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Predicted Temperatures in a Bedded-Salt Repository Resulting From Burial of DOE High-Level Nuclear Waste Canisters

Carl E. Sisson

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PREDICTED TEMPERATURES IN A BEDDED-SALT REPOSITORY RESULTING FROM BURIAL OF DOE HIGH-LEVEL NUCLEAR WASTE CANISTERS*

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ABSTRACT

A 2-D thermal model is defined and used to calculate temperatures within support pillars of a bedded salt repository. The particular configuration considered includes DOE high-level waste canisters (producing 300 W each) buried three abreast below the floor of a 20-foot wide drift.

A 3-D "close-in" thermal model is also defined and used to estimate the thermal response of bedded salt near the buried canisters. This model uses boundary conditions from the 2-D "global" model.

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PREDICTED TEMPERATURES IN A BEDDED-SALT REPOSITORY RESULTING FROM BURIAL OF DOE HIGH-LEVEL NUCLEAR WASTE CANISTERS

I. Introduction

A 2-D thermal model is defined and used to calculate the thermal response of a natural bedded-salt repository to the burial of DOE high-level nuclear waste canisters. The particular configuration of drift/canister emplacement geometry considered is of current interest in the Waste Isolation Pilot Plant (WIPP) program-development effort. The thermal-response calculations were requested for use in temperature-dependent creep studies. Of particular interest are the temperatures in the bedded salt surrounding the access drift (i.e., in the pillars).

In addition, a 3-D "close-in" thermal model is defined to investigate thermal response of the bedded salt close to the buried canisters. This "close-in" model uses boundary conditions from the 2-D "global" model. The primary result desired from this 3-D model is the peak temperature in the bedded salt. However, the detailed results may also be of interest in canister buoyancy and water-migration studies.

This report discusses the drift/canister burial configuration, defines the thermal models, and provides an overview of the temperature results. Complete temperature results are retained on magnetic tape for use in other engineering studies.

II. Definition of Burial Configuration and Basic Constraints of Study

The following information was provided¹ to describe the drift/waste canister burial geometry and the basic constraints for the thermal study:

- Drift dimensions ~ 20 feet (width) by 15 feet (height).
- Pillar width ~ 80 feet.
- Thermal heating ~ 3-300 W canisters spaced 5 feet apart across drift, at 5-foot intervals along drift.
- Canisters geometry ~ 20-foot diameter by 10-foot length buried 10 feet below drift floor.
- Bedded salt thermal properties per Reference 2.
- Waste heat decay curve--See Figure 8.
- Time duration of interest ~ 50 years.

The thermal model will consider diffusion effects in a single homogeneous material (salt). No attempt will be made to model the effect of aquifers, layered geologic material stratifications, geothermal gradients, repository-edge effects (i.e., lateral far-field effects), or drift ventilation effects. All nuclear waste canisters are assumed to be dimensionally identical, simultaneously emplaced, and have identical heat generation histories. Effects of overburden, drift closure, etc., are not considered in this study.

III. Thermal Model Geometry

Figure 1 shows an elevation view of the drift with the three canisters buried below the drift floor. A plan view of drifts, pillars, and canister emplacement geometry is shown in Figure 2. Note that cross-drifts (service tunnels) are not shown. For the current study, it is assumed that such service tunnels will not significantly alter temperatures. Thus, as implied in Figure 2, we are considering an extensive pattern of drifts, directing interest toward a region enclosed by adiabatic boundaries. Since all canisters are assumed to be emplaced simultaneously, adiabatic boundaries are defined by Figure 2. The shaded region (2.5 feet by 50 feet), containing 1/4-canister plus 1/2-canister volumes, defines the portion included in the thermal model.

The primary purpose of the thermal model is to estimate pillar temperatures for use in temperature-dependent creep studies. To obtain pillar temperatures, a 2-D "global" model is defined (Figures 3 and 4). In addition, a 3-D "close-in" model is defined (Figures 5 and 6) to investigate thermal response of the bedded salt close to the buried canisters. This "close-in" model uses boundary temperatures from the 2-D "global" model.

The vertical dimensions of the 2-D thermal model were selected arbitrarily (Figure 3). Since these are assumed to be adiabatic boundaries, temperature results must be reviewed to validate the assumption (see Section IV, Boundary Conditions, and Section IX, Concluding Remarks).

Figures 3 through 6 show all thermal model dimensions, geometric subdivisions, node numbering to define lumped-mass diffusion nodes, and the relationship between the 2-D "global" model and 3-D "close-in" model (see Section VII, Numerical Calculations).

Tables I and II list coordinates of node centers for the 2-D and 3-D thermal models.

IV. Boundary Conditions

As noted in Figures 3 and 5, most of the model surfaces are adiabatic. For the vertical surfaces (except drift wall), the adiabatic conditions arise from the choice of model boundaries (Figure 2). However, at the upper and lower bounding surfaces ($z = 700$ and $z = -800$), the adiabatic boundaries are assumed. For an exact representation, these model bounds would have to extend upward to the earth's surface (with some real boundary condition applied there) and downward, possibly to the earth's geometric center (where an adiabatic boundary might truly

apply). Extending the model to such bounds would certainly violate the homogeneous material restraint and would surely be impractical for numerical solution. Accepting the adiabatic upper and lower boundary conditions means that no thermal energy can flow across these boundaries. Thus, we can judge acceptance of the adiabatic assumption (and the assumed dimensional location of the boundaries) by reviewing temperature results from the model. If temperatures of the bounding nodes do not increase significantly above initial conditions, there will be little potential for transfer of heat across the boundaries and the assumptions have little effect on results. On the other hand, significant increase in temperature of bounding nodes indicates that energy is retained in the model which, with different boundary conditions, could be transferred out of the existing model.

For wall, ceiling, and floor surfaces of the drift, the adiabatic assumption is reasonable only if the drift is not ventilated. If unventilated, the air in the drift has very small thermal capacitance relative to the surrounding salt and would absorb very little thermal energy. If the drift were ventilated, appropriate forced convective cooling of the drift wall, ceiling, and floor surfaces would have to be considered.

V. Material Properties

The entire mass of 1500 vertical feet is assumed to be salt. The vertical extensiveness of salt in potential repository sites is thought to be greater than 1500 feet¹. The waste material emplaced and the crushed salt back-fill are not treated separately. This simplification of the 2-D "global" thermal model is justified because interest is primarily in the region of the model immediately surrounding the drift and includes the pillar. For the 2-D "close-in" thermal model, the all-salt assumption is a simplification made to improve ease of modeling. Capacitance of the waste and the bedded salt are essentially the same. Capacitance of the crushed salt is about one-fourth that of the bedded salt, but comprises a very small part of the model. The thermal properties of bedded salt are taken from Reference 2 and are shown by Figures 3 and 7.

VI. Volumetric Heating in Nuclear Waste

By definition, the emplaced nuclear waste will generate 300 W/canister at time of emplacement. This heat generation rate decays with time in accordance with Figure 8¹. Waste heat, a total of $(3/4 \text{ canister}) \times (300 \text{ W/canister}) = 225 \text{ W}$, is input to model nodes as indicated by Figures 4 and 6.

VII. Numerical Calculations

Thermal model geometries were discussed earlier and are shown with node numbering in Figures 3 through 6. Actual calculation of the lumped-mass diffusion node networks for the 2-D and 3-D thermal models was performed using IITMSH^{3,4} which formatted the networks for solution using CINDA^{5,6}. The 2-D "global" thermal model consists of 138 diffusion nodes and 248 conductors. The 3-D "close-in" thermal model consists of 360 diffusion nodes, 53 boundary nodes,

and 936 conductors. Variable conductivity is considered--all conductances were recalculated at each printout time interval (defined below) to account for temperature variation.

The thermal network solutions employed an implicit finite-difference numerical solution scheme⁷ with:

- All node temperatures initialized at 0.0°C.
- Computational time interval

DTIMEI = 0.01 years (time < 10 years) }	2-D "global" model
= 0.02 years (time > 10 years) }	
DTIMEI = 0.0005 years (time < 1.0 years) }	3-D "close-in" model
= 0.001 years (time > 1.0 years) }	
- Data output intervals

OUTPUT = 0.1 years (time < 0.5 years) }	2-D "global" model
= 0.5 years (time > 0.5 years) }	
OUTPUT = 0.05 years (time < 0.5 years) }	3-D "close-in" model
= 0.10 years (0.5 < t < 1.0 years) }	
= 0.25 years (1.0 < t < 3.0 years) }	
= 0.50 years (time > 3.0 years) }	
- Time of solution

0 to 50 years for 2-D "global" model
0 to 10+ years for 3-D "close-in" model

Computational time intervals for the 3-D model were required to be very small to avoid numerical instability--mostly because of the small nodes in model regions where temperature gradients were small. Having this solution, future models would certainly be improved.

During the 2-D model solution, energy input to the model and energy stored in the model were summed for comparison. The values were equal for the full solution, indicating good energy balance. For the 3-D solution only the energy input was summed (for comparison with 2-D solution). An energy balance for the 3-D model is difficult with time-varying temperature boundaries.

VIII. Temperature Results

All temperature results from the thermal model are increases above ambient conditions (because initial conditions of 0°C were used), where ambient level temperatures are those existing without the heat generated by nuclear waste materials. The geothermal gradient is one source of ambient temperature level. Ambient levels could also be altered by mine ventilation, by heat generated by machines operating in the mine, or by aquifers which might alter heat transfer rates or cause transport of thermal energy.

Temperature results from the thermal models, at previously defined output intervals, are (temporarily) saved on magnetic tape for use in other engineering studies and are presented here in a more summarized form.

2-D Global Model Results

- Figure 9 shows temperature histories for various nodes along a horizontal path at $z = -30$.
- Figure 10 shows temperature histories for various nodes along a vertical path upward from access tunnel.
- Figure 11 shows temperature histories for various nodes along a vertical path downward from access tunnel.
- Figure 12 shows temperature profiles of nodes along a vertical path 30 feet off the tunnel centerline.
- Figure 13 shows temperature profiles of nodes along a horizontal path at $z = -30$.
- Appendix A presents tabulated temperature results from the 2-D "global" model for selected times. Node numbers are "actual" node numbers as shown in Figures 3 and 4.
- Appendix B presents a detailed tabulation of node numbers and node temperatures (for nodes in the range $-35 < z < 7.5$ feet) versus coordinate location of node centers.

3-D Close-In Thermal Model Results

- Figure 14 shows the peak temperature history of bedded salt which occurs for node 244 ($x = 0.98$, $y = 0.262$, $z = -30$).
- Figures 15 through 17 show temperature profiles of nodes along horizontal paths near fore and aft surfaces ($x = 0$ and $x = 2.50$) at $z = -30$. Superimposed on these figures (dashed lines) are the corresponding horizontal profiles from Figure 13. Differences in temperature are believed to result from the differences in node sizes. The smaller nodes in the 3-D model heat up faster and are assigned the corresponding smaller conductivity (Figure 7). Reduced conductivities result in more thermal energy being retained.
- Appendix C presents tabulated temperature results from the 3-D "close-in" model for selected times. Node numbers shown are "relative" node numbers substituted during solution. "Actual" node numbers (as used in Figures 5 and 6) are related to "relative" node numbers by the initial tabulation of Appendix C.

