OPTIMUM MRS SITE LOCATION TO MINIMIZE

SPENT FUEL TRANSPORTATION IMPACTS

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ABSTRACT

A range of spent fuel transportation system parameters are examined in terms of attributes important to minimizing transportation impacts as a basis for identifying geographic regions best suited for siting a monitored retrievable storage (MRS) facility. Transportation system parameters within existing transport cask design and transportation mode capabilities were systematically analyzed. The optimum MRS location was found to be very sensitive to transportation system assumptions particularly with regard to the relative efficiencies of the reactor-to-MRS and MRS-to-repository components of the system. Moreover, dramatic improvements in the reactor-to-MRS component can be made through use of multiple cask shipment of the largest practical casks by dedicated train compared to the traditional single cask rail (70%) and truck (30%) shipments assumed the Department of Energy in their studies that defined the optimum MRS location in the vicinity of Tennessee. It is important to develop and utilize an efficient transportation system irrespective of whether or not an MRS is in the system. Assuming reasonably achievable efficiency in reactor-to-MRS spent fuel transportation and assigning equal probabilities to the three western sites selected for characterization of being the repository site, the optimum MRS location would be in the far-mid-western states. Based on various geographic criteria including barge access and location in a nuclear service area, the State of Tennessee ranks any place from 12th to the 25th at a penalty of about 30% over the minimum achievable impacts. While minimizing transportation impacts is an important factor, other criteria should also be considered in selecting an MRS site.

INTRODUCTION

This paper is based on a study performed for the State of Tennessee Safe Growth Team as part of their evaluation of the Department of Energy's (DOE) proposal to build a monitored retrievable storage (MRS) facility in Tennessee as an integral part of the commercial high-level waste management system.(1,2) In selecting candidate MRS sites DOE considered a region of approximately circular shape centered in East Tennessee with a radius of about 400 miles.(3) By location of the MRS in this region overall transportation system requirements would not exceed 20 percent of the minimum achievable when measured in terms of TRIP-MILES for the transportation system assumed. The State of Tennessee's spent fuel transportation analysis indicated that major improvements could and should be made in the transportation system compared to the assumptions made by DOE.(4) Other studies have shown that there is potential for significant improvement in transportation systems and the important transportation impacts of having an MRS in the system is very sensitive to the transportation system assumptions.(5)

The purpose of the study was to locate those geographic regions that are best suited for successfully siting an MRS in terms of minimizing transportation impacts. A range of transportation system technologies that are within existing transport cask design and transportation mode capabilities are systematically analyzed and compared in terms of proxy measures for important impacts. It is assumed that spent fuel is shipped from reactors to the MRS and consolidated fuel is shipped from the MRS to a geologic repositorty for disposal. Since the repository site is not known, equal probabilities are assigned to sites in Texas, Nevada, and Washington that were selected by DOE for characterization. Only geographic factors relating to: distances, access to transport modes, and nuclear service area location are considered in the analysis. It is important to recognize that other factors should also be considered and weighed with detailed site specific transportation impacts in selecting a site for an MRS facility.

METHODOLOGY

A systematic analysis was conducted for important transportation system parameters to determine their effects on minimizing transportation impacts. The best available data on spent fuel quantities and at-reactor cask handling capabilities were used. Modified great circle distances were used to compute proxy measures at grid points throughout the contiguous 48 states. The location and magnitude of each of the proxy measures was determined and plotted on a map with the envelope defining a 25 percent increase in the minimum values. Insights into the behavior of the relative impacts was gained permitting selection of an appropriate reference transportation system and reference MRS sites in 28 states. Reference MRS sites were selected to have good highway and railroad access and where possible on a navigable waterway with preference to location in a nuclear utility service area. Proxy measures were then calculated using modified great circle distances and the percent increase over the minimum achievable determined for each site. Sites were ranked according to various combinations of geographic criteria based on the average increase in proxy measures.

The following three easily computed and understood values were used as proxy measures for comparing the relative effects of various parameters on transportation system impacts:

TRIP-MILES. This is the total number of one-way spent fuel shipment miles and is related to perceptions of apparent spent fuel shipment activity, likelihood that a shipment will be involved in an accident, and the cost of security, monitoring and emergency response. TRIP-MILES can be lowered by: using larger cask, multiple cask shipments, and/or shorter shipping distances.

CASK-DAYS. This is the total number of days cask containing spent fuel are in transit and is related to the radiological dose to the public and occupational workers. CASK-DAYS can be lowered by: using larger cask, increasing average shipping speed, and/or shorter shipping distances.

TON-MILES. This is the total gross round trip (fuel one-way) cask weight times miles shipped and is related to freight charges for spent fuel transportation. TON-MILES can be lowered by: using the largest capacity cask practical, using higher capacity cask per unit of cask weight, and/or shorter shipping distances.

There are an endless number of transportation system concepts and variations that could be considered. However, for purposes of this study a limited number of cases were considered that was designed to bracket the choices available and provide an understanding of the interactions of the parameters. The following transportation system parameters were considered:

FROM REACTOR TRANSPORTATION SYSTEM used to move fuel from the reactor to the MRS in terms of: make-up of the cask fleet, transportation mode, and number of casks per shipment. The following four types of systems were analyzed:

1. TRADITIONAL. This system is similar to assumptions DOE has traditionally made except larger capacity casks made possible by shipping older fuel is assumed. It is assumed that 70 percent of the fuel is shipped by rail in nominal 100 ton casks and 30 percent is shipped by truck in nominal 25 ton casks. All shipments are single cask by general commerce.

2. IMPROVED. This is the same as the TRADITIONAL system except 90 percent is shipped by rail and 10% is shipped by truck.

3. MIXED INTEGRATED. This system uses largest of five (25, 40, 100, 125, and 150 ton) nominal cask sizes consistent with plant cask handling capability. Multiple cask shipments are made by dedicated train assuming five casks per shipment. Where a plant does not have rail access it is assumed that the casks are moved to a nearby railhead by truck, barge or heavy-haul vehicle as appropriate.

4. LARGE INTEGRATED. This system uses a single nominal large (125 ton) cask size in conjunction with a transfer cask to move fuel from reactor pools to the large cask where the large cask cannot be handled in the reactor *building*. Multiple casks shipments are made by dedicated train as in the MIXED INTEGRATED system.

LOCATION OF ROD CONSOLIDATION assuming that fuel will be consolidated for disposal. Two options are considered.

1. NO AT-REACTOR CONSOLIDATION. In this case intact fuel assemblies are shipped to the MRS where they are consolidated and packaged for storage and disposal.

2. FULL AT-REACTOR CONSOLIDATION. In this case all fuel is consolidated at the reactors before it is shipped to the MRS where it is then packaged for storage and disposal.

MRS CASK SIZE used to make multiple cask shipment of consolidated fuel packages by dedicated train to the geologic repository for disposal. Five cask per shipment was assumed for the following two cask sizes:

1. NOMINAL MRS CASK. This cask has a gross weight of 140 tons when loaded with 8.1 MTU of consolidated fuel.

2. LARGE MRS CASK. This cask has a gross weight of 150 tons when loaded with 19.4 MTU of consolidated fuel in the repository.

RESULTS

The geographic location of the minimum value and related 25% envelope for the three impact proxy measures is shown in Fig.1 for the 16 parametric base study cases. A corresponding normalized graphical comparison of proxy measure minimum values are shown in Fig.2. All values are normalized to the TRADITIONAL SYSTEM/NO AT-REACTOR CONSOLIDATION/NOMINAL MRS CASK case since it has the highest overall impacts and is the closest approximation to the DOE assumptions. DOE used significantly lower capacity casks, typical of casks designed in the 1960's for 180 day old fuel, for shipment from the reactors to the MRS. The following conclusions are drawn from these results:

- Major reductions in transportation impacts can be achieved through using the largest cask practical and multiple cask shipment of fuel from reactors to the MRS by dedicated train.
- The reduction in transportation impacts that can be achieved by improving the technology are greater than can be achieved by geographic location of the MRS and should be vigorously pursued without regard to the MRS or its location.
- The optimum MRS site location to minimize transportation impacts is a

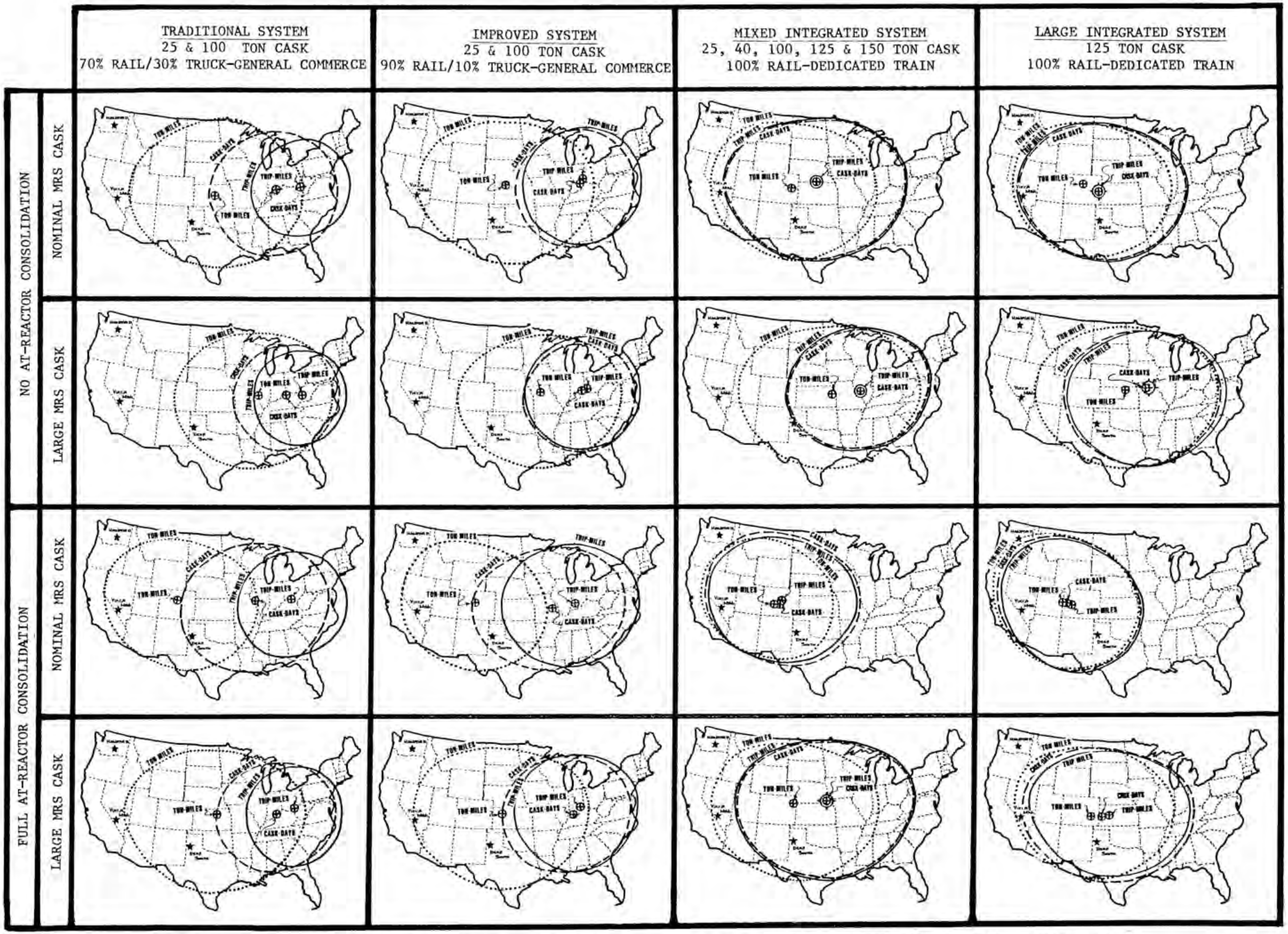

Fig. 1. - LOCATION OF MINIMUM VALUES AND 25% INCREASE ENVELOPES OF IMPACT MEASURES FOR A RANGE OF TRANSPORTATION SYSTEM PARAMETERS

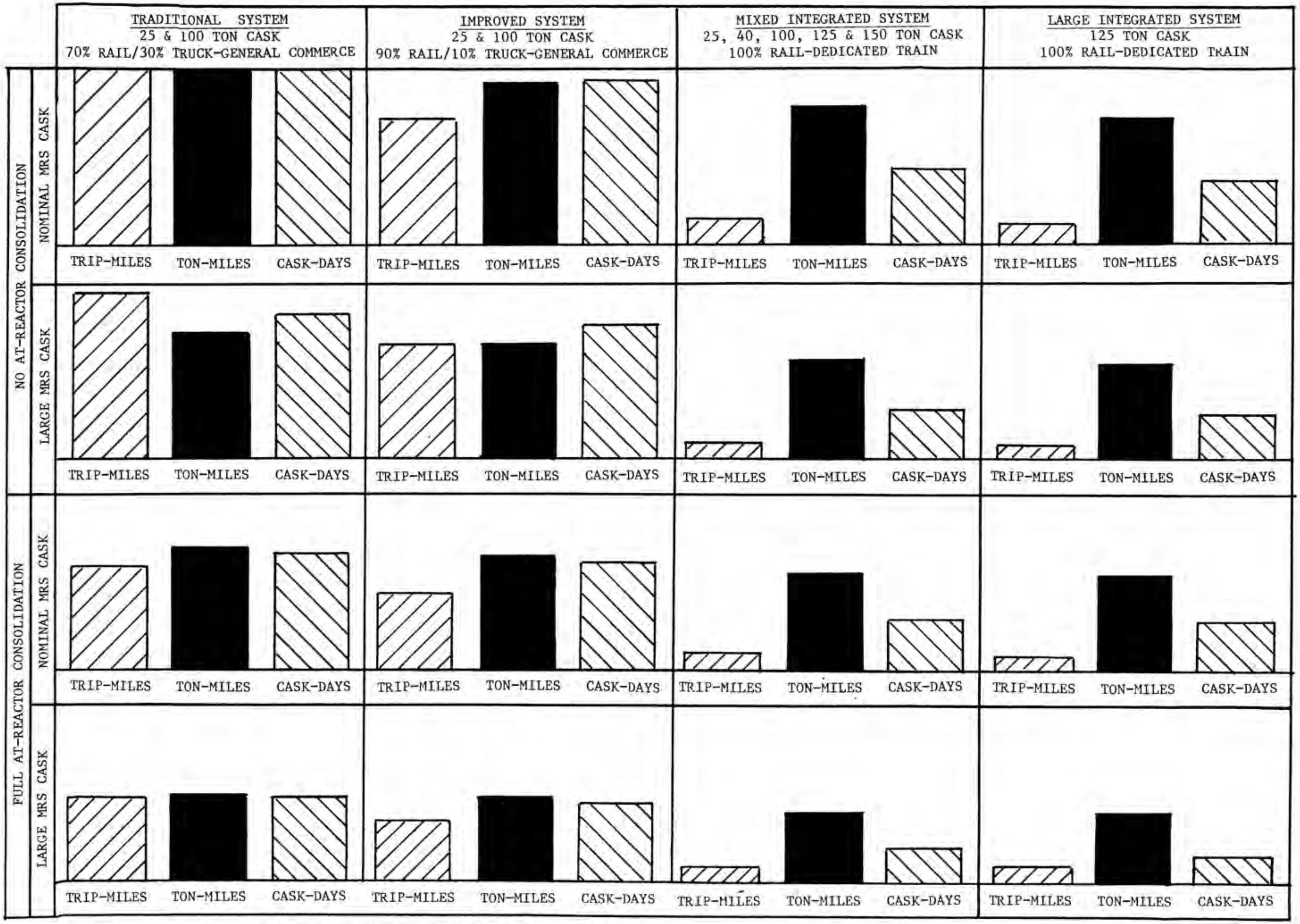

Fig. 2. - NORMALIZED COMPARISON OF MINIMUM VALUES OF IMPACT MEASURES FOR A RANGE OF TRANSPORTATION SYSTEM PARAMETERS

function of the relative efficiencies of the reactor-to-MRS and the MRS-to-repository legs of the *transportation* system.

- As the efficiency of the reactor-to-MRS leg improves relative to the MRS-to-reactor leg the minimum values of all proxy measures converge into the same geographic area as near the repository as possible.

- Over 90% of the potential reductions in transportation impacts can be achieved with the MIXED INTEGRATED SYSTEM compared to the LARGE INTEGRATED SYSTEM.

- The MIXED INTEGRATED system would have greater flexibility to accommodate a wide range of physical and institutional considerations than the LARGE INTEGRATED SYSTEM.

A sensitivity analysis was conducted to examine the effects of shipment of western reactor fuel directly to the repository and shifting of repository probabilities which did not alter the conclusions.

Based on the foregoing conclusions, the MIXED INTEGRATED SYSTEM utilizing a LARGE MRS CASK is selected as a reasonable basis for comparison of transportation impacts for different potential MRS sites. It is anticipated that a significant, but undeterminable, amount of spent fuel will be consolidated at-reactors to provide increased storage capacity until DOE begins accepting fuel for disposal on a large scale. The average of the NO AT-REACTOR CONSOLIDATION and the FULL AT-REACTOR CONSOLIDATION cases are assumed recognizing that their minimum proxy measures are in the same general geographic area. The average percent increase in impacts for this reference transportation system are given in Table I for reference sites in 28 states. These sites are also ranked by various combinations of geographic criteria omitting Texas and Nevada from the ranking since as potential repository states they are exempt from hosting an MRS. Transportation impacts at DOE's preferred site in Tennessee would be about 30 percent greater than the

TABLE I

Ranking of Reference Sites to Minimize Transportation Impacts

	Average** Percent Increase	RANK BY GEOGRAPHIC CRITERIA: Overland Only	Overland & Barge	Overland & Nuclear	All
Nebraska	2.47	1	1	1	1
Kansas	3.65	2	2	2	***
Colorado	4.11	3	-	3	-
Iowa	4.11	4	3	4	2
Oklahoma	4.67	5	4	-	-
Missouri	5.05	6	5	5	3
South Dakota	5.65	7	-	-	-
Wyoming	6.64	8	-	-	-
Arkansas	7.71	9	6	6	4
Minnesota	8.75	10	7	7	5
Illinois	8.91	11	8	8	6
New Mexico	9.19	12	-	-	-
Texas	10.11	*	*	*	*
Wisconsin	13.38	13	9	9	7
Utah	13.67	14	-	-	-
Arizona	14.49	15	-	-	-
North Dakota	14.61	16	-	-	-
Montana	14.81	17	-	-	-
Louisiana	16.46	18	10	11	8
Mississippi	17.56	19	11	12	9
Idaho	17.96	20	-	-	-
Indiana	19.49	21	12	13	***
Nevada	22.92	*	*	*	*
Kentucky	26.42	22	13	-	-
Michigan	27.79	23	14	14	10
Alabama	31.41	24	15	15	11
Tennessee	31.41	25	16	16	12
Ohio	36.68	26	17	17	13

*Texas and Nevada were omitted from ranking since repository states are exempt from hosting an MRS.

**Average increase in the proxy measures for the no at-reactor and full at-reactor consolidation cases assuming a mixed integrated transportation system with large MRS to repository shipping cask.

***Barge access not available in nuclear service area.

minimum achievable under these conditions. Twenty-four states would be comparable or better than the Tennessee site if only overland (highway and rail) criteria are considered. Sixteen states could offer comparable or potentially better sites if barge transportation or location in a nuclear service area are used as siting criteria. This number is reduced to twelve states if it is necessary to meet both barge and nuclear service area criteria. In performing an evaluation of actual MRS sites specific transportation system impacts should be used in conjunction with other considerations appropriate to selecting an MRS site.

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