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# Public Information Circular for Shipments of Irradiated Reactor Fuel

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Manuscript Completed: April 1995  
Date Published: April 1995

Division of Industrial and Medical Nuclear Safety  
Office of Nuclear Material Safety and Safeguards  
U.S. Nuclear Regulatory Commission  
Washington, DC 20555-0001



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## **ABSTRACT**

This circular has been prepared to provide information on the shipment of irradiated reactor fuel (spent fuel) subject to regulation by the U.S. Nuclear Regulatory Commission (NRC). It provides a brief description of spent fuel shipment safety and safeguards requirements of general interest, a summary of data for 1979-1994 highway and railway shipments, and a listing, by State, of recent highway

and railway shipment routes.

The enclosed route information reflects specific NRC approvals that have been granted in response to requests for shipments of spent fuel. This publication does not constitute authority for carriers or other persons to use the routes described to ship spent fuel, other categories of nuclear waste, or other materials.



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# 1 INTRODUCTION

The Nuclear Regulatory Commission (NRC) is authorized under the Atomic Energy Act of 1954, as amended, to regulate the commercial nuclear industry for the purpose of protecting the public health and safety and the common defense and security of the United States. Included in this authority is the regulation of certain aspects of the transportation of irradiated reactor fuel (spent fuel). NRC's role in this regard is explained in Section 2 of this report. Section 3 provides descriptive statistics on spent fuel shipments in the commercial nuclear industry for the period 1979-1994. Section 4 contains a listing, by State, of highway and railway segments used in each State for transporting spent fuel in recent years (1993-1994).

## 2 REGULATORY REQUIREMENTS FOR SPENT FUEL SHIPMENTS

Spent fuel shipments are regulated from both the safety and safeguards standpoints. Safety deals with protection of public health and safety during routine transport as well as in the event of handling or transportation accidents, whereas safeguards deals with the protection of shipments against deliberate, malevolent acts by persons.

### 2.1 Safety Requirements

Federal regulatory responsibility for spent fuel transportation safety is shared by NRC and the U.S. Department of Transportation (DOT). Basically, NRC's safety role is to ensure that the spent fuel packagings meet strict regulatory design rules, and includes approving packaging designs and Quality Assurance Programs, and conducting inspections. NRC packaging requirements are specified in 10 CFR Part 71. The DOT role in regulating spent fuel shipment safety is broad, and covers all aspects of actual transportation, including route selection, vehicle condition and placarding, driver training, package marking, labeling, other shipping documentation, etc. These requirements are specified in 49 CFR Parts 171-178. Of the NRC and DOT safety requirements for spent fuel shipments, NRC's packaging standards and DOT's routing rules have been of most general interest, and are briefly described below.

#### 2.1.1 Packaging Standards

The basic strategy for regulating spent fuel shipments is to rely on the packaging to protect the public health and safety during transportation. The packaging standards that have been established in the regulations

provide that a spent fuel packaging (cask) shall prevent the loss or dispersion of the radioactive contents, provide adequate shielding and heat dissipation, and prevent nuclear criticality under both normal and accident conditions of transportation. The normal conditions of transportation that must be considered are specified in the regulations in terms of hot and cold environments, pressure differential, vibration, water spray, impact, puncture, and compression tests. Accident conditions that must be considered are specified in terms of impact, puncture, fire conditions, and immersion.

The NRC initially reviews the cask design to verify its resistance to accidents. NRC must issue a certificate before a cask fabricated from the reviewed design can be used to transport spent fuel.

The ability of packaging to provide protection has been demonstrated by the responses of packaging during actual traffic accidents. For example, an accident occurred on December 8, 1971, on a major highway near Oak Ridge, Tennessee. In this accident, the driver of a vehicle carrying a spent fuel cask swerved to avoid colliding with an oncoming vehicle, lost control, and overturned off the roadway. The cask assembly was thrown into a ditch, traveling more than 100 feet before coming to rest. No release of contents or release of radiation occurred. The outer surface of the cask sustained minor damage. The spent fuel cask was placed on another trailer and taken to its destination. The cask was returned to service after repair of the minor damage and inspection.

The accident resistance of casks has also been demonstrated in controlled tests. In one test, sponsored by the U.S. Department of Energy (DOE), a truck bearing a cask was deliberately placed in the path of and struck by a 120-ton locomotive traveling about 80 miles per hour. In another DOE test, a cask aboard a truck moving about 80 miles per hour was deliberately crashed into an immovable concrete structure. Subsequent examination in both these tests confirmed that no radioactive material would have been released from the casks had they been loaded with spent fuel. Thus, both field experience and controlled tests have substantiated the strategy of depending on packaging design for safety in transit.

For further information on spent fuel shipment safety, please consult NUREG/BR-0111, *Transporting Spent Fuel-Protection Provided Against Severe Highway and Railroad Accidents*."

#### 2.1.2 Routing Requirements

DOT requirements in 49 CFR 177.825(b) designate the use of the Interstate System of highways and available city beltways as the primary roadways over which

radioactive material shipments under an NRC safeguards-approved route plan are to be carried. There is no routing rule for rail shipments. The general designation as preferred highways is given to roadways, based on their capacity for reducing transit times. Appropriate State routing agencies, following prescribed criteria, may designate an alternate route to the preferred Interstate System. It is the responsibility of spent fuel carriers to abide by the routing rule when they transport spent fuel by highway.

### 2.1.3 Spent Fuel Shipment Safety Record

The safety record for spent fuel shipments in the U.S. and in other industrialized nations is enviable. Of the thousands of shipments completed over the last 30 years, none has resulted in an identifiable injury through release of radioactive material.

## 2.2 Safeguards Requirements

In May 1979, NRC adopted new regulations, in 10 CFR 73.37, for strengthening the protection of shipments of spent fuel against radiological sabotage. The material requiring physical protection is identified in 10 CFR 73.37(a) as "...a quantity of irradiated fuel in excess of 100 grams in net weight of irradiated fuel, exclusive of cladding or other structural or packaging material which has a total external dose rate in excess of 100 rems per hour at a distance of 3 feet from any accessible surface without intervening shielding...." These regulations were subsequently revised in May 1980, in response to public comments. The regulations require, among other actions, NRC approval of routes for the transportation of spent fuel, to ensure adequate planning for physical protection against actual or attempted acts of radiological sabotage. Physical protection requirements for NRC licensees who transport or deliver spent fuel to a carrier for transport include: shipment prenotification to NRC; procedures for coping with emergencies; a communications center; contact with the communications center every 2 hours; a written log of shipment events; arrangements with local law enforcement agencies (NRC often coordinates this item); avoidance of intermediate stops; surveillance of the shipment vehicle while stopped; armed escorts in heavily populated areas; escort training; onboard communications; immobilization devices on trucks; driver training; and notification of State governors before shipments. Of these safeguards requirements, route approval and State notification have been of most general interest, and are briefly described below.