- Appendix D gives a graphical presentation of node temperatures at mid-canister depth ($z = -30$ feet) for selected times.

IX. Concluding Remarks

The thermal-response information obtained from the 2-D "global" and 3-D "close-in" models are believed to be sufficiently accurate for preliminary design studies. The major restrictions imposed on the use of the temperature results are those discussed in Section II -- the problem definition. However, since the thermal models are not idealized, some noteworthy comments are presented in the paragraphs below.

The comparison (Figures 15 through 17) of 2-D and 3-D results indicates a difference in energy storage in the region of the canisters. However, the argument that such differences result from node sizing and variable conductivity interactions appears valid. The pillar temperatures from the 2-D model might be slightly altered if a more detailed noding were tried.

The assumptions regarding location and boundary conditions at upper and lower extremes of the 2-D model must be reviewed. At 50 years, the node temperatures were 1.9°C at top ($z = 700$) of model and 1.5°C at bottom ($z = -800$) of model. Thus, the model could be improved by extending upper and lower boundary locations. These non-zero temperatures imply retention of energy; that is, energy which could have diffused beyond the selected upper and lower boundary locations. However, at 30 years, these "end" node temperatures are almost negligible and pillar temperatures are essentially the same as for 50 years. Thus, peak pillar temperatures are essentially unaffected, although 50-year temperatures could be slightly high (maybe 1°C).

Some concern must be directed to choice of initial conditions. In particular, the waste material (at time of emplacement) will truly be at some temperature greater than the (implied) ambient of 32°C . Thus, an initial temperature profile would include a step at the canister/salt interface. However, the additional energy of concern should be small compared to the total heat generated over the first year of burial history. Consideration of higher initial waste temperatures would not significantly alter peak-pillar temperature or peak-salt temperature but might slightly alter their time of occurrence.

Figure 1. Elevation View Normal to Drift
Showing Waste Canister Burial Geometry

Calculation of Peak Thermal Energy Density:

$$\begin{aligned} & (300 \text{ w/canister}) (3 \text{ canisters}) / (500 \text{ ft}^2) (1 \text{ acre} / 43560 \text{ ft}^2) \\ & = 78.4 \text{ kw/acre} \end{aligned}$$

Figure 2. Plan View of Drift and Canister Emplacement Geometry

Figure 3. 2-D Thermal Model Geometry (Global)

Figure 4. Additional Details of 2-D Thermal Model Geometry for Global Solution

Figure 5. 3-D "Close-in" Thermal Model Geometry

NODE NUMBERS SHOWN ARE FOR HORIZONTAL LAYER Z--15.0 TO Z--18.333
AND RANGE FROM 1-45 (PLUS BOUNDARY NODE 46, NOT SHOWN).

NODE NUMBERS FOR OTHER HORIZONTAL LAYERS INCREASE BY 50 PER LAYER.

HEAT GENERATED IN NUCLEAR WASTE TO Y-AXIS
NODES 150 = 114, 15, 16, 17, 22, 41-43
225 = 41, 17, 15, 16, 22, 41-43
350 = 12, 15, 16, 17, 22, 41-43

(SEE FIGURE 5 ALSO)

Figure 6. 3-D Close-in Thermal Model for DOE Waste
Node Numbers in Layer 1

Figure 7. Thermal Conductivity of Salt

Figure 8. Normalized Heat Generated by Waste

Figure 9. 2-D Salt Model for DOE Waste---Nodes Along Horizontal Path at Mid-Canister Depth

Figure 10. 2-D Salt Model for DOE Waste---Nodes Along Vertical Path Upward from Access Tunnel

Figure 11. 2-D Salt Model for DOE Waste---Nodes Along Vertical Path Downward from Access Tunnel

Figure 12. 2-D Salt Model for DOE Waste--Vertical Temperature Profiles 30.0 Feet off Tunnel Centerline

Figure 13. 2-D Salt Model for DOE Waste--Lateral Temperature Distribution at Z = -30 Feet

Figure 14. 3-D Close-in Salt Model for DOE Waste---Peak Temperature in Bedded Salt

Figure 15. 3-D Close-in Model for DOE Waste--Lateral Temperature Distributions at Z = -30 Feet -- Time = 5.00 Years

Figure 16. 3-D Close-in Model for DOE Waste--Lateral Temperature Distributions at Z = -30 Feet -- Time = 10.00 Years

Figure 17. 3-D Close-in Model for DOE Waste--Lateral Temperature Distributions at Z = 30 Feet -- Time = 15.00 Years

TABLE I

Coordinates of Node Centers for 2-D Thermal Model

NODE NO.	X	Y	Z	NODE NO.	X	Y	Z	NODE NO.	X	Y	Z
1	1.7500	75.0000	75.0000	41	1.7500	75.0000	75.0000	121	1.7500	75.0000	75.0000
2	1.7500	75.0000	75.0000	42	1.7500	75.0000	75.0000	122	1.7500	75.0000	75.0000
3	1.7500	75.0000	75.0000	43	1.7500	75.0000	75.0000	123	1.7500	75.0000	75.0000
4	1.7500	75.0000	75.0000	44	1.7500	75.0000	75.0000	124	1.7500	75.0000	75.0000
5	1.7500	75.0000	75.0000	45	1.7500	75.0000	75.0000	125	1.7500	75.0000	75.0000
6	1.7500	75.0000	75.0000	46	1.7500	75.0000	75.0000	126	1.7500	75.0000	75.0000
7	1.7500	75.0000	75.0000	47	1.7500	75.0000	75.0000	127	1.7500	75.0000	75.0000
8	1.7500	75.0000	75.0000	48	1.7500	75.0000	75.0000	128	1.7500	75.0000	75.0000
9	1.7500	75.0000	75.0000	49	1.7500	75.0000	75.0000	129	1.7500	75.0000	75.0000
10	1.7500	75.0000	75.0000	50	1.7500	75.0000	75.0000	130	1.7500	75.0000	75.0000
11	1.7500	75.0000	75.0000	51	1.7500	75.0000	75.0000	131	1.7500	75.0000	75.0000
12	1.7500	75.0000	75.0000	52	1.7500	75.0000	75.0000	132	1.7500	75.0000	75.0000
13	1.7500	75.0000	75.0000	53	1.7500	75.0000	75.0000	133	1.7500	75.0000	75.0000
14	1.7500	75.0000	75.0000	54	1.7500	75.0000	75.0000	134	1.7500	75.0000	75.0000
15	1.7500	75.0000	75.0000	55	1.7500	75.0000	75.0000	135	1.7500	75.0000	75.0000
16	1.7500	75.0000	75.0000	56	1.7500	75.0000	75.0000	136	1.7500	75.0000	75.0000
17	1.7500	75.0000	75.0000	57	1.7500	75.0000	75.0000	137	1.7500	75.0000	75.0000
18	1.7500	75.0000	75.0000	58	1.7500	75.0000	75.0000	138	1.7500	75.0000	75.0000
19	1.7500	75.0000	75.0000	59	1.7500	75.0000	75.0000	139	1.7500	75.0000	75.0000
20	1.7500	75.0000	75.0000	60	1.7500	75.0000	75.0000	140	1.7500	75.0000	75.0000
21	1.7500	75.0000	75.0000	61	1.7500	75.0000	75.0000	141	1.7500	75.0000	75.0000
22	1.7500	75.0000	75.0000	62	1.7500	75.0000	75.0000	142	1.7500	75.0000	75.0000
23	1.7500	75.0000	75.0000	63	1.7500	75.0000	75.0000	143	1.7500	75.0000	75.0000
24	1.7500	75.0000	75.0000	64	1.7500	75.0000	75.0000	144	1.7500	75.0000	75.0000
25	1.7500	75.0000	75.0000	65	1.7500	75.0000	75.0000	145	1.7500	75.0000	75.0000
26	1.7500	75.0000	75.0000	66	1.7500	75.0000	75.0000	146	1.7500	75.0000	75.0000
27	1.7500	75.0000	75.0000	67	1.7500	75.0000	75.0000	147	1.7500	75.0000	75.0000
28	1.7500	75.0000	75.0000	68	1.7500	75.0000	75.0000	148	1.7500	75.0000	75.0000
29	1.7500	75.0000	75.0000	69	1.7500	75.0000	75.0000	149	1.7500	75.0000	75.0000
30	1.7500	75.0000	75.0000	70	1.7500	75.0000	75.0000	150	1.7500	75.0000	75.0000
31	1.7500	75.0000	75.0000	71	1.7500	75.0000	75.0000	151	1.7500	75.0000	75.0000
32	1.7500	75.0000	75.0000	72	1.7500	75.0000	75.0000	152	1.7500	75.0000	75.0000
33	1.7500	75.0000	75.0000	73	1.7500	75.0000	75.0000	153	1.7500	75.0000	75.0000
34	1.7500	75.0000	75.0000	74	1.7500	75.0000	75.0000	154	1.7500	75.0000	75.0000
35	1.7500	75.0000	75.0000	75	1.7500	75.0000	75.0000	155	1.7500	75.0000	75.0000
36	1.7500	75.0000	75.0000	76	1.7500	75.0000	75.0000	156	1.7500	75.0000	75.0000
37	1.7500	75.0000	75.0000	77	1.7500	75.0000	75.0000	157	1.7500	75.0000	75.0000
38	1.7500	75.0000	75.0000	78	1.7500	75.0000	75.0000	158	1.7500	75.0000	75.0000
39	1.7500	75.0000	75.0000	79	1.7500	75.0000	75.0000	159	1.7500	75.0000	75.0000
40	1.7500	75.0000	75.0000	80	1.7500	75.0000	75.0000	160	1.7500	75.0000	75.0000
41	1.7500	75.0000	75.0000	81	1.7500	75.0000	75.0000	161	1.7500	75.0000	75.0000
42	1.7500	75.0000	75.0000	82	1.7500	75.0000	75.0000	162	1.7500	75.0000	75.0000
43	1.7500	75.0000	75.0000	83	1.7500	75.0000	75.0000	163	1.7500	75.0000	75.0000
44	1.7500	75.0000	75.0000	84	1.7500	75.0000	75.0000	164	1.7500	75.0000	75.0000
45	1.7500	75.0000	75.0000	85	1.7500	75.0000	75.0000	165	1.7500	75.0000	75.0000
46	1.7500	75.0000	75.0000	86	1.7500	75.0000	75.0000	166	1.7500	75.0000	75.0000
47	1.7500	75.0000	75.0000	87	1.7500	75.0000	75.0000	167	1.7500	75.0000	75.0000
48	1.7500	75.0000	75.0000	88	1.7500	75.0000	75.0000	168	1.7500	75.0000	75.0000
49	1.7500	75.0000	75.0000	89	1.7500	75.0000	75.0000	169	1.7500	75.0000	75.0000
50	1.7500	75.0000	75.0000	90	1.7500	75.0000	75.0000	170	1.7500	75.0000	75.0000
				91	1.7500	75.0000	75.0000	171	1.7500	75.0000	75.0000
				92	1.7500	75.0000	75.0000	172	1.7500	75.0000	75.0000
				93	1.7500	75.0000	75.0000	173	1.7500	75.0000	75.0000
				94	1.7500	75.0000	75.0000	174	1.7500	75.0000	75.0000
				95	1.7500	75.0000	75.0000	175	1.7500	75.0000	75.0000
				96	1.7500	75.0000	75.0000	176	1.7500	75.0000	75.0000
				97	1.7500	75.0000	75.0000	177	1.7500	75.0000	75.0000
				98	1.7500	75.0000	75.0000	178	1.7500	75.0000	75.0000
				99	1.7500	75.0000	75.0000	179	1.7500	75.0000	75.0000
				100	1.7500	75.0000	75.0000	180	1.7500	75.0000	75.0000

TABLE II

Coordinates of Node Centers for 3-D Thermal Model

NODE NO.	Y	X	Z
1	.7715	9.3753	-16.6665
2	.7715	9.3753	-16.6665
3	1.7715	9.3753	-16.6665
4	1.9715	9.3753	-16.6665
5	.6715	7.7165	-16.6665
6	.4619	6.0699	-16.6665
7	.3265	6.1267	-16.6665
8	.4921	5.4321	-16.6665
9	1.2675	6.2675	-16.6665
10	2.0011	7.0011	-16.6665
11	1.1963	5.7265	-16.6665
12	1.6493	5.6539	-16.6665
13	2.2165	5.6366	-16.6665
14	.1565	5.0000	-16.6665
15	.7416	5.7416	-16.6665
16	.5692	5.6692	-16.6665
17	.2675	5.9796	-16.6665
18	.9093	5.6756	-16.6665
19	.7416	4.6516	-16.6665
20	.5692	4.4704	-16.6665
21	.2675	4.0704	-16.6665
22	.9093	4.4752	-16.6665
23	1.1963	4.6735	-16.6665
24	1.6493	4.5361	-16.6665
25	2.2165	4.3644	-16.6665
26	.4921	4.1979	-16.6665
27	1.2675	3.7125	-16.6665
28	2.0011	2.9789	-16.6665
29	.3265	3.4137	-16.6665
30	.4639	3.7502	-16.6665
31	.6759	2.7479	-16.6665
32	.6366	2.2166	-16.6665
33	.4639	1.6494	-16.6665
34	.3265	1.1963	-16.6665
35	.4921	.4321	-16.6665
36	1.2675	1.2675	-16.6665
37	2.0011	2.0011	-16.6665
38	1.1963	.7265	-16.6665
39	1.6493	.6539	-16.6665
40	2.2165	.6366	-16.6665
41	.1179	.1179	-16.6665
42	.7416	.7416	-16.6665
43	.5692	.5692	-16.6665
44	.2675	.9796	-16.6665
45	.9093	.6756	-16.6665
46	1.2533	12.5000	-16.6665

THE FOLLOWING NODE GROUPS
HAVE THE SAME X-Y COORDINATE
AS NODES 1-46

THESE COORDINATES ARE
THE SAME AS NODES 1-46

51 = 52
111 = 112
151 = 152
201 = 202
251 = 252
301 = 302
351 = 352
401 = 402

References

1. Informal request from J. R. Wayland, Jr., 5311, and H. C. Shefelbine, 5312.
2. Encl. memo, dtd 5/19/77, to P. D. O'Brien, 1141, from M. L. Fewell, 1262, and C. L. Sisson, 1262, subject: *Thermin: Analysis of the WPP Canister Design.*
3. Encl. memo, dtd 8/2/76, C. L. Sisson, 1263, to CINDA Users, subject: *Program HTMSH-01, A Modified Version of HEAT MESH.*
4. ECL DR-72004, "HEAT MESH-71: A Computer Code for Generating Geometrical Data Required for Studies of Heat Transfer in Axisymmetric Structures," by V. K. Gabrielson, September 1972.
5. TN-AP-67-287, "Chrysler Improved Numerical Differencing Analyzer (CINDA) for Third-Generation Computers," October 20, 1967.
6. Numerous additions and modifications to CINDA by SLA personnel (numerous memoranda).
7. TN-AP-67-287, *op. cit.*

Table N.10.1
Temperatures From 1971 to 2000: World
(continued from p. 1)

Note: Temperatures presented are averages above ambient T_{ref} (defined as 10°C).

2-1) Thermal Model Results for DOE Waste

[illegible]

2-D Thermal Model Results for DOE Waste

ACTUAL NODE NUMBERS

TEMPERATURES IN 76 DEGREES CELSIUS

TIME= .400000000000 YEARS

1	1	70	53	29.6	27.1	29.0	29.7	33.0	31.8	32.7	31.5	21.7	27.3	27.2	27.6	28.3	28.0	28.3	28.6	28.3	74.7	29.4	28.8
2	1	70	43	29.6	27.1	29.0	29.7	33.0	31.8	32.7	31.5	21.7	27.3	27.2	27.6	28.3	28.0	28.3	28.6	28.3	74.7	29.4	28.8
3	1	70	60	34.2	36.3	38.8	41.2	43.3	45.8	48.4	47.2	47.6	47.3	46.5	46.3	46.2	46.0	45.2	46.2	45.4	48.9	32.9	32.5
4	1	70	80	40.3	41.3	41.6	44.6	41.1	39.9	32.2	31.4	32.5	33.7	35.2	36.0	36.0	37.5	34.1	34.4	34.6	34.5	38.3	37.2
5	1	70	100	70.1	71.3	32.3	33.5	34.6	35.6	36.3	35.3	37.4	33.7	32.8	32.8	37.6	34.4	60.3	62.6	64.6	73.5	52.7	72.4
6	1	70	120	60.6	62.4	66.2	71.9	77.5	77.4	69.3	61.7	65.4	72.3	72.4	64.7	53.8	60.6	64.1	71.9	72.3	62.6	64.3	67.7
7	1	70	140	60.4	63.4	64.3	62.8	62.6	58.7	58.3	52.1	31.5	32.5	32.5	32.7	32.7	32.1	34	31	30	30	30	30

TIME= .10000E+02 YEARS

[illegible]

TIME= .15003E+02 YEARS

1 TO 73	40.0	40.1	42.2	44.4	46.5	48.5	50.5	52.5	54.5	56.5	58.5	60.5	62.5	64.5	66.5	68.5	70.5	72.5	74.5	76.5	78.5	80.5	82.5	84.5	86.5	88.5	90.5	92.5	94.5	96.5	98.5	100.5	102.5	104.5	106.5	108.5	110.5	112.5	114.5	116.5	118.5	120.5	122.5	124.5	126.5	128.5	130.5	132.5	134.5	136.5	138.5	140.5	142.5	144.5	146.5	148.5	150.5	152.5	154.5	156.5	158.5	160.5	162.5	164.5	166.5	168.5	170.5	172.5	174.5	176.5	178.5	180.5	182.5	184.5	186.5	188.5	190.5	192.5	194.5	196.5	198.5	200.5	202.5	204.5	206.5	208.5	210.5	212.5	214.5	216.5	218.5	220.5	222.5	224.5	226.5	228.5	230.5	232.5	234.5	236.5	238.5	240.5	242.5	244.5	246.5	248.5	250.5	252.5	254.5	256.5	258.5	260.5	262.5	264.5	266.5	268.5	270.5	272.5	274.5	276.5	278.5	280.5	282.5	284.5	286.5	288.5	290.5	292.5	294.5	296.5	298.5	300.5	302.5	304.5	306.5	308.5	310.5	312.5	314.5	316.5	318.5	320.5	322.5	324.5	326.5	328.5	330.5	332.5	334.5	336.5	338.5	340.5	342.5	344.5	346.5	348.5	350.5	352.5	354.5	356.5	358.5	360.5	362.5	364.5	366.5	368.5	370.5	372.5	374.5	376.5	378.5	380.5	382.5	384.5	386.5	388.5	390.5	392.5	394.5	396.5	398.5	400.5	402.5	404.5	406.5	408.5	410.5	412.5	414.5	416.5	418.5	420.5	422.5	424.5	426.5	428.5	430.5	432.5	434.5	436.5	438.5	440.5	442.5	444.5	446.5	448.5	450.5	452.5	454.5	456.5	458.5	460.5	462.5	464.5	466.5	468.5	470.5	472.5	474.5	476.5	478.5	480.5	482.5	484.5	486.5	488.5	490.5	492.5	494.5	496.5	498.5	500.5	502.5	504.5	506.5	508.5	510.5	512.5	514.5	516.5	518.5	520.5	522.5	524.5	526.5	528.5	530.5	532.5	534.5	536.5	538.5	540.5	542.5	544.5	546.5	548.5	550.5	552.5	554.5	556.5	558.5	560.5	562.5	564.5	566.5	568.5	570.5	572.5	574.5	576.5	578.5	580.5	582.5	584.5	586.5	588.5	590.5	592.5	594.5	596.5	598.5	600.5	602.5	604.5	606.5	608.5	610.5	612.5	614.5	616.5	618.5	620.5	622.5	624.5	626.5	628.5	630.5	632.5	634.5	636.5	638.5	640.5	642.5	644.5	646.5	648.5	650.5	652.5	654.5	656.5	658.5	660.5	662.5	664.5	666.5	668.5	670.5	672.5	674.5	676.5	678.5	680.5	682.5	684.5	686.5	688.5	690.5	692.5	694.5	696.5	698.5	700.5	702.5	704.5	706.5	708.5	710.5	712.5	714.5	716.5	718.5	720.5	722.5	724.5	726.5	728.5	730.5	732.5	734.5	736.5	738.5	740.5	742.5	744.5	746.5	748.5	750.5	752.5	754.5	756.5	758.5	760.5	762.5	764.5	766.5	768.5	770.5	772.5	774.5	776.5	778.5	780.5	782.5	784.5	786.5	788.5	790.5	792.5	794.5	796.5	798.5	800.5	802.5	804.5	806.5	808.5	810.5	812.5	814.5	816.5	818.5	820.5	822.5	824.5	826.5	828.5	830.5	832.5	834.5	836.5	838.5	840.5	842.5	844.5	846.5	848.5	850.5	852.5	854.5	856.5	858.5</
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TYPE= .20000E+02 YEARS

