TRANSIT: A MODEL FOR PROVIDING GENERIC TRANSPORTATION INPUT FOR PRELIMINARY SITING ANALYSIS

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ABSTRACT

To assist the U.S. Department of Energy's efforts in potential facility site screening in the nuclear waste management program, a computerized model, TRANSIT, is being developed. Utilizing existing data on the location and inventory characteristics of spent nuclear fuel at reactor sites, TRANSIT derives isopleths of transportation mileage, costs, risks and fleet requirements for shipments to storage sites and/or repository sites. This technique provides a graphic, first-order method for use by the Department in future site screening efforts.

INTRODUCTION

In the process of screening various areas of the U.S. to determine potential sites for placement of a spent fuel/nuclear waste storage system, the impacts of transportation must be examined as part of the formal evaluation process. Transportation impacts are evolved from a variety of different considerations. These considerations include (but are not limited to) economics, public health and safety, environmental and socio-economic concern. In the early stages of the screening process it becomes important to obtain a first order estimate of transportation impacts. Pacific Northwest Laboratory (PNL) under the sponsorship of the Transportation Technology Center (TTC) has developed a model (TRANSIT) to assess the first order impacts of transportation to various areas of the U.S.

TRANSIT is based on deriving isopleths (lines of constant value) of transportation cost, risk, mileages and fleet requirements in various areas of U.S. These lines are derived from the number and location of the various sites that will ship spent fuel/nuclear waste within the U.S. and the amounts of spent fuel/nuclear waste that will be transported within a given time frame. The model then overlays a set of 10 x 10 grid points across the U.S. to establish equally spaced positions for facility locations. A weighted great circle transport methodology (applying circuity factors to more nearly estimate the actual distance of truck and rail routes) to arrive at the total number of shipments, the weighted average cost per shipment, the weighted average risk (radiological, non-radiological and total) per shipment, and the weighted average cask-use days per shipment is then calculated for each grid point. An interpolation routine established isopleths between the grid points for each of the values listed above. This information may then be used to make first order estimates of the transportation impacts (over time) for various regions of the U.S.

CAPABILITIES

The TRANSIT model is interactive with the user and is programmed for use on the IBM-PC attached to an HP-7475 plotter for graphical presentation of results. The model presently allows the user to select any of the following areas to be calculated:

1. Weighted average distance per shipment
2. Weighted average transport cost per shipment (includes shipping cost plus lease cost)
3. Weighted average cask-days usage per shipment
4. Weighted average risk per shipment (includes radiological and non-radiological)

The results in each of these areas may be calculated by assuming the transport mode to be any one of the following:

1. 100% truck shipments
2. 100% rail shipments
3. Shipment mode determined by reactor handling capability

In addition, the user may select the weighting option for calculating the average distance per shipment. The available options include:

1. No weighting
2. Weighting by MTU shipped
3. Weighting by number of shipments

The model allows the user to choose one of three systems configurations to analyze equipotential data contours. The available systems configurations include:

1. Shipments from reactors directly to an unspecified repository locations.
2. Shipments from reactors through an unspecified intermediate facility (FIS, MRS, reprocessing) to a specific repository location.
3. Shipments from reactors through a specified intermediate facility to an unspecified repository location.

The model is capable of being integrated within the WASTES[1] logistics model framework. The WASTES model is run to determine the number of shipments and the amount of spent fuel to be shipped from individual reactors over a specified period of time. This information is then input to TRANSIT to determine the generic transportation characteristics for various segments of the U.S.

The results of the TRANSIT calculation may be displayed on the HP plotter on any one of the following map projections:

1. U.S. boundary map without state lines
2. U.S. boundary map with state lines
3. Northeast U.S. map
4. Southeast U.S. map
5. Upper midwest U.S. map
6. Lower midwest U.S. map
7. Northwest U.S. map
8. Southwest U.S. map
9. User controlled longitude/latitude selection

SAMPLE PROBLEM

To demonstrate the various capabilities of TRANSIT, a WASTES logistics run was made to determine the reactors and amount of spent fuel from each reactor that would be involved in the transport of 70,000 MTU of spent fuel from individual reactor sites directly to an unknown repository site. The logistics run gave preference to reactor shipments in the following priority scheme:

1. Reactors experiencing full core reserve (FCR) loss in a given year.

2. Decommissioning reactors (two years following decommissioning)

3. Oldest fuel in system

The transportation system utilized present day cask designs (1 pressurized water reactor (PWR), or 2 boiling water reactor (BWR) assemblies per truck cask and 7 PWR or 18 BWR assemblies per rail cask) to transport the spent fuel. It was further assumed that reactors that could presently ship by rail were allowed to do so and the remaining reactors would ship by truck. The unit risk input into TRANSIT for this series of runs correspond directly to those listed in Ref. 2.

The isopleths calculated for weighted average cask-miles per shipment, weighted averages cost per shipment, weighted average cask-use days (truck and rail) and weighted average risk (radiological plus non-radiological) per shipment are shown in Fig. 1-5.

INTERPRETATION OF RESULTS

The results shown in Fig. 1-5 represent the analyses performed for the total number of shipments (16,054 rail and 49,436 truck) predicted by the WASTES logistics model. The results for individual cases are explained below:

1. Average Cask-Miles per Shipment

   The results shown in Fig. 1 represent the estimated average cask-miles per shipment that would be realized if a repository were located in various regions of the U.S. A repository located inside of the 800 mile circle would tend to minimize total cask miles within the waste management system. The actual total cask-miles for a repository located at a given site may be estimated by multiplying the average cask-miles per trip (at that location) by the total number of shipments (65,490). Estimated average cask-miles per shipment for locations that do not fall directly on a given contour line may be obtained by interpolation. A detailed breakdown of the average cask-miles associated with shipments made by truck or shipments made by rail are also available as output from TRANSIT.

2. Average Cost per Shipment

   The results shown in Fig. 2 represent the estimated average cost per shipment that would be realized if a repository were located in various regions of the U.S. The estimated total transportation cost (shipping, security and cask-lease) for a given site may be estimated in a manner analogous with that described for cask-miles. A detailed breakdown of the estimated average cost per shipment associated with either truck or rail shipments is also available as output from TRANSIT.

3. Average Cask-Use Days per Shipment

   The results shown in Fig. 3 and 4 represent the estimate average cask-use days per shipment associated with shipments made by truck and rail respectively. The results include both transit times and turn-around times for each mode of transport. The estimated total cask-use days required to transport 70,000 MTU of spent fuel may be obtained by multiplying the average cask-use days results by the total number of shipments required (16,054 rail and 49,436 truck). An estimate of the total number of truck and rail casks required may be obtained by introducing the cask-use days per year for each cask and its associated lifetime.

4. Estimated Risk per Shipment

   The results shown in Fig. 5 represent the estimated total risk per shipment that would be anticipated if a repository were located in various regions of the U.S. The average risk per shipment shown in Fig. 5 is a weighted average risk involving both radiological and non-radiological risk for both occupational and non-occupational exposures. The risk includes both normal (incident-free) transport and accident conditions. The risk factors input into TRANSIT are taken from Reference 2 and assumes an averaged population density distribution similar to that described by the cited document. The numbers describing the contour lines in Fig. 5 represent calculated fatalities per shipment. To calculate the anticipated risk for transporting 70,000 MTU of spent fuel directly to a given site, the risk numbers shown in FIG 5 may be multiplied by the total number of shipments (65,490).

CONCLUSIONS

The TRANSIT model provides a graphic first order site screening methodology for use in future siting efforts throughout the nuclear waste management system. This technique can be linked with the calculational capabilities of the WASTES transportation logistics model for further refinement and detail. Additional

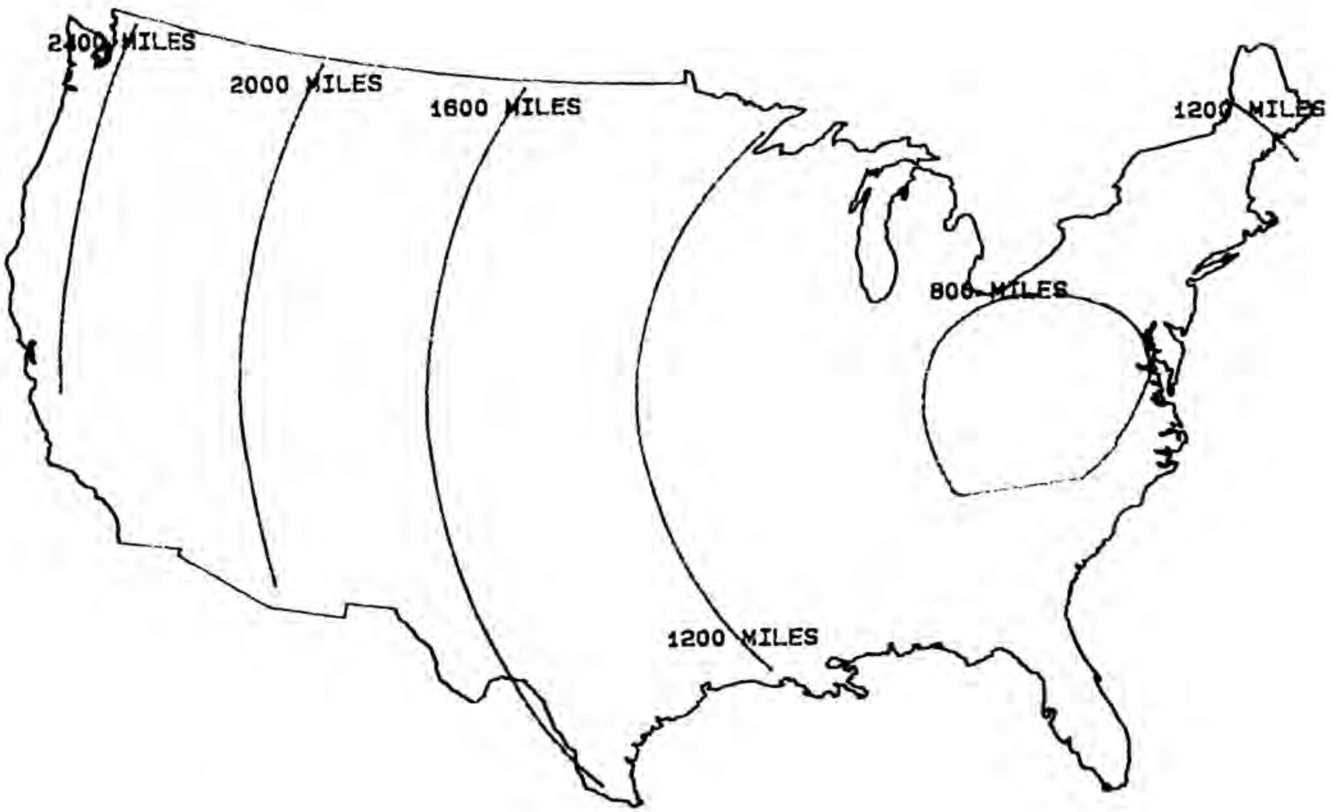

Fig. 1. Average Cask-Miles Per Trip for Shipments From All Reactors Directly to a Repository

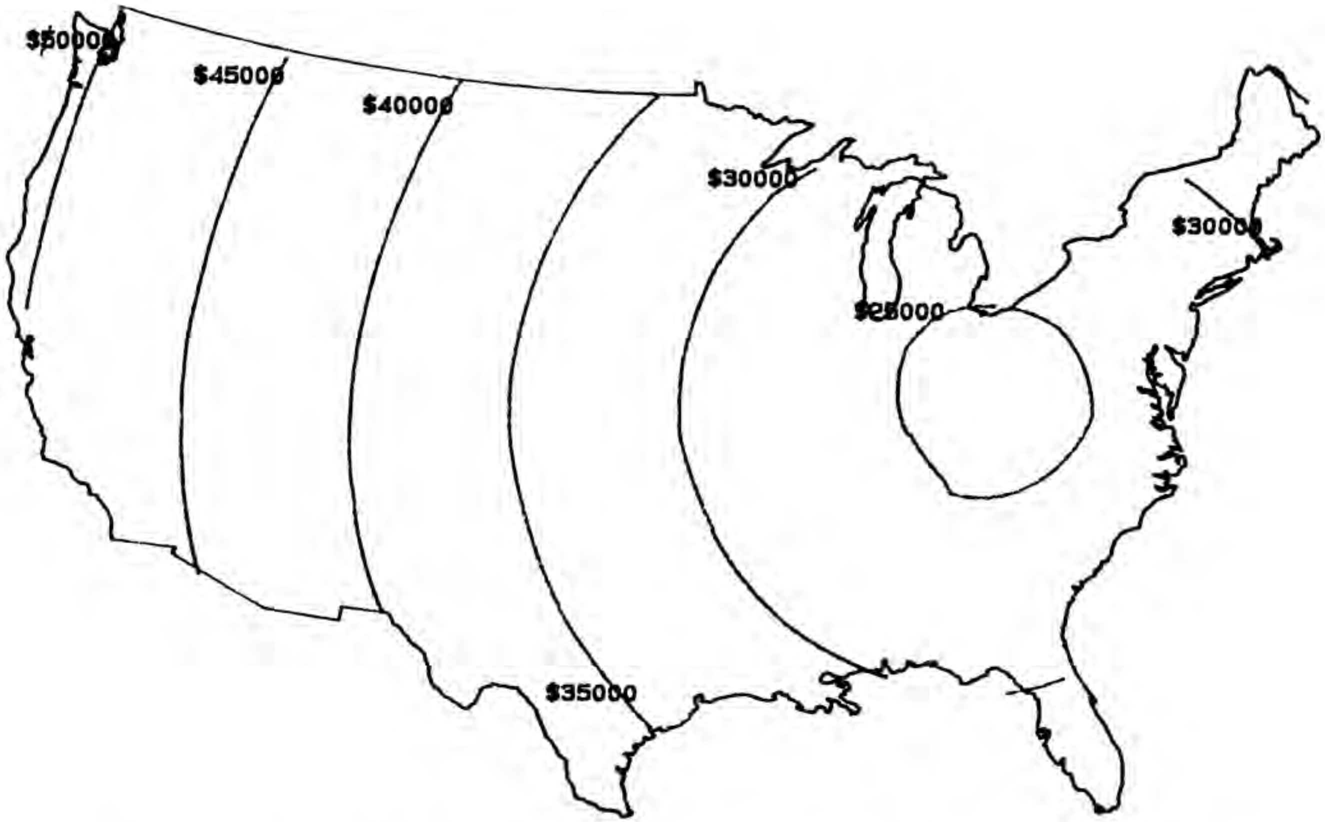

Fig 2. Average Cost Per Trip for Shipments From All Reactors Directly to a Repository

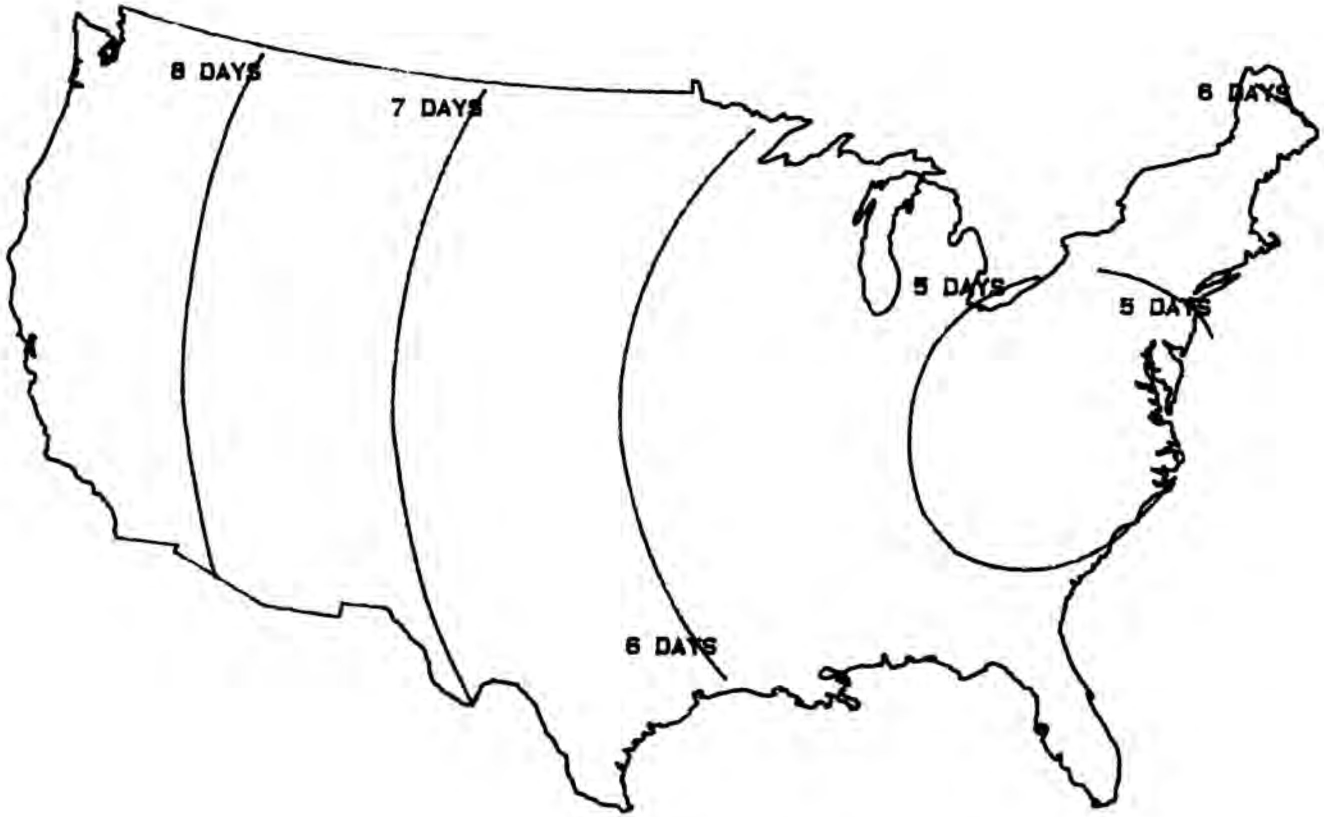

Fig 3. Average Truck Cask-Use Days Per Trip for Shipments From Reactors Without Rail Capability Directly to a Repository

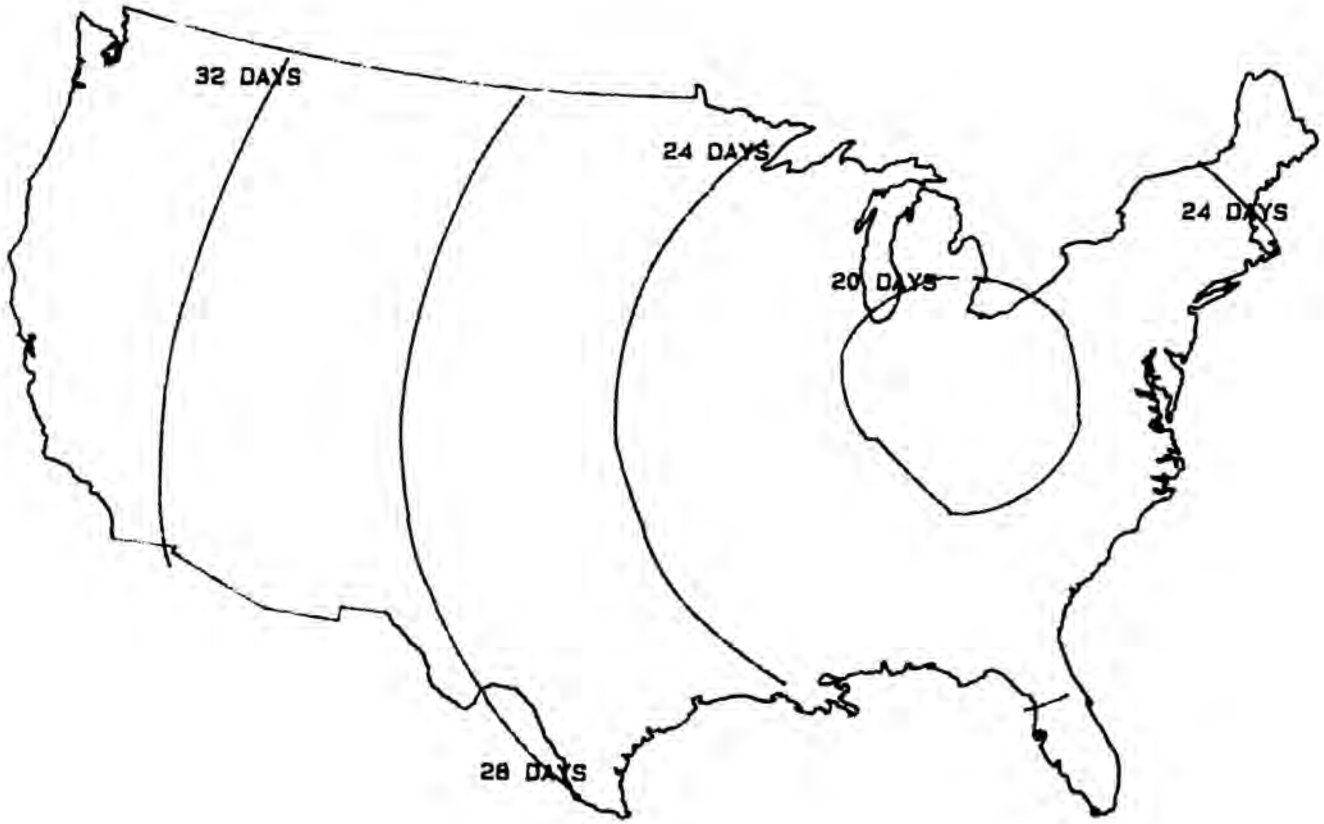

Fig 4. Average Rail Cask-Use Days Per Trip for Shipments From Reactors With Rail Capability Directly to a Repository

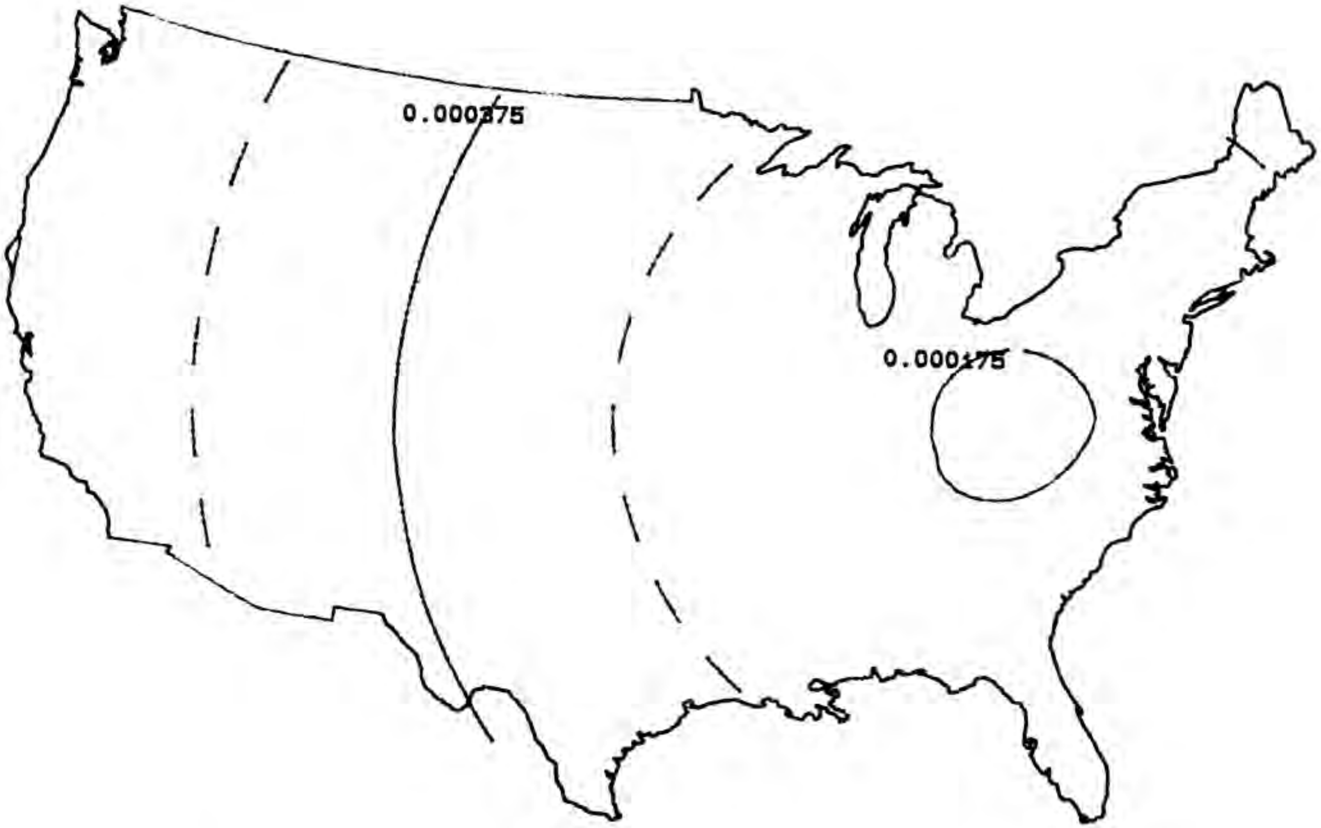

Fig 5. Average Total Risk Per Shipment for Shipments From All Reactors Directly to a Repository

efforts toward development of the technique will follow a detailed peer review of TRANSIT (and other conceptual methods) to aid in facility site screening.

REFERENCES

1. Neuhauser, K. S., J. W. Cashwell, P. C. Reardon, G. W. McNair, A Preliminary Cost and Risk Analysis for Transporting Spent Fuel and High Level Waste to Candidate Repository Sites. SAND-84-1795/TTC-0506.

2. Shay, M. R., A. L. Thorpe and G. W. McNair, WASTES: Waste System Transportation and Economic Simulation. SAND-84-7173, TTC-0533, PNL-5413.