### 2.2.1 Route Approval

NRC licensees planning to ship spent fuel are required to submit proposed routes for such shipments to the

NRC for approval, from the safeguards standpoint, before the use of a given route. For highway shipments, the licensee must propose a route that conforms with DOT's routing rules. NRC surveys proposed routes for communication reception, location of safe havens, etc. Routes may be approved for a single shipment, or a specified series of shipments. Once a shipment series is approved, the route may be used for all shipments, without reapproval of the route for each shipment, provided that NRC is notified in advance of each shipment. The route approval is for a stated number of shipments only; any subsequent shipments not part of an approval must be additionally approved. NRC approval authorizes only spent fuel shipments, and does not include other categories of nuclear waste material. From time to time, NRC may authorize alternate routes or detours, as circumstances dictate at the time of shipment. Also, detours may be taken without prior approval, in response to unforeseen circumstances that arise during a shipment. Criteria for determining when and how such detours may be taken are provided in published regulatory guidance ("Physical Protection of Irradiated Spent Fuel," NUREG-0561, Rev. 1).

### 2.2.2 Notification of State Governors

NRC requires its licensees to notify the governor or the governor's designee before the transport of spent fuel within or through the State [10 CFR 73.37 (f)]. The notification must be in writing and postmarked at least 7 days before transport, if mailed, or delivered at least 4 days before transport, if sent by messenger. The notification must include:

- the name, address, and telephone number of the shipper, carrier, and receiver
- a description of the shipment, as specified by DOT
- a listing of the routes to be used within the State
- a statement that NRC requires that shipment schedule information (provided as an enclosure) be protected from unauthorized disclosure.

The enclosure to the notification provides:

- the estimated date and time of departure from the point of origin of the shipment
- the estimated date and time of entry into the governor's State
- a statement that schedule information must be protected from unauthorized disclosure until at least 10 days after the shipment (or 10 days after the last shipment of a series) has entered or originated within the State.

The licensee must also notify the governor of schedule changes that differ by more than 6 hours from the

furnished schedule. Subsequent distribution of the schedule information is at the governor's discretion, but NRC regulations require all persons who receive the schedule information to protect it from unauthorized disclosure.

### 2.2.3 Spent Fuel Shipment Safeguards Record

Safeguards incidents for spent fuel shipments are those that involve attempts at radiological sabotage of spent fuel, or purposeful acts that threaten or result in significant degradation of the safeguards system used to protect the shipment. Licensees are required, under existing regulations, to immediately notify law enforcement authorities upon the occurrence or discovery of a safeguards incident, for the purpose of initiating an appropriate response. In addition, licensees are required to promptly report safeguards incidents to NRC by telephone, followed by a written report. To date, no safeguards incidents involving the shipment of spent fuel have occurred. However, a number of citations have been issued for minor procedural infractions: one in 1986, two in 1987, two in 1990 and one in 1991.

## 3 DESCRIPTIVE STATISTICS FOR 1979-1994 HIGHWAY AND RAILWAY SPENT FUEL SHIPMENTS

NRC began approving spent fuel shipments in 1979. This section provides descriptive statistics on the shipments that have occurred through 1994. Only shipments of academic, industrial, and utility irradiated reactor fuel subject to NRC regulation are included; DOE shipments are not regulated by the NRC and are excluded. Figure 3.1 and Table 3.1 provide a geographical perspective for spent fuel shipments. Figure 3.1 shows the highway and railway routes used for spent fuel transport during 1979-1994. Table 3.1 shows the number of shipments and quantity of spent fuel shipped between specific organization/destination pairs for the period.

Table 3.3 shows the pattern of highway and rail shipments throughout the period 1979-1994. The number of domestic highway shipments (except for the year 1981) rose to a high of 209 in 1984, then declined until 1988, when the recent average of 10 highway shipments per year was reached. Import shipments have generally declined since 1980, with only one import after 1989. The number of export shipments has been low (0-3) through the entire period. Also, in 1990-1994

five international shipments have been made in which US ports were transited.

Figure 3.2 shows that most (90 percent) of approximately 1,282 spent fuel shipments during the 1979-1994 period were completed over highways. Figure 3.3 shows that most of the shipping activity occurred during 1980-1987, with relatively low shipping activity after 1987.

Figure 3.4 shows that the larger quantity (71.5 percent) of spent fuel was shipped by railway, which reflects the greater capacity of rail spent fuel containers versus that for trucks. In addition, a few rail shipments included multiple spent fuel containers, further increasing the rail shipment payload. The figure indicates that 1,249,100 kilograms, or more than a thousand metric tons, of spent fuel were shipped. Figure 3.5 shows that the greatest quantities of spent fuel were shipped during 1984-1987, and that since then, most spent fuel has been shipped by rail.

Figure 3.6 shows that the highway mode accounted for most (94.5 percent) of the 824,503 spent fuel shipment miles. Figure 3.7 shows that shipment mileage peaked in 1984, with a general decline in subsequent years.

Figure 3.8 shows the cumulative movement of spent fuel, calculated by summing the product of quantity and distance for all shipments, and is expressed in kilogram-miles. This unit is analogous to "ton-miles," a unit commonly used to measure the flow of commodities. The figure shows that the railway mode accounted for the majority (68.4 percent) of the 442.8 million kilogram-miles associated with spent fuel shipments. Figure 3.9 shows the kilogram-miles distribution by year.

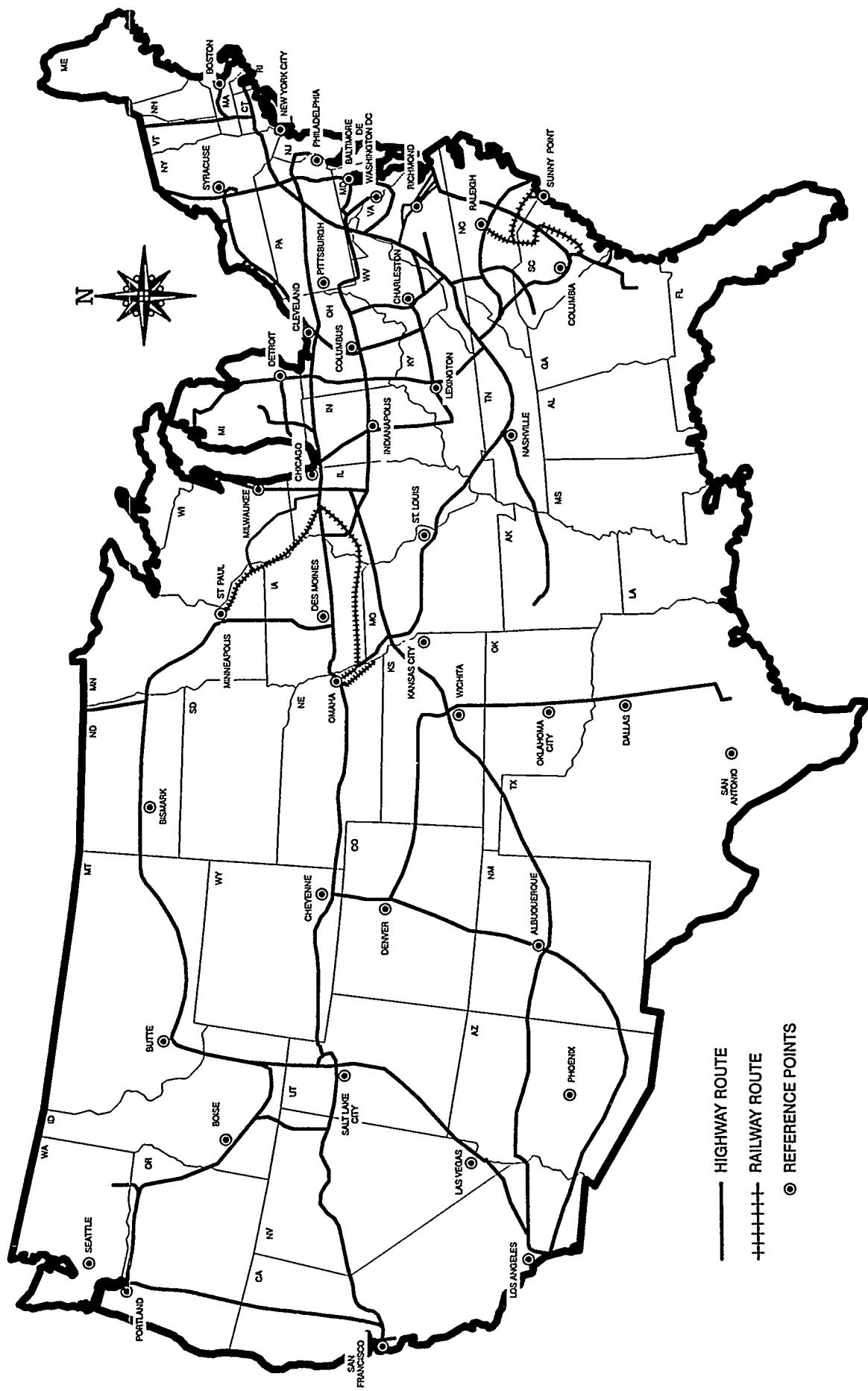
Finally, Figures 3.10 and 3.11 provide an operational perspective for the spent fuel shipments. Figure 3.10 shows the distribution of shipments by individual shipment quantity, and the corresponding total quantity shipped. The individual shipment quantities have been grouped into ranges, with highway shipments most frequently falling within the 0-10, 400-500, and 1300-1400 kilogram ranges, and with most railway shipments within the 6000-11000 kilogram range. The smallest quantity range accounts for the largest number of shipments (513, or 40 percent of highway and railway shipments combined), yet comprises only 2,000 kilograms (0.2 percent) of the combined quantity shipped. Conversely, the 45 railway shipments in the 7000-11000 kilogram shipment range comprise only 3.1 percent of the combined total shipments, but 35 percent of the combined quantity of spent fuel shipped. (All shipments less than 1400 kilograms were shipped by highway, with one exception, and all shipments greater than 1400 kilograms were shipped by railway.)