1	70	82	43	41	46	41.4	5.8	15.1	21.7	78.3	33.2	44.6	44.4	44.1	45.8	45.6	45.8	45.7	45.8	46.2	46.3	46.1	46.2	46.3	46.4	46.5	46.6	46.7	46.8	46.9	47.0	47.1	47.2	47.3	47.4	47.5	47.6	47.7	47.8	47.9	48.0	48.1	48.2	48.3	48.4	48.5	48.6	48.7	48.8	48.9	49.0	49.1	49.2	49.3	49.4	49.5	49.6	49.7	49.8	49.9	50.0	50.1	50.2	50.3	50.4	50.5	50.6	50.7	50.8	50.9	51.0	51.1	51.2	51.3	51.4	51.5	51.6	51.7	51.8	51.9	52.0	52.1	52.2	52.3	52.4	52.5	52.6	52.7	52.8	52.9	53.0	53.1	53.2	53.3	53.4	53.5	53.6	53.7	53.8	53.9	54.0	54.1	54.2	54.3	54.4	54.5	54.6	54.7	54.8	54.9	55.0	55.1	55.2	55.3	55.4	55.5	55.6	55.7	55.8	55.9	56.0	56.1	56.2	56.3	56.4	56.5	56.6	56.7	56.8	56.9	57.0	57.1	57.2	57.3	57.4	57.5	57.6	57.7	57.8	57.9	58.0	58.1	58.2	58.3	58.4	58.5	58.6	58.7	58.8	58.9	59.0	59.1	59.2	59.3	59.4	59.5	59.6	59.7	59.8	59.9	60.0	60.1	60.2	60.3	60.4	60.5	60.6	60.7	60.8	60.9	61.0	61.1	61.2	61.3	61.4	61.5	61.6	61.7	61.8	61.9	62.0	62.1	62.2	62.3	62.4	62.5	62.6	62.7	62.8	62.9	63.0	63.1	63.2	63.3	63.4	63.5	63.6	63.7	63.8	63.9	64.0	64.1	64.2	64.3	64.4	64.5	64.6	64.7	64.8	64.9	65.0	65.1	65.2	65.3	65.4	65.5	65.6	65.7	65.8	65.9	66.0	66.1	66.2	66.3	66.4	66.5	66.6	66.7	66.8	66.9	67.0	67.1	67.2	67.3	67.4	67.5	67.6	67.7	67.8	67.9	68.0	68.1	68.2	68.3	68.4	68.5	68.6	68.7	68.8	68.9	69.0	69.1	69.2	69.3	69.4	69.5	69.6	69.7	69.8	69.9	70.0	70.1	70.2	70.3	70.4	70.5	70.6	70.7	70.8	70.9	71.0	71.1	71.2	71.3	71.4	71.5	71.6	71.7	71.8	71.9	72.0	72.1	72.2	72.3	72.4	72.5	72.6	72.7	72.8	72.9	73.0	73.1	73.2	73.3	73.4	73.5	73.6	73.7	73.8	73.9	74.0	74.1	74.2	74.3	74.4	74.5	74.6	74.7	74.8	74.9	75.0	75.1	75.2	75.3	75.4	75.5	75.6	75.7	75.8	75.9	76.0	76.1	76.2	76.3	76.4	76.5	76.6	76.7	76.8	76.9	77.0	77.1	77.2	77.3	77.4	77.5	77.6	77.7	77.8	77.9	78.0	78.1	78.2	78.3	78.4	78.5	78.6	78.7	78.8	78.9	79.0	79.1	79.2	79.3	79.4	79.5	79.6	79.7	79.8	79.9	80.0	80.1	80.2	80.3	80.4	80.5	80.6	80.7	80.8	80.9	81.0	81.1	81.2	81.3	81.4	81.5	81.6	81.7	81.8	81.9	82.0	82.1	82.2	82.3	82.4	82.5	82.6	82.7	82.8	82.9	83.0	83.1	83.2	83.3	83.4	83.5	83.6	83.7	83.8	83.9	84.0	84.1	84.2	84.3	84.4	84.5	84.6	84.7	84.8	84.9	85.0	85.1	85.2	85.3	85.4	85.5	85.6	85.7	85.8	85.9	86.0	86.1	86.2	86.3	86.4	86.5	86.6	86.7	86.8	86.9	87.0	87.1	87.2	87.3	87.4	87.5	87.6	87.7	87.8	87.9	88.0	88.1	88.2	88.3	88.4	88.5	88.6	88.7	88.8	88.9	89.0	89.1	89.2	89.3	89.4
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TIME = .25000E+02 YEARS

1	70	20	44,9	50,7	55,2	57,8	61,1	63,4	65,6	67,8	69,9	72,0	74,1	76,2	78,3	80,4	82,5	84,6	86,7	88,8	90,9	93,0	95,1	97,2	99,3	101,4	103,5	105,6	107,7	109,8	111,9	114,0	116,1	118,2	120,3	122,4	124,5	126,6	128,7	130,8	132,9	135,0	137,1	139,2	141,3	143,4	145,5	147,6	149,7	151,8	153,9	156,0	158,1	160,2	162,3	164,4	166,5	168,6	170,7	172,8	174,9	177,0	179,1	181,2	183,3	185,4	187,5	189,6	191,7	193,8	195,9	198,0	200,1	202,2	204,3	206,4	208,5	210,6	212,7	214,8	216,9	219,0	221,1	223,2	225,3	227,4	229,5	231,6	233,7	235,8	237,9	240,0	242,1	244,2	246,3	248,4	250,5	252,6	254,7	256,8	258,9	261,0	263,1	265,2	267,3	269,4	271,5	273,6	275,7	277,8	279,9	282,0	284,1	286,2	288,3	290,4	292,5	294,6	296,7	298,8	300,9	303,0	305,1	307,2	309,3	311,4	313,5	315,6	317,7	319,8	321,9	324,0	326,1	328,2	330,3	332,4	334,5	336,6	338,7	340,8	342,9	345,0	347,1	349,2	351,3	353,4	355,5	357,6	359,7	361,8	363,9	366,0	368,1	370,2	372,3	374,4	376,5	378,6	380,7	382,8	384,9	387,0	389,1	391,2	393,3	395,4	397,5	399,6	401,7	403,8	405,9	408,0	410,1	412,2	414,3	416,4	418,5	420,6	422,7	424,8	426,9	429,0	431,1	433,2	435,3	437,4	439,5	441,6	443,7	445,8	447,9	450,0	452,1	454,2	456,3	458,4	460,5	462,6	464,7	466,8	468,9	471,0	473,1	475,2	477,3	479,4	481,5	483,6	485,7	487,8	489,9	492,0	494,1	496,2	498,3	500,4	502,5	504,6	506,7	508,8	510,9	513,0	515,1	517,2	519,3	521,4	523,5	525,6	527,7	529,8	531,9	534,0	536,1	538,2	540,3	542,4	544,5	546,6	548,7	550,8	552,9	555,0	557,1	559,2	561,3	563,4	565,5	567,6	569,7	571,8	573,9	576,0	578,1	580,2	582,3	584,4	586,5	588,6	590,7	592,8	594,9	597,0	599,1	601,2	603,3	605,4	607,5	609,6	611,7	613,8	615,9	618,0	620,1	622,2	624,3	626,4	628,5	630,6	632,7	634,8	636,9	639,0	641,1	643,2	645,3	647,4	649,5	651,6	653,7	655,8	657,9	660,0	662,1	664,2	666,3	668,4	670,5	672,6	674,7	676,8	678,9	681,0	683,1	685,2	687,3	689,4	691,5	693,6	695,7	697,8	699,9	702,0	704,1	706,2	708,3	710,4	712,5	714,6	716,7	718,8	720,9	723,0	725,1	727,2	729,3	731,4	733,5	735,6	737,7	739,8	741,9	744,0	746,1	748,2	750,3	752,4	754,5	756,6	758,7	760,8	762,9	765,0	767,1	769,2	771,3	773,4	775,5	777,6	779,7	781,8	783,9	786,0	788,1	790,2	792,3	794,4	796,5	798,6	800,7	802,8	804,9	807,0	809,1	811,2	813,3	815,4	817,5	819,6	821,7	823,8	825,9	828,0	830,1	832,2	834,3	836,4	838,5	840,6	842,7	844,8	846,9	849,0	851,1	853,2	855,3	857,4	859,5	861,6	863,7	865,8	867,9	870,0	872,1	874,2	876,3	878,4	880,5	882,6	884,7	886,8	888,9	891,0	893,1	895,2	897,3	899,4	901,5	903,6	905,7	907,8	909,9
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2-D Thermal Model Results for DOE Waste

ACTUAL NODE NUMBERS

TEMPERATURES IN DEGREES CELSIUS

TIME = .150000E+02 YEARS

1 TO 20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
101 TO 120	121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138	139	140	141	142	143	144	145	146	147	148	149	150	151	152	153	154	155	156	157	158	159	160	161	162	163	164	165	166	167	168	169	170	171	172	173	174	175	176	177	178	179	180	181	182	183	184	185	186	187	188	189	190	191	192	193	194	195	196	197	198	199	200

TIME = .350000E+02 YEARS

1 TO 20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
101 TO 120	121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138	139	140	141	142	143	144	145	146	147	148	149	150	151	152	153	154	155	156	157	158	159	160	161	162	163	164	165	166	167	168	169	170	171	172	173	174	175	176	177	178	179	180	181	182	183	184	185	186	187	188	189	190	191	192	193	194	195	196	197	198	199	200

TIME = .600000E+02 YEARS

1 TO 20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
101 TO 120	121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138	139	140	141	142	143	144	145	146	147	148	149	150	151	152	153	154	155	156	157	158	159	160	161	162	163	164	165	166	167	168	169	170	171	172	173	174	175	176	177	178	179	180	181	182	183	184	185	186	187	188	189	190	191	192	193	194	195	196	197	198	199	200

TIME = .850000E+02 YEARS

1 TO 20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
101 TO 120	121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138	139	140	141	142	143	144	145	146	147	148	149	150	151	152	153	154	155	156	157	158	159	160	161	162	163	164	165	166	167	168	169	170	171	172	173	174	175	176	177	178	179	180	181	182	183	184	185	186	187	188	189	190	191	192	193	194	195	196	197	198	199	200

TIME = .150000E+03 YEARS

1 TO 20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
101 TO 120	121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138	139	140	141	142	143	144	145	146	147	148	149	150	151	152	153	154	155	156	157	158	159	160	161	162	163	164	165	166	167	168	169	170	171	172	173	174	175	176	177	178	179	180	181	182	183	184	185	186	187	188	189	190	191	192	193	194	195	196	197	198	199	200

APPENDIX B
Temperature versus Coordinate Location
2-D "Global" Model
(Nodes Near Drift)

This Appendix presents a detailed tabulation of temperatures versus coordinate location of node centers for all nodes in the range $-35 < z < 7.5$ feet. Temperatures shown are increases above ambient.

Table B-1 lists the node numbers.

Table B-2 to B-11 list the corresponding node temperatures.

TABLE B-1

Node Numbers versus Y-Z Coordinates

Z=ELEVATION (FEET) (ZERO AT TUNNEL CEILING)	0.450	1.700	3.300	5.000	7.950	12.500	20.000	30.000	40.000	47.500
5.417	15.0	17.0	19.0	21.0	23.0	25.0	39.0	53.0	67.0	81.0
1.667	16.0	18.0	20.0	22.0	24.0	26.0	40.0	54.0	68.0	82.0
-1.667						27.0	41.0	55.0	69.0	83.0
-5.417						28.0	42.0	56.0	70.0	84.0
-9.583						29.0	43.0	57.0	71.0	85.0
-13.133						30.0	44.0	58.0	72.0	86.0
-16.667	95.0	101.0	107.0	113.0	119.0	31.0	45.0	59.0	73.0	87.0
-20.000	96.0	102.0	108.0	114.0	120.0	32.0	46.0	60.0	74.0	88.0
-23.333	97.0	103.0	109.0	115.0	121.0	33.0	47.0	61.0	75.0	89.0
-26.667	98.0	104.0	110.0	116.0	122.0	34.0	48.0	62.0	76.0	90.0
-30.000	99.0	105.0	111.0	117.0	123.0	35.0	49.0	63.0	77.0	91.0
-33.333	100.0	106.0	112.0	118.0	124.0	36.0	50.0	64.0	78.0	92.0

