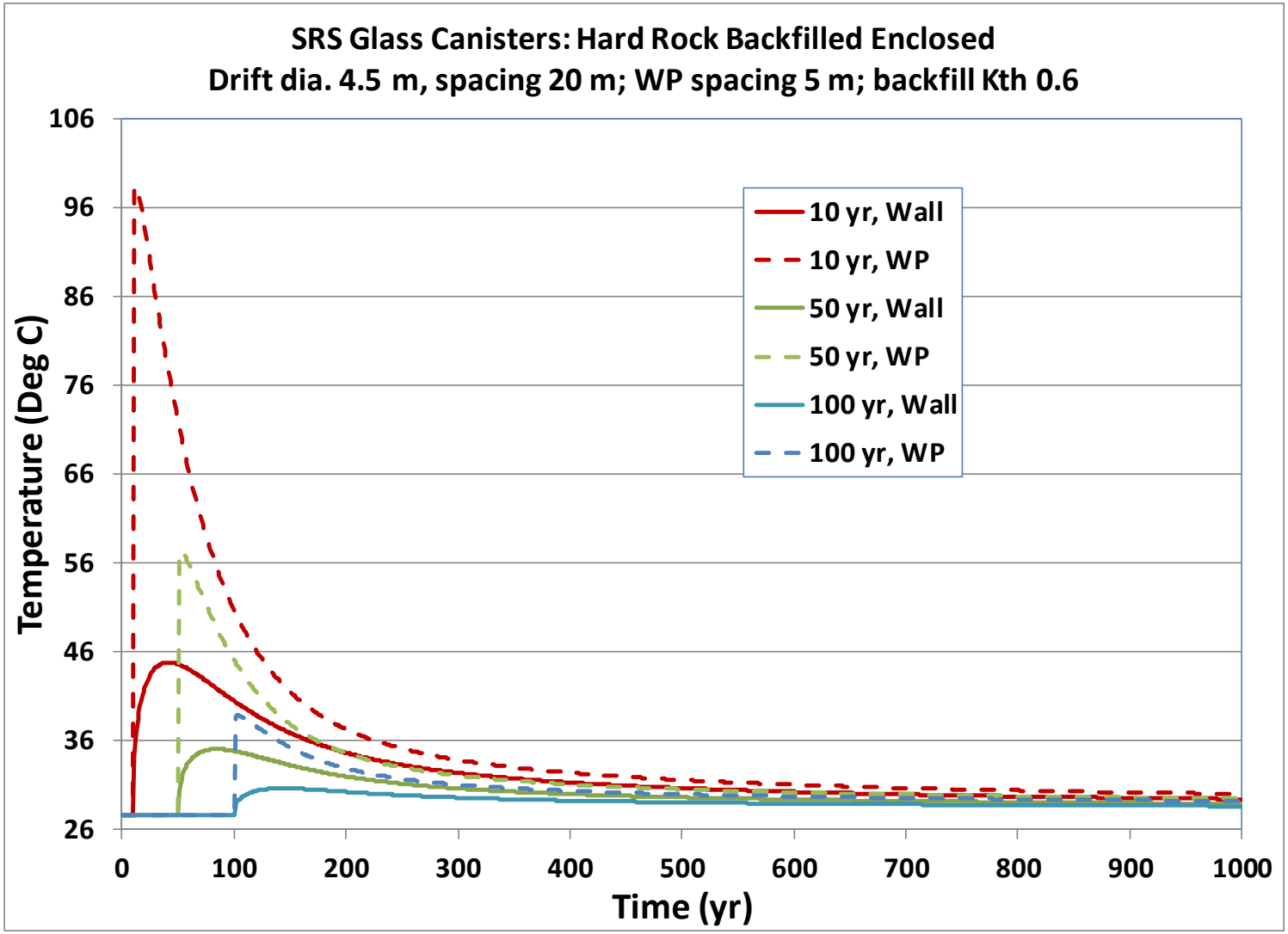
Used Fuel Disposition

Thermal-Only Calculation Results Multi Pack (with 5 Canisters) Crystalline Host Rock

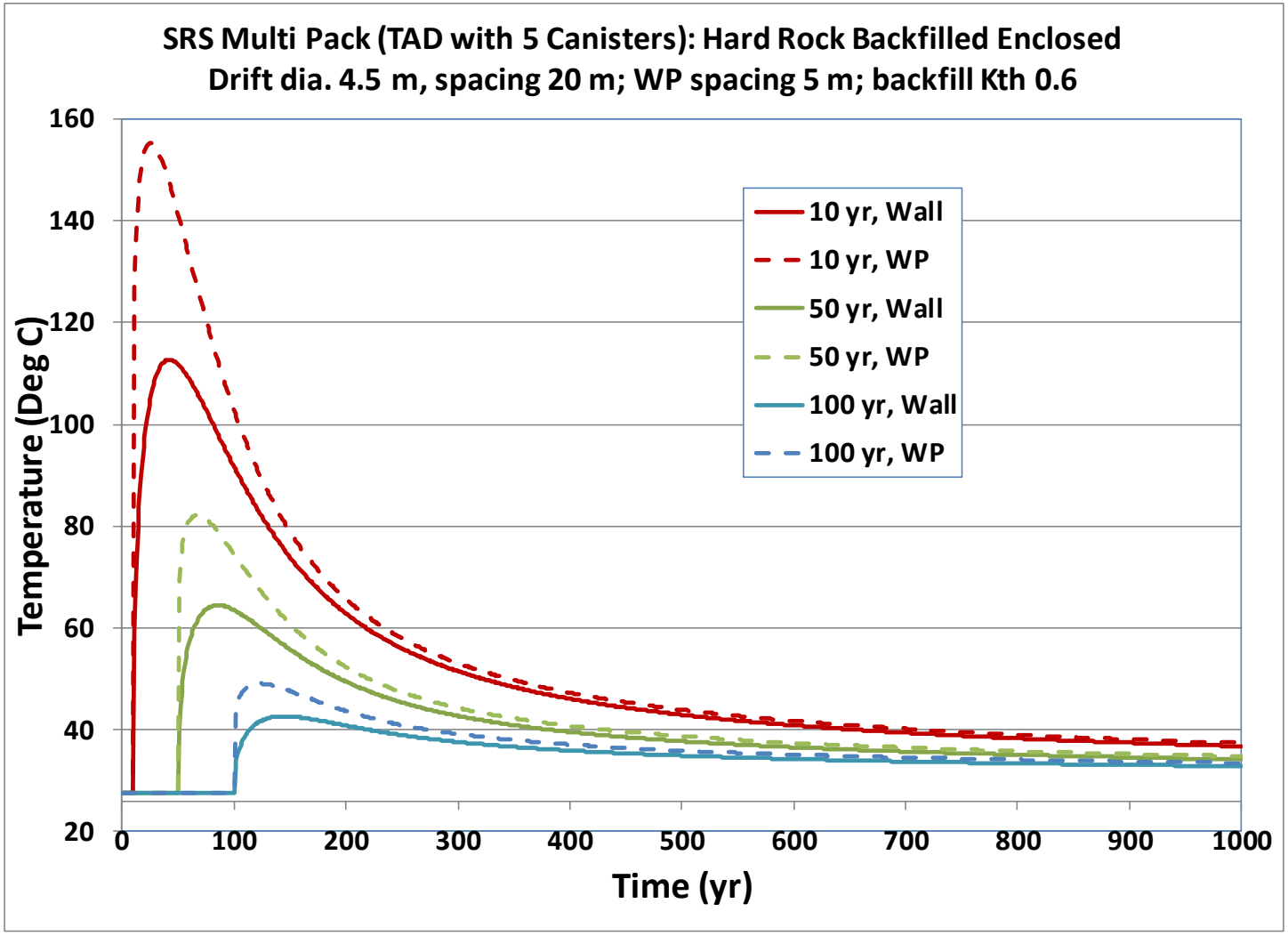
Waste Type	Drift Spacing	WP Spacing	Buffer Kth	Tmax WP	Tmax DW
SRS Glass					
2340 W at t=0	10	5	0.6	263	209.4
	20	1	0.6	407.5	377.1
	20	5	0.6	155.3	112.7
	20	5	1.43	128.7	112.7
HS Glass					
1090 W at t=0	10	5	0.6	114.5	93.3
	20	1	0.6	201.7	186.9
	20	5	0.6	86.4	63.3
	20	5	1.43	74	65.7
Calcine Glass					
119 W at t=0	10	5	0.6	36.9	34.6
	20	1	0.6	46.3	44.7
	20	5	0.6	33.9	31.4
	20	5	1.43	32.5	31.6

10-Year Storage Time

Temperature vs Time Plot for SRS SP Canisters – Crystalline Host Rock



Temperature vs Time Plot for SRS Multi Pack Containers – Crystalline Host Rock

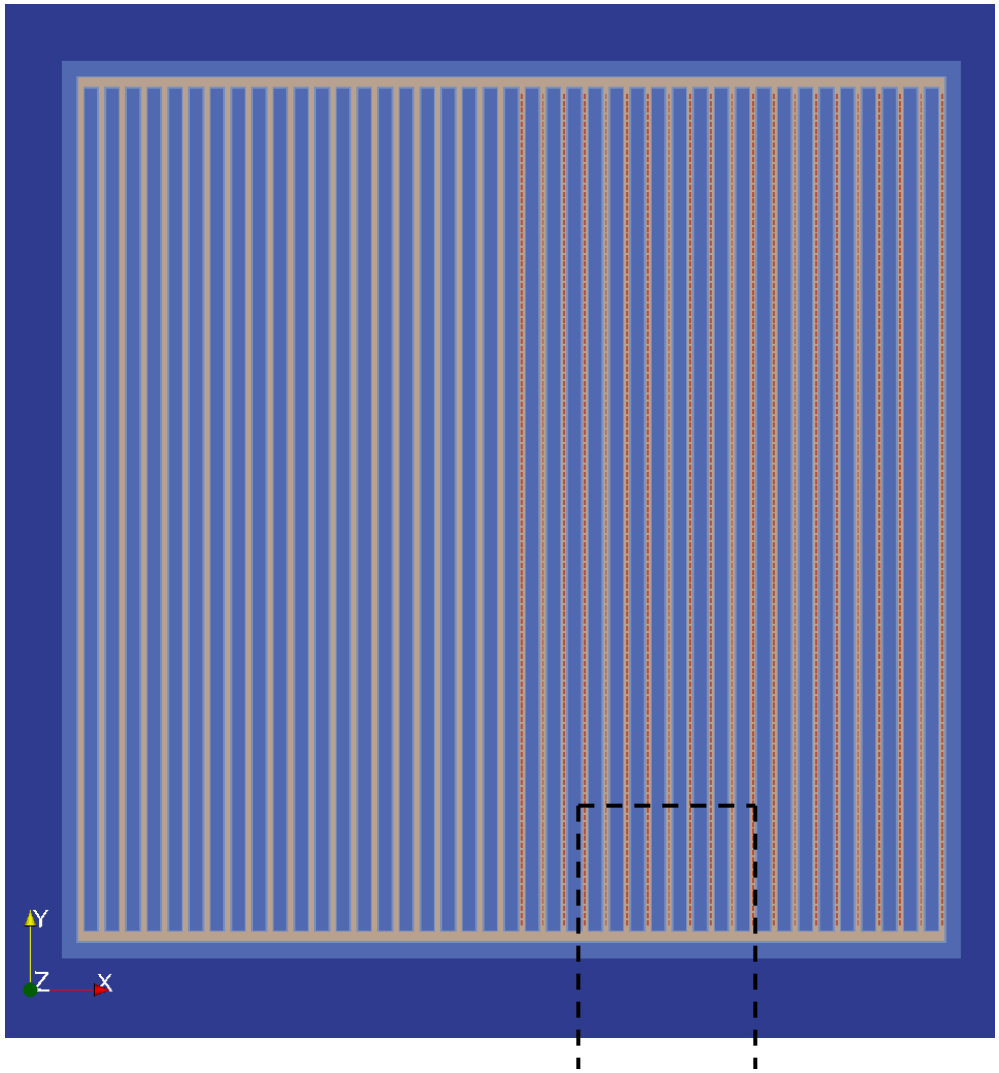


Numerical Modeling of Thermal-Hydrology- Crystalline Host Rock

- Domain represented by granite rock with repository at 500 m depth
- Simulation domain: 180 m x 1116 m by 1000 m depth – Symmetry on three sides (mesh with 984,240 grid blocks)
- Boundary Conditions:
  - Top: Constant Temperature (10 °C) and pressure (1 Atm.)
  - Bottom: Constant temperature of 35 °C and no fluid flux
  - No fluid or heat flux on sides
- Ambient temperature gradient corresponds to 25 °C /km
- Multi pack waste package (5 glass canisters)

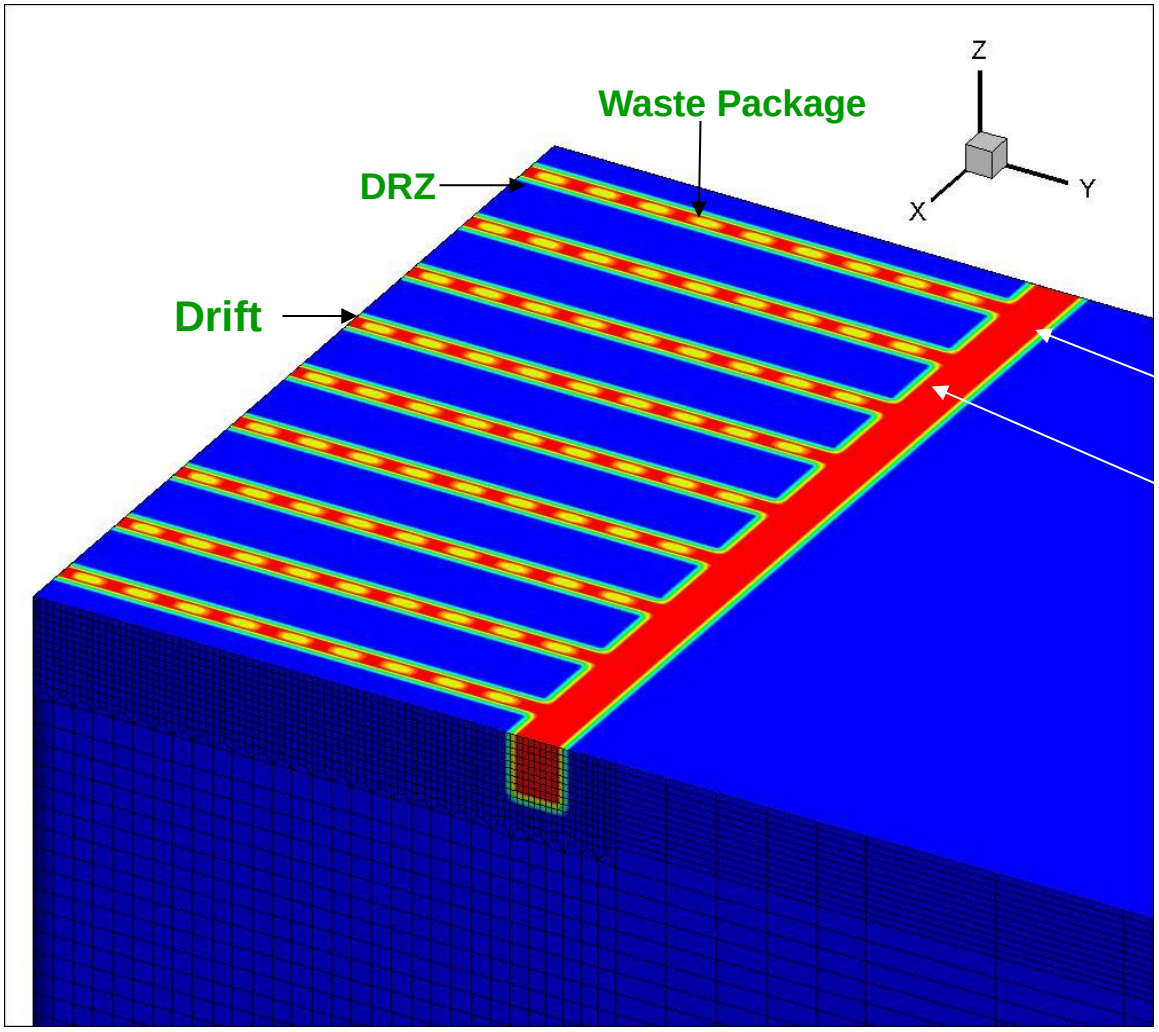
Material	Permeability (m^2)	Porosity (-)	Thermal K (W/m/K)	Heat Capacity (J/kg/K)
Granite	1×10^{-18}	0.01	2.5	800.
DRZ	1×10^{-16}	0.01	2.5	800.
Buffer	1×10^{-19}	0.2	0.6/0.85	800.
Waste Package	1×10^{-20}	0.47	46.0	493.

Repository Layout

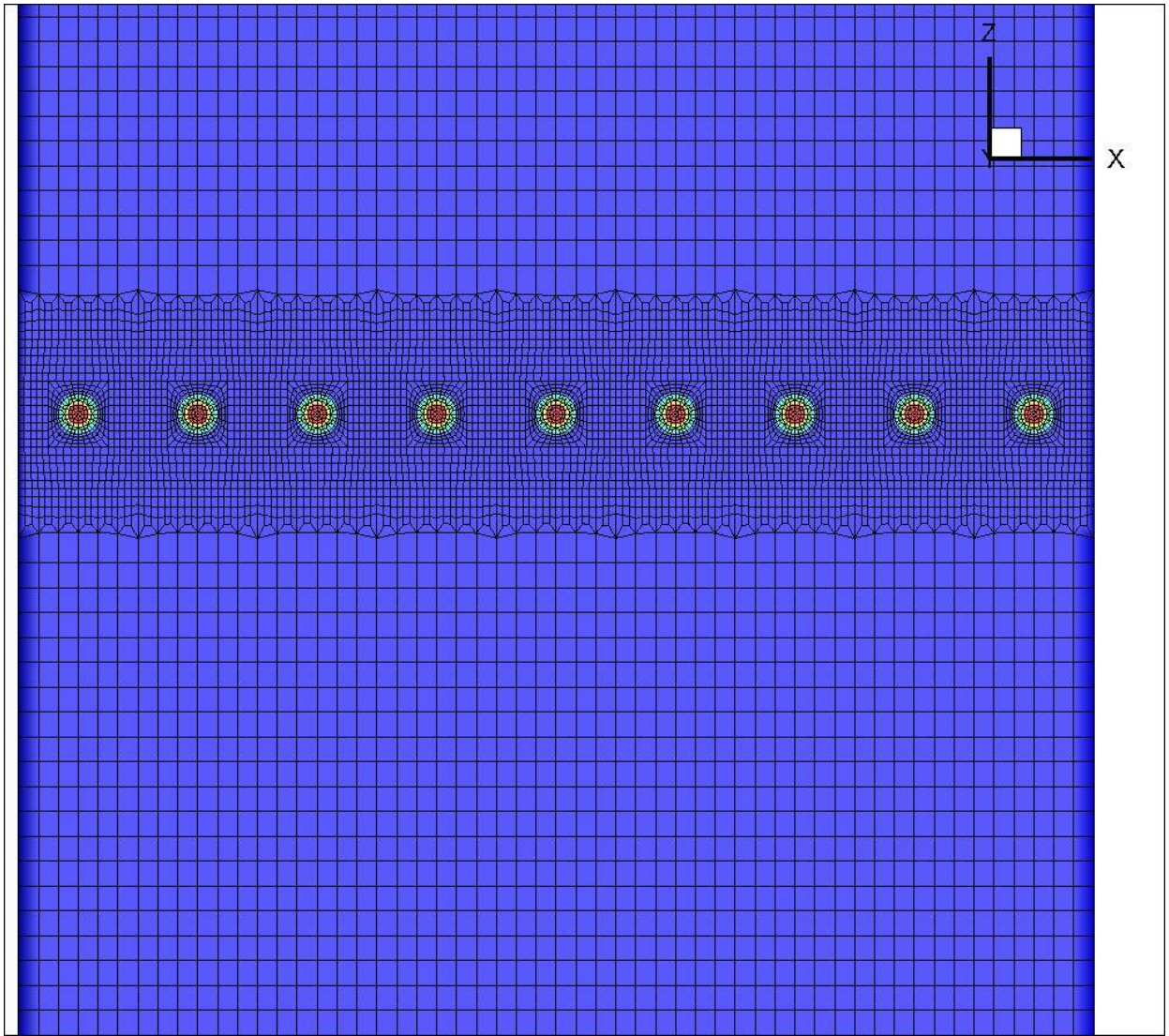


Stein et al. (2016)

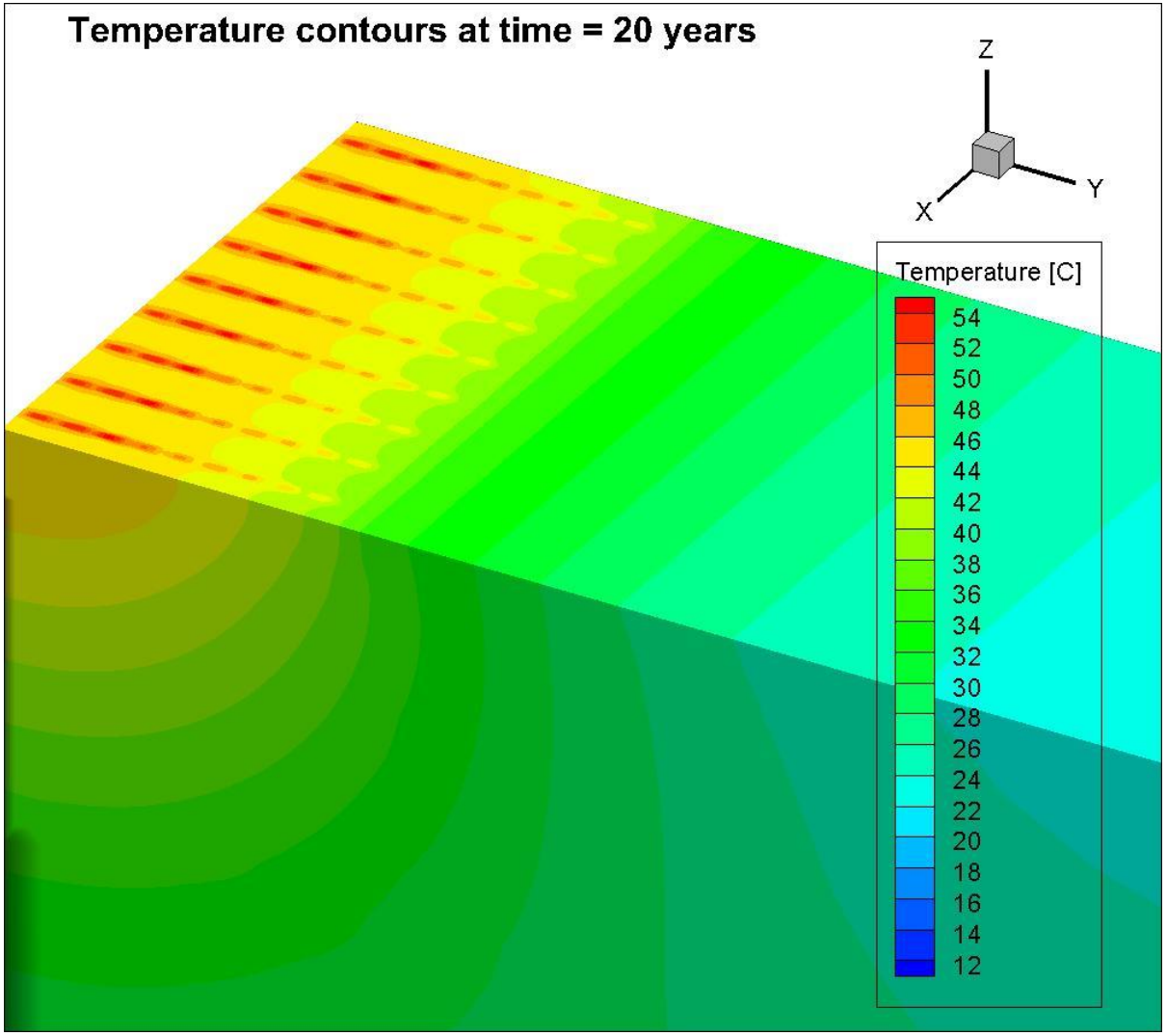
Thermal-Hydrologic Model Mesh, Contd. Crystalline Host Rock



Thermal-Hydrologic Model Mesh, Contd. – Crystalline Host Rock



Thermal-Hydrologic Model: Preliminary Results – Crystalline Host Rock



References

- E. HARDIN, T. HADGU, D. CLAYTON, H. GREENBURG, J. BLINK, M. SHARMA, M., SUTTON, J. CARTER, M. DUPONT, and P. RODWELL, *Disposal Concepts/Thermal Load Management (FY11/12 Summary Report).* FCRD-USED-2012-000219 Rev. 1. September, 2012. U.S. Department of Energy, Used Fuel Disposition R&D Campaign. (2012).
- Wilson, J. (2016) Decay Heat of Selected DOE Defense Waste Materials, FCRD-UFD-2016-000636, SRNL-RP-2016-00249.