Figure 3.11 shows the distribution of shipments by distance range, and the corresponding total quantity of spent fuel shipped. For highway shipments, the number of shipments generally decreases with shipment distance, although a significant number of shipments exceeded 900 miles. Of the 356 metric tonnes shipped by highway, 173 tonnes (49 percent) traveled less than 200 miles. The number of rail shipments was somewhat uniform over the ranges, with 400–700 mile shipments accounting for 38 percent of the total quantity shipped by rail.

## 4 ROUTE SEGMENT LISTING FOR RECENT HIGHWAY AND RAILWAY SPENT FUEL SHIPMENTS

Table 4.1 is a listing of highway and railway routes that have recently been used to transport spent fuel. The table identifies the spent fuel shipments that occurred in each State. The table also lists the highway or railway route segments within the State that were used for each shipment, and when the shipment was completed. The table shows that highway spent fuel shipments were made in or through 23 States, and that railway shipments were made in or through 2 States during the period discussed.

Figure 3.1 Routes Used for Spent Fuel Shipments: 1979 – 1994



**Table 3.1** Number of Shipments and Quantity of Spent Fuel (Kilograms) Shipped for Origination/Destination Pairs: 1977-1994

**Table 3.1 (cont'd) Number of Shipments and Quantity of Spent Fuel (Kilograms) Shipped for Origination/Destination Pairs: 1979-1994**

Origination (Facility, State)	Destination (Facility, State)	Number of Shipments	Quantity of Spent Fuel (Kilograms)
M.I.T., MA	Monica, MN (via railway)	261	455
Natl'l. Inst. Sids. & Tech., MD			123
Newport News, VA*			424
Norfolk Int'l Terminal, VA*			17
Nuclear Fuel Services, West Valley, NY			114250 (114345)
Oconee, SC			1151
Ogallala, NE			1143
Oyster Creek, NJ			13
Pembina, ND*			26739
Portland, OR*			32700
Portsmouth, VA*			16
Port of Oakland, CA*			365
Port of Savannah, GA*			1215
Quad Cities, IL			454
Rhode Island A.E.C., RI			112
Richmond, CA*			112
Robinson, SC (via railway)			16560 (16571)
San Onofre, CA			16560
Southport, NC* (via railway)			1122
Surry, VA			120
Univ. of California (Berkeley), CA			321
Univ. of Michigan, MI			1050
Univ. of Missouri, MO			27742
Univ. of Virginia, VA			1531
Virgil Summer, SC*			1015
Zion, IL			2920

\* Port of Entry

\*\* Port of Departure

Table 3.2 Summary Data for 1979–1994 Spent Fuel Shipment Information

Year	Number of Shipments		Kilograms Spent Fuel Shipped (Thousand)		Shipment Miles (Thousand)		Kilogram-Miles (Million)	
	Highway	Railway	Highway	Railway	Highway	Railway	Highway	Railway
1979	16	11	0.1	30.2	8.0	2.3	0.1	6.2
1980	130	5	10.0	13.6	115.9	1.0	17.2	2.8
1981	81	2	7.9	6.0	38.5	0.4	1.7	1.2
1982	124	0	7.1	0.0	106.8	0.0	1.8	0.0
1983	117	0	36.6	0.0	83.6	0.0	12.7	0.0
1984	245	3	84.5	23.8	181.3	1.6	51.4	12.7
1985	135	18	74.0	119.4	70.9	8.7	28.3	57.8
1986	105	15	40.4	97.5	47.8	8.7	8.8	56.3
1987	107	15	82.3	101.4	41.8	8.4	14.8	56.5
1988	25	7	12.8	41.8	11.4	4.3	2.4	25.7
1989	16	6	0.1	30.8	16.7	1.7	0.1	8.7
1990	2	8	(0.03)*	70.5	1.5	1.6	(0.02)*	12.7
1991	11	10	0.1	98.4	9.6	1.5	0.1	15.0
1992	17	6	0.1	61.3	15.7	0.8	0.1	8.1
1993	16	12	0.1	114.0	23.2	2.3	0.3	21.9
1994	7	10	(0.02)*	84.2	6.6	2.2	(0.01)*	17.4
TOTAL	1154	128	356.2	892.9	779.3	45.5	139.8	303.0

\*Entries in parentheses rounded to nearest hundredth; All others rounded to nearest tenth.

Table 3.3 Number of Domestic and International Spent Fuel Shipments: 1979–1994

Year	Domestic		International		
	Highway	Railway	Export	Import	Transient
1979	2	11	0	14	0
1980	73	5	2	55	0
1981	30	2	3	48	0
1982	80	0	1	43	0
1983	92	0	2	23	0
1984	209	3	2	34	0
1985	114	18	0	21	0
1986	88	15	0	17	0
1987	85	15	3	19	0
1988	10	7	0	15	0
1989	11	6	1	4	0
1990	0	8	2	0	3
1991	7	10	4	0	1
1992	17	6	0	0	0
1993	16	12	1	0	1
1994	7	10	1	1	0

## TOTAL NUMBER OF SHIPMENTS - 1282

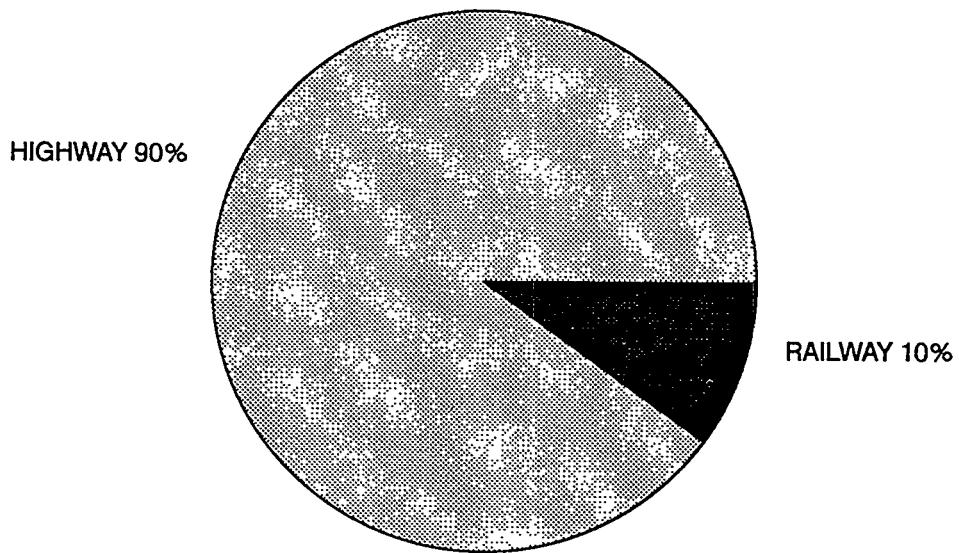


Figure 3.2 Number of Spent Fuel Shipments by Mode: 1979–1994

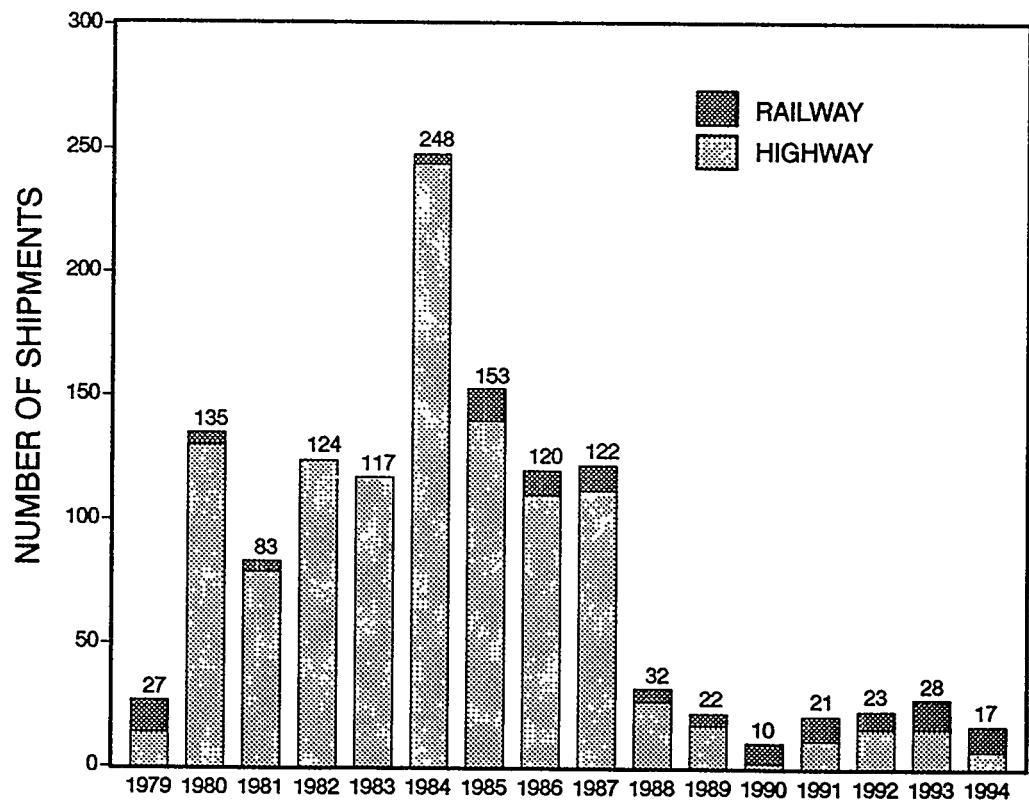


Figure 3.3 Number of Spent Fuel Shipments by Year: 1979–1994

## TOTAL KILOGRAMS OF SPENT FUEL SHIPPED – 1249.1 THOUSAND

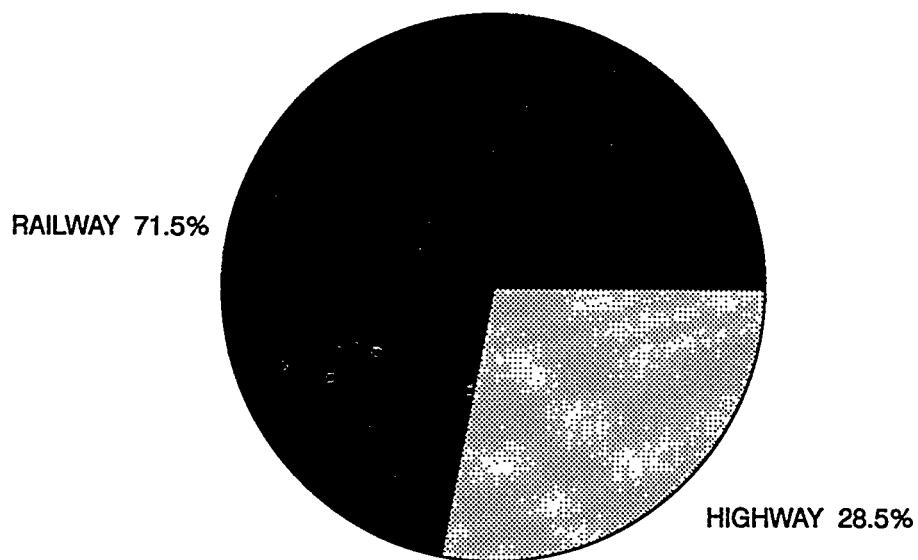


Figure 3.4 Quantity of Spent Fuel Shipped by Mode: 1979–1994

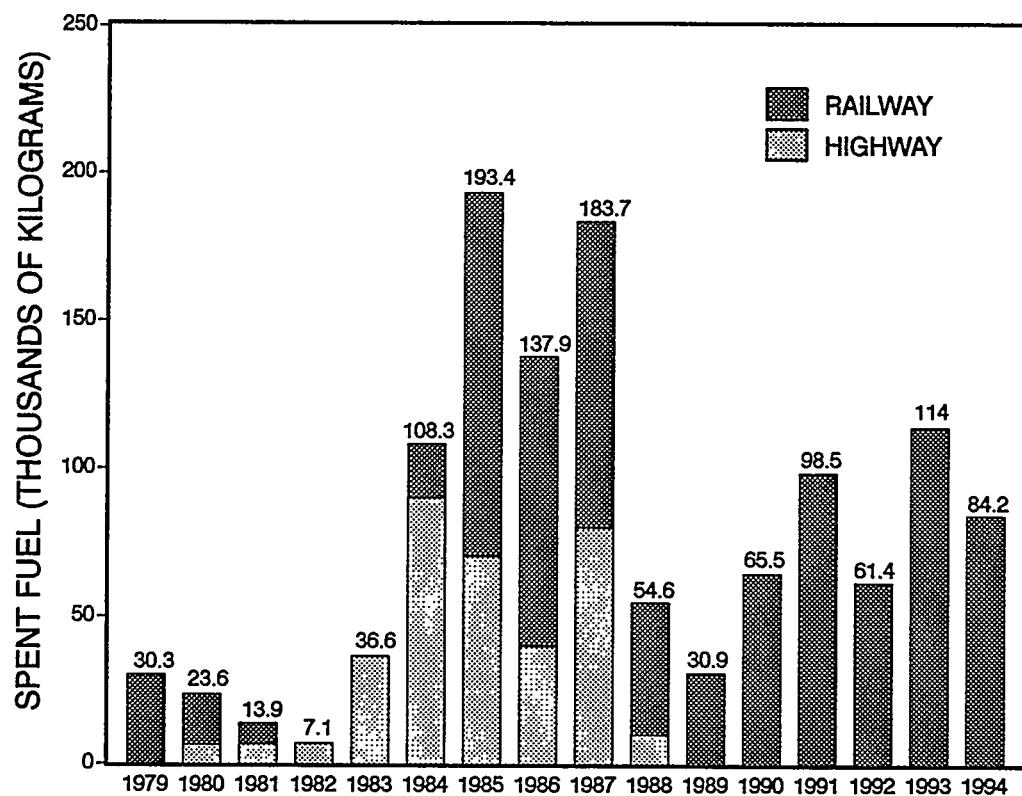


Figure 3.5 Quantity of Spent Fuel Shipped by Year: 1979–1994

**TOTAL SHIPMENT MILES – 824,503**

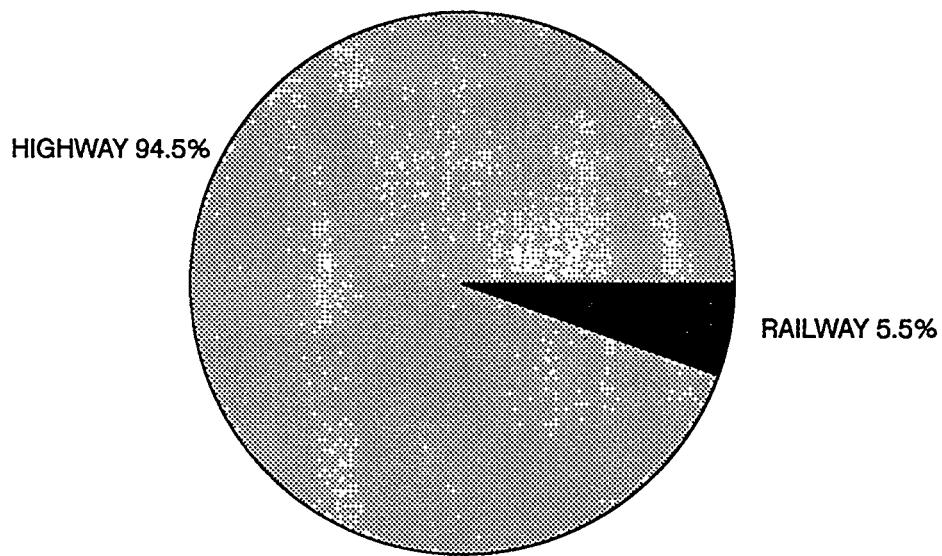


Figure 3.6 Spent Fuel Shipment Miles by Mode: 1979–1994

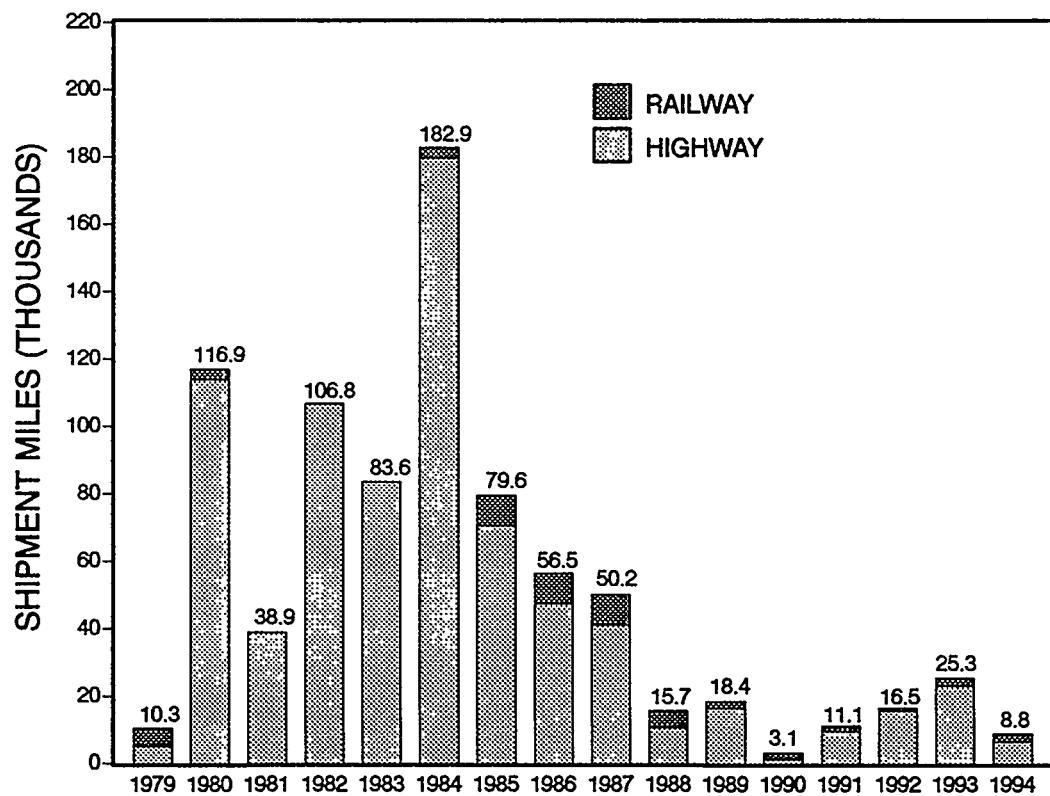


Figure 3.7 Spent Fuel Shipment Miles by Year: 1979–1994

**TOTAL KILOGRAM-MILES – 442.8 MILLION**

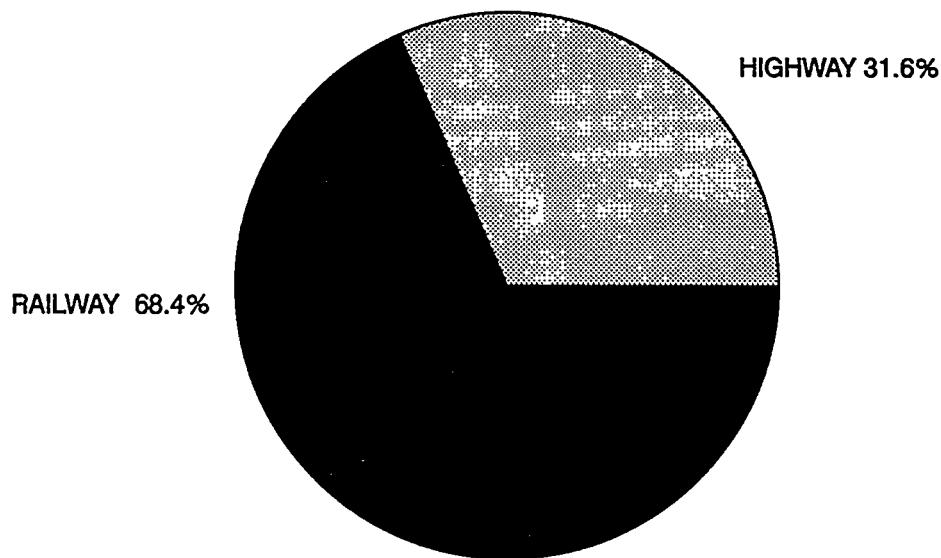


Figure 3.8 Spent Fuel Shipment Kilogram–Miles by Mode: 1979–1994

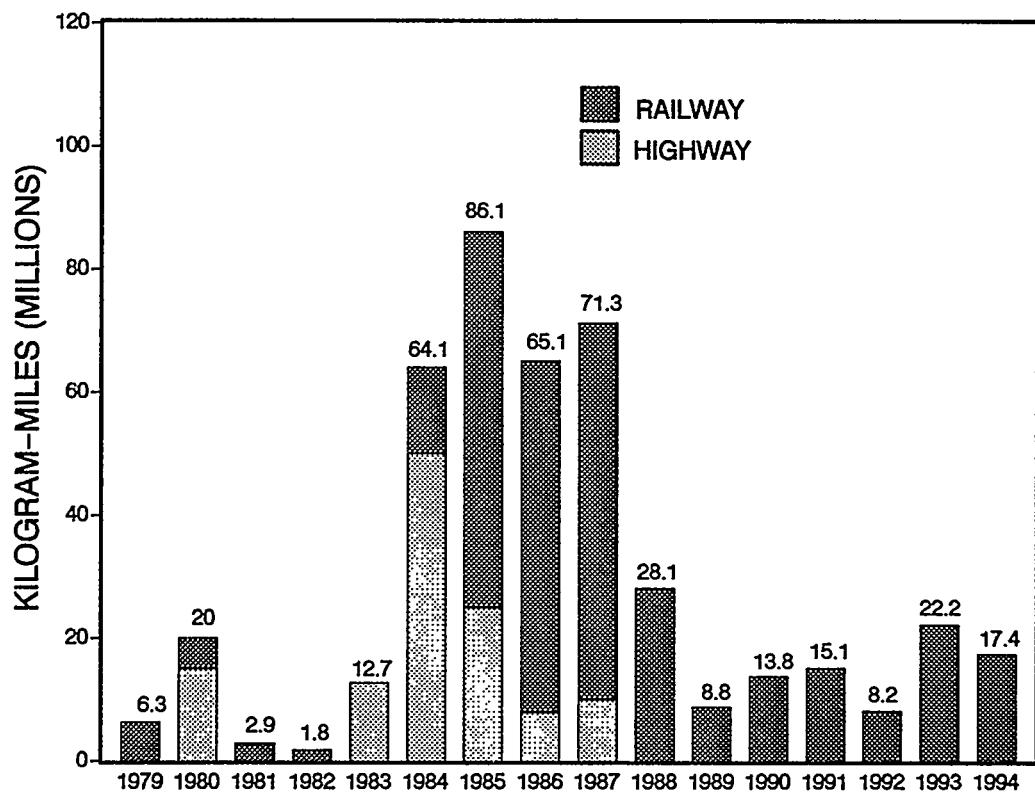


Figure 3.9 Spent Fuel Shipment Kilogram–Miles by Year: 1979–1994

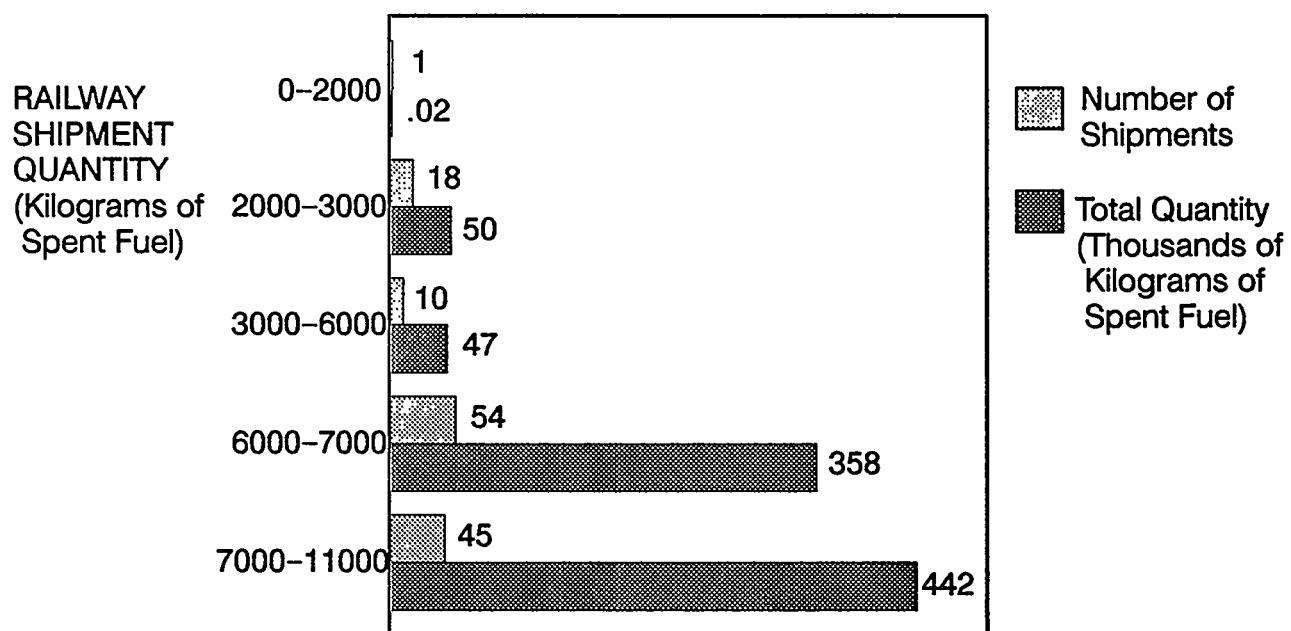
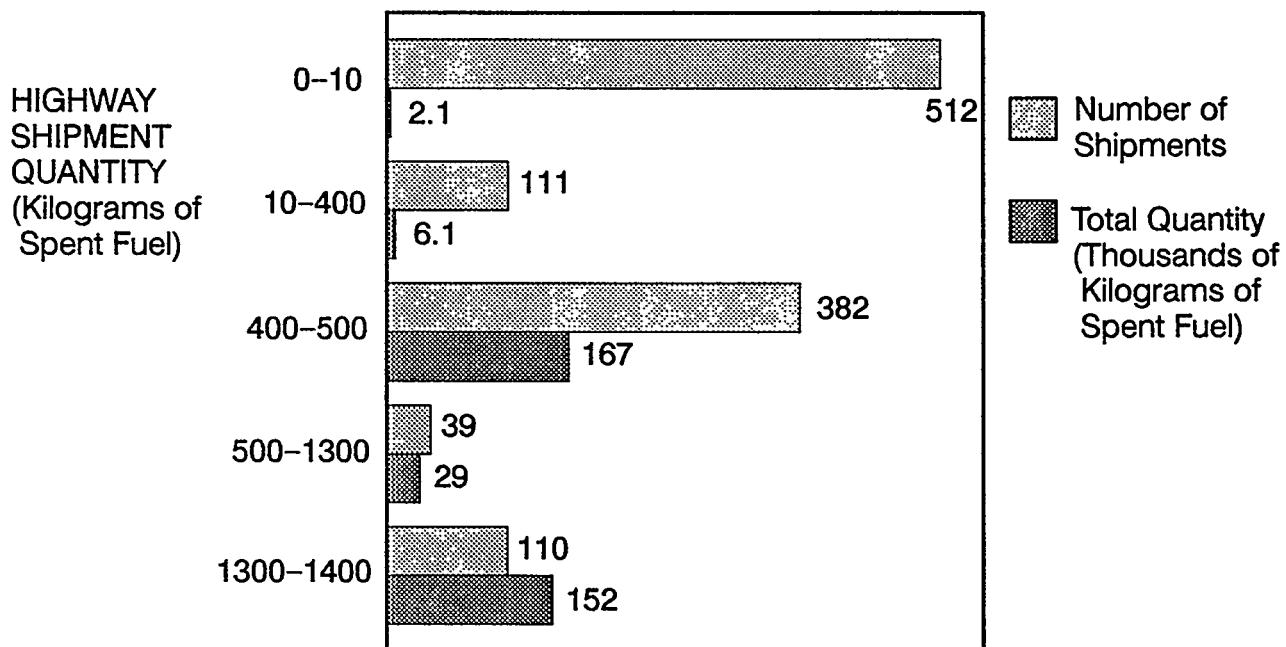
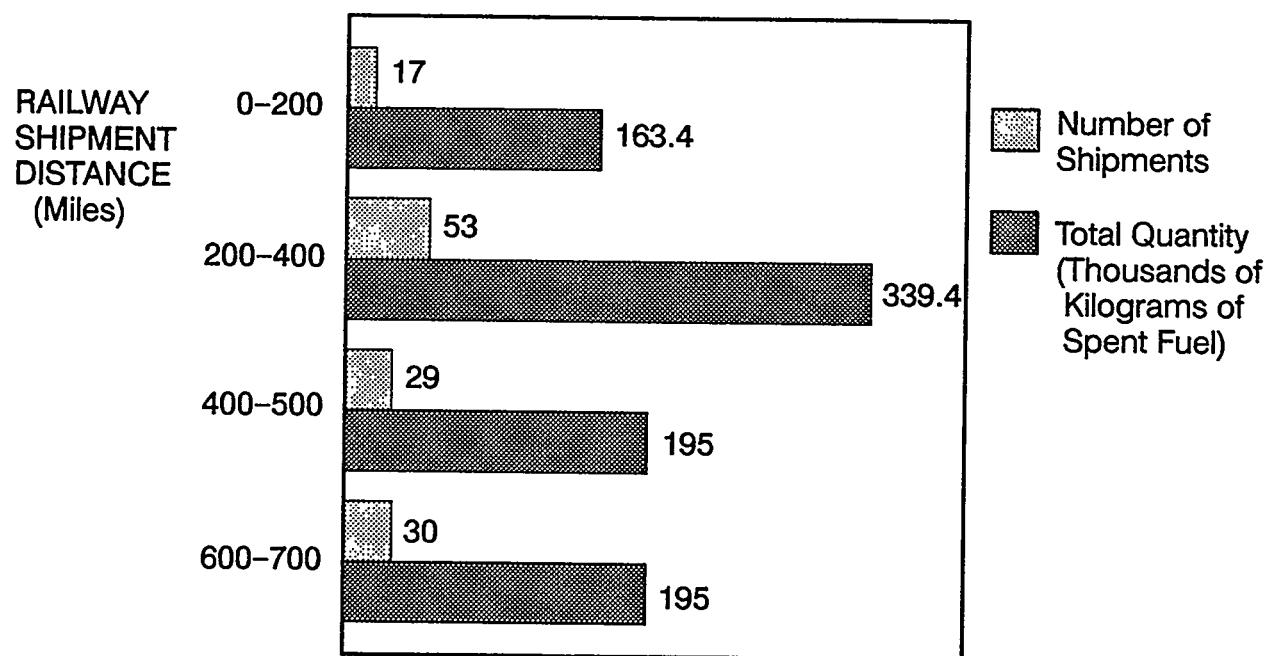
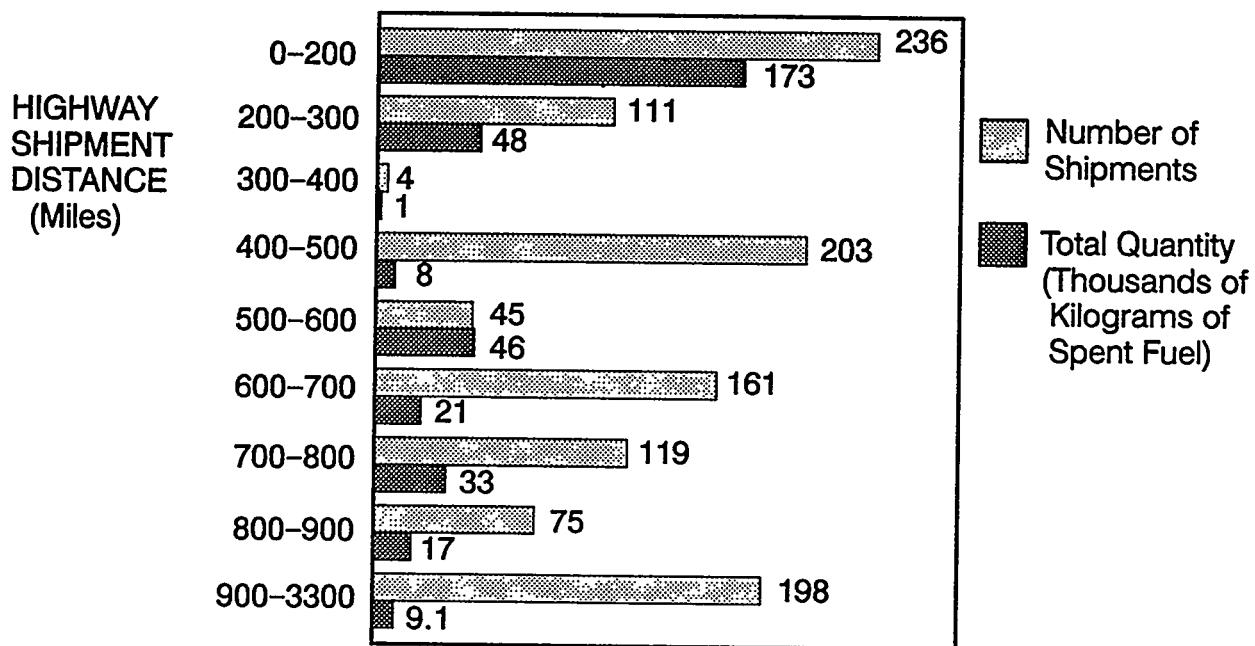


Figure 3.10 Number and Total Quantity of Spent Fuel Shipments by Shipment Quantity Range: 1979–1994



**Figure 3.11 Number and Total Quantity of Spent Fuel Shipments by Shipment Distance Range: 1979-1994**

Table 4.1 Highway and Railway Spent Fuel Shipment Routes Used in 1993–1994

State	Shipment	Highway Shipment Route Segment			Shipments Completed
		From:	Route	To:	
CA	Duane Arnold to GE/Vallecitos	NV line	I-80 W	I-5	1993
		I-80	I-5 S	I-205	
		I-5	I-205 W	I-580	
		I-205	I-580 W	I-680	
		I-580	I-680 S	CA-84	
		I-680	CA-84 E	GE/VAL	
	Hope Creek to GE/Vallecitos		(same as above route)		1993
	GE/Vallecitos to Dundalk Marine Terminal	GE/VAL	CA-84 E	I-580	1994
		CA-84	I-580 E	I-205	
		I-580	I-205 E	I-5	
		I-205	I-5 N	I-80	
		I-5	I-80 E	NV line	
CT	Babcock & Wilcox, Lynchburg to GE/Vallecitos	NV line	I-80 W	I-5	1993
		I-80	I-5 S	I-205	
		I-5	I-205 W	I-580	
		I-205	I-580 W	I-680	
		I-580	I-680 S	CA-84	
		I-680	CA-84 E	GE/VAL	
	Quad Cities to GE/Vallecitos		(same as above route)		1993
	Massachusetts Institute of Technology to Savannah River Project	MA line	I-84 W	NY line	1993/94
		I-84			
DE	Hope Creek to GE/Vallecitos	Hope Creek	I-295 S	I-95	1993
		I-295	I-95 S	MD line	
IL	Babcock & Wilcox, Lynchburg to GE/Vallecitos	IN line	I-74 W	I-474	1993
		I-74	I-474 W/N	I-74	
		I-474	I-74 W	I-280	
		I-74	I-280 W	IA line	
	Hope Creek to GE/Vallecitos		(same as above route)		1993
	GE/Vallecitos to Dundalk Marine Terminal		(reverse of above route)		1994
	Quad Cities to GE/Vallecitos	Plant	IL-84 S	I-80	1993
		IL-84	I-80 W	IA line	
IN	University of Missouri to Savannah River Project	MO line	I-255 E	I-64	1993/94
		I-255	I-64 E	I-57	
		I-64	I-57 S	I-24	
		I-57	I-24 S	KY line	
	Hope Creek to GE/Vallecitos	OH line	I-70 W	I-465	1993
		I-70	I-465 S/W/N	I-74	
		I-465	I-74 W	IL line	

Table 4.1 (Continued)

State	Shipment	Highway Shipment Route Segment			Shipments Completed
		From:	Route	To:	
IN (Cont.)	Babcock & Wilcox, Lynchburg to GE/Vallecitos		(same as above route)		1993
	GE/Vallecitos to Dundalk Marine Terminal		(reverse of above route)		1994
IA	Duane Arnold to GE/Vallecitos	Plant Local Rds. I-380 I-80	Local Roads E I-380 S I-80 W I-680 SW	I-380 I-80 I-680 NE line	1993
	Quad Cities to GE/Vallecitos	IL line I-80 I-35 I-80	I-80 W I-35 S I-80 W I-680 W	I-35 I-80 I-680 NE line	1993
	GE/Vallecitos to Dundalk Marine Terminal		(reverse of above route)		1994
	Babcock & Wilcox, Lynchburg to GE/Vallecitos	IL line I-280 I-80	I-280 W/N I-80 W I-680 W	I-80 I-680 NE line	1993
	Hope Creek to GE/Vallecitos		(same as above route)		1993
KY	University of Missouri to Savannah River Project	IL line I-24	I-24 S	TN line	1993/94
MA	Massachusetts Institute of Technology to Savannah River Project	MIT Albany St. Mass. Ave. I-90	Albany St. Mass. Ave. I-90 W I-84 S	Mass. Ave. I-90 I-84 CT line	1993/94
MD	Ginna Plant to Dundalk Marine Terminal	PA line I-83 I-695	I-83 S I-695 E/S Dundalk Ave.	I-695 Dundalk Ave. Terminal	1993
	Massachusetts Institute of Technology to Savannah River Project	PA line I-81	I-81 S	WV line	1993/94
	GE/Vallecitos to Dundalk Marine Terminal	WV line I-68 I-70	I-68 E I-70 E I-695 E	I-70 I-695 Dundalk Marine Terminal	1994
	Hope Creek to GE/Vallecitos	DE line I-95 I-695 I-70	I-95 S I-695 N/W/S I-70 NW I-68 W	I-695 I-70 I-68 WV line	1993

Table 4.1 (Continued)

State	Shipment	Highway Shipment Route Segment			Shipments Completed
		From:	Route	To:	
MO	University of Missouri to Savannah River Project	Univ. of Missouri	MO-163 N	MO-740	1993/94
		MO-163	MO-740 E	MO-63	
		MO-740	MO-63 N	I-70	
		MO-63	I-70 E	I-270	
		I-70	I-270 S/E	I-255	
		I-270	I-255 E	IL line	
NE	Babcock & Wilcox, Lynchburg to GE/Vallecitos	IA line	I-680 W	I-80	1993
		I-680	I-80 W	WY line	
	Duane Arnold to GE/Vallecitos	(same as above route)			1993
	Hope Creek to GE/Vallecitos	(same as above route)			1993
NJ	GE/Vallecitos to Dundalk Marine Terminal	(reverse of above route)			1994
		Plant	Local Rd.	NJ-49	1993
		Local Rd.	NJ-49 NW	I-295	
		NJ-49	I-295 S	DE line	
NV	Babcock & Wilcox, Lynchburg to GE/Vallecitos	UT line	I-80 W	CA line	1993
		I-80			
	Duane Arnold to GE/Vallecitos	(same as above route)			1993
	Hope Creek to GE/Vallecitos	(same as above route)			1993
	Quad Cities to GE/Vallecitos	(same as above route)			1993
NY	GE/Vallecitos to Dundalk Marine Terminal	(reverse of above route)			1994
		Plant	Local Rds.	NY-104	1993
		Local Rds.	NY-104 W	NY-590	
		NY-104	NY-590 S	I-490	
		NY-590	I-490 E	I-90	
		I-490	I-90 E	I-690	
MA	Ginna Plant to Dundalk Marine Terminal	I-90	I-690 E	I-81	
		I-690	I-81 S	PA line	
MA	Massachusetts Institute of Technology to Savannah River Project	CT line	I-84 W	PA line	1993/94
		I-84			
NC	McGuire Plant to Babcock & Wilcox, Lynchburg	NC-73	NC-73 E	I-77	1994
		I-77	I-77 N	VA line	
VA	University of Virginia to Savannah River Project	VA line	I-77 S	SC line	1993/94
		I-77			

Table 4.1 (Continued)

State	Shipment	Highway Shipment Route Segment			Shipments Completed
		From:	Route	To:	
NC (Cont.)	Massachusetts Institute of Technology to Savannah River Project		(same as above route)		1993/94
	University of Missouri to Savannah River Project	TN line I-40	I-40 E I-26 E	I-26 SC line	1993/94
OH	Hope Creek to GE/Vallecitos	WV line I-470 I-70 I-270	I-470 W I-70 W I-270 S/W/N I-70 W	I-70 I-270 I-70 IN line	1993
	GE/Vallecitos to Dundalk Marine Terminal		(reverse of above route)		1994
PA	Babcock & Wilcox, Lynchburg to GE/Vallecitos	WