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NEAR-TERM COMMERCIAL SPENT FUEL SHIPPING CASK REQUIREMENTS

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ABSTRACT

This report describes an analysis of the near-term commercial light water reactor (LWR) spent fuel transportation system. The objective of this study was to determine if the existing commercial spent fuel shipping cask fleet is adequate to provide the needed transportation services for the period of time the U.S. government would be authorized to accept spent fuel for Federal Interim Storage (FIS). A spent fuel shipping cask supply-demand analysis was performed to evaluate the existing fleet size. The supply-demand calculations were facilitated by the development of a comprehensive spent fuel shipping schedule. The shipping schedule included assignment of a particular cask type (legal-weight truck, overweight truck, or rail) to each shipment. The cask assignments were determined in a concurrent study that examined the spent fuel shipping cask handling capabilities and limitations at reactors currently projected to lose FCR capability in their storage basins. This allowed transport mode-specific shipping cask requirements to be calculated. These projected requirements were then compared with the existing shipping cask fleet.

The results of the shipping cask handling capability study indicated that by weight, 75% of the spent fuel shipments will be by truck (overweight plus legal-weight truck). From the results of the shipping cask supply-demand analysis it was concluded that, if utilities begin large-scale applications for FIS, the five legal-weight truck (LWT) casks currently in service would be inadequate to perform all of the needed shipments as early as 1987. This further assumes that a western site would be selected for the FIS facility. If the FIS site were to be located in the East, the need for additional LWT casks would be delayed by about two years. The overweight truck (OWT) cask fleet (two PWR and two BWR versions) will be adequate through 1992 if some shipments to FIS can be made several years before a reactor is projected to lose full core reserve. This is because OWT cask requirements increase gradually over the next several years. The feasibility of shipping before losing full core reserve has not been evaluated. Cask utilization requirements in later years will be reduced if some shipments can be made prior to the time they are actually needed. The existing three rail casks are adequate to perform near-term shipments.

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1.0 INTRODUCTION

Many nuclear power plants are nearing their maximum onsite spent fuel storage capacity (DOE 1984). To ensure the continued, orderly operation of these reactors, the Department of Energy (DOE) has the responsibility to provide Federal Interim Storage (FIS) capacity for those utilities that the Nuclear Regulatory Commission (NRC) determines cannot provide storage by other means. This responsibility was assigned to the DOE in the Nuclear Waste Policy Act (NWPA 1982).

This study examines the availability of light water reactor (LWR) spent fuel shipping casks when they are needed. Shipping campaigns include transshipments of spent fuel from reactors nearing their maximum spent fuel storage capacity to reactors with less-full storage basins, potential shipments to FIS, shipments of fuel from the Western New York Nuclear Service Center (West Valley) back to the originating utilities, shipments to/from the spent fuel storage facility at Morris, Illinois, and shipments to Federal Research and Development sites. These shipments must use NRC-approved shipping casks of which there are only limited numbers. For this study, "near future" is defined as lasting through the last year that DOE could accept fuel for shipment to FIS, i.e., 1992 according to the ACT. This report, prepared in support of the Commercial Spent Fuel Management (CSFM) Program, presents these analyses.

Commercial spent fuel shipping casks are available for three modes of transport; legal-weight truck, overweight truck, and rail. Some reactors have the capability to receive and handle all three modes. Many reactors, however, are not equipped to handle the larger rail casks. If a large fraction of reactors that could ship to FIS are not capable of handling rail casks, FIS transportation requirements could severely reduce the availability of the existing truck cask fleet for use in other shipping campaigns. Therefore, spent fuel cask handling capabilities can have an impact on shipping cask fleet requirements. This study factors the cask handling capabilities and limitations of reactors with near-term storage problems into a comprehensive transportation network. This allows the required number of shipping casks of each transport mode to be calculated. Cask handling capabilities and limitations were reported in a study performed concurrently with this study (Konzek and Daling 1984).

The remainder of this report is divided into 5 sections. Section 2.0 presents a summary of the results and conclusions from this study. The approach used is discussed in Section 3.0. A description of the spent fuel transportation network is presented in Section 4.0. Section 5.0 discusses the availability (fleet size) of existing spent fuel shipping casks. Spent fuel shipping cask requirements are calculated in Section 6.0. The adequacy of the existing shipping cask fleet is discussed in Section 7.0.

2.0 SUMMARY AND CONCLUSIONS

A significant increase in the transportation of irradiated fuel from commercial nuclear reactors is anticipated in the next several years. Potentially, the greatest portion of this increase could arise from shipments of spent fuel to Federal Interim Storage (FIS). The purpose of these shipments; i.e, to extend the capability of a utility to maintain full core reserve in its spent fuel storage basin, could be accomplished in many cases by transhipping spent fuel to a less full storage basin. The objective of this study was to evaluate the adequacy of the existing commercial spent fuel shipping cask fleet to meet the expected demand for transportation services. In addition, if it is determined that the existing shipping cask fleet cannot provide sufficient capabilities, this study was to recommend the specific transport modes (i.e., legal-weight truck, overweight truck, or rail) of casks that will be needed to supplement the existing fleet.

The approach to this study consisted of two phases that were performed concurrently. The first phase involved an assessment of the spent fuel shipping cask handling capabilities at reactors that project to have near-term spent fuel storage problems. The objective of this phase was to determine the shipping cask types that each of these reactors can currently receive and handle at their sites. The results from this assessment (Konzek and Daling 1984) were used to assign a preferred transport mode to these reactors. Preferred transport modes were used as input for the second phase, an analysis of the supply and demand for spent fuel shipping casks. This phase, discussed in this report, developed a range of spent fuel shipping cask fleet sizes and projected cask usage requirements through 1992. Separate shipping cask usage requirements were estimated for each transport mode. These requirements were then compared with a range of potential cask availabilities to determine, on a mode-specific basis, if sufficient numbers of commercial spent fuel shipping casks are available. Because the analysis was performed on a transport mode-specific basis, the required number of casks of each type were estimated.

The size of the existing cask fleet was determined from discussions with spent fuel shipping cask supplier companies. Due to uncertainty regarding the future availability of some shipping casks, two shipping cask supply cases were developed that bound the potential size range of the existing shipping cask fleet. Table 2.1 presents the assumed upper and lower limits of availability for the existing spent fuel shipping cask fleet. The lower shipping cask fleet case represents the current situation in the spent fuel transportation industry.

If and when new spent fuel shipping casks are added to the existing fleet, they are anticipated to be of significantly different designs than the existing fleet. This study assumed that new shipping cask designs would have approximately twice the cargo capacity of the existing designs. This difference was considered when calculating the number of new shipping casks that will be needed (in addition to the current fleet).

TABLE 2.1. Assumed Upper and Lower Limits of the Commercial Spent Fuel Shipping Cask Fleet Size

	Number of Shipping Casks	
Type of Cask [a]	Lower Limit	Upper Limit
LWT	5	10
OWT-PWR	2	2
OWT-BWR	2	2
Rail	3	5

(a) LWT = Legal Weight Truck;
OWT-PWR = Overweight Truck-Pressurized Water Reactor (PWR) version;
OWT-BWR = Overweight Truck-Boiling Water Reactor (BWR) version

A spent fuel transportation network was developed in this study to facilitate calculation of spent fuel shipping cask fleet requirements. This network was used to develop a shipping schedule that indicated origin and destination facilities for near-term spent fuel shipments as well as the amounts of fuel transported. The cask handling capability information was used as input for this portion of the study. These data were used to assign a particular shipping cask transport mode to each shipment. This allowed transport mode-specific analyses of the adequacy of the existing shipping cask fleet.

Near-term spent fuel shipping cask fleet requirements are shown in Table 2.2. Two hypothetical FIS sites, one eastern and one western, were considered, because no utility has applied for FIS as of this date. As a result, DOE has not initiated site selection activities. Shipping cask requirements were calculated for both an eastern and a western FIS site to determine upper and lower limits for future shipping cask requirements. It should be noted that utilities in some cases may be able to ship fuel to a less full storage basin within their utility system (i.e., tranship) rather than to FIS. In these cases, transportation requirements would be reduced because transshipments represent shorter shipping distances than FIS shipments.

The spent fuel shipping cask supply cases were compared with the projected demand to evaluate the adequacy of the existing shipping cask fleet. The conclusions are discussed below:

- If utilities begin large-scale applications for FIS, the existing certified LWT cask fleet size would become inadequate as early as 1987 for the case in which the FIS is located in the West, and 1989 for the eastern FIS case.

- Up to two additional LWT casks (new design) will be needed to prevent a shortage of these shipping casks through 1992 if the hypothetical FIS site is assumed to be in the West. For the hypothetical eastern FIS site, only one additional LWT cask will be required. If copies of the existing casks were built to prevent this shortage, four additional LWT casks would needed for the western FIS case, and two more for the eastern FIS case.

TABLE 2.2. Summary of Projected Annual Demand for Spent Fuel Shipping Casks; 1984 to 1992.

	NUMBER OF SHIPPING CASKS OF EACH TRANSPORT MODE NEEDED (a)							
	WESTERN FIS SITE				EASTERN FIS SITE			
YEAR	LWT	OWT-P	OWT-B	RAIL	LWT	OWT-P	OWT-B	RAIL
1984	4	1	1	1	4	1	1	1
1985	2	2	1	2	2	1	1	2
1986	5	2	0	3	4	1	0	3
1987	7	1	0	3	5	1	0	3
1988	6	2	0	1	4	1	0	1
1989	9	2	3	2	6	1	2	1
1990	9	2	3	3	7	1	2	2
1991	7	3	1	3	5	2	1	2
1992	9	3	4	2	5	2	3	2

(a) LWT = Legal-weight Truck; OWT-P = Overweight Truck-PWR version; OWT-B = Overweight Truck BWR version

- The OWT-PWR shipping cask fleet will become inadequate to perform the needed shipments in 1991. However, the shortage in later years may be avoided through judicious scheduling; i.e., OWT-PWR cask utilization may have to be increased in early years to prevent a projected shortage in 1991. This could potentially reduce the maximum annual OWT-PWR cask requirements to the level of the existing fleet.

- OWT-BWR shipping cask fleet requirements (western FIS site case) will exceed the number of existing, certified OWT-BWR casks by 1989. Up to two additional OWT-BWR casks (existing designs) are projected to be needed by 1992. Alternatively, three LWT or one OWT-BWR cask of the new designs could be brought into service instead of the two current-design OWT-BWR casks.

- Modification of LWT-only cask handling systems to accommodate OWT casks could reduce the potentially high utilization of LWT casks, particularly if the LWT casks that are not currently operational cannot be returned to service. If these modifications (such as upgrading cask handling cranes) could be made, some reactors that are currently limited to using LWT casks could choose to use the OWT casks, thus reducing the calculated LWT cask fleet requirements.

- The existing rail cask fleet was determined to be adequate under all cases considered. The three existing IF-300 rail casks will be sufficient to perform the required rail shipments.

Some additional conclusions were derived regarding the transportation requirements for the potential FIS facility. First, rail utilization is generally low for these shipments. This could have significant implications for the design and operation of the FIS receiving and handling facility. Although the FIS receiving facility should be designed for both rail and truck cask unloading, it appears that such a facility should be designed to receive a large fraction (about 75% by weight) of the spent fuel by truck (LWT plus OWT). Secondly, if utilities begin large-scale applications for FIS, transportation requirements for the FIS alone may exceed the existing shipping cask fleet size. This conclusion depends upon the number of utility applications for FIS and on NRC concurrence that the utilities are eligible.

The final conclusion related to FIS concerns the siting of the storage facility. Total shipping distances were approximated for both an eastern and a western FIS site. It was determined that selection of the eastern site could reduce the total distance traveled by about a factor of three. The shorter distance is due to the majority of the nuclear power plants being located in the East. Therefore, transportation cask requirements could be significantly reduced if an eastern site is selected for the FIS.