TABLE B-2

Temperature Rise Above Ambient versus Y-Z Coordinates

Time (yrs) = 1.0

Z=ELEVATION (FEET) (ZERO AT TUNNEL CEILING)	0.450	1.750	3.300	5.000	7.350	12.500	20.000	30.000	40.000	47.500
5.417	4.8	4.8	4.1	4.2	4.5	5.2	5.5	5.1	4.5	4.4
1.667	4.2	4.3	4.3	4.5	4.9	6.3	6.6	5.9	5.2	5.0
-1.667						8.1	7.8	6.7	5.7	5.5
-5.417						15.2	9.4	7.7	6.4	6.1
-9.583						13.1	11.4	8.8	7.1	6.7
-13.333						16.6	13.3	9.8	7.8	7.3
-16.667	32.0	31.8	31.2	30.1	27.4	20.7	15.1	10.7	8.3	7.7
-20.000	33.9	33.7	33.0	31.9	29.1	23.4	16.6	11.4	8.7	8.0
-23.333	38.0	37.7	36.8	35.5	31.7	25.5	17.7	12.0	9.0	8.3
-26.667	45.5	43.8	42.7	42.7	34.3	27.0	18.5	12.4	9.2	8.5
-30.000	47.4	45.6	44.4	44.3	35.8	27.5	18.7	12.5	9.3	8.6
-33.333	44.2	42.6	41.6	41.5	34.3	26.7	18.5	12.4	9.3	8.5

TABLE B-3
Temperature Rise Above Ambient versus Y-Z Coordinates
Time (yrs) = 2.0

Z=ELEVATION (FEET) (ZERO AT TUNNEL CEILING)	4.450	1.700	3.300	5.000	7.950	12.500	20.000	30.000	40.000	47.500
5.417	9.2	9.2	9.3	9.5	9.9	10.7	11.3	11.0	10.4	10.3
1.667	9.5	9.5	9.6	9.8	10.4	12.2	12.7	12.1	11.4	11.2
-1.667						14.3	14.1	13.1	12.2	11.9
-5.417						16.7	16.0	14.7	13.1	12.0
-9.593						19.9	18.2	15.7	14.1	13.7
-13.333						23.5	20.3	16.9	14.9	14.4
-16.667	39.7	39.5	39.8	39.7	39.8	27.9	22.2	17.9	15.6	15.0
-20.000	41.6	41.4	40.7	39.5	36.6	31.7	23.8	18.8	16.1	15.5
-23.333	45.8	45.5	44.6	43.2	39.1	32.9	25.0	19.4	16.5	15.8
-26.667	53.5	51.8	50.7	50.6	42.5	34.4	25.8	19.8	16.8	16.1
-30.000	55.3	53.5	52.3	52.2	43.4	36.9	26.0	20.0	16.9	16.1
-33.333	52.1	50.4	49.3	49.3	41.9	34.1	25.8	19.9	16.8	16.1

TABLE B-4

Temperature Rise Above Ambient versus Y-Z Coordinates

Time (yrs) = 3.0

Z=ELEVATION (FEET) (ZERO AT TUNNEL CEILING)	Y=LATERAL DISTANCE FROM CENTERLINE OF TUNNEL (FEET)									
	.450	1.700	3.350	5.000	7.350	12.500	20.000	30.000	40.300	47.500
5.417	13.5	13.5	13.6	13.6	14.2	15.1	15.8	15.5	15.0	14.9
1.667	13.8	13.9	14.0	14.2	14.9	16.7	17.3	16.7	16.1	15.9
-1.667						19.9	19.8	17.9	17.0	16.8
-5.417						21.5	20.8	19.7	18.0	17.7
-9.583						24.7	23.1	20.7	19.1	18.7
-13.733						28.5	25.3	22.0	20.0	19.5
-16.667	45.0	44.8	44.1	42.9	40.3	32.9	27.7	23.0	20.7	20.2
-20.000	47.0	46.8	45.0	44.5	41.5	35.5	28.0	23.9	21.3	20.7
-23.333	51.2	50.8	50.0	48.6	44.4	39.1	30.1	24.6	21.7	21.1
-26.667	58.7	57.0	55.9	55.9	47.5	39.7	30.0	25.0	22.0	21.3
-30.000	60.5	58.7	57.6	57.5	48.5	40.2	31.2	25.7	22.1	21.4
-33.333	57.3	55.6	54.6	54.5	47.2	39.3	31.0	25.1	22.1	21.4

TABLE B-5

Temperature Rise Above Ambient versus Y-Z Coordinate

Time (yrs) = 4.0

Z=ELEVATION (FEET) (ZERO AT TUNNEL CEILING)	Y=LATERAL DISTANCE FROM CENTERLINE OF TUNNEL (FEET)									
	.450	1.700	3.300	5.000	7.350	12.500	20.000	30.000	40.000	47.500
5.417	17.2	17.2	17.3	17.5	17.9	18.9	19.6	19.7	19.7	19.9
1.667	17.5	17.6	17.7	17.9	18.5	20.5	21.1	20.6	20.0	19.9
-1.667						22.7	22.7	21.8	21.3	21.7
-5.417						25.6	24.7	23.2	22.0	21.7
-9.583						29.7	27.1	24.7	23.2	22.4
-13.333						32.6	29.4	26.0	24.1	23.7
-16.667	49.3	49.1	48.6	47.2	44.3	37.1	31.4	27.1	24.3	24.3
-20.000	51.3	51.1	50.3	49.1	46.1	40.1	33.1	28.1	25.5	24.9
-23.333	55.4	55.1	54.2	52.8	48.9	42.3	34.4	28.8	26.0	25.3
-26.667	62.9	61.2	60.1	60.0	52.1	46.0	35.2	29.2	26.3	25.6
-30.000	64.6	62.9	61.7	61.6	53.1	46.5	35.5	29.4	26.4	25.7
-33.333	61.5	59.8	58.8	58.7	51.5	43.5	35.3	29.3	26.3	25.6

TABLE B-6
 Temperature Rise Above Ambient versus Y-Z Coordinates
 Time (yrs) = 5.0

Z=ELEVATION (FEET) (ZERO AT TUNNEL CEILING)	Y=LATERAL DISTANCE FROM CENTERLINE OF TUNNEL (FEET)									
	.450	1.700	3.300	5.000	7.350	12.500	20.000	30.000	40.000	47.500
5.417	20.4	20.5	20.5	20.7	21.1	22.1	22.8	22.6	22.2	22.1
1.667	20.8	20.8	20.9	21.2	21.8	23.0	24.4	23.9	23.3	23.2
-1.667						26.1	26.1	25.7	24.4	24.1
-5.417						28.3	28.1	26.6	25.5	25.2
-9.583						32.2	30.6	28.2	26.7	26.3
-13.133						36.1	32.9	29.6	27.7	27.2
-16.667	52.9	52.7	52.0	50.8	47.3	40.7	34.9	30.7	28.4	27.9
-20.000	54.4	54.6	53.9	52.7	49.7	41.7	36.7	31.7	29.1	28.4
-23.333	58.9	58.6	57.8	56.4	52.5	44.0	38.0	32.4	29.6	28.9
-26.667	66.3	64.6	63.6	63.5	55.7	47.6	38.9	32.9	29.9	29.2
-30.000	68.8	66.3	65.1	65.0	56.6	48.1	39.2	33.1	30.0	29.3
-33.333	64.9	63.2	62.3	62.2	55.1	47.3	38.9	33.0	30.0	29.3

TABLE B-7

Temperature Rise Above Ambient versus Y-z Coordinates

Time (yrs) = 10.0

Z=ELEVATION (FEET) (ZERO AT TUNNEL CEILING)	.450	1.700	3.300	5.000	7.950	12.500	20.000	30.000	40.000	47.500
5.417	32.4	32.5	32.6	32.7	33.1	34.2	35.0	34.4	34.4	34.3
1.667	32.8	32.8	33.0	33.2	33.8	35.9	36.7	36.2	35.7	35.5
-1.667						38.4	38.4	37.6	36.4	36.6
-5.417						41.1	40.5	39.1	38.0	37.7
-9.583						44.5	43.0	40.7	39.3	38.9
-13.333						48.5	45.4	42.2	40.3	39.9
-16.667	64.4	64.2	63.6	62.5	59.8	53.0	47.4	43.3	41.2	40.6
-20.000	66.2	66.0	65.4	64.2	61.5	55.3	49.7	44.3	41.4	41.3
-23.333	70.0	69.7	68.9	67.6	64.0	59.0	50.5	45.1	42.4	41.7
-26.667	76.7	75.2	74.2	74.1	67.0	59.5	51.4	45.6	42.7	42.0
-30.000	78.3	76.7	75.7	75.6	67.8	60.1	51.7	45.8	42.9	42.2
-33.333	75.4	73.9	73.0	73.0	66.4	59.3	51.4	45.7	42.8	42.1

TABLE B-8
 Temperature Rise Above Ambient versus Y-Z Coordinates
 Time (yrs) 20.0

Z=ELEVATION (FEET) (ZERO AT TUNNEL CROWN)	Y=LATERAL DISTANCE FROM CENTERLINE OF TUNNEL (FEET)	1.450	1.700	Y=3.000	5.000	7.950	12.500	20.000	30.000	40.300	47.500
5.417		45.8	45.8	45.9	46.1	46.5	47.4	48.2	48.1	47.9	47.7
1.667		46.2	46.2	46.3	46.5	47.1	49.0	49.8	49.4	49.0	49.8
-1.667							51.3	51.3	50.6	50.0	49.8
-5.417							53.7	53.2	52.0	51.1	50.9
-9.583							56.8	55.4	53.6	52.3	52.0
-13.333							60.1	57.5	54.8	53.3	52.9
-16.667		73.3	73.1	72.6	71.7	69.5	63.8	59.2	55.9	54.0	53.6
-20.000		74.7	74.6	74.0	73.1	70.9	66.2	60.7	56.7	54.7	54.2
-23.333		77.8	77.5	76.9	75.8	72.9	68.0	61.9	57.4	55.2	54.6
-26.667		83.2	82.0	81.7	81.1	75.3	69.3	62.6	57.9	55.5	54.9
-30.000		84.5	83.2	82.4	82.3	76.1	69.7	62.9	58.1	55.6	55.1
-33.333		82.2	81.0	80.3	80.2	74.9	69.1	62.7	58.0	55.6	55.0

TABLE B-3
Temperature Rise Above Ambient versus Y-Z Coordinates
Time (hrs) = 30.0

Z=ELEVATION (FEET) (ZERO AT TUNNEL CEILING)*	.450	1.700	3.300	5.000	7.950	12.530	20.000	30.000	40.000	47.500
5.417	52.2	52.2	52.3	52.4	52.9	53.6	54.2	54.1	53.9	53.9
1.667	52.5	52.5	52.6	52.8	53.3	54.9	55.6	55.1	54.9	54.9
-1.667						56.8	56.9	56.3	55.9	55.7
-5.417						58.9	59.5	57.5	56.9	56.5
-9.543						61.4	60.9	58.9	57.9	57.4
-13.333						64.1	62.8	59.9	58.4	58.3
-16.667	74.8	74.7	74.2	73.5	71.7	67.2	61.5	60.7	59.1	58.9
-20.000	75.9	75.8	75.4	74.6	72.9	69.1	64.7	61.5	59.8	59.4
-23.333	78.4	78.2	77.7	76.8	74.5	70.6	65.6	62.0	60.2	59.9
-26.667	82.7	81.8	81.1	81.1	76.4	71.6	66.7	62.4	60.5	60.1
-30.000	83.7	82.7	82.1	82.0	77.0	72.8	66.5	62.6	60.6	60.2
-33.333	81.9	81.0	80.4	80.3	74.1	71.5	66.3	62.6	60.6	60.2

TABLE B-10
 Temperature Rise Above Ambient versus Y-Z Coordinates
 Time (yrs) = 40.0

Z=ELEVATION (FEET) (ZERO AT TUNNEL CEILING)	.450	1.700	3.300	5.000	7.950	12.500	20.000	30.000	40.000	47.500
5.417	54.9	54.9	55.0	55.1	55.4	56.0	56.6	56.5	56.3	56.3
1.667	55.2	55.2	55.3	55.4	55.3	57.2	57.7	57.5	57.2	57.1
-1.667						58.7	58.8	58.4	58.0	57.8
-5.417						60.4	60.1	59.3	58.8	58.6
-9.583						62.5	61.6	60.4	59.6	59.4
-13.333						64.7	63.0	61.3	60.3	60.0
-16.667	73.2	73.1	72.8	72.2	70.8	67.1	64.7	62.0	60.8	60.5
-20.000	74.1	74.0	73.7	73.1	71.7	68.7	65.2	62.6	61.3	60.9
-23.333	76.0	75.9	75.5	74.9	73.0	69.9	65.9	63.1	61.6	61.3
-26.667	79.5	78.7	78.2	78.2	74.5	70.7	66.4	63.4	61.8	61.5
-30.000	80.3	79.5	79.0	78.9	75.0	71.0	66.6	63.5	62.0	61.6
-33.333	78.8	78.1	77.6	77.6	74.3	70.5	66.5	63.5	62.0	61.6

TABLE B-11

Temperature Rise Above Ambient versus Y-Z Coordinates

Time (yrs) = 50.0

Z=ELEVATION (FEET) (ZERO AT TUNNEL CEILING)	.450	1.700	3.300	5.000	7.350	12.500	20.000	30.000	40.000	47.500
5.417	55.4	55.4	55.5	55.6	55.8	56.3	56.8	56.8	56.6	56.6
1.667	55.5	55.6	55.7	55.8	56.2	57.3	57.7	57.6	57.3	57.3
-1.667						58.5	58.6	58.4	58.0	57.9
-5.417						59.9	59.7	59.1	58.6	58.5
-9.583						61.6	60.9	60.9	59.3	59.2
-13.333						63.3	62.0	60.7	59.9	59.7
-16.667	70.1	70.1	69.4	69.3	68.2	65.3	63.0	61.7	60.3	60.1
-20.000	70.9	70.8	70.5	70.0	68.3	66.6	63.8	61.7	60.7	60.4
-23.333	72.4	72.2	72.0	71.4	70.0	67.5	64.4	62.1	61.0	60.7
-26.667	75.1	74.5	74.1	74.1	71.2	68.2	64.8	62.4	61.2	60.9
-30.000	75.7	75.1	74.7	74.6	71.6	68.4	64.9	62.5	61.3	61.0
-33.333	74.6	74.0	73.6	73.6	71.0	68.1	64.9	62.5	61.3	61.0

APPENDIX C
Temperatures From 3-D 'Close-in' Model
(Selected Times)

Note: Temperatures presented are increases above ambient (see Text discussion).

Correspondence Between Actual and Relative Node Numbers 3-D Close-in Thermal Model

RELATIVE NODE NUMBERS			ACTUAL NODE NUMBERS (SEE FIGURES 5 AND 6)									
1	THRU	10	1	2	3	4	5	6	7	8	9	10
11	THRU	20	11	12	13	14	15	16	17	18	19	20
21	THRU	30	21	22	23	24	25	26	27	28	29	30
31	THRU	40	31	32	33	34	35	36	37	38	39	40
41	THRU	50	41	42	43	44	45	46	47	48	49	50
51	THRU	60	51	52	53	54	55	56	57	58	59	60
61	THRU	70	61	62	63	64	65	66	67	68	69	70
71	THRU	80	71	72	73	74	75	76	77	78	79	80
81	THRU	90	81	82	83	84	85	86	87	88	89	90
91	THRU	100	91	92	93	94	95	96	97	98	99	100
101	THRU	110	101	102	103	104	105	106	107	108	109	110
111	THRU	120	111	112	113	114	115	116	117	118	119	120
121	THRU	130	121	122	123	124	125	126	127	128	129	130
131	THRU	140	131	132	133	134	135	136	137	138	139	140
141	THRU	150	141	142	143	144	145	146	147	148	149	150
151	THRU	160	151	152	153	154	155	156	157	158	159	160
161	THRU	170	161	162	163	164	165	166	167	168	169	170
171	THRU	180	171	172	173	174	175	176	177	178	179	180
181	THRU	190	181	182	183	184	185	186	187	188	189	190
191	THRU	200	191	192	193	194	195	196	197	198	199	200
201	THRU	210	201	202	203	204	205	206	207	208	209	210
211	THRU	220	211	212	213	214	215	216	217	218	219	220
221	THRU	230	221	222	223	224	225	226	227	228	229	230
231	THRU	240	231	232	233	234	235	236	237	238	239	240
241	THRU	250	241	242	243	244	245	246	247	248	249	250
251	THRU	260	251	252	253	254	255	256	257	258	259	260
261	THRU	270	261	262	263	264	265	266	267	268	269	270
271	THRU	280	271	272	273	274	275	276	277	278	279	280
281	THRU	290	281	282	283	284	285	286	287	288	289	290
291	THRU	300	291	292	293	294	295	296	297	298	299	300
301	THRU	310	301	302	303	304	305	306	307	308	309	310
311	THRU	320	311	312	313	314	315	316	317	318	319	320
321	THRU	330	321	322	323	324	325	326	327	328	329	330
331	THRU	340	331	332	333	334	335	336	337	338	339	340
341	THRU	350	341	342	343	344	345	346	347	348	349	350
351	THRU	360	351	352	353	354	355	356	357	358	359	360
361	THRU	370	361	362	363	364	365	366	367	368	369	370
371	THRU	380	371	372	373	374	375	376	377	378	379	380
381	THRU	390	381	382	383	384	385	386	387	388	389	390
391	THRU	400	391	392	393	394	395	396	397	398	399	400
401	THRU	410	401	402	403	404	405	406	407	408	409	410
411	THRU	420	411	412	413	414	415	416	417	418	419	420

3-D Close-in Thermal Model Results for DOE Waste

[illegible]

3-D Close-in Thermal Model Results for DOE Waste

		RELATIVE NODE NUMBERS										TEMPERATURES IN DEGREES CELSIUS										
TIME = .20000E+01 YEARS																						
1	TO	20	32.7	34.4	32.7	34.4	35.4	34.1	36.7	37.3	35.6	35.3	37.7	37.7	37.2	37.4	37.4	37.7	36.9	37.2	37.4	37.0
21	TO	40	34.2	34.3	34.0	34.3	33.1	34.2	34.5	34.8	34.4	34.7	34.9	34.1	34.3	34.4	34.5	34.4	34.2	34.5	34.5	
41	TO	60	34.5	34.6	34.5	34.4	34.5	34.7	34.7	34.7	34.7	34.7	34.9	34.5	34.7	34.4	34.4	34.5	34.0	34.4	34.2	
61	TO	80	34.2	34.7	34.9	34.7	34.9	40.0	34.9	34.8	34.8	34.9	40.0	42.3	40.7	40.2	42.5	40.8	41.2	41.7	41.4	
81	TO	100	41.3	41.1	41.4	41.4	41.4	41.4	41.4	41.4	41.4	41.4	41.4	41.4	41.4	41.4	41.4	41.4	41.4	41.4	41.4	
101	TO	120	42.5	42.5	42.4	41.0	42.7	42.4	42.1	42.4	42.2	42.6	41.7	42.5	42.4	43.5	43.5	43.7	44.2	44.5	44.3	
121	TO	140	44.4	44.9	45.1	45.3	45.8	46.7	45.0	45.9	45.4	45.3	45.4	45.4	45.4	45.4	45.4	45.4	45.4	45.4	45.4	
141	TO	160	45.9	47.0	47.5	47.8	48.5	49.3	47.9	47.7	48.9	49.4	49.5	47.5	47.9	49.1	49.5	49.8	49.5	49.4	49.4	
161	TO	180	49.8	50.1	51.6	50.3	53.5	51.3	51.7	51.5	51.3	51.3	51.7	51.3	51.3	51.4	51.4	51.4	51.4	51.4	51.4	
181	TO	200	42.4	44.2	42.3	44.0	43.4	51.7	55.4	57.4	54.4	53.3	58.2	54.2	55.0	44.8	41.4	41.2	38.9	31.5	44.2	
201	TO	220	62.3	61.7	62.1	64.2	57.5	47.5	52.3	54.2	52.8	53.5	59.2	53.5	61.9	61.1	61.1	61.2	58.9	61.3	61.3	
221	TO	240	54.7	64.9	64.3	64.7	64.7	39.6	42.7	34.5	42.0	44.8	45.2	45.1	45.6	45.9	46.5	47.2	47.0	45.8	47.3	
241	TO	260	47.1	64.6	47.2	46.3	44.5	48.7	48.5	44.5	44.3	44.3	44.7	45.0	45.5	45.2	43.4	40.8	53.1	55.4	55.8	
261	TO	280	51.5	50.1	50.8	50.7	53.5	51.0	51.3	52.8	52.8	51.5	51.5	51.5	51.5	51.5	51.5	51.5	51.5	51.5	51.5	
281	TO	300	34.9	34.8	34.8	40.3	44.7	34.8	34.5	34.8	40.5	42.4	40.8	42.7	42.4	42.7	42.7	42.7	41.1	41.5	41.7	
301	TO	320	41.5	41.4	42.0	42.1	42.1	42.1	41.9	42.2	42.2	42.2	42.2	42.2	42.2	42.2	42.2	42.2	42.2	42.2	42.2	
321	TO	340	31.2	31.5	31.6	31.4	31.1	31.4	31.4	31.4	31.4	31.4	31.4	31.4	31.4	31.4	31.4	31.4	31.4	31.4	31.4	
341	TO	360	32.4	32.5	32.7	32.5	32.6	32.8	32.9	32.9	32.9	32.9	32.9	32.9	32.9	32.9	32.9	32.9	32.9	32.9	32.9	
361	TO	380	27.9	27.7	32.9	34.4	34.9	34.1	31.9	27.5	32.7	32.7	32.7	32.7	32.7	32.7	32.7	32.7	32.7	32.7	32.7	
381	TO	400	10.7	10.7	10.7	13.7	12.7	12.7	10.7	10.7	10.7	10.7	10.7	10.7	10.7	10.7	10.7	10.7	10.7	10.7	10.7	
401	TO	420	10.7	10.7	10.7	10.7	10.7	10.7	10.7	10.7	10.7	10.7	10.7	10.7	10.7	10.7	10.7	10.7	10.7	10.7	10.7	
TIME = .30000E+01 YEARS																						
1	TO	20	37.9	34.6	37.9	34.6	43.6	41.3	41.9	42.7	41.8	41.7	42.5	42.4	42.4	42.9	42.6	42.4	42.4	43.1	43.2	
21	TO	40	42.4	41.3	41.2	41.7	41.3	41.4	41.7	44.1	43.6	41.3	44.2	44.4	44.4	44.4	44.4	44.4	44.4	44.4	44.4	
41	TO	60	44.4	44.8	44.7	44.7	44.7	44.7	44.7	44.7	44.7	44.7	44.7	44.7	44.7	44.7	44.7	44.7	44.7	44.7	44.7	
61	TO	80	44.2	44.9	44.2	44.3	45.1	45.2	45.1	45.2	45.2	45.1	45.2	45.1	45.2	45.1	45.2	45.1	45.2	45.1	45.2	
81	TO	100	46.5	46.3	46.8	46.5	46.6	46.7	46.5	46.7	46.6	46.5	46.7	46.6	46.5	46.7	46.6	46.5	46.7	46.6	46.5	
101	TO	120	47.7	47.7	47.6	48.2	47.3	47.7	47.1	47.8	47.6	47.7	47.8	47.7	47.8	47.7	47.8	47.7	47.8	47.7	47.8	
121	TO	140	49.9	50.1	50.1	50.5	51.5	50.9	50.7	51.6	51.6	51.6	51.6	51.6	51.6	51.6	51.6	51.6	51.6	51.6	51.6	
141	TO	160	51.1	51.1	51.6	51.3	52.5	51.1	51.2	51.9	51.9	51.9	51.9	51.9	51.9	51.9	51.9	51.9	51.9	51.9	51.9	
161	TO	180	54.3	54.2	55.8	51.1	55.6	54.0	56.7	57.0	57.1	57.0	57.0	57.0	57.0	57.0	57.0	57.0	57.0	57.0	57.0	
181	TO	200	47.6	51.3	47.5	51.5	56.9	54.8	51.6	52.8	52.8	52.8	52.8	52.8	52.8	52.8	52.8	52.8	52.8	52.8	52.8	
201	TO	220	44.3	46.7	46.0	43.1	42.3	45.4	46.7	47.0	46.4	46.5	46.9	46.4	46.5	46.4	46.5	46.4	46.5	46.4	46.5	
221	TO	240	71.5	72.8	71.7	69.5	69.7	44.9	47.2	44.8	47.2	44.3	47.3	47.2	47.2	47.2	47.2	47.2	47.1	47.1	47.1	
241	TO	260	52.9	51.7	52.1	53.4	51.4	51.8	53.5	51.4	51.4	51.4	51.4	51.4	51.4	51.4	51.4	51.4	51.4	51.4	51.4	
261	TO	280	58.6	55.2	55.9	55.9	55.7	55.1	56.1	55.3	55.9	55.3	55.7	55.7	55.7	55.7	55.7	55.7	55.7	55.7	55.7	
281	TO	300	45.3	45.0	45.0	45.9	45.2	45.0	44.7	44.3	44.6	44.6	44.6	44.6	44.6	44.6	44.6	44.6	44.6	44.6	44.6	
301	TO	320	46.7	46.9	47.1	47.2	47.1	47.7	47.7	47.3	47.3	47.3	47.3	47.3	47.3	47.3	47.3	47.3	47.3	47.3	47.3	
321	TO	340	36.3	34.6	34.8	34.6	35.2	34.5	34.9	35.3	34.2	34.2	34.3	34.3	34.3	34.3	34.3	34.3	34.3	34.3	34.3	
341	TO	360	37.5	37.6	37.9	37.4	37.8	37.9	38.2	38.1	38.2	38.1	38.2	38.1	38.2	38.1	38.2	38.1	38.2	38.1	38.2	
361	TO	380	31.3	31.8	31.1	33.7	41.2	34.3	37.1	32.7	34.4	34.5	34.5	34.5	34.5	34.5	34.5	34.5	34.5	34.5	34.5	
381	TO	400	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	
401	TO	420	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	
421	TO	440	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	

3-D Close-in Thermal Model Results for DOE Waste

RELATIVE NODE NUMBERS

TEMPERATURES IN DEGREES CELSIUS

TIME= .40000E+01 YEARS

[illegible]

TIME= .50000E+01 YEARS

1	T0	T0	45.7	47.4	45.7	47.4	45.1	49.2	40.7	50.3	43.6	49.0	52.3	52.1	52.7	55.7	50.4	50.2	50.0	53.2	45.9	41.0
2	T0	T0	51.2	51.1	51.0	51.1	51.1	51.2	51.5	51.3	51.4	51.7	52.3	52.7	52.7	57.5	57.5	57.5	57.5	52.2	52.5	52.5
4	T0	T0	52.6	52.5	52.5	52.5	52.5	47.7	49.2	47.7	43.7	52.3	52.3	52.3	51.6	51.2	50.8	52.0	52.0	52.3	52.7	52.2
6	T0	T0	52.0	51.7	52.0	52.2	52.3	51.0	52.9	45.8	51.8	52.3	52.2	52.1	51.7	51.2	51.5	51.8	52.0	52.3	52.3	50.3
8	T0	T0	54.3	54.1	54.4	54.4	54.4	54.4	54.4	54.2	54.4	54.3	54.1	52.4	52.1	53.3	54.1	54.7	54.0	54.6	54.6	54.6
10	T0	T0	55.4	55.4	55.3	55.3	55.6	55.4	55.0	55.3	56.1	55.4	55.6	56.4	56.3	56.4	56.4	56.6	56.6	57.4	54.1	57.1
12	T0	T0	57.5	57.4	58.0	58.1	58.2	58.1	57.8	58.7	58.7	58.7	58.7	58.7	58.7	58.7	58.2	57.3	55.6	53.3	55.6	57.4
14	T0	T0	58.7	58.7	51.2	50.5	58.1	62.7	60.6	62.4	61.6	61.1	63.7	62.7	62.6	61.2	62.1	62.4	62.2	62.0	61.3	60.6
16	T0	T0	52.4	52.7	51.2	52.5	61.2	63.5	61.8	61.1	62.4	62.3	63.2	63.2	64.5	64.5	64.4	64.4	64.7	54.6	64.6	64.6
18	T0	T0	55.3	54.9	55.3	58.3	62.4	67.4	68.9	69.6	65.7	63.4	72.4	68.5	67.4	76.4	75.3	73.3	71.0	71.6	76.4	75.2
20	T0	T0	74.3	73.8	77.2	72.4	89.5	72.6	71.7	70.4	73.2	71.7	71.4	71.4	71.4	71.1	75.1	73.1	71.1	75.1	73.4	72.5
22	T0	T0	24.0	24.7	75.2	75.6	74.7	52.6	54.0	52.5	56.9	56.4	57.4	58.8	58.1	58.6	57.4	59.8	59.7	59.5	60.6	60.6
24	T0	T0	59.5	59.3	59.7	60.3	52.1	61.3	61.2	61.0	61.0	61.3	61.4	61.7	62.7	61.6	62.0	62.4	62.7	63.0	63.3	63.4
26	T0	T0	63.7	62.7	63.7	63.3	51.5	61.6	61.6	63.5	63.4	63.5	63.7	63.1	64.7	64.7	64.0	61.7	62.2	62.5	62.2	61.6
28	T0	T0	52.8	52.9	51.7	51.7	51.0	51.7	52.7	53.1	53.4	53.5	53.7	53.4	51.6	51.5	51.5	51.6	51.4	51.3	51.3	51.3
30	T0	T0	59.5	59.3	59.7	60.3	52.1	61.3	61.2	61.0	61.0	61.3	61.4	61.7	62.7	61.6	62.0	62.4	62.7	63.0	63.3	63.4
32	T0	T0	54.4	54.5	54.3	54.3	52.0	56.0	55.7	55.0	55.0	55.3	55.2	55.2	55.2	55.2	55.0	55.0	55.0	55.0	55.0	55.0
34	T0	T0	44.2	46.4	45.4	44.6	44.5	44.1	44.4	44.4	44.4	44.3	44.3	44.3	44.3	44.3	44.3	44.3	44.3	44.2	44.2	44.2
36	T0	T0	45.3	45.5	45.7	45.4	45.4	45.4	45.7	45.8	45.3	45.0	45.3	45.2	45.6	45.6	45.0	45.0	45.0	45.0	45.0	45.0
38	T0	T0	40.7	43.7	44.0	47.6	44.1	47.7	44.1	44.3	43.3	43.3	43.3	43.3	43.3	43.3	43.3	43.3	43.3	43.1	43.1	43.1
40	T0																					

3-D Close-in Thermal Model Results for DOE Waste

RELATIVE NODE NUMBERS

TEMPERATURES IN DEGREES CELSIUS

TIME = .75000E+01 YEARS

1	TO	20	52.7	54.3	52.7	64.3	55.4	54.1	56.4	55.9	55.5	55.9	57.1	57.1	57.1	57.5	57.5	57.1	56.8	57.1	57.7	57.9
21	TO	40	58.1	57.0	57.4	57.3	59.2	57.1	58.3	58.7	58.2	58.5	59.8	59.2	59.7	59.3	59.2	59.1	59.1	59.1	59.1	59.3
41	TO	60	59.4	59.4	59.3	59.3	59.3	59.7	59.1	59.7	59.2	59.5	59.5	59.8	59.8	59.8	59.8	59.8	59.8	59.8	59.8	59.8
61	TO	80	59.8	59.8	59.8	59.8	59.8	59.8	59.8	59.8	59.8	59.8	59.8	59.8	59.8	59.8	59.8	59.8	59.8	59.8	59.8	59.8
81	TO	100	61.1	61.1	61.1	61.1	61.1	61.1	61.1	61.1	61.1	61.1	61.1	61.1	61.1	61.1	61.1	61.1	61.1	61.1	61.1	61.1
101	TO	120	62.1	62.1	62.1	62.1	62.1	62.1	62.1	62.1	62.1	62.1	62.1	62.1	62.1	62.1	62.1	62.1	62.1	62.1	62.1	62.1
121	TO	140	64.1	64.1	64.1	64.1	64.1	64.1	64.1	64.1	64.1	64.1	64.1	64.1	64.1	64.1	64.1	64.1	64.1	64.1	64.1	64.1
141	TO	160	65.2	65.2	65.2	65.2	65.2	65.2	65.2	65.2	65.2	65.2	65.2	65.2	65.2	65.2	65.2	65.2	65.2	65.2	65.2	65.2
161	TO	180	67.8	67.8	67.8	67.8	67.8	67.8	67.8	67.8	67.8	67.8	67.8	67.8	67.8	67.8	67.8	67.8	67.8	67.8	67.8	67.8
181	TO	200	69.0	69.0	69.0	69.0	69.0	69.0	69.0	69.0	69.0	69.0	69.0	69.0	69.0	69.0	69.0	69.0	69.0	69.0	69.0	69.0
201	TO	220	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0
221	TO	240	71.0	71.0	71.0	71.0	71.0	71.0	71.0	71.0	71.0	71.0	71.0	71.0	71.0	71.0	71.0	71.0	71.0	71.0	71.0	71.0
241	TO	260	72.1	72.1	72.1	72.1	72.1	72.1	72.1	72.1	72.1	72.1	72.1	72.1	72.1	72.1	72.1	72.1	72.1	72.1	72.1	72.1
261	TO	280	73.1	73.1	73.1	73.1	73.1	73.1	73.1	73.1	73.1	73.1	73.1	73.1	73.1	73.1	73.1	73.1	73.1	73.1	73.1	73.1
281	TO	300	74.1	74.1	74.1	74.1	74.1	74.1	74.1	74.1	74.1	74.1	74.1	74.1	74.1	74.1	74.1	74.1	74.1	74.1	74.1	74.1
301	TO	320	75.1	75.1	75.1	75.1	75.1	75.1	75.1	75.1	75.1	75.1	75.1	75.1	75.1	75.1	75.1	75.1	75.1	75.1	75.1	75.1
321	TO	340	76.1	76.1	76.1	76.1	76.1	76.1	76.1	76.1	76.1	76.1	76.1	76.1	76.1	76.1	76.1	76.1	76.1	76.1	76.1	76.1
341	TO	360	77.1	77.1	77.1	77.1	77.1	77.1	77.1	77.1	77.1	77.1	77.1	77.1	77.1	77.1	77.1	77.1	77.1	77.1	77.1	77.1
361	TO	380	78.1	78.1	78.1	78.1	78.1	78.1	78.1	78.1	78.1	78.1	78.1	78.1	78.1	78.1	78.1	78.1	78.1	78.1	78.1	78.1
381	TO	400	79.1	79.1	79.1	79.1	79.1	79.1	79.1	79.1	79.1	79.1	79.1	79.1	79.1	79.1	79.1	79.1	79.1	79.1	79.1	79.1
401	TO	418	80.1	80.1	80.1	80.1	80.1	80.1	80.1	80.1	80.1	80.1	80.1	80.1	80.1	80.1	80.1	80.1	80.1	80.1	80.1	80.1

TIME = .10000E+02 YEARS

1	TO	20	57.7	59.3	57.7	59.3	60.9	60.9	61.5	61.7	61.4	61.4	61.9	61.9	61.9	62.3	62.1	61.9	61.7	61.7	61.7	61.7
21	TO	40	62.9	62.7	62.7	62.7	62.9	62.9	63.1	63.9	63.0	63.1	63.5	63.4	63.7	64.2	64.1	64.2	63.9	64.1	64.1	64.1
41	TO	60	64.1	64.1	64.1	64.1	64.1	64.1	64.1	64.1	64.1	64.1	64.1	64.1	64.1	64.1	64.1	64.1	64.1	64.1	64.1	
61	TO	80	65.1	65.1	65.1	65.1	65.1	65.1	65.1	65.1	65.1	65.1	65.1	65.1	65.1	65.1	65.1	65.1	65.1	65.1	65.1	
81	TO	100	65.8	65.8	65.8	65.8	65.8	65.8	65.8	65.8	65.8	65.8	65.8	65.8	65.8	65.8	65.8	65.8	65.8	65.8	65.8	
101	TO	120	66.7	66.7	66.7	66.7	66.7	66.7	66.7	66.7	66.7	66.7	66.7	66.7	66.7	66.7	66.7	66.7	66.7	66.7	66.7	
121	TO	140	67.7	67.7	67.7	67.7	67.7	67.7	67.7	67.7	67.7	67.7	67.7	67.7	67.7	67.7	67.7	67.7	67.7	67.7	67.7	
141	TO	160	69.7	69.7	69.7	69.7	69.7	69.7	69.7	69.7	69.7	69.7	69.7	69.7	69.7	69.7	69.7	69.7	69.7	69.7	69.7	
161	TO	180	71.7	71.7	71.7	71.7	71.7	71.7	71.7	71.7	71.7	71.7	71.7	71.7	71.7	71.7	71.7	71.7	71.7	71.7	71.7	
181	TO	200	73.7	73.7	73.7	73.7	73.7	73.7	73.7	73.7	73.7	73.7	73.7	73.7	73.7	73.7	73.7	73.7	73.7	73.7	73.7	
201	TO	220	75.7	75.7	75.7	75.7	75.7	75.7	75.7	75.7	75.7	75.7	75.7	75.7	75.7	75.7	75.7	75.7	75.7	75.7	75.7	
221	TO	240	77.7	77.7	77.7	77.7	77.7	77.7	77.7	77.7	77.7	77.7	77.7	77.7	77.7	77.7	77.7	77.7	77.7	77.7	77.7	
241	TO	260	79.7	79.7	79.7	79.7	79.7	79.7	79.7	79.7	79.7	79.7	79.7	79.7	79.7	79.7	79.7	79.7	79.7	79.7	79.7	
261	TO	280	81.7	81.7	81.7	81.7	81.7	81.7	81.7	81.7	81.7	81.7	81.7	81.7	81.7	81.7	81.7	81.7	81.7	81.7	81.7	
281	TO	300	83.7	83.7	83.7	83.7	83.7	83.7	83.7	83.7	83.7	83.7	83.7	83.7	83.7	83.7	83.7	83.7	83.7	83.7	83.7	
301	TO	320	85.7	85.7	85.7	85.7	85.7	85.7	85.7	85.7	85.7	85.7	85.7	85.7	85.7	85.7	85.7	85.7	85.7	85.7	85.7	
321	TO	340	87.7	87.7	87.7	87.7	87.7	87.7	87.7	87.7	87.7	87.7	87.7	87.7	87.7	87.7	87.7	87.7	87.7	87.7	87.7	
341	TO	360	89.7	89.7	89.7	89.7	89.7	89.7	89.7	89.7	89.7	89.7	89.7	89.7	89.7	89.7	89.7	89.7	89.7	89.7	89.7	
361	TO	380	91.7	91.7	91.7	91.7	91.7	91.7	91.7	91.7	91.7	91.7	91.7	91.7	91.7	91.7	91.7	91.7	91.7	91.7	91.7	
381	TO	400	93.7	93.7	93.7	93.7	93.7	93.7	93.7	93.7	93.7	93.7	93.7	93.7	93.7	93.7	93.7	93.7	93.7	93.7	93.7	
401	TO	418	95.7	95.7	95.7	95.7	95.7	95.7	95.7	95.7	95.7	95.7	95.7	95.7	95.7	95.7	95.7	95.7	95.7	95.7	95.7	

3-D Close-in Thermal Model Results for DOL Waste

		RELATIVE NODE NUMBERS										TEMPERATURES IN DEGREES CELSIUS										
TIME= .16147E+02 YEARS																						
1	T0	70	69.1	69.6	69.1	69.6	69.5	69.1	69.6	69.7	69.5	69.3	69.3	69.0	69.0	69.0	69.1	69.0	69.7	69.9	69.5	69.5
21	T0	90	69.8	69.7	69.6	69.6	69.7	69.9	70.0	70.3	69.9	70.2	70.4	70.6	70.7	70.9	70.9	70.9	70.6	70.9	70.9	70.9
41	T0	50	70.9	70.9	70.9	70.9	70.9	69.9	69.1	69.3	69.1	69.3	69.5	70.0	70.2	69.9	69.9	70.4	70.4	70.4	70.5	70.5
61	T0	40	70.4	70.2	70.4	71.0	71.1	71.2	71.1	71.1	71.1	71.2	71.3	71.5	71.9	71.4	71.6	71.3	72.1	72.2	72.3	72.3
81	T0	100	72.3	72.1	72.4	72.4	72.4	72.4	72.4	72.4	72.3	72.4	72.5	72.5	72.5	72.5	72.5	72.5	72.5	72.6	72.6	72.6
101	T0	120	73.2	73.2	73.1	73.5	73.3	73.2	73.9	73.1	73.5	74.3	74.1	74.0	73.9	74.0	74.0	74.2	74.4	74.8	74.3	74.6
121	T0	140	74.3	74.1	75.3	75.4	75.5	75.4	75.7	75.5	75.5	75.5	75.5	75.5	75.5	75.5	75.5	75.5	75.4	75.5	73.4	74.8
141	T0	160	75.9	76.7	77.1	76.5	75.5	77.6	77.4	77.3	79.2	77.9	77.5	77.1	77.4	79.4	79.6	79.9	79.7	79.5	79.5	79.5
161	T0	180	73.9	79.1	73.5	79.1	73.4	73.7	81.0	81.3	80.5	80.5	80.6	80.3	80.6	80.5	80.5	80.7	80.7	80.4	80.4	80.4
181	T0	200	73.1	75.0	73.1	75.3	74.9	81.3	80.0	80.6	80.4	79.7	80.1	80.9	80.9	80.9	80.9	80.9	80.9	80.9	80.9	80.9
201	T0	220	89.3	89.1	86.4	85.3	84.5	89.1	86.0	86.4	86.4	86.4	86.1	86.5	87.6	89.0	89.2	89.5	89.3	89.3	87.9	87.3
221	T0	240	93.5	92.9	91.6	91.4	91.4	91.9	91.8	91.3	91.4	91.9	91.9	91.9	91.9	91.9	91.9	91.9	91.9	91.9	91.9	91.9
241	T0	260	76.4	76.4	76.7	76.7	77.9	77.9	77.9	77.9	77.7	77.7	77.7	77.7	77.7	77.7	77.7	77.7	77.7	77.7	77.7	77.7
261	T0	280	79.5	79.2	79.7	79.7	79.9	79.9	79.9	79.9	79.7	79.7	79.7	79.7	79.7	79.7	79.7	79.7	79.7	79.7	79.7	79.7
281	T0	300	71.1	71.0	71.0	71.4	71.2	71.2	71.9	71.2	71.4	71.7	71.7	71.7	71.7	71.7	71.7	71.7	71.7	71.7	71.7	71.7
301	T0	320	70.4	70.4	70.3	70.3	70.3	70.3	70.3	70.3	70.3	70.3	70.3	70.3	70.3	70.3	70.3	70.3	70.3	70.3	70.3	70.3
321	T0	340	63.9	64.1	64.2	64.3	63.8	64.3	64.3	64.3	64.3	64.3	64.3	64.3	64.3	64.3	64.3	64.3	64.3	64.3	64.3	64.3
341	T0	360	64.7	64.8	65.0	64.9	64.9	65.0	65.1	65.1	65.2	65.3	65.2	65.2	65.2	65.2	65.2	65.2	65.2	65.2	65.2	65.2
361	T0	380	65.9	65.5	65.5	65.9	67.3	66.6	66.8	67.0	67.2	67.2	67.2	67.2	67.2	67.2	67.2	67.2	67.2	67.2	67.2	67.2
381	T0	400	65.2	65.2	65.7	65.2	65.2	65.9	65.9	65.9	65.9	65.9	65.9	65.9	65.9	65.9	65.9	65.9	65.9	65.9	65.9	65.9
401	T0	420	65.2	65.2	65.2	65.2	65.2	65.2	65.2	65.2	65.2	65.2	65.2	65.2	65.2	65.2	65.2	65.2	65.2	65.2	65.2	65.2

APPENDIX D
Temperatures at Mid-Canister Depth
(Selected Times)

This Appendix gives a graphical presentation of node temperatures (rise above ambient) at mid-canister depth (z = -30 feet). Node numbers are not shown.

Figure D-1. Temperature Rise Above Ambient (Deg. C) at $z = -30$ Feet

Figure D-2. Temperature Rise Above Ambient (Deg. C) at $z = -30$ Feet

Figure D-3. Temperature Rise Above Ambient (Deg. C) at $z = -30$ Feet

Figure D-4. Temperature Rise Above Ambient (Deg. C) at $z = -30$ Feet

Figure D-5. Temperature Rise Above Ambient (Deg. C) at $z = -30$ Feet

Figure D-6. Temperature Rise Above Ambient (Deg. C) at $z = -30$ Feet

Figure D-7. Temperature Rise Above Ambient (Deg. C) at -30 Feet