Waste Isolation Pilot Plant

Compliance Certification Application

Reference 625

Thorne, B.J., and D.K. Rudeen, 1980.
Regional Effects of TRU Repository Heat, SAND80-7161, Albuquerque, NM, Sandia National Laboratories.

THORNE,M BILLY JOE
RUDEEN, D.K.
1980
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REGIONAL EFFECTS OF TRU REPOSITORY HEAT

LONG-TERM REGULATORY COMPLIANCE

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INTRODUCTION

A modification of a calculation reported in Reference 1 was used to estimate the impact of heat from a 730,000 m^2 (180 acre) 0.69 W/m^2 (2.8 kW/acre) RH TRU repository at the WIPP site. The original calculation, reported in SAI-FR-145, was designed to estimate the effect of a 81,000 m^2 (20 acre) 7.4 W/m^2 (30 kW/acre) spent fuel repository. This calculation is on much too coarse a scale to accurately predict details of the response. However, estimates obtained by this method are accurate enough to determine whether or not heat effects are large enough to justify more finely zoned calculations.

COMPUTATIONAL SETUP

All materials models, boundary conditions, initial conditions and computing techniques were identical to those described in Reference 1. The initial temperature distribution (Figure 1a) is a piece-wise linear solution to the equilibrium equations completely determined by the surface and bottom boundary temperature. Only five significant figures of the equilibrium solution were used for initial temperatures. For the calculation in Reference 1, this was adequate. However, the heat source in this calculation is so weak that initial temperatures should have been set accurate to at least 12 significant figures. The damping was changed to $w_o = 5 \times 10^{11}$ and the initial time step

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[1] D.E. Maxwell, K.K. Wahi, B. Dial, The Thermomechanical Response of WIPP Repositories, Science Applications, Inc., SAI-FR-145, Sandia National Laboratories, SAND 79-7111, May 1980.

was reduced to 1 x 10^6 s (11.6 days) in order to restrict any numerical oscillations to early time.

The major change required was a modification of the size of the first three zones in from the center line to give a disk area of 730,000 m^2 (180 acres) to approximate the repository size. This resulted in using zones with a 160-m radial dimension (Figure 1b). With the 151-m vertical dimension of the zone at the 637 m (2100 feet) depth of the repository this gives a volume of 12 million m^3 (430 million cubic feet) for the center repository zone. Thus heat in the center repository zone is spread out over 26 x 10^9 kg (290 million tons) of salt. This averaging effect causes the peak calculated temperature to be much lower than would be expected in a drift of the repository.

The heat source used was taken from a Sandia-Labs-provided list of the thermal power produced by various actinides and fission products expected to be in RH TRU wastes. The first 200 years of the normalized decay curve is given in Figure 2. In order to show more detail, Figure 3 gives a log-log plot of this curve to 10,000 years assuming a start date of 10 years (since 0 cannot be used as a reference on log paper). Emplacement density is assumed to yield a 0.69 W/m^2 (2.8 kW/acre) initial power density.

COMPUTATIONAL RESULTS

The peak temperature rise of 1.6°C occurs in the central repository zone at 80 years (Figure 4). With such a small temperature increase in the hottest source zone it is clear that the total impact of heat will be small. This is confirmed by the 0.25°C peak temperature rise at the top of both the Salado and the Rustler Formations (Figures 5 & 6).

In the surface zone the temperature rise is so small (0.03°C) that a 0.006°C temperature drop is significant in Figure 7. This small change in temperature is the result of the grid moving into temperature equilibrium from initial conditions that were in equilibrium to 5 significant digits. This initial temperature drop resulted in a small downward motion of the grid which must be taken into account when estimating uplift.

The top of the central repository zone reaches its peak uplift of 10.4 mm at 200 years (Figure 8). At 1000 years Figure 8 indicates an uplift of 4.3 mm. However, Figure 9 indicates that far outside zones of the grid have moved down 2.1 mm because of the temperature drop resulting from inaccuracies in the equilibrium temperature. Thus the effective uplift at 1000 years is 6.4 mm. By 1500 years (Figure 10) the effective uplift has dropped to 5.4 mm of which more than half is masked by the downward motion resulting from the grid coming into equilibrium more accurately.

Figures 11 thru 16 give uplift profiles at 1000 and 1500 years for the top of the Salado (Figures 11 & 12), the top of the Rustler (Figures 13 & 14) and the surface (Figures 15 & 16). In all cases uplift is much smaller than for the 730,000 m^2 (20 acre) 7.4 W/m^2 (30 kW/acre) spent fuel repository modeled in Reference 1 (Figure 17). Even though the initial energy-deposition rate in the TRU repository is 84 percent of the energy-deposition rate in the spent fuel repository, the TRU-waste heat output falls off much more rapidly, dropping to less than half the spent fuel energy-deposition rate in 100 years. Thus, the total energy deposited by the TRU waste is very small, resulting in negligible temperature change and uplift.

CONCLUSION

The calculated temperature increase and uplift are so small that further study of the regional effects of RH TRU-repository heat is not justified.

FOREWORD

The calculations presented here were performed for Sandia National Laboratories in 1979 and are consistent with the evaluation of options for the Waste Isolation Pilot Plant (WIPP) at that time.

The information here was presented in draft form in CSI 2053-05, by Civil Systems, Incorporated.

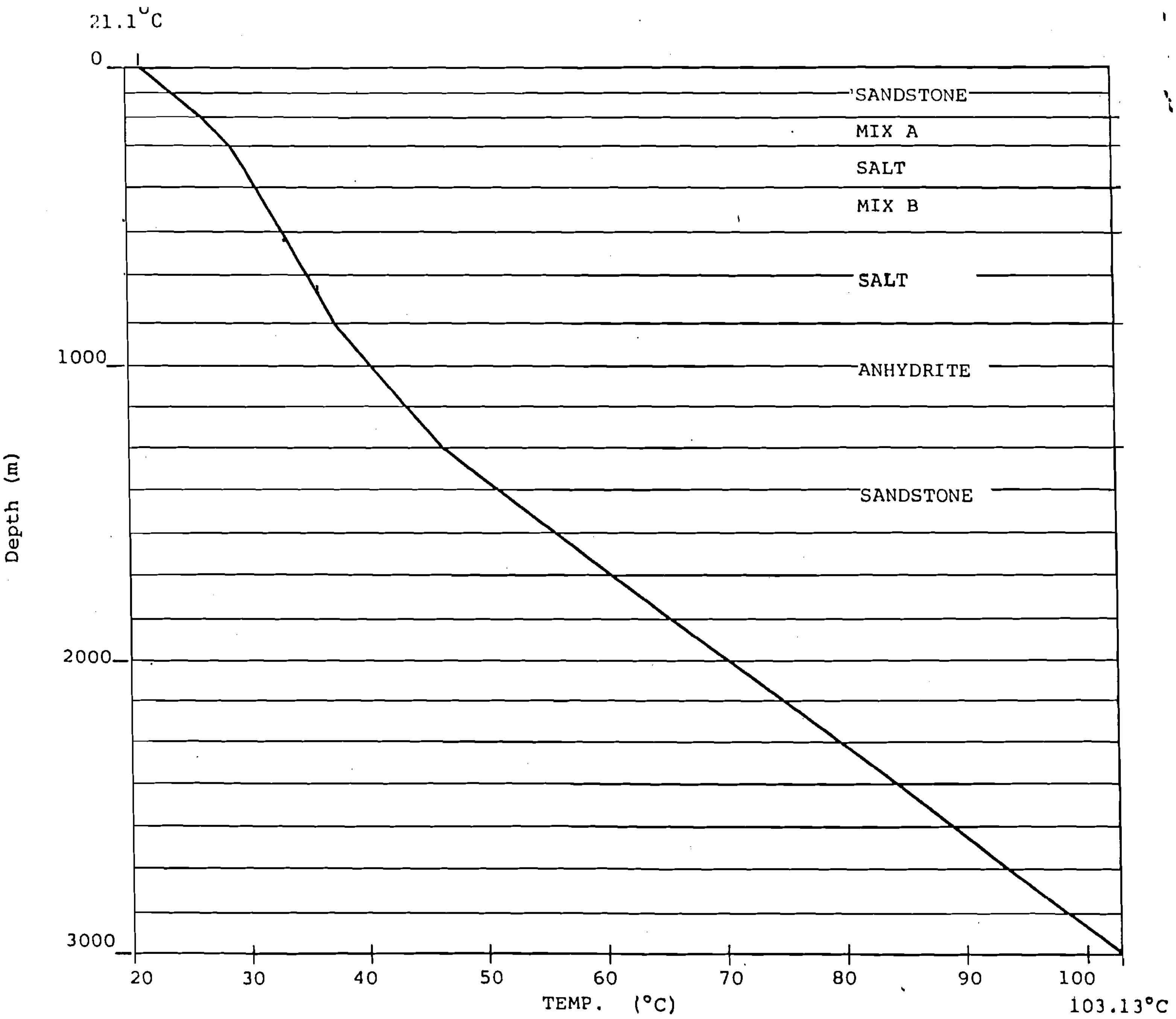

Figure 1a: Initial Equilibrium Temperature Versus Depth

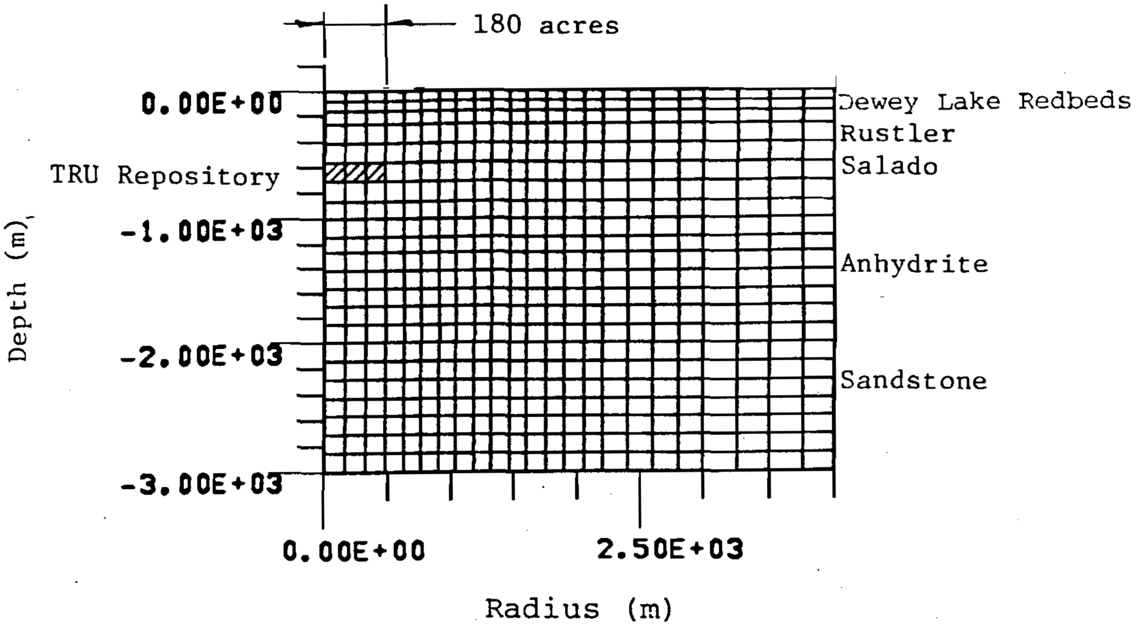

Figure 1b: Computational Grid Showing Repository Location and Layering.

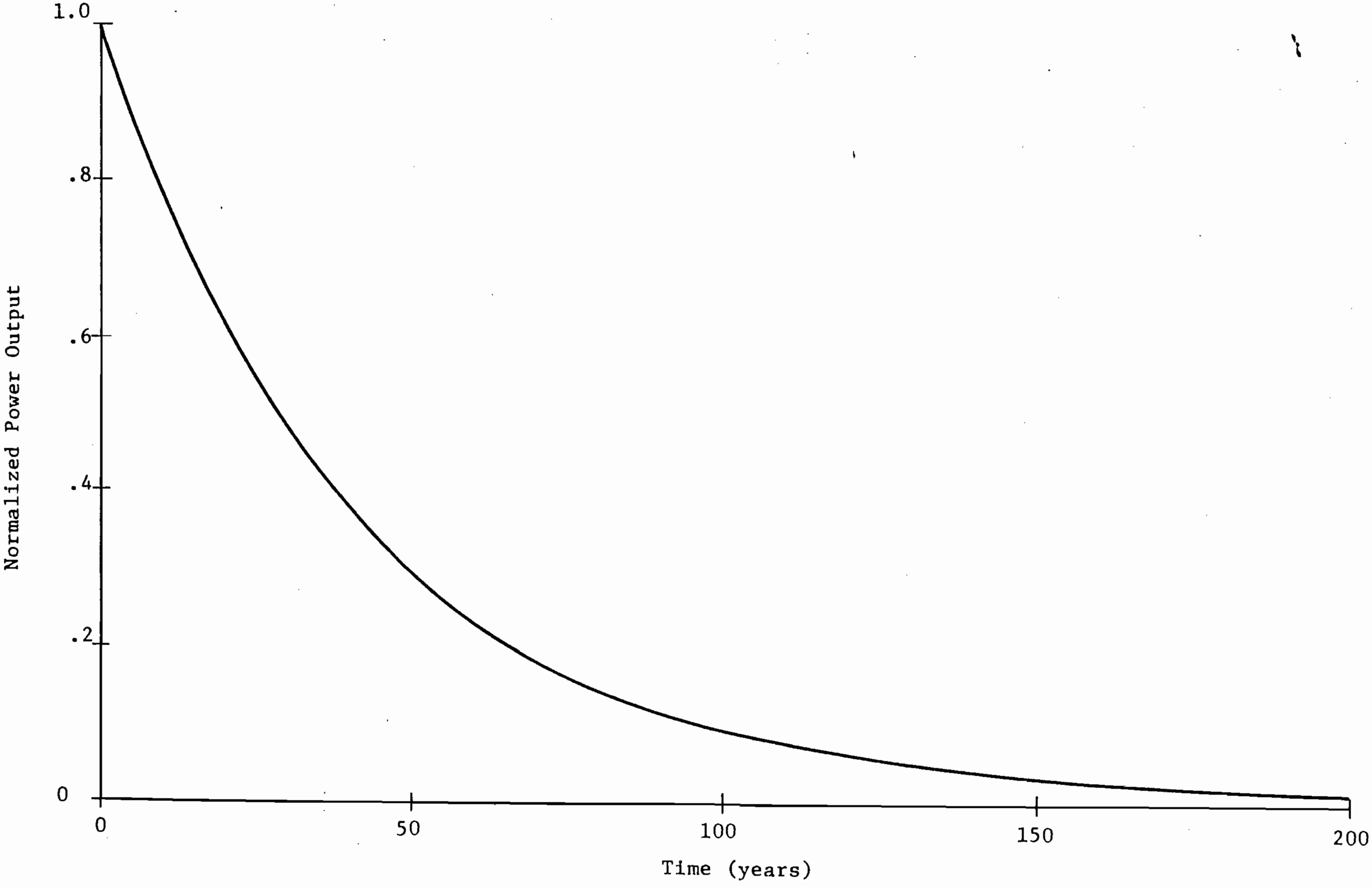

Figure 2. RH TRU Normalized Reference Waste Power Output

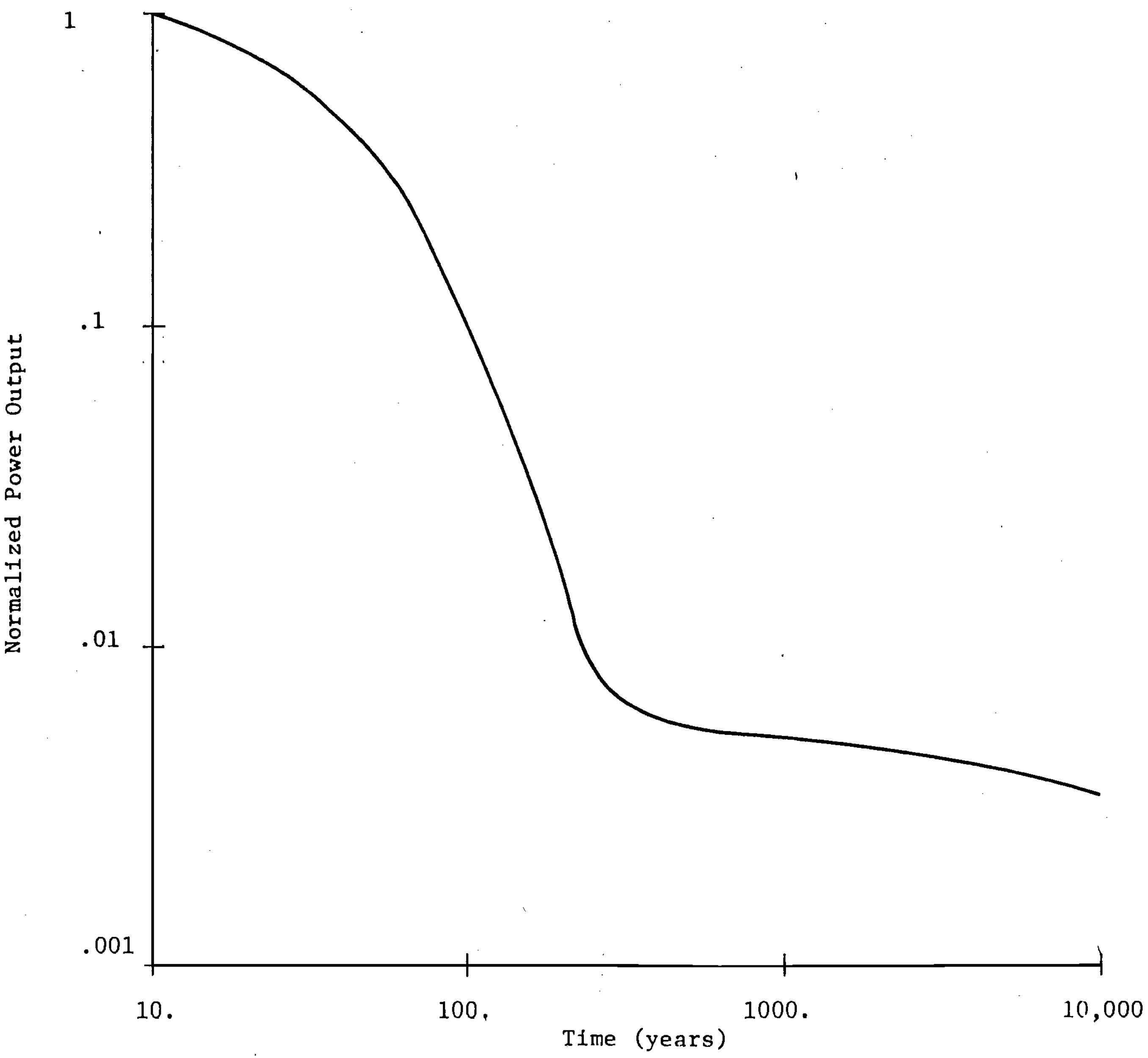

Figure 3. RH TRU Normalized Reference Waste Power Output

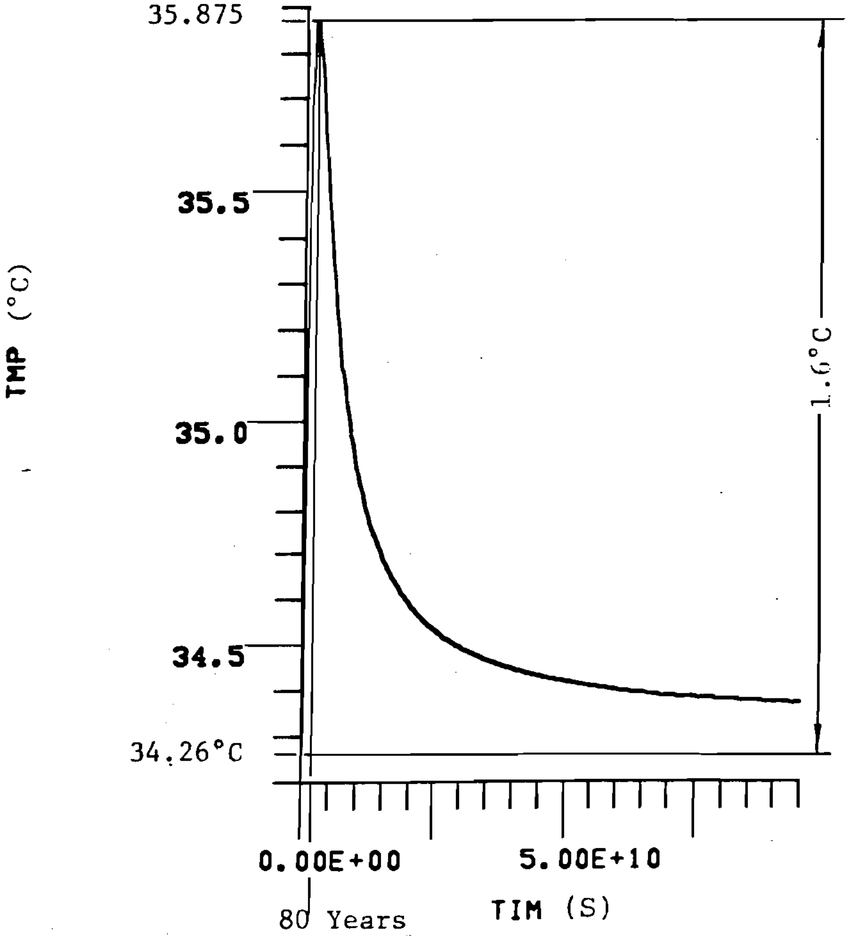

Figure 4: Temperature in Central Zone of the Repository

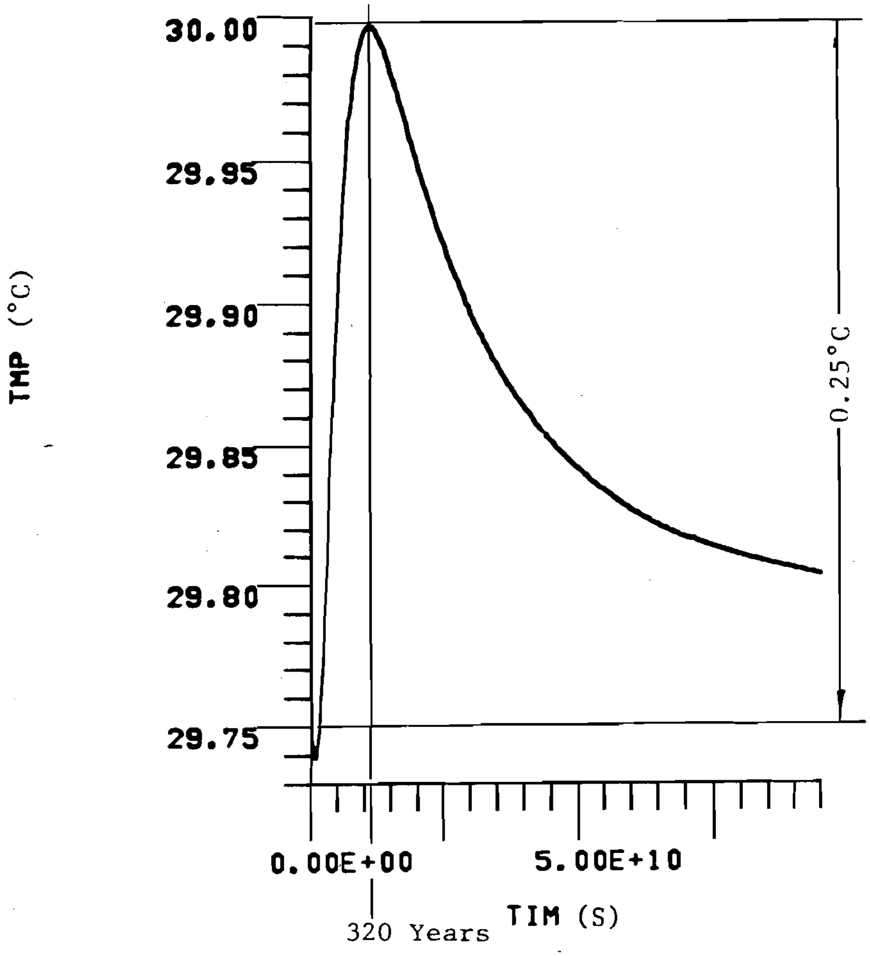

Figure 5: Temperature in Central Zone at Top of Salado

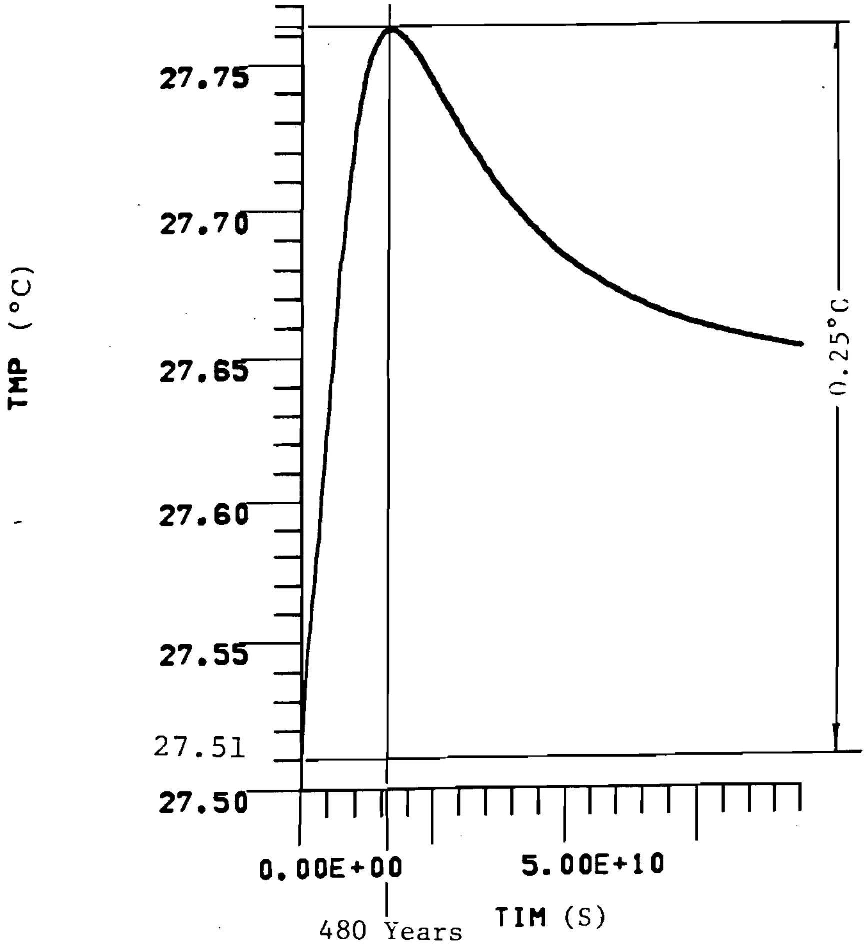

Figure 6: Temperature in Central Zone at Top of Rustler

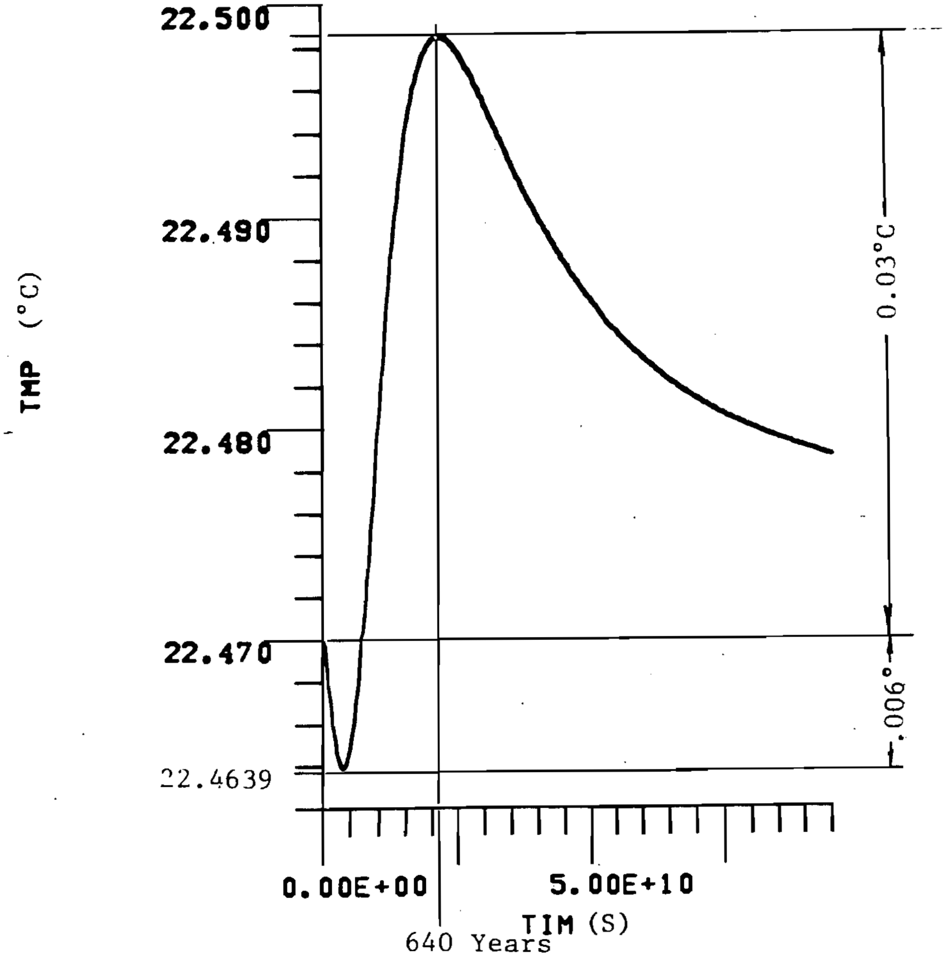

Figure 7: Temperature in Central Zone at Surface

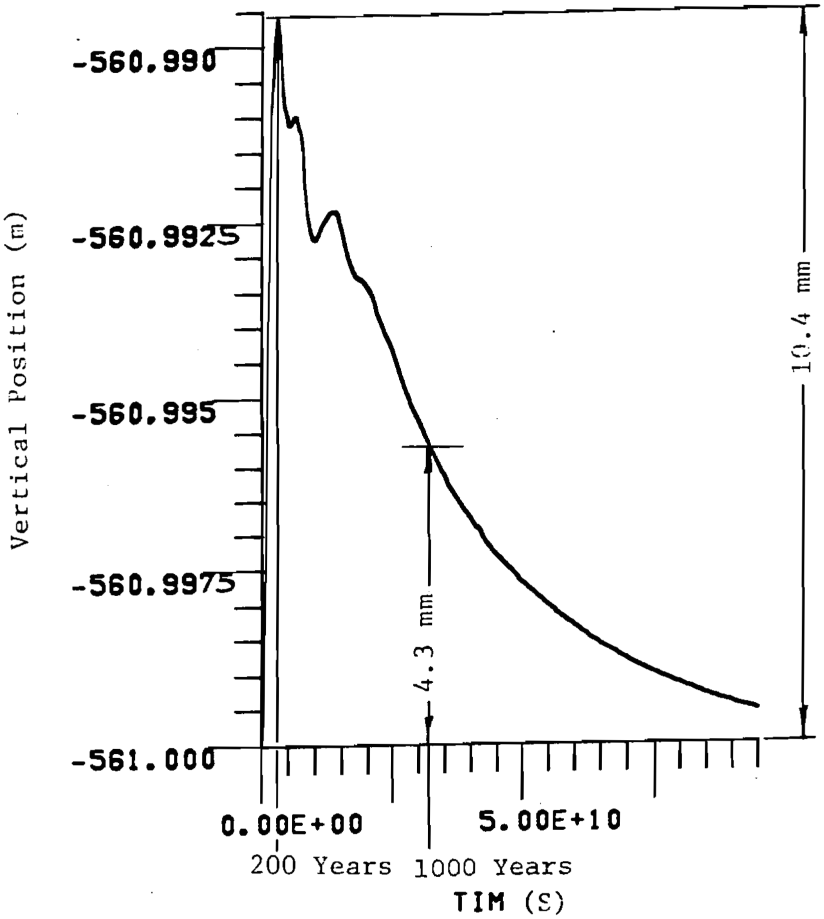

Figure 8: Uplift of Top of Repository Zone

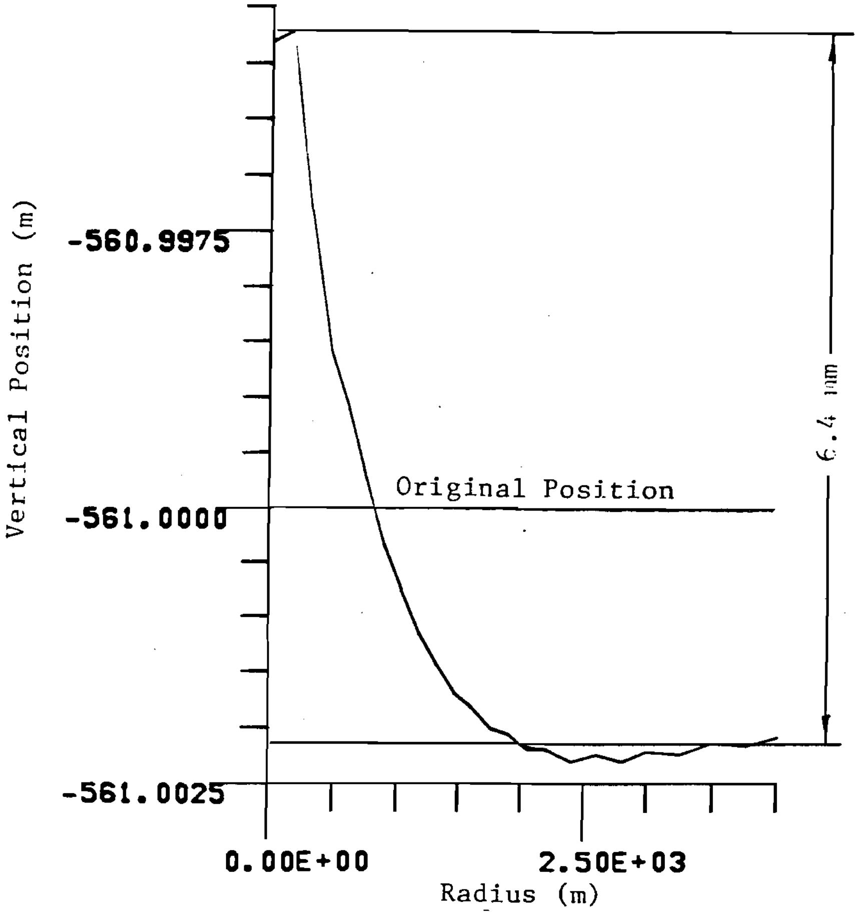

Figure 9: Uplift Profile at Repository Level at 1000 Years

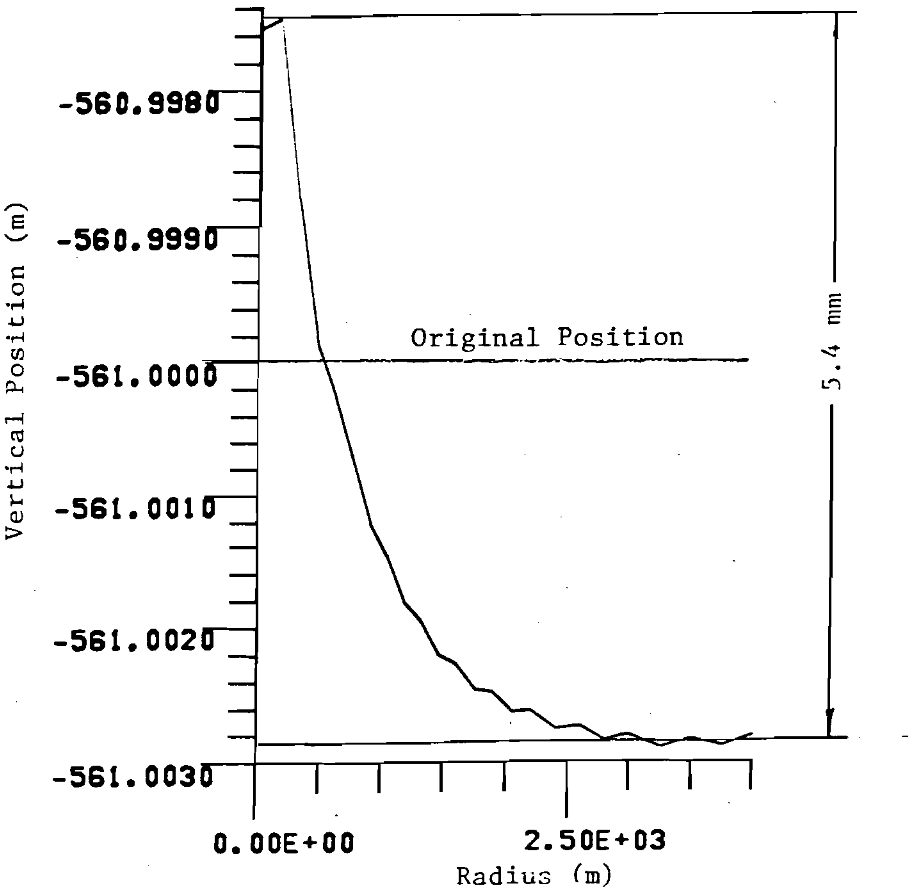

Figure 10: Uplift Profile at Repository Level at 1500 Years

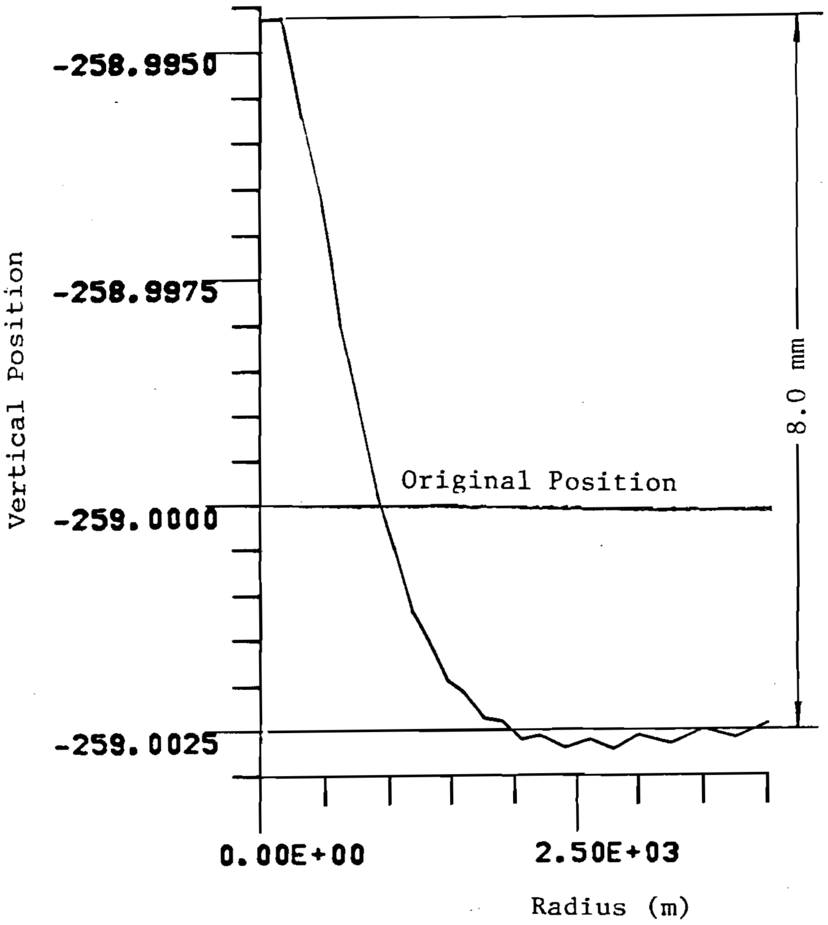

Figure 11: Uplift Profile at Top of Salado at 1000 Years

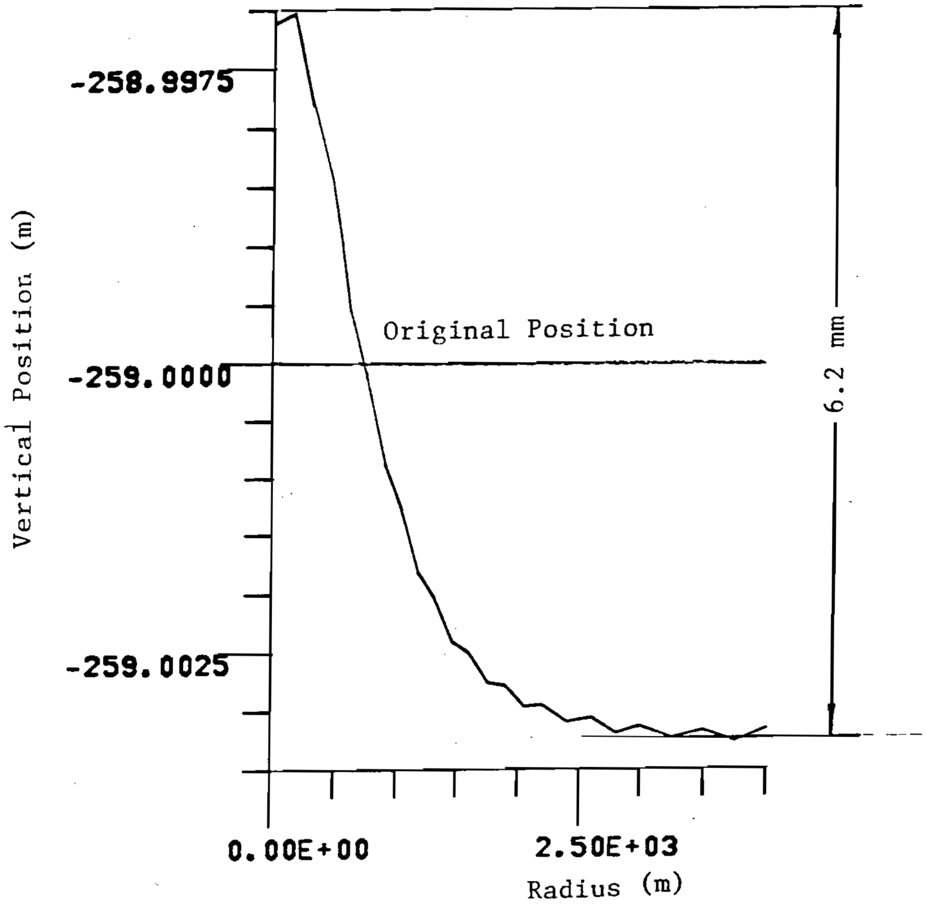

Figure 12: Uplift Profile at Top of Salado at 1500 Years

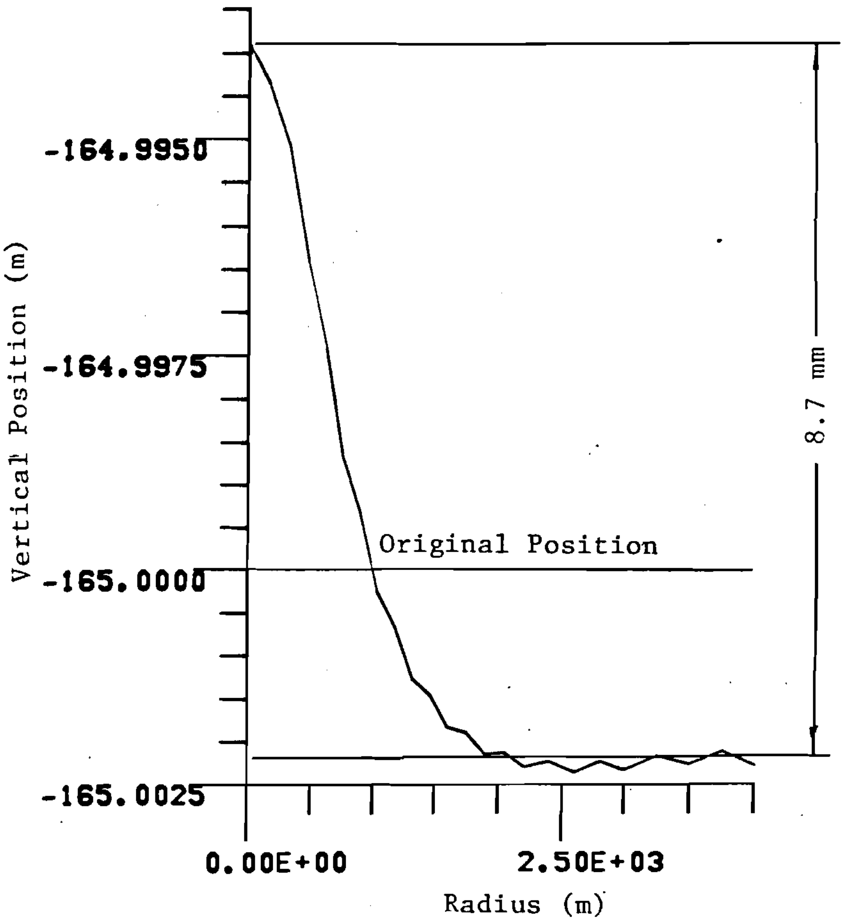

Figure 13: Uplift Profile at Top of Rustler at 1000 Years

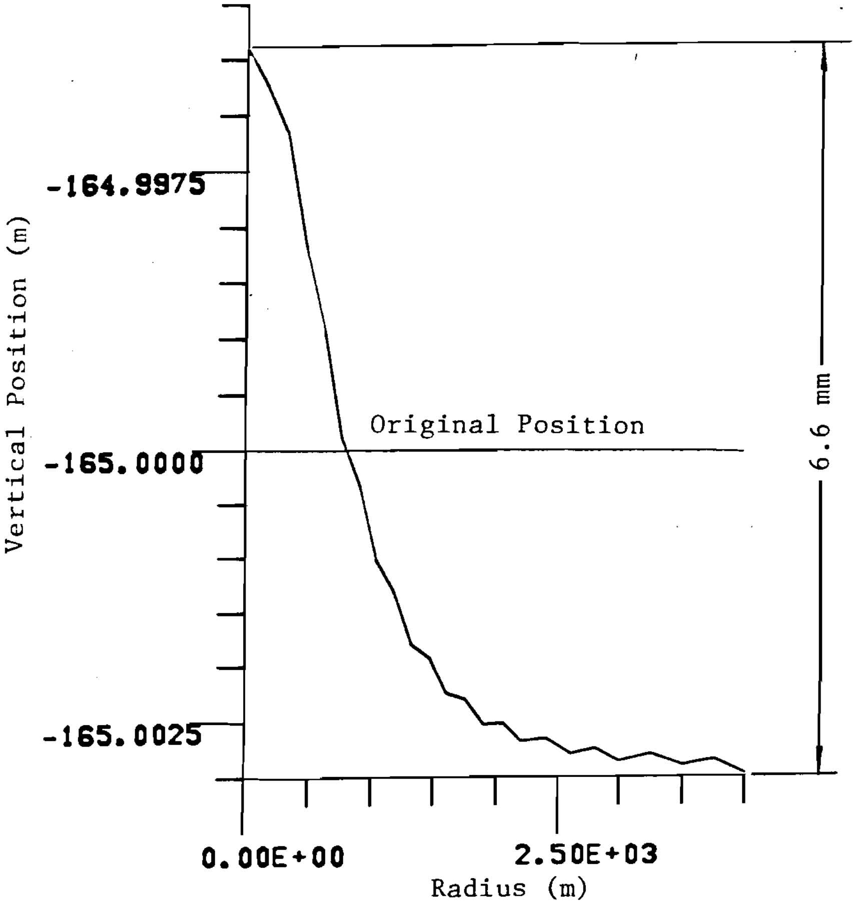

Figure 14: Uplift at Top of Rustler at 1500 Years

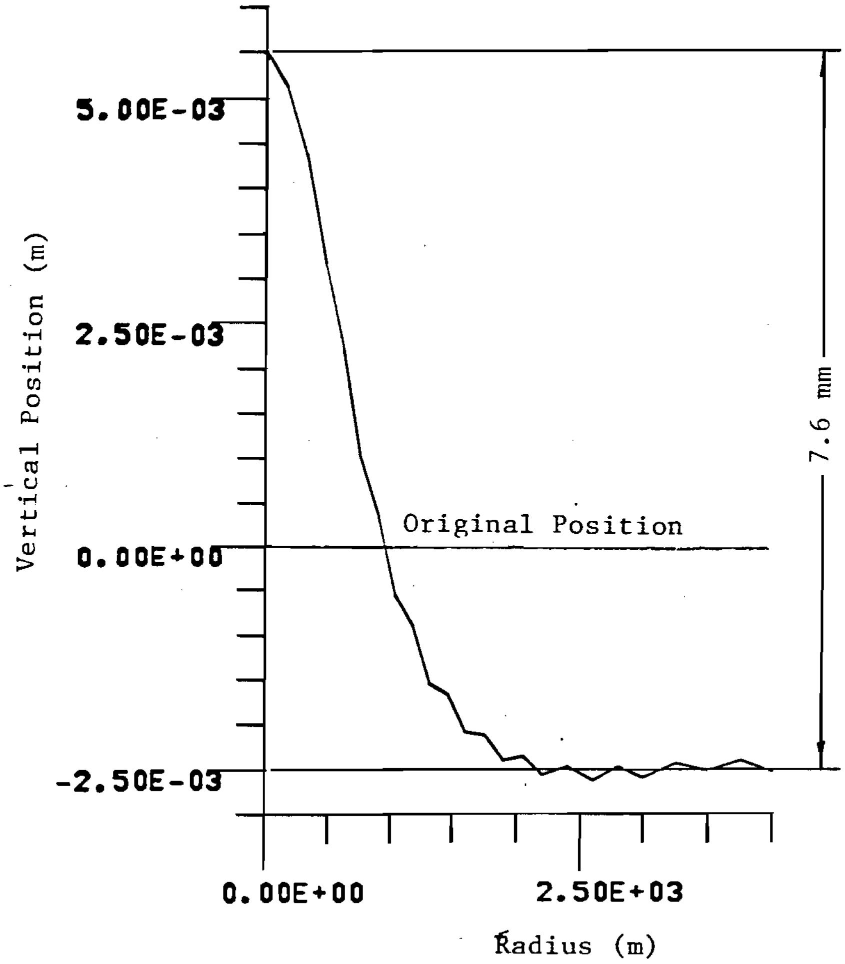

Figure 15: Surface Profile at 1000 Years

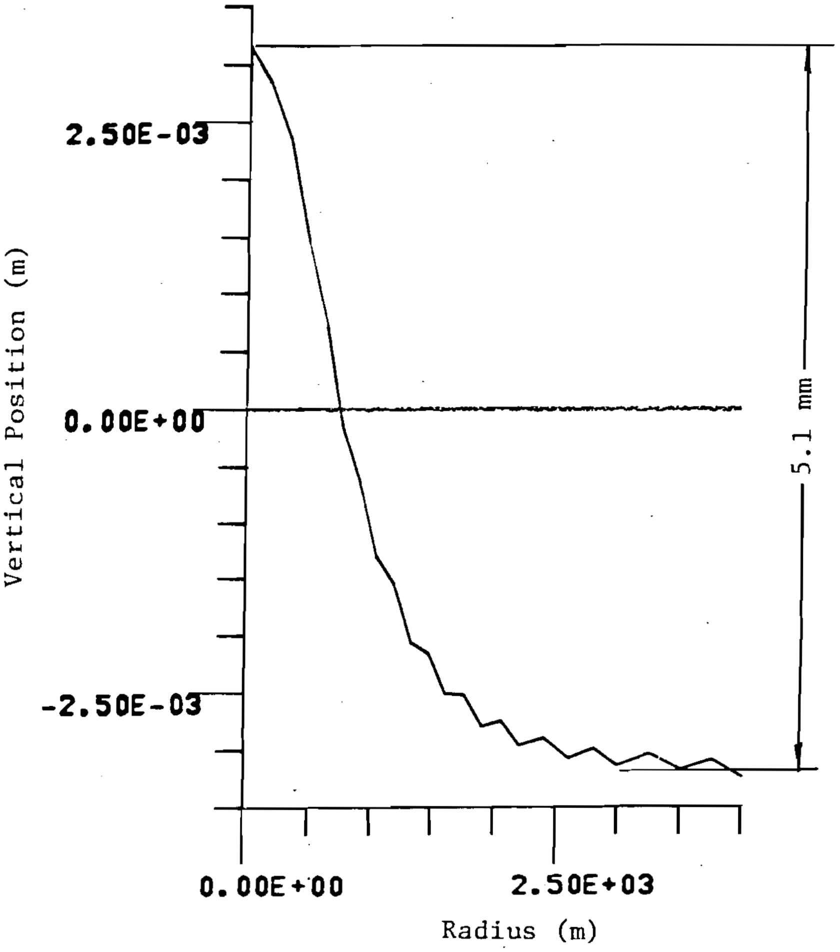

Figure 16: Surface Profile at 1500 Years

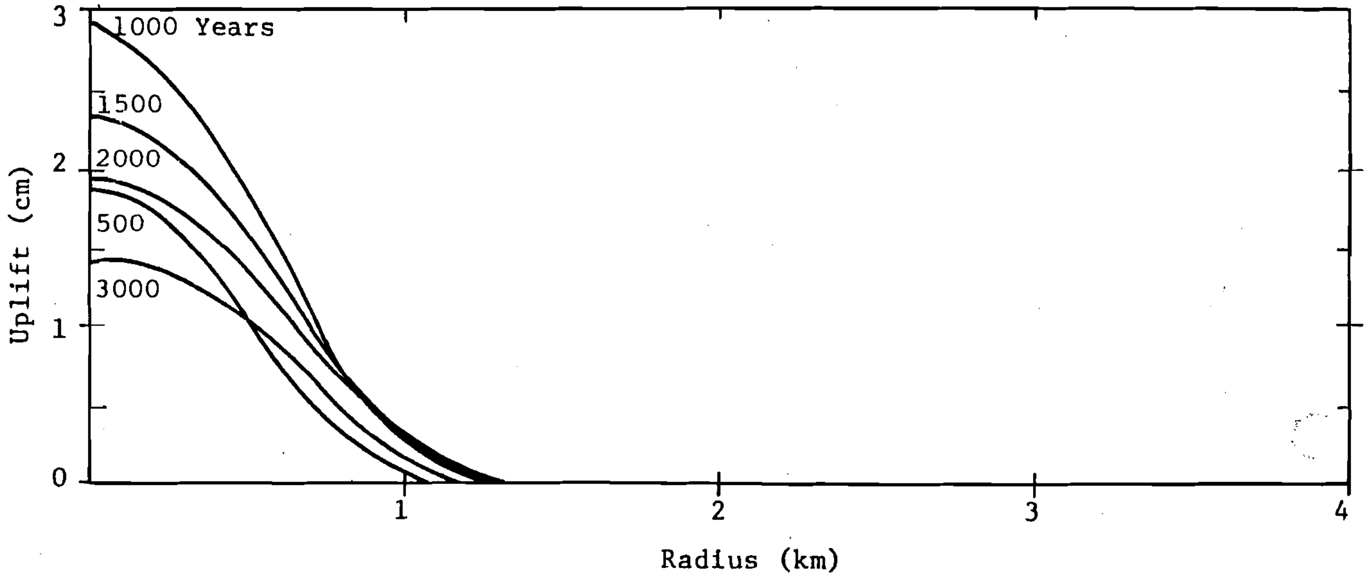

Figure 17. Surface Profiles at Selected Times for 20-Acre 30kW/acre Spent Fuel Repository (Ref. 1)