The primary purpose of this document is as a planning and decision-making tool. In order for it to be used in this manner, the effects of varying the assumptions are important. Table 2.3 presents a qualitative summary of the effects of changing various assumptions relative to a base case. The base case selected for comparison purposes was the case in which the FIS facility is located at a hypothetical western site. Table 2.3 shows the effects (increase, decrease, or no effect) on the numbers of additional casks that are needed in the near-term.

As shown on Table 2.3, most changes of the assumptions result in a reduction of the number of additional shipping casks needed. The only assumption that will increase the number of additional LWT casks needed is the one in which OWT casks are excluded from performing shipments to FIS. No changes were found to increase the need for additional OWT casks. No effect was determined for excluding the existing casks from performing the shipments of the damaged TMI core. Most changes of the assumptions had no effect on the number of additional rail casks needed. This was because most changes resulted in a decrease of rail utilization and since the existing rail fleet was found to be adequate, the net effect was that no additional rail casks were needed.

TABLE 2.3. Qualitative Effect On the Need for Additional Shipping Casks of Changing Various Assumptions

Assumption	Effect on Numbers of Additional Shipping Casks Needed[a][b] LWT	OWT	RAIL
Base Case[c]	4	1/2[d]	0
Use hypothetical Eastern FIS site	↓	↓	—
Use future cask capabilities	↓	↓	—
Transship to minimum possible extent	↓	↓	—
Use rail (intermodal) to maximum extent	↓	↓	↑
Loading level	↓	↓	—
Exclude OWT shipments from FIS	↑	↓	—
Exclude TMI shipments	—	—	—

(a) LWT = Legal-Weight Truck; OWT = Overweight Truck
(b) Symbols are defined as follows: (↑) = The effect of changing the assumption is an increase in the number of additional shipping casks needed; (↓) = A decrease in the number of additional shipping casks needed; (—) = No effect on the number of additional shipping casks needed. If the (—) is shown, cask utilization may increase or decrease slightly but the number of additional casks needed is not expected to change.
(c) The base case assumes a hypothetical western site for the FIS; see Table 6.4 for shipping cask requirements.
(d) One PWR version and two additional BWR versions are needed.

3.0 OBJECTIVES AND APPROACH

Spent fuel transportation services will be required for a number of utility and DOE controlled shipments. DOE and utility needs for available shipping casks should not conflict with each other. This study was performed to determine if adequate quantities of each type of shipping cask will be available when needed.

The overall objective of this study was to evaluate the adequacy of the existing commercial LWR spent fuel shipping cask fleet to perform needed near-term spent fuel shipments. This objective can be determined by evaluating the following questions:

- Are there sufficient numbers of NRC-certified spent fuel shipping casks to perform the projected number of DOE and utility shipments in the near-term?

- How many new shipping casks and of which type (i.e., legal-weight truck, overweight truck, or rail) should be built, and when?

The existing commercial shipping cask fleet includes casks designed for three different transport modes; legal-weight truck (LWT), overweight truck (OWT), and rail. Essentially all reactors are capable of receiving and handling LWT casks. However, some plants are incapable of receiving and handling the larger and heavier rail casks. This is due to either ex-plant conditions, such as lack of a rail spur, or in-plant conditions, such as a cask loading pool with inadequate clearance. This could cause an excess of demand for LWT casks over the supply represented by the existing fleet. Consequently, the adequacy of the existing spent fuel shipping cask fleet depends to a large extent upon the cask handling capabilities and limitations of reactors.

A two-phase approach was used in this study. Phase 1 consisted of a cask handling capability assessment of reactors that could potentially ship fuel to FIS. The results of the Phase 1 cask handling assessment (performed concurrently with this study) are contained in a separate report (Konzek and

Daling). Phase 2 uses the results from Phase 1 to calculate shipping cask requirements. This report contains the results of Phase 2. The approach is illustrated in Figure 3.1. Further details concerning the approach are discussed below.

The first phase of this study consisted of an evaluation of the spent fuel shipping cask handling capabilities for reactors that are potential users of FIS capability. The purpose of Phase 1 was to determine which commercial nuclear power plants are limited to specific transport modes of spent fuel shipping casks. This assessment included only those reactors that have potential near-term spent fuel storage problems, as determined from DOE/RL-83-1 (DOE 1983). The utilities that own these reactors are currently attempting to solve their spent fuel storage problems, which may require the use of the existing spent fuel shipping casks. The cask handling capability information is incorporated into a spent fuel transportation network that is developed in Phase 2. Information in the open literature was also used to identify specific shipping casks for utility shipping campaigns for which this information has been announced.

The second phase of the analysis, discussed in this report, consisted of a spent fuel shipping cask supply-demand analysis. The objective of this analysis was to determine if sufficient shipping casks exist to provide the needed near-term transportation services. This analysis was comprised of two parts; 1) determining the availability of the existing shipping cask fleet, and 2) calculating shipping cask requirements. The availability of the existing fleet was determined in this study through discussions with spent fuel shipping cask supplier companies. This represents the "supply" of shipping casks. Due to uncertainty in future availability of NRC-approved spent fuel shipping casks, two cask supply cases were developed that represent lower and upper limits of cask availability. These data were compared with calculated cask usage requirements to determine the adequacy of the existing fleet.

Shipments of spent fuel to FIS represent the greatest potential near-term demand for spent fuel transportation casks, and thus particular attention was

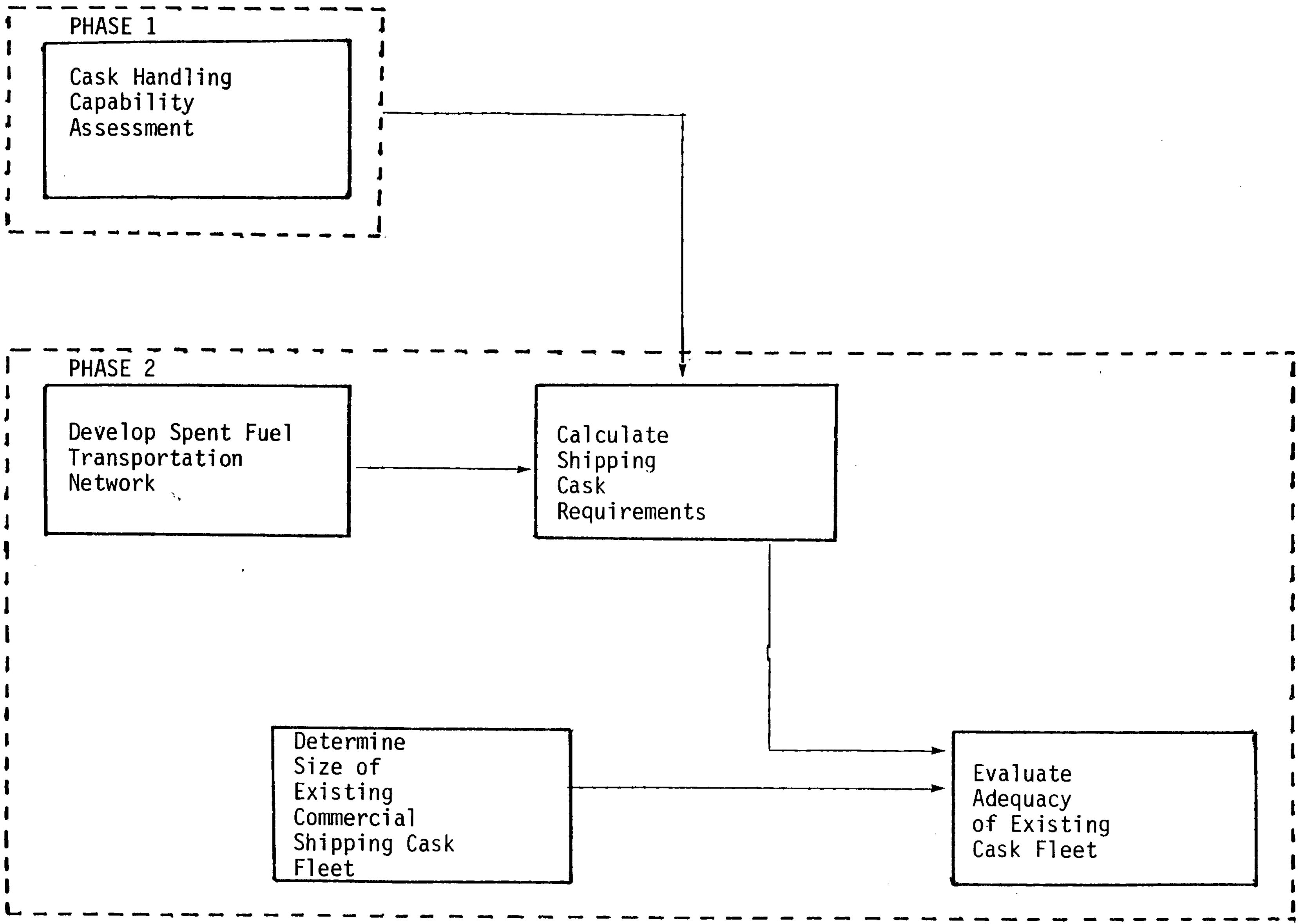

Figure 3.1 Illustration of Approach used in this study

paid to calculating FIS transportation requirements. FIS transportation requirements were calculated for two hypothetical locations; one in the eastern U.S. and one in the western U.S. Transportation requirements for both assumed sites, including approximate total highway and rail distances for all shipments, cask usage requirements, and numbers of casks needed for FIS, were examined. Since most reactors are located in the East and are nearer to the eastern site than the western site, the calculated transportation requirements represent upper (western FIS site) and lower (eastern FIS site) limits.

The calculation of shipping cask requirements was facilitated by the development of a spent fuel transportation network. The network included information on the potential origins and destinations of shipments, the type of cask to be used, and the number and type of fuel assemblies planned to be shipped. This information was used to develop a shipping schedule. The shipping schedule illustrated the "demand" for spent fuel shipping casks and formed the baseline for calculating cask requirements. Results of the cask handling capability assessment were incorporated into the transportation network and used to assign a specific type or mode of cask (i.e. LWT, OWT, or rail) to each shipment. For example, if the cask loading pool at a particular reactor is too small to accommodate a large rail cask, this reactor can only consider legal- or overweight truck shipping casks.

The method used to calculate shipping cask requirements consisted of three series of calculations; one series for rail cask requirements, one for LWT, and one for OWT. A key assumption was that those reactors capable of receiving and handling a large rail cask were given highest priority for their use. This was done because essentially all reactors can use LWT casks. The assumption results in rail transportation capability being used where possible. If rail cask availability is exhausted in any given year, those reactors capable of shipping by rail could revert to using LWT or OWT casks to complete their specified shipments. The opposite is not necessarily true; i.e., if LWT cask availability is exhausted first, it is possible that some plants without rail capability would be unable to complete their scheduled shipments even though an excess of rail capability might be projected. As a result, this study assumed an "optimum" shipping schedule based on the cask handling capabilities assessment.

Shipping cask requirements were calculated based on the number of cask-days per year that are required for each transport mode. The following formula was used to calculate the number of cask-days per year required to complete each shipping campaign:

$$\text{Cask-days per year} = [\ (DIST / VEL) + TT\ ] \times [\ NAS / CAP\ ] \qquad [1]$$

where DIST = Round-trip shipping distance (km)
VEL = Average transit speed (km/day)
TT = Turnaround time (days)
NAS = Number of assemblies to be shipped (annual basis)
CAP = Shipping cask capacity (assemblies per shipment)

The first term in brackets calculates the shipment duration in units of days per shipment. The second term calculates the number of shipments per year. These two terms are then multiplied to determine the number of cask-days per year for each shipping campaign. Calculations are performed separately for LWT, OWT, and rail casks to determine, on an annual basis, the expected cask usages for each transport mode. The number of casks of each type needed in any given year was determined by dividing the calculated cask usages (cask-days/year) by a 300 day per year maximum cask availability factor (Wilmot et al. 1983). The result was rounded to the next highest whole number to eliminate fractions of shipping casks. By calculating truck and rail cask requirements separately, the number and types of new shipping casks needed could be determined.

Some of the values for the variables in equation 1 (i.e., DIST, NAS, and CAP) will be presented in Section 4.0, in which each of the potential shipping campaigns are discussed. The remaining variables are identical in all calculations, and are discussed below.

LWT shipments were assumed to travel at an average speed of 1340 km/day (840 mi/day; Wilmot et al. 1983). OWT shipments must allow for time of day restrictions in some states and thus travel at lower average speeds. An average speed of 900 km/day (560 mi/day) was assumed. Both LWT and OWT shipments were assumed to include a two person driver/escort team and travel 24 hours per day. Although OWT shipments do not typically travel 24 hours per day, time of day restrictions were accounted for in the aforementioned average daily speed.

Average rail transit speeds were obtained from a recent report by Wilmot et al. (1983). The average speed used on this analysis was 19 km/hr (12 mph).

In addition to the travel time, the total duration of each round-trip shipment includes the time for loading fuel into the casks at the shipment origin and for unloading at the destination facility. According to Wilmot et al. (1983), a total loading plus unloading time is assumed to be five days for rail shipments and three days for truck shipments (includes both LWT and OWT shipments).

As mentioned previously, additional calculations were performed to determine detailed transportation requirements for two assumed FIS sites. Shipping cask usage requirements were estimated as well as total transport distances. Total transport distance refers to the total number of miles that spent fuel shipments will travel when delivering fuel to FIS. This distance was estimated by multiplying approximate round-trip shipping distances times the number of shipments from each reactor in each year and then summing the annual transport distances for all reactors. Total transport distances could then be compared between the two assumed sites.

4.0 NEAR-TERM SPENT FUEL TRANSPORTATION NETWORK

This section describes the near-term spent fuel transportation network. This network includes information on the locations of potential origin and destination facilities and the number and type (BWR or PWR) of fuel assemblies that are planned to be shipped. The following list of spent fuel shipments was used to develop the spent fuel transportation network:

- Transshipments
- Return of fuel from the former reprocessing plant at West Valley, New York to the originating nuclear power stations
- Shipment of the damaged core from the Three Mile Island Nuclear Power Station to the Idaho National Engineering Laboratory (INEL/)[a]
- Shipments from nuclear power stations with near-term storage problems to a FIS facility
- Shipments in support of spent fuel research and development programs
- Shipments from an unspecified nuclear power station to the proposed Test and Evaluation Facility.

The overall transportation network developed in this study is illustrated in Figure 4.1.

Specific spent fuel shipping casks have been designated for some shipping campaigns (further information regarding the existing shipping casks are presented in Section 5.0). This information was incorporated into the spent fuel transportation network, where appropriate. A cask transport mode was assigned for those shipping campaigns in which no specific shipping cask has been selected. The following subsections provide specific details, including start and end dates, numbers of fuel assemblies to be shipped, and type or transport mode of shipping cask to be used, on the shipping campaigns listed previously.

(a) Special rail casks are currently being designed to transport the damaged TMI core. However, inclusion of these shipments does not affect the conclusions derived in this study.

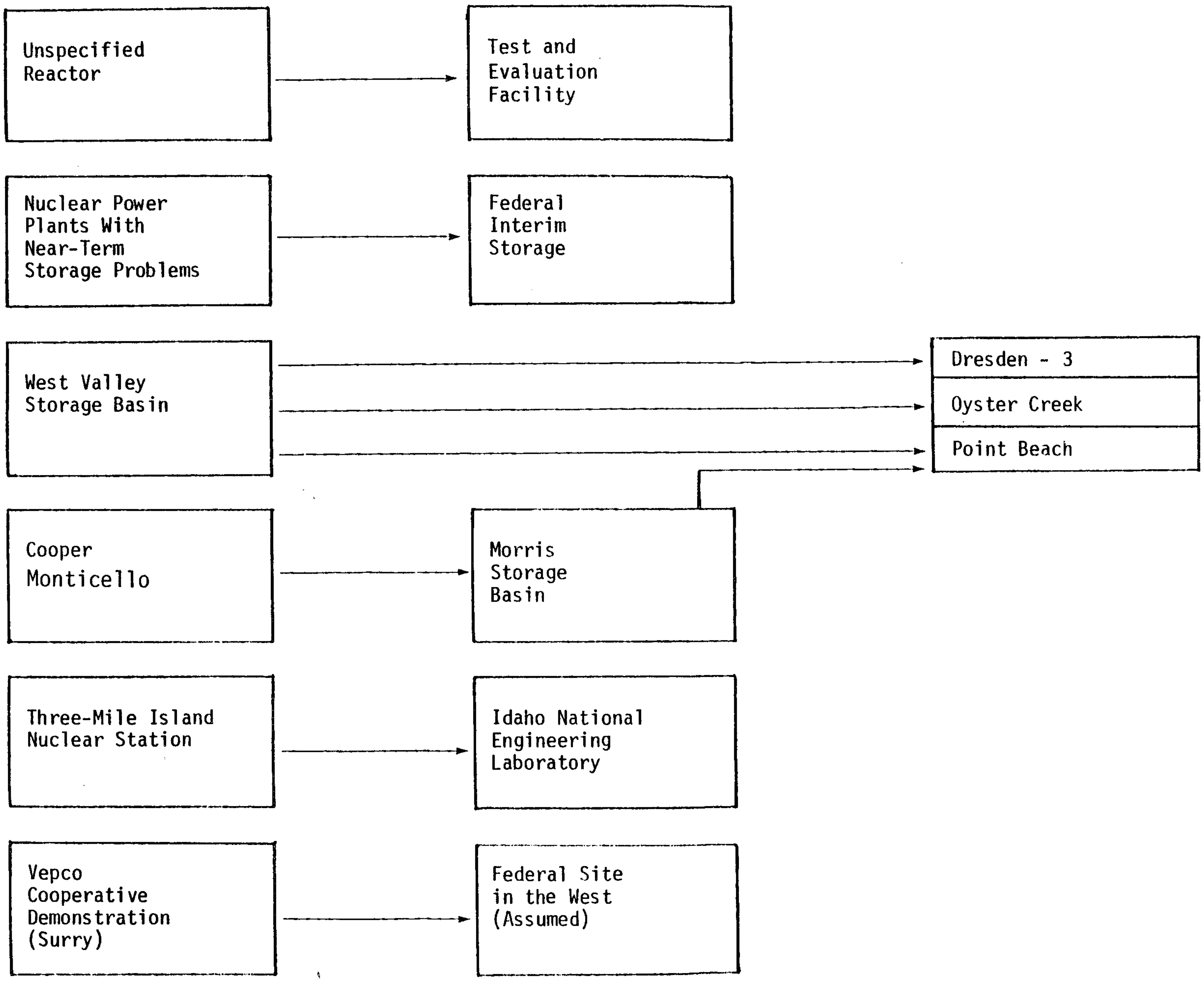

FIGURE 4.1. Overall Near-Term Spent Fuel Transportation Network

4.1 TRANSSHIPMENTS

Transshipments can be defined as spent fuel shipments between separate spent fuel storage basins. Two types of transshipments are expected to occur over the next decade. The first type includes transshipments from reactors to the storage basin at the former Midwest Fuel Reprocessing Plant at Morris, Illinois (Morris). Some fuel that has been in storage at Morris is also being returned to the original utilities. The second type of transshipment occurs between reactors owned by the same utility (intrautility transshipment). Typically, these shipments involve moving fuel between storage basins on the same site. Although many multiple-unit power stations (one site with more than one reactor) have interconnected or shared storage pools, some have completely separate (unconnected) pools for each unit at a site. Some intrautility transshipments may also occur between different sites. Transshipments between non-connected pools require a spent fuel shipping cask.

Three spent fuel shipping campaigns are currently scheduled involving the Morris facility. Spent fuel from the Cooper nuclear station is planned to be shipped to Morris beginning in May, 1984. The G.E. IF-300 rail cask will be used to make 59 shipments between Cooper and Morris (Nucleonics Week 1983a). This campaign will use two IF-300's and should be completed in 1985. The second campaign will consist of 109 shipments from Morris to the Point Beach nuclear station (Nucleonics Week 1983a). These shipments have already begun and are estimated to be approximately 80% complete (Ingels 1984). They are anticipated to be completed prior to the end of 1984. One NLI-1/2 truck cask is being used for these shipments. The third shipping campaign involving the Morris facility consists of shipping a total of 1058 BWR assemblies from the Monticello nuclear power plant (Nuclear Fuel 1984b). The utility has selected the IF-300 rail cask for the shipments and is planning to begin shipping in late 1984. The shipments are assumed to be completed by the end of 1986.

Some utilities that operate multiple-unit power stations are considering transshipments between units to allow more efficient use of available storage capacity. A literature review supplemented by the utility responses to the 1983 data collection activities for the CSFM Program's spent fuel data base was used to develop intrautility transshipment data. Multiple-unit reactors that are not provided with interconnected or shared pools were identified by reviewing data from DOE's 1984 Spent Fuel Storage Requirements Report (DOE 1984). These power stations are assumed to be candidates for intrautility transshipments.

The quantities of spent fuel that are anticipated to be transshipped were determined based on data from DOE documents (DOE 1983a and 1984). Current pool inventories and annual discharge data were used to determine the quantities of fuel to be transshipped to maintain at least one full core reserve at a multiple-unit station. These transshipments were assumed to occur in the year preceeding loss of full core reserve unless utilities specified otherwise.

Five nuclear power stations were identified as potential candidates for intrautility transshipments: San Onofre, Oconee, Brunswick, Millstone, and Surry. Shipping details are presented in Table 4.1 for these shipments and for the Morris shipments. The assumptions used to determine the shipping quantities and other intrautility transshipment details are discussed below.

The Oconee shipments are listed in the utility-supplied data were used as input to the spent fuel data base. These shipments are assumed in this study to occur according to the utility's plans. The Brunswick transshipments are also listed in the spent fuel data base. However, these transshipments are assumed to not affect the existing commercial cask fleet because Carolina Power and Light, the plant's owner, has its own IF-300 rail cask and is assumed to use it for the shipments. The other four plants must use shipping casks from the existing fleet to perform their shipments.

A representative from Northeast Utilities Service co. (NUSCO) recently indicated they are considering transshipping fuel from Millstone-1 and 2 to Millstone-3 to maintain full core reserve (Bishop 1984). The amount of spent fuel assumed to be transshipped is based on their storage requirements in DOE (1984). In addition, NUSCO is currently negotiating a cooperative agreement with DOE to demonstrate consolidation of an entire storage pool. Consolidation refers to disassembling fuel elements and placing fuel rods into canisters in a more compact array. This demonstration will ultimately solve the storage problem at Millstone-2. The demonstration is planned to be completed in 1989. However, some fuel may have to be shipped to Millstone-3 in the early years of the demonstration to maintain full core reserve at Unit-2. No fuel is assumed to be shipped from Millstone-2 after that date. It is further assumed that NUSCO will apply for and construct BWR storage racks in the Millstone-3 PWR storage pool to accommodate the Unit-1 BWR fuel. The storage requirements for Unit-1 are assumed to be unaffected by the demonstration. It is assumed this plant will transship to Unit-3 to maintain it's full core reserve.

VEPCO recently completed negotiation of a cooperative agreement with DOE to demonstrate dry cask storage. This demonstration will involve spent fuel from the Surry nuclear power station. The demonstration will be conducted both at a Federal site involving up to about 144 fuel assemblies and at Surry involving about 120 fuel assemblies. The details of the off-site shipments of spent fuel to the Federal site are presented in Section 4.5. The on-site demonstration is not anticipated to involve any of the existing shipping casks. However, it does impact the storage requirements presented in DOE (1984). VEPCO has previously applied for NRC approval to transship and store Surry fuel in the North Anna storage pool. It is assumed that VEPCO will perform transshipments to maintain full core reserve at Surry. The storage requirements for Surry in DOE (1984) did not consider the 120 assemblies that will be used in the at-reactor demonstration. The amounts anticipated to be transshipped are calculated by subtracting these 120 assemblies from the storage requirements in DOE (1984). This delays the start date of the transshipments by one year.

TABLE 4.1 Transshipment Data

Year(s)	Origin Facility	Destination Facility	Type of Fuel	Number of Assemblies[a]	Source
1984, 85	Cooper	Morris	BWR	1062	b
1984, 85	Morris	Point Beach	PWR	109	b
1984	Monticello	Morris	BWR	54[c]	d
1985	Oconee-1	Oconee-3	PWR	60	e
1985	Oconee-2	Oconee-3	PWR	140	e
1985	Monticello	Morris	BWR	486	d
1986	Oconee-1	Oconee-3	PWR	140	e
1986	Oconee-2	Oconee-3	PWR	60	e
1986	Millstone-2	Millstone-3	PWR	133	f
1986	Millstone-1	Millstone-3	BWR	132	f
1986	Monticello	Morris	BWR	518	d
1987	Surry-1,2	North Anna	PWR	97	g
1987	Millstone-2	Millstone-3	PWR	81	f
1988	Millstone-1	Millstone-3	BWR	200	f
1988	Surry-1,2	North Anna	PWR	61	g
1989	Millstone-2	Millstone-3	PWR	81	f
1989	San Onofre-1	San Onofre-2	PWR	35	h
1989	Surry-1,2	North Anna	PWR	60	g
1990	Millstone-2	Millstone-3	PWR	77	f
1990	Surry-1,2	North Anna	PWR	121	g
1991	San Onofre-1	San Onofre-2	PWR	53	h
1991	Surry-1,2	North Anna	PWR	61	g
1991	Millstone-2	Millstone-3	PWR	73	f
1992	Surry-1,2	North Anna	PWR	60	g

(a) See text for specific shipping casks that will be used.
(b) From Nucleonics Week (1983a).
(c) Annual shipping quantities for Monticello shipments are assumed to be as follows: 1984-one special train shipment of three loaded IF-300 shipping casks; 1985-nine special train shipments; and 1986-ten special train shipments.
(d) Source for total number of fuel assemblies to be shipped was Nuclear Fuel 1984b.
(e) Shipping records supplied by utility for the spent fuel data base. See also DOE (1984).
(f) Calculated from pool inventories and discharge data in DOE (1984). Account is taken for the planned NUSCO rod consolidation demonstration.
(g) Number of assemblies was calculated by subtracting 120 assemblies planned for use in the VEPCO/DOE Demonstration at Surry site from data in DOE (1984).
(h) Southern California Edison staff indicate that all three units will share storage space. One full core reserve will be maintained for the largest core at the site (217 assemblies). Timing and quantities of fuel to be transported are based on data in DOE (1983) and DOE (1984).

4.2. RETURN OF FUEL CURRENTLY IN STORAGE AT WEST VALLEY

In June, 1983, a Federal court order was handed down that requires removal of spent fuel from the storage pool at the former Western New York Nuclear Service Center at West Valley, New York (Nucleonics Week 1983b). This court order resulted from a law suit brought by the New York State Energy Research and Development Authority (NYSERDA) against Nuclear Fuels Services, Inc. (NFS) (the former plant operator) and three utilities who own the spent fuel (GPU Nuclear Corp., Commonwealth Edison Co., and Wisconsin Electric Power Co.). A fourth utility (Rochester Gas and Electric Co.) also owns fuel at West Valley but was not named in the suit because NYSERDA cannot sue a New York corporation in Federal court (Nucleonics Week 1983b). There is a total of 515 BWR and 235 PWR assemblies currently at West Valley, totaling approximately 169 MTU. Of these, NFS owns 40 PWR and 85 BWR assemblies. The NFS-owned spent fuel is to be shipped to the Idaho National Engineering Laboratory (INEL) in a dual-purpose transport/storage cask demonstration under a cost-sharing agreement with DOE. Shipment of this fuel will not affect the availability of the existing cask fleet. However, the remaining fuel assemblies will be transported using the existing cask fleet.

The four nuclear power stations that will be receiving fuel back from West Valley include Oyster Creek, Dresden-3, Point Beach-1 and 2, and Ginna. Shipments to Point Beach and Dresden-3 began in late 1983 using the NLI-1/2 and TN-9 shipping casks, respectively. The shipments to Dresden-3, which are using a utility-owned cask, were temporarily interrupted due to an "incident" during the first shipment (a trailer uncoupled from the truck tractor, but did not overturn) (Nuclear News 1984a). The shipping campaign was resumed after the utility took steps to improve the locking connections on the truck (Nuclear News 1984b). The Point Beach shipments have occurred without incident.

Table 4.2 contains the shipping information regarding the West Valley shipments. The Table includes the type of shipping cask that is being or will be used and identifies starting and ending dates for the shipping campaigns. The bulk of the information was obtained from Teer (1984) and Nucleonics Week (1983b).

TABLE 4.2 . Details of Shipments from West Valley[a]

Years	Destination Facility	Type of Fuel	Number of Assemblies	Type of Cask[b]
1984,85	Oyster Creek	BWR	224	TN-9(2)
1984	Dresden-3	BWR	206	TN-9(1)[c]
1984,85	Ginna	PWR	81	(d)
1984	Point Beach-1	PWR	104	NLI-1/2(3)

a. Sources: Teer (1984) and Nucleonics Week 1983.

b. Numbers in parentheses indicate the numbers of casks being used.

c. The cask being used is owned by Commonwealth Edison.

d. Specific cask to be used is not known at this time. However, it is assumed that Ginna can only handle a LWT cask.

4.3 THREE MILE ISLAND DAMAGED CORE SHIPMENTS

The damaged core from the Three Mile Island (TMI) nuclear station is to be shipped to INEL for examination and storage. McLaughlin (1983) estimates that approximately 250 canisters of intact fuel assemblies, fuel assembly stubs, rubble, and core debris will be required to ship the entire core. The initial shipments were projected by McLaughlin to be received in the last quarter of Fiscal Year-1984. However, the TMI cleanup effort has suffered some delays. Removal of the damaged core is not expected to begin until 1986 (Nuclear Fuel 1984a). The shipments are assumed to be completed in late calender-year 1987 based on the scheduled completion of the overall TMI cleanup effort in mid-1988 (Kalman and Weller 1984). One-half of the shipments are assumed to be made in each year. TMI is assumed to be provided with rail capability based on their Final Safety Analysis Report. To date, no spent fuel shipments have been performed at TMI.

4.4 FEDERAL INTERIM STORAGE

The DOE has the responsibility to provide FIS capacity for spent fuel that the NRC determines the utilities cannot store despite their best efforts (Newman and Cole 1984). The CSFM Program's spent fuel data base (DOE 1984) provides estimates of the storage requirements that utilities will have in excess of their maximum projected storage capacities. The spent fuel that could potentially be shipped to FIS is listed in Table A.5 of DOE (1984). This table is reproduced as Table 4.3 of this report. These data provide the source terms for calculating FIS transportation requirements.

The storage requirements represent the amounts of fuel that will be discharged from the reactors that is in excess of their maximum projected storage capacities. New technologies such as dry storage and rod consolidation may be available in time to relieve many of the utilities' storage problems. However, for this study, these technologies were assumed not to be implemented until after 1993.

The NWPA identifies a period of eligibility for utilities to apply for FIS. The data in Table 4.3 include all eligible nuclear power plants and the amounts of fuel that are eligible, subject to NRC approval. Thus, Table 4.3 represents the maximum quantities of spent fuel that could be shipped to FIS. However, these data do not consider all of the potential transshipments discussed in section 4.1. The table must be modified to reflect the changes in spent fuel storage requirements that result from these transshipments. The shipments to/from Morris and from West Valley are already included in the table.

To date, no site has been selected for a FIS facility. For this study, two sites were assumed; one in the Eastern U.S. and one in the Western U.S. The eastern FIS establishes a lower bound for the FIS transportation requirements because most nuclear power plants are located in the East. This tends to

TABLE 4.3. Spent Fuel Storage Requirements: Potential Users of Federal Interim Storage (DOE 1984)

REACTOR	ASSEMBLIES									
	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
Millstone-2	0	3	57	73	81	0	81	77	73	0
Turkey Point-3	0	0	9	0	68	52	0	68	52	0
Palisades	0	0	0	19	68	0	68	68	0	68
Oconee-3	0	0	0	12	0	68	68	0	68	0
Turkey Point-4	0	0	0	31	64	0	64	64	0	64
St Lucie-1	0	0	0	21	0	88	76	0	88	76
Millstone-1*	0	0	0	132	0	200	0	200	0	200
Surry-1	0	0	0	0	0	90	61	0	60	61
Surry-2	0	0	0	0	60	61	0	60	61	0
Prairie Island-1	0	0	0	0	0	5	40	40	40	40
Prairie Island-2	0	0	0	0	0	0	40	40	40	40
Robinson-2	0	0	0	0	0	0	43	52	52	52
Brunswick-2*	0	0	0	0	0	0	179	0	180	180
La Salle-1*	0	0	0	0	0	0	220	232	0	224
La Salle-2*	0	0	0	0	0	0	13	232	0	224
La Crosse	0	0	0	0	0	0	64	24	0	0
Oconee-2	0	0	0	0	0	0	0	0	68	68
Oconee-1	0	0	0	0	0	0	3	64	0	64
Monticello*	0	0	0	0	0	0	206	104	104	0
Peach Bottom-2*	0	0	0	0	0	0	196	256	0	256
Peach Bottom-3*	0	0	0	0	0	0	26	256	0	256
Ginna	0	0	0	0	0	0	0	28	28	28
Pilgrim-1*	0	0	0	0	0	0	0	32	0	192
Brunswick-1*	0	0	0	0	0	0	0	179	180	0
Fitzpatrick*	0	0	0	0	0	0	0	132	200	0
Calvert Cliffs-1	0	0	0	0	0	0	0	0	45	0
Calvert Cliffs-2	0	0	0	0	0	0	0	0	0	72
Oyster Creek*	0	0	0	0	0	0	0	0	136	0
Arkansas Nucl One-1	0	0	0	0	0	0	0	0	0	1
Indian Point-2	0	0	0	0	0	0	0	0	0	21
Cooper*	0	0	0	0	0	0	0	0	0	82
Sequoyah-2	0	0	0	0	0	0	0	0	0	67
Davis-Besse-1	0	0	0	0	0	0	0	0	0	31

* Asterisk denotes BWRs; all others are PWRs

minimize shipping distances and reduce cask requirements. The second case assumes a western FIS which represents an upper bound for FIS transportation requirements. It should be noted that these are hypothetical cases used only to establish minimum and maximum FIS shipping requirements.

Estimated shipping distances between reactors that could potentially ship to FIS and the assumed FIS locations are presented in Table 4.4 (DOE 1983b). The distances shown are for truck shipments. Rail shipping distances are calculated by increasing the truck distances by 10%. This factor accounts for the less direct rail routes. Also presented in Table 4.4 are the cask handling capabilities and limitations of reactors that are potential users of FIS. The table shows the specific transport modes of shipping casks that this group nuclear power plant may receive and handle. It should be noted that the cask capabilities and limitations represent the current situation at the plants and are subject to change as utilities begin to make detailed plans for shipping spent fuel offsite.

4.5 SHIPMENTS IN SUPPORT OF FEDERAL RESEARCH AND DEVELOPMENT PROGRAMS

There are currently two major spent fuel shipping campaigns planned in support of Federal research and development (R&D) programs. These shipments will involve the existing commercial shipping cask fleet. The two R&D programs are the VEPCO/DOE dry storage cask demonstration and a shipping campaign involving the spent fuel used in the Climax tests at EMAD on the Nevada Test Site. It is likely that additional R&D programs in the future may require the use of the existing cask fleet. However, these shipments are anticipated to involve only a few assemblies at a time and thus are assumed to not significantly increase the demand for shipping casks.

In March, 1984, DOE signed a cooperative agreement with VEPCO to demonstrate dry storage concepts for PWR spent fuel. The program will involve the testing of four metal storage casks at a Federal site as well as a licensed

TABLE 4.4. One-way Shipping Distances to Assumed FIS Locations[a]

Shipment Origin	Approximate Distance (km) Eastern	Western
Millstone	1600	3600
Turkey Point	1500	4300
Palisades	900	2400
Oconee	500	3300
St. Lucie	1300	4100
Surry	900	3300
Prairie Island	1500	1700
Robinson	600	3400
Brunswick	800	3600
LaSalle	900	2200
Monticello	1600	1700
Peach Bottom	1100	3200
Ginna	1500	3300
Pilgrim	1700	3700
Fitzpatrick	1500	3400
Calvert Cliffs	1000	3200
Oyster Creek	1300	3500

(a) Based on data in DOE (1983b).

demonstration with five metal casks at VEPCO's Surry power station. The Federal site program will require that spent fuel be shipped from Surry to a Federal site. The specific site has not been selected. The Surry program will be conducted at the reactor site and will not require the use of existing shipping casks.

For the Federal site program, VEPCO will ship up to about 144 PWR fuel assemblies to a Federal site, assumed to be located in the West. For this study, the shipping distance shown on Table 4.4 will be used. Due to this long shipping distance, this is considered to be a conservative assumption. VEPCO has indicated they will use two TN-8L (OWT) shipping casks to perform these shipments. The at-Federal-site demonstration will involve two phases; the first will require 96 assemblies (storage of intact fuel) and an additional 48 assemblies will be needed for the second phase (consolidated fuel storage). The initial shipments are scheduled to occur in late 1984 and continue through 1985. The additional assemblies for the second phase are assumed to be shipped to the Federal site in 1986.

The second shipping campaign in support of Federal R&D programs involves the spent fuel from the Climax tests at EMAD. These assemblies have been placed in deep and surface drywells, a silo, and an air-cooled vault during dry storage demonstrations. A total of 17 PWR spent fuel assemblies were used in the Climax tests. These assemblies are assumed to be shipped to the western site in 1986. The estimated shipping distance is about 1600 km (1000 miles). It is assumed that a LWT cask will be used because EMAD is not provided with direct rail access. This does not preclude use of a rail cask that is capable of being transported short distances in a heavy-haul truck configuration.

4.6 SHIPMENTS TO A TEST AND EVALUATION FACILITY

The NWPA contains provisions for siting and construction of a Test and Evaluation (T&E) facility. This facility, if constructed, would be an underground repository research and development facility. The T&E facility would be used for the collection of data related to the safe handling and disposal of radioactive wastes. Construction of the T&E facility would require authorization by Congress. No decision has yet been made whether such a facility should be constructed. However, for conservatism, it was assumed that a T&E facility would be included in the spent fuel transportation network.

Some provisions of the NWPA help to define the transportation requirements for the T&E facility. Section 217(a) indicates that the capacity of the facility is limited to no more than 100 canisters of high-level waste or spent fuel. Under Section 217(c), operation of the facility must begin no later than 88 months after enactment of the NWPA. This means the T&E facility should begin conducting insitu tests with these materials in about May, 1990. These provisions form the basis for the following assumptions regarding the potential T&E facility:

- 100 PWR spent fuel assemblies are assumed to be shipped to the T&E facility from an unspecified reactor located 4000 km (2500 miles) from the T&E facility.
- These shipments are assumed to begin in late 1989 and will be completed in early 1990.
- Since the T&E facility is planned to collect data on safe handling as well as safe disposal of wastes, both truck and rail versions of spent fuel shipping cask are assumed to be used. It is further assumed that one-half of the assemblies will be transported in rail casks and one-half in truck casks.

4.7 ASSIGNMENT OF SPECIFIC TRANSPORT MODES TO NEAR-TERM SHIPMENTS

As mentioned previously, the spent fuel transportation network includes the type of shipping cask that will be used in near-term spent fuel shipments. The results of a concurrent study that analyzed the spent fuel shipping cask handling capabilities and limitations of reactors that are potential users of FIS capability (Konzek and Daling 1984) were incorporated into the transportation network. The results are summarized in Table 4.5. This table shows the cask types that can be received and loaded at reactors that are assumed to perform spent fuel shipments in the near future. All of the reactors mentioned in Sections 4.1 through 4.6 are listed on Table 4.5. Some shipping cask assignments were made based on information in the literature. These are noted on the table.

TABLE 4.5. Assignment of Specific Transport Modes to Reactors That are Performing Near-Term Spent Fuel Shipments

Plant Name	Shipping Cask Handling Capability[a] LWT	OWT	Rail
Brunswick 1,2	X	X	X
Calvert Cliffs 1,2	X	X	
Cooper	X	X	X[b]
Davis-Besse	X[c]		
Dresden 2,3	X	X[d]	
Fitzpatrick	X	X	X
Indian Point 2	X[c]		
La Crosse	X		
La Salle 1,2	X	X	?[e]
Millstone 1,2,3	X		[f]
Monticello	X	X	X
Oconee 1,2,3	X	X	
Oyster Creek	X	X	
Palisades	X		
Peach Bottom 2,3	X	X	
Pilgrim	X	X	
Point Beach	X[d]		
Prairie Island 1,2	X	X	X
Robinson 2	X	X	X
San Onofre 1,2,3	X[c]		
Sequoyah 2	X[c]		
St. Lucie 1	X		
Surry 1,2	X	X	
Turkey Point 3,4	X		

(a) Source: Konzek and Daling (1984) unless stated otherwise. LWT = Legal weight truck; OWT = Overweight truck.
(b) Data was not collected for Cooper; however, Cooper is using rail casks to make the shipments to Morris.
(c) Insufficient data was received to assign specific shipping cask transport modes to these reactors. It was conservatively assumed that these reactors are limited to LWT shipments.
(d) Point Beach is currently using the NLI-1/2 and Dresden is using the TN-9 (Teer 1984).
(e) Insufficient data was received in time to determine if La Salle can handle the rail casks. It was assumed that La Salle is capable of receiving and handling the OWT cask that is owned by the utility.
(f) Insufficient data was obtained to evaluate Millstone. It is conservatively assumed that Millstone can handle only LWT casks separate.

5.0 COMMERCIAL SPENT FUEL SHIPPING CASK AVAILABILITY

This section presents information on the size of the existing commercial spent fuel shipping cask fleet. Some of the existing casks are currently not in service for reasons that will be discussed later. Consequently, uncertainty exists regarding the number of existing shipping casks that will be available to perform the required shipments. To account for this, two shipping cask supply cases were developed that represent upper and lower limits of shipping cask availability. Also presented are assumptions related to designs of new shipping cask systems that are assumed to be added to the existing fleet if the demand exceeds the supply in any given year.

5.1 EXISTING COMMERCIAL SHIPPING CASK FLEET

The number of existing commercial spent fuel shipping casks was determined through discussions with supplier companies. The companies currently providing spent fuel transportation casks are:

- Nuclear Assurance Corp. (NAC)
- Transnuclear, Inc. (TN)
- General Electric Company (GE).

The existing fleet can be separated into three types of casks: legal-weight truck (LWT), overweight truck (OWT) and rail casks. LWT casks are those which can be transported at a gross vehicle weight (GVW)[a] less than 36,400 kg (80,000 lbs.). OWT casks are defined as casks that must be shipped at a GVW in excess of this weight. Except for requiring special overweight permits for each state a shipment passes through, OWT truck casks operate in much the same manner as LWT shipments; e.g., pre-notification of state officials, safeguards, and security requirements. Rail casks are more massive than the truck versions and are generally designed for rail service, only. However, provisions can be made

(a) Gross vehicle weight includes the weight of the tractor, trailer, cask, cargo, and ancillary equipment.

for a special short distance, heavy haul[a] transfer by truck of a rail cask to a rail siding or dock, where the cask can be loaded onto a railcar or barge. This has not been performed in this country for spent fuel shipments although some nuclear-related equipment such as steam generators and reactor vessels, have been moved in this manner.

This section presents the total numbers of the various LWT, OWT, and rail shipping casks that have been fabricated and the number that is currently available and/or certified by the NRC. Summaries of the cask availability information are discussed in the following subsections for each supplier. A summary of some important features of the existing spent fuel shipping cask fleet is presented in Table 5.1. Additional details regarding usage of some of the existing casks were presented in Section 4.0 for shipping campaigns for which the specific cask has already been selected.

TABLE 5.1. Existing Commercial LWR Spent Fuel Shipping Cask Fleet

Designation	Primary Transport Mode[a]	Capacity PWR/BWR Assemblies	Number of Casks Completed	Number Currently Certified
NAC-1	LWT	1/2	5[b]	0
NFS-4	LWT	1/2	2	0
NLI-1/2	LWT	1/2	5	5
NLI-10/24	Rail	10/24	2[c]	0
TN-8	OWT	3 PWR	2	2
TN-9	OWT	8 BWR	2[d]	2
IF-300	Rail	7/18	4[e]	4

(a) LWT = Legal weight truck; OWT = Overweight truck
(b) Includes two casks that are owned by a utility company and are not available for lease from NAC.
(c) There are no internal baskets for these casks. Therefore, they cannot be used until new baskets are fabricated.
(d) Includes one TN-9 cask owned by a utility company.
(e) Includes one IF-300 cask owned by a utility company.

(a) Heavy Haul is the transport of oversized and/or overweight objects by truck where special equipment is required.

Nuclear Assurance Corp. (NAC)

NAC supplies a variety of legal-weight truck and rail shipping casks. Their truck cask fleet includes the NFS-4, NAC-1 (same design as the NFS-4), and NLI-1/2 shipping casks. The rail cask supplied by NAC is the NLI-10/24 model. Some of the important features as well as the total number of completely fabricated casks are presented in Table 5.1.

NAC either owns or has long term leases on all of the equipment listed above. All seven of the NAC-1 and NFS-4 casks were temporarily suspended from use by the NRC in 1979. Two of the NAC-1 casks (one owned by NAC and one owned by a utility) were declared not licensed pending resubmittal of their Safety Analysis Report for Packaging (SARP). These casks were modified slightly (some copper patches were added) during the manufacturing process and the NRC had not reviewed and approved the modification. As a result, these two casks can not be used until NRC has reviewed and approved updated SAR's.

The remaining NAC-1 and NFS-4 shipping casks can not be used for spent fuel shipments due to an agreement between the NRC and NAC. NAC has agreed not to use these casks because NRC believes there is a potential for buckling of the internal cavity that could cause the lead shielding to change position. This could cause the radiation shielding to lose effectiveness at some locations on the casks. Subsequent inspections of the casks have shown no evidence of buckling or loss of ovality. However, because NRC believes there is potential for this type of fault, they have asked NAC not to use these casks for spent fuel shipments pending further analyses. According to NAC, all of the NAC-1 and NFS-4 shipping casks will ultimately be recertified.

NAC possesses long-term lease agreements for the NLI-10/24 rail casks and the NLI-1/2 legal-weight truck casks. These casks were previously supplied by NL Industries, Inc., which leased the casks to NAC in 1980. All five of the NLI-1/2 casks are certified and operational. Both completed NLI-10/24 casks are not available due to a lack of internal baskets. New baskets would have to be fabricated for these casks. If new baskets are fabricated using the original design that was approved by the NRC, little difficulty is expected in reactivating the casks. However, analysis and testing of the new design will be required if the new baskets are designed differently,. Submission of the safety analysis of a new basket design and subsequent review and approval by the NRC would also be required. These casks are currently considered to be unavailable.

Transnuclear, Inc.

Transnuclear, Inc. (TN) supplies the TN-8L and TN-9 overweight truck shipping casks. The TN-8L is designed to transport three PWR assemblies; the TN-9 has a design capacity of seven BWR assemblies. As shown on Table 5.1, there are currently two TN-8Ls and two TN-9s in this country. One of the TN-9 casks has been sold to a utility company, Commonwealth Edison, but is assumed to be available for use by TN if it is not being used by the utility. The other three casks are owned by TN and are certified and operational.

General Electric Co.

General Electric Co. (G.E.) supplies the IF-300 rail shipping system. Currently there are four completed IF-300 casks; one is owned by a utility and three are owned by G.E., as shown in Table 5.1. All of these casks are currently operating only with dry internal cavities at reduced thermal capacities. Consequently, only long-cooled fuel may be shipped in the IF-300 as a full load which reduces some of the flexibility of the shipping casks. However, since most of the fuel expected to be shipped in the near future is relatively old, this is not anticipated to restrict the use of the cask in most instances.

5.2 SHIPPING CASK SUPPLY CASES

Due to uncertainty regarding the availability of some shipping casks (i.e., NLI-10/24, NAC-1, and NFS-4 models), two supply cases have been developed that bound the near-term shipping cask fleet size. The lower limit of availability is represented by the current situation; i.e., assuming the NLI-10/24, NAC-1 and

NFS-4 casks will not be available. The upper limit of availability is obtained by assuming that the NAC-1 and NFS-4 casks will be recertified and available for use in 1985. In addition, the maximum fleet size includes the two NLI-10/24 rail casks. A two year delay in their availability (i.e., they are assumed to be unavailable until early 1987) allows for analysis, construction, and approval of new internal baskets. The utility-owned IF-300 cask is assumed to be unavailable due to its planned extensive use for the Brunswick transshipments and the Carolina Power and Light dry storage demonstration (Newman and Cole 1984). The TN-9 owned by Commonwealth Edison is assumed to available for use by TN as long as it would not interfere with the utility's shipping plans. The resulting range of cask fleet sizes is summarized in Table 5.2.

TABLE 5.2. Spent Fuel Shipping Cask Fleet Supply Cases

Cask Designation	Number of Casks Available Lower Limit	Upper Limit
NAC-1	0	3[(a)]
NFS-4	0	2
NLI-1/2	5	5
NLI-10/24	0	2
TN-8L	2	2
TN-9	2[(b)]	2[(b)]
IF-300	3[(c)]	3[(c)]

(a) Does not include two utility-owned NAC-1 casks.
(b) Includes one utility-owned TN-9 cask.
(c) Does not include one utility-owned IF-300 cask.

The data in Table 5.2 can be converted to the number of days per year that a cask for each transport mode is available. This is done using the assumption that shipping casks may be used up to 300 days per year (Wilmot et al. 1983). This allows sufficient time for periodic inspection and maintenance of the casks. The resulting number of available cask-days per year for each transport mode under the two supply scenarios is presented in Table 5.3. The data in Table 5.3 will be compared with the number of cask-days required to complete the shipping programs described in Section 5.2.

TABLE 5.3 . Availability of Shipping Casks for Each Supply Scenario

Transport Mode	Availability (cask-days/yr) Lower Bound	Upper Bound
Legal-weight truck	1500	3000[a]
Overweight truck		
BWR	600	600
PWR	600	600
Rail	900	1500[b]

(a) Assumed to be available beginning in 1985.

(b) The additional 600 cask-days/yr is assumed to be available beginning in 1987.

5.3 CHARACTERISTICS OF FUTURE SPENT FUEL SHIPPING CASKS

When the calculated shipping cask demand exceeds the supply in any given year, additional transportation hardware will be needed. The additional capabilities can be provided in two ways; 1) load leveling, or 2) building additional shipping casks. Load leveling attempts to reduce the demand for transportation casks by performing shipments when the demand is low that would otherwise be performed in years when the demand is high. It is not known whether it is feasible for DOE to practice load leveling, since it would require some utilities to ship fuel to FIS several years prior to losing full core reserve discharge capability. Load leveling was considered to be an option in this study.

Additional transportation capabilities would also be provided by constructing additional transportation hardware. Designs of the existing spent fuel shipping casks may be considered to be inefficient for transporting long-cooled spent fuel. Future designs are expected to be substantially different. Dry shipment of spent fuel (i.e., no internal water coolant) has been established as a more cost-effective method than wet shipments for shipping aged spent fuel. This concept reduces the heat transfer capabilities of new casks in comparison with the existing designs. Dry casks will be designed to ship older and colder fuel (5 to 10 years after reactor discharge compared with 3 to 6 months). Since the older fuel has been allowed to decay in storage basins for several years, it emits less radiation. Therefore, gamma and neutron shielding thicknesses can be reduced on the new designs. This reduction in shielding requirements allows the cask cavity to be enlarged which increases the payload. The overall result is that future cask designs are expected to have larger payload capacities than the existing designs. These designs are conceptual in nature and thus their characteristics are subject to uncertainty. The projected design capacities of new spent fuel shipping casks are obtained from Wilmot et al. (1983) and are shown in Table 5.4.

TABLE 5.4. Assumed Design Capacities of Future Spent Fuel Shipping Casks

	Payload Capacity (Assemblies)	
Transport Mode	PWR	BWR
Legal-weight truck	2	5
Overweight truck	4	9
Rail	12	32

6.0 SPENT FUEL SHIPPING CASK REQUIREMENTS

This section presents the results of the spent fuel transportation hardware requirements calculations. This information represents the near-term demand for commercial LWR spent fuel shipping casks. Shipping cask requirements for each transport mode (i.e., LWT, OWT, and rail) were calculated on an annual basis through 1993. Separate calculations were performed for each transport mode as discussed previously in Section 3.0. Since potential FIS transportation requirements represent the greatest demand for spent fuel shipping casks in the near-future, they will be discussed separately.

6.1 FIS TRANSPORTATION REQUIREMENTS

Transportation requirements for the two assumed locations for the potential FIS site are presented in Tables 6.1 and 6.2 for the western and eastern sites, respectively. Transportation requirements generally increase with each successive year which reflects the increasing spent fuel storage requirements in later years. As shown, rail cask utilization is generally much lower than truck cask utilization.

Transportation scheduling in industry is more flexible than the assumptions used in this study to develop a shipping schedule. This inflexibility caused a substantial idle period for one or more shipping casks in some years. For example, OWT-PWR shipping cask usage is estimated to be about 610 cask-days in 1991 on Table 6.1. Three shipping casks are needed, based on assumptions used in this study, to provide these services. As a result, the equivalent of one OWT-BWR shipping cask is used less than 10% of the available time in 1991. This small percentage of a cask-year could easily be accommodated in 1990, which would negate the need for the third OWT-PWR shipping cask. A more optimum shipping schedule could potentially reduce the required number of shipping casks in some years.

FIS transportation requirements are affected to a large extent by the location of the storage facility. This can be illustrated by comparing Tables

6.1 and 6.2. Approximate distances traveled are about two to three times larger in each year for the western FIS site compared to the eastern FIS site. Total highway distance traveled for the assumed western FIS site is approximately 13.5 million km (8.5 million miles) compared with about 4.5 million km (2.8 million miles) for an eastern FIS site. This illustrates that selecting an eastern FIS site may be desirable due to its relative proximity to a large number of the commercial nuclear reactors.

A sensitivity case was analyzed to determine the effect of limiting highway shipments to legal weight; i.e., no OWT shipments were assumed to be made to FIS. The results of this sensitivity case are shown in Table 6.3. As shown on the table, the assumption that only LWT truck casks will be used causes a substantial increase in LWT cask requirements. Additional LWT casks will be needed by 1987 for the western FIS case and by 1989 for the eastern FIS case (assuming the lower cask availability case). Up to 25 LWT casks (existing designs), or 20 more than the existing fleet, will be needed by 1992. This capability could be provided by the five existing LWT casks and ten new shipping casks (future designs). The existing fleet becomes inadequate in 1989 for both FIS site assumptions, assuming the upper limit of LWT cask availability.

A comparison was made of the results in Tables 6.1 and 6.2 with Table 6.3. As discussed above, 20 additional LWT casks (existing designs) will be needed by 1992 for the LWT-only case (or ten additional LWT casks of future designs). This can be compared with the requirement for one additional OWT-PWR and two additional OWT-BWR casks of existing designs (or one OWT-PWR and one OWT-BWR of future designs) if OWT shipping is used. Therefore, FIS transportation requirements (and the number of additional shipping casks needed) will be significantly increased if highway shipments are limited to LWT casks.

A further calculation was performed to determine the percentage of spent fuel that will be shipped to FIS using each transport mode. This was done by summing the quantities of fuel that will be shipped by LWT, OWT, or rail and dividing by the total amount of fuel that will be shipped to FIS. The

TABLE 6.1. Transportation Requirements for Federal Interim Storage Site Assumed to be Located in Western U.S.

	Approximate Distance Traveled (10^3 km)		Cask Usage (days/year)(a)(b)				Number of Shipping Casks Needed (c)			
YEAR	HIGHWAY	RAIL	LWT	OWT-P	OWT-B	RAIL	LWT	OWT-P	OWT-B	RAIL
1985	77	0	90	0	0	0	1	0	0	0
1986	440	0	632	40	0	0	3	1	0	0
1987	1,500	0	1796	0	0	0	6	0	0	0
1988	1,600	3.4	1312	230	0	22	5	1	0	1
1989	2,400	44	2050	450	606	156	7	2	2	1
1990	2,400	120	2092	220	881	622	7	1	3	3
1991	1,900	140	1536	610	200	738	6	3	1	3
1992	3,200	56	2490	630	1110	324	9	3	4	2

(a) LWT = Legal-weigt truck; OWT-P = Overweight Truck-PWR; OWT-B = Overweight Truck-BWR.
(b) Numbers contain excess significant figures for calculation purposes.
(c) Based on shipping capacity of existing casks. Future cask designs may be more efficient.

TABLE 6.2. Transportation Requirements for Federal Interim Storage Site Assumed to be Located in Eastern U.S.

	Approximate Distance Traveled (10^3 km)		Cask Usage (days/year)(a)(b)				Number of Shipping Casks Needed (c)			
YEAR	HIGHWAY	RAIL	LWT	OWT-P	OWT-B	RAIL	LWT	OWT-P	OWT-B	RAIL
1985	27	0	54	0	0	0	1	0	0	0
1986	150	0	386	16	0	0	2	1	0	0
1987	520	0	1132	0	0	0	4	0	0	0
1988	590	3.0	752	92	0	20	3	1	0	1
1989	790	40	1295	180	373	156	5	1	2	1
1990	870	82	1360	88	544	286	5	1	2	1
1991	600	93	920	259	100	496	4	1	1	2
1992	1,000	56	1460	296	690	355	5	1	3	2

(a) LWT = Legal-weight truck; OWT-PWR = Overweight Truck-PWR; OWT-BWR = Overweight Truck-BWR
(b) Numbers contain excess significant figures for calculation purposes.
(c) Based on shipping capacity of existing casks. Future cask designs may be more efficient.

TABLE 6.3. FIS Transportation Requirements: Rail and LWT Only

	Cask Usage (days/yr)(a)(b)				Number of Shipping Casks Needed			
	Western FIS		Eastern FIS		Western FIS		Eastern FIS	
YEAR	LWT	Rail	LWT	Rail	LWT	Rail	LWT	Rail
1985	90	0	54	0	1	0	1	0
1986	728	0	434	0	3	0	2	0
1987	1796	0	1132	0	6	0	4	0
1988	1856	22	1024	20	7	1	4	1
1989	4902	156	3148	156	17	1	11	1
1990	5180	622	3377	286	18	3	12	1
1991	3528	738	2029	496	12	3	7	2
1992	7362	324	4549	355	26	2	16	2

(a) LWT = Legal-weight truck
(b) Numbers contain excess significant figures for calculation purposes.
(c) Based on shipping capacity of existing casks. Future cask designs may be more efficient.

quantities of spent fuel that will be shipped by LWT and OWT are added to obtain an overall truck percentage. The resulting truck and rail percentages were determined to be 75% and 25% (on an MTU basis).

6.2 TOTAL NEAR-TERM TRANSPORTATION REQUIREMENTS

The total near-term spent fuel transportation requirements are presented in this subsection. These data include the FIS transportation hardware requirements as well as requirements for the other shipments discussed in Section 4.0. The data presented in these tables assume the shipping capacities of the existing cask designs. Therefore, the numbers of casks required are based on the designs of the existing shipping cask fleet. Since new designs of spent fuel shipping casks are expected to have larger cargo capacities (by approximately a factor of two), fewer new casks would have to be built to provide a shipping cask fleet equivalent to the existing fleet.

Projections of the total near-term spent fuel shipping cask usage and fleet requirements are presented in Tables 6.4 and 6.5. Table 6.4 was prepared for an assumed western FIS location. Table 6.5 assumes an eastern FIS location.

In general, commercial shipping cask fleet requirements are expected to gradually increase in the next several years. LWT cask requirements increase from four in 1984 to nine in 1989 for the case in which the FIS site is assumed to be located in the West. For an eastern FIS site, LWT cask requirements increase from four in 1984 to seven in 1990. OWT and rail cask requirements are also projected to have similar increases. Note that the greatest portion of these increases are a result of shipments to FIS (see Tables 6.1 and 6.2).

TABLE 6.4. Total Near-Term Spent Fuel Shipping Cask Usage and Fleet Requirements--Western FIS

	Cask Usage (days/year)(a)(b)				Number of Shipping Casks Needed (c)			
YEAR	LWT	OWT-P	OWT-B	RAIL	LWT	OWT-P	OWT-B	RAIL
1984	1012	80	270	43	4	1	1	1
1985	571	324	70	306	2	2	1	2
1986	1331	302	0	682	5	2	0	3
1987	2039	132	0	682	7	1	0	3
1988	1612	314	0	22	6	2	0	1
1989	2506	530	606	202	9	2	3	2
1990	2665	384	881	760	9	2	3	3
1991	1914	694	200	738	7	3	1	3
1992	2490	760	1110	324	9	3	4	2

(a) LWT; Legal-Weight truck; OWT-P = Overweight truck - PWR; OWT-B = Overweight truck - BWR.
(b) Numbers contain excess significant figures for calculation purposes.
(c) Based on shipping capacity of existing casks. Future cask designs may be more efficient.

TABLE 6.5 Total Near-Term Spent Fuel Shipping Cask Usage and Fleet Requirements--Eastern FIS

	Cask Usage (days/year)(a)(b)				Number of Shipping Casks Needed (c)			
YEAR	LWT	OWT-P	OWT-B	RAIL	LWT	OWT-P	OWT-B	RAIL
1984	1012	64	270	43	4	1	1	1
1985	535	294	70	306	2	1	1	2
1986	1085	278	0	682	4	1	0	3
1987	1375	132	0	682	5	1	0	3
1988	1052	176	0	20	4	1	0	1
1989	1751	260	373	202	6	1	2	1
1990	1933	252	544	424	7	1	2	2
1991	1298	343	100	496	5	2	1	2
1992	1460	376	690	355	5	2	3	2

(a) LWT; Legal-Weight truck; OWT-P = Overweight truck - PWR; OWT-B = Overweight truck - BWR.
(b) Numbers contain excess significant figures for calculation purposes.
(c) Based on shipping capacity of existing casks. Future cask designs may be more efficient.

7.0 EVALUATION OF THE ADEQUACY OF THE EXISTING COMMERCIAL SPENT FUEL SHIPPING CASK FLEET

The adequacy of the existing commercial spent fuel shipping cask fleet to perform needed near-term shipments is evaluated in this section. The evaluations are performed by comparing the shipping cask supply and demand information presented in Sections 5.0 and 6.0, respectively. The important results from these two sections are set forth in Figures 7.1 and 7.2 for assumed western and eastern FIS sites, respectively.

The results in Figure 7.1 (western FIS case) indicate that, assuming the lower existing fleet availability, the projected LWT shipping cask requirements will exceed the supply of LWT casks in 1987. By 1989, up to nine of the existing casks will be needed. These annual requirements exceed LWT cask capabilities (lower limit) by two and four casks, in those years. If new LWT shipping cask systems are brought into service, they are anticipated to have approximately twice the cargo capacity of the existing designs; i.e., one new cask is equivalent to two existing casks (see Table 5.4). Using this factor of two difference, one LWT cask of the new design will be needed by 1987 and a second by 1989 (in addition to the existing fleet).

LWT shipping cask requirements do not exceed the upper limit of their availability (ten cask-years per year). However, since the maximum annual requirement (nine cask-years) is only one less than the maximum LWT cask fleet size, any significant delays in recertification of the NAC-1 and NFS-4 casks could cause a shortage as early as 1989. If the reapproval of these shipping cask systems is delayed, the additional new LWT casks discussed above would be needed.

Referring back to Table 6.1, FIS transportation requirements for a western site may require all of the available LWT spent fuel shipping casks. The

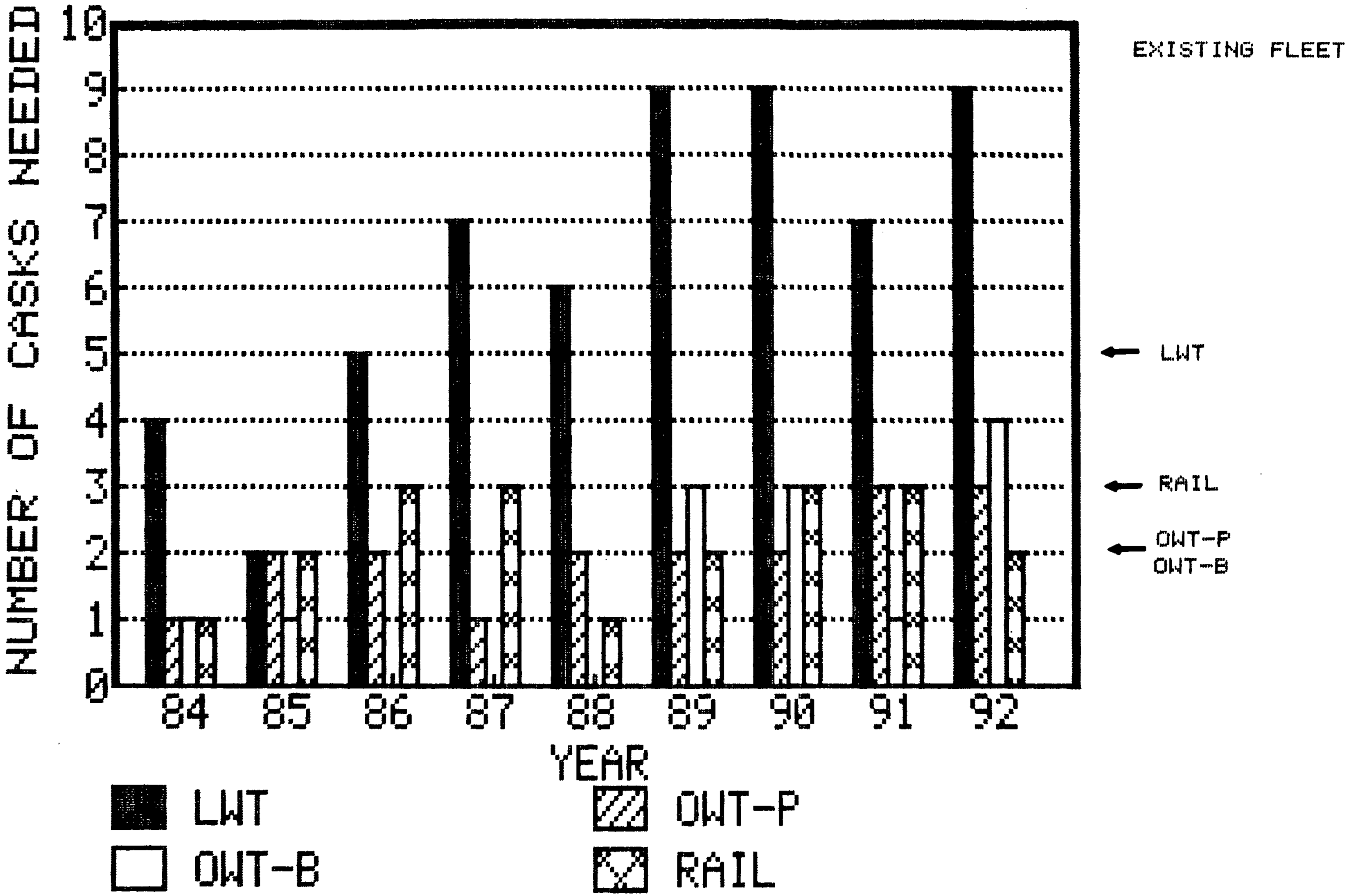

FIGURE 7.1 Comparison of Annual Shipping Cask Requirement (Western FIS) With the Lower Limit Cask Availability.

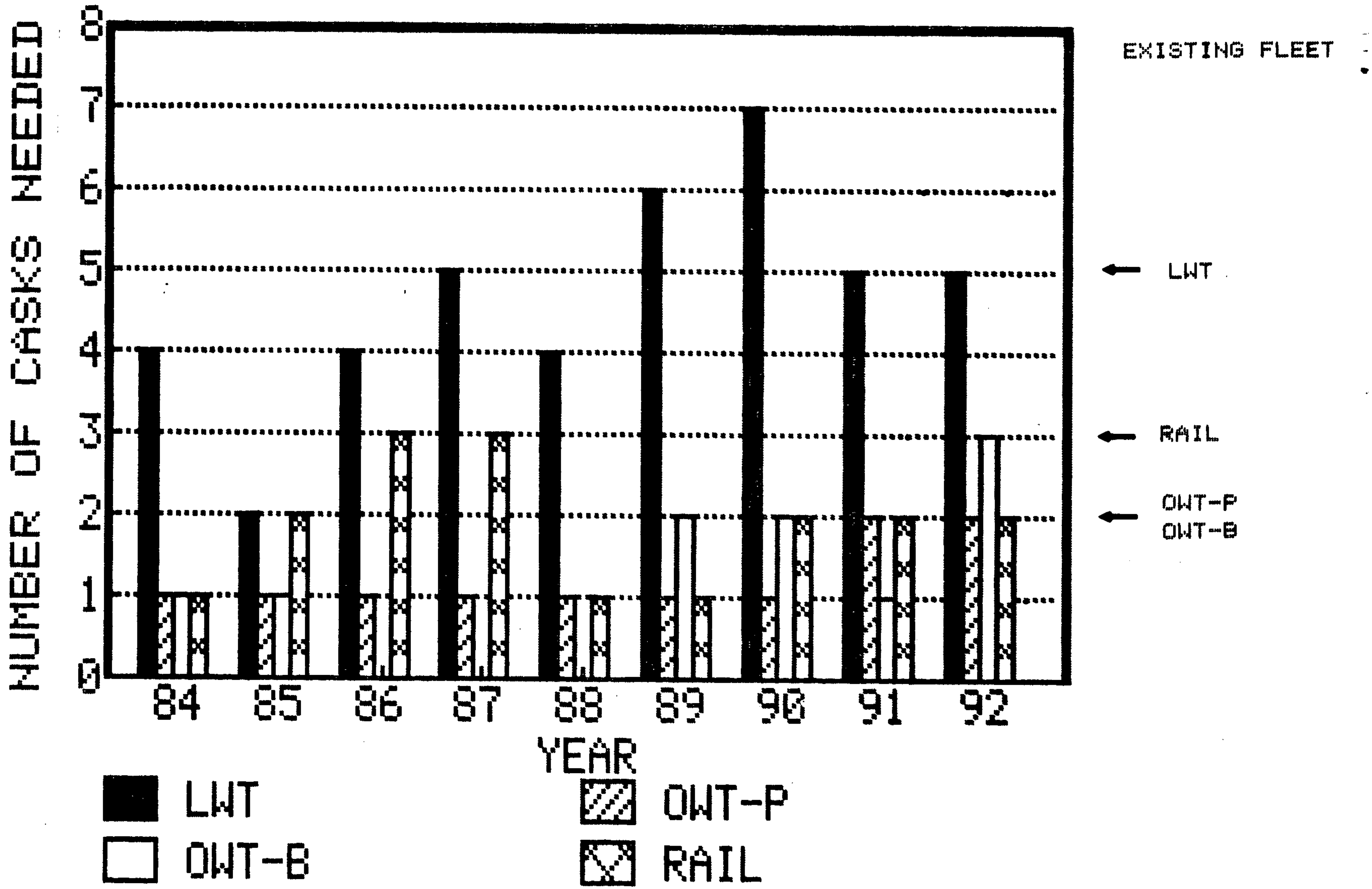

FIGURE 7.2 Compariosn of Annual Shipping Cask Requirements (Eastern FIS) With the Lower Limit of Cask Availability

projected demand for transportation services for FIS will exceed the lower limit of LWT shipping cask availability as early as 1987. This shortage of LWT casks could be delayed by two years if DOE and the utilities agree to a load leveling operation; i.e., agree to ship fuel to FIS in 1986 assumed to be shipped in 1987. This assumption allows more efficient use of the existing certified LWT casks; i.e., higher cask utilization in 1986 could compensate for a potential shortage in 1987. Even if this could be done, additional LWT capability will be needed by 1989. Significant delays in recertification of the NAC-1 and NFS-4 casks could cause a shortage by that year. If these delays appear likely and if utilities begin large-scale applications for FIS (subject to NRC approval), new LWT shipping casks will be needed by 1989.

The number of new LWT casks required for shipments to a western FIS site can be estimated by subtracting the LWT cask usage requirements in Table 6.1 from the LWT cask availability (lower limit) presented in Table 5.3. These values are divided by the cask availability fraction (300 days per year) and then by the factor of two increase in cargo capacity for new cask designs discussed above. The result is that one additional LWT cask of the new design will be needed by 1987 and a second by 1992.

In Figure 7.2 (eastern FIS case), maximum annual LWT cask requirements will exceed the existing certified LWT cask fleet size in 1989. This represents about a two year delay compared with the case in which the FIS site is assumed to be located in the West. Either the NAC-1 or NFS-4 casks must be returned to service or, alternatively, new LWT casks must be available by that date or a shortage will occur. Load leveling could possibly achieve near-maximum utilization of the five currently certified LWT casks from 1985 through 1992 so that no shortage would occur. This assumes that DOE would be ready to accept fuel at FIS in 1985 and that no operational problems occur with one or more of the existing LWT casks. Again, this assumes that utilities begin large-scale applications for FIS in the next year and that NRC agrees that they are eligible. As of September, 1984, no utility had applied for FIS.

Projected OWT-PWR shipping cask requirements (see Figure 7.1) will exceed the existing certified fleet size by 1991. One additional OWT-PWR cask is needed in that year. However, referring back to Table 6.3, the third cask will be used only about one-third of the available time in 1991 (694 cask-days divided by 300 cask-days available per year results in about 2.3 cask-years) and one-half in 1992. These fractions of OWT cask usage could be accommodated in earlier years. With advance planning and proper dispatching, the existing OWT-PWR cask fleet could be adequate to perform the needed shipments. This further assumes DOE can practice load leveling by agreeing to receive spent fuel at FIS several years before a particular reactor is estimated to lose full core reserve discharge capability. The existing OWT-PWR casks will otherwise be insufficient.

The number of existing certified OWT-PWR casks is sufficient to perform the assumed shipments for the eastern FIS site. In the year with the highest projected OWT-PWR cask usage (see Table 6.4), only a small fraction in excess of one cask-year is needed. These shipments could suffer some significant delays and still be completed before 1992. Alternatively, the unused portion of the cask-year could be used for other shipments if some utilities were to modify their plants to handle these shipping casks. This could reduce the potentially high utilization of the existing LWT casks, particularly if the NAC-1 and NFS-4 casks were not available.

The BWR versions of the OWT shipping casks are anticipated to be in use for only a fraction of their available time over the next several years. After 1989, these shipping casks are expected to be used more frequently. Under the western FIS case assumptions, OWT-BWR cask will requirements exceed the near-term supply in 1990. Up to two additional OWT-BWR casks will be needed by 1992. The additional transport capability provided by these two OWT-BWR casks could also be provided by three LWT casks of the new designs described in Table 5.4.

In the eastern FIS case, the supply of OWT-BWR shipping casks will be adequate through 1991. One additional OWT-BWR cask will be needed in 1992. However, if DOE can implement load leveling, some shipments scheduled for 1992 could be completed in 1991. This would reduce the projected OWT-BWR cask usage in 1992. Only two OWT-BWR casks would then be needed in 1992 and the two existing OWT-BWR casks would provide sufficient capability through at least that year.

The results of a sensitivity case illustrated the effects of limiting highway shipments to FIS to LWT casks. It was determined that the number of additional LWT casks that will be needed (i.e., to replace the OWT casks) was significantly higher than the additional OWT casks that will be needed. The cost of ten new LWT casks (of new designs) will more than offset the cost of two additional OWT casks (see Section 6.1).

In all cases, the existing certified rail cask fleet is adequate to perform the projected rail shipments. The largest rail cask annual usage projection is about 760 cask-days per year in 1990 (see Table 6.3). This rail cask usage value represents the equivalent of full utilization of two rail casks and fractional utilization of a third. Consequently, projected rail shipments could undergo substantial delays without causing a shortage of rail cask availability. This may require that appropriate modifications to the FIS shipping schedule be made if delays are expected. A further implication is that it may not be necessary to reactivate the NLI-10/24 rail casks to prevent a near-term shortage of rail capability. This is not to say that the NLI-10/24 casks should not be reactivated. It simply implies that the three currently operational IF-300 rail casks are projected to be able to provide all of the rail transport capability needed through at least 1992.

The primary use of this document is a planning and decision-making tool. Since the results and conclusions presented are specific to the assumptions used in this study, there is significant uncertainty relative to what will actually occur in the near-term. Thus, it is necessary to indicate, in a qualitative manner, the affects on the cask requirements of varying each of the assumptions.

These effects are shown in Table 7.1. The arrows in the table indicate either an increase (↑), decrease (↓) or no effect (—) on the additional number of shipping casks needed relative to a base case. The base case to which the effects are compared is the case were the hypothetical FIS site is located in the western United States.

The first row of Table 4.1 shows the additional numbers of each type of shipping cask that will be needed in the near-term according to the base case assumptions (see Figure 7.1). The lower limit of shipping cask availability was assumed. These values are shown for comparison purposes. The remainder of the table indicates the effects on these values of changing the listed assumptions. The effects shown on the table are due to changing only the assumption shown; i.e., the effects are not compounded as the reader proceeds down the table.

The first assumption that was varied was the hypothetical location of the FIS site. As shown, if the FIS site is located in the eastern United States, the numbers of additional casks of each type that are needed decreases. This was due to the fact that shipping distances are minimized when the FIS site is located in the East where most of the reactors are located. Note that no effect on the rail cask fleet is shown. This is because the existing rail cask fleet is projected to be sufficient, and even though there would be a reduction in rail utilization, "no effect" is shown because there would be no reduction of the number of additional rail casks needed.

The effect of using assumed cask capacities of future casks is also a decrease in the number of additional shipping casks needed. This effect was evaluated quantitatively earlier in this report and will not be repeated here. Again, "no effect" is shown for rail casks because of the reason discussed above.

The next assumption that was changed was related to the utilization of FIS. Utilities could potentially transship fuel to less full storage basins within their utility systems rather than make large-scale utilization of FIS. This would cause a reduction of the number of additional LWT and OWT casks needed

TABLE 7.1. Qualitative Effect On the Need for Additional Shipping Casks of Changing Various Assumptions

Assumption	Effect on Numbers of Additional Shipping Casks Needed[a][b] LWT	OWT	RAIL
Base Case [c]	4	1/2[d]	0
Use hypothetical Eastern FIS site	↓	↓	—
Use future cask capabilities	↓	↓	—
Transship to minimum possible extent	↓	↓	—
Use rail (intermodal) to maximum extent	↓	↓	↑
Loading level	↓	↓	—
Exclude OWT shipments from FIS	↑	↓	—
Exclude TMI shipments	—	—	—

(a) LWT = Legal-Weight Truck; OWT = Overweight Truck
(b) Symbols are defined as follows: (↑) = The effect of changing the assumption is an increase in the number of <u>additional</u> shipping casks needed; (↓) = A decrease in the number of <u>additional</u> shipping casks needed; (—) = No effect on the number of <u>additional</u> shipping casks needed. If the (—) is shown, cask utilization may increase or decrease slightly but the number of additional casks needed is not expected to change.
(c) The base case assumes a hypothetical western site for the FIS; see Table 6.4 for shipping cask requirements.
(d) One PWR version and two additional BWR versions are needed.

because of shorter shipping distances required to perform most intrautility transhipments relative to shipments to FIS. According to DOE (1984), intrautility transshipments could reduce FIS utilization up to a factor of six (on the basis of the amount in units of MTU of fuel to be stored). Therefore, a large portion of the fuel assumed to be shipped to FIS in the base case could potentially be transshipped over significantly shorter distances.

The next assumption that was changed was that intermodal shipments using rail casks would be used for reactors that could handle a rail cask in-plant but were not provided with rail access. In comparison, the base case assumed that reactors without rail access would ship by either LWT or OWT, depending upon their in-plant limitations. A review of the data presented by Konzek and Daling (1984) indicates that 11 plants that were assumed to ship by LWT or OWT in the base case could potentially use rail casks for intermodal shipments (i.e., heavy haul truck shipment of a rail cask between the reactor and the nearest rail access point). This would significantly reduce the pressure on the existing LWT and OWT fleet but would also increase the pressure on the existing rail casks.

The next assumption examined was the potential use of load leveling to reduce pressure on certain cask types in some years. The results of the base case indicate that one additional OWT-PWR cask is needed in the near term. There is significant underutilization of the two existing OWT-PWR casks in early years (see Table 6.4), which means that these casks would be idle for a large portion of those years. The need for the additional OWT-PWR cask would be delayed if some shipments that were projected to be made in 1991 or 1992 could be made earlier. Load leveling would also delay the need for additional LWT casks. Load leveling would reduce the need for additional LWT casks but to a lesser extent; i.e., additional LWT casks would still be needed but fewer casks would be needed to meet the near-term demand. Load leveling would also reduce the need for additional OWT-BWR casks and has the potential for negating the need for any new OWT-BWR casks.

As shown on Figure 7.1, the effect of excluding OWT shipments from FIS would increase the demand for LWT casks and decrease the demand for OWT casks. The results of a sensitivity study indicated that a large number of additonal

LWT casks would be needed if this assumption is made (see Table 6.3). This effect was discussed previously and will not be repeated here.

The final assumption that was examined was the assumption that the shipments of the damaged core from TMI would be made in existing rail casks. There is the possibility that special shipping casks will be designed and constructed to perform these shipments. As shown on Table 7.1, the effect would be insignificant although a slight reduction of rail utilization would result. This slight reduction of rail utilization would not reduce the near-term base-case demand for a total of three rail casks (i.e., no additional casks). This assumption has no effect on the demand for LWT or OWT casks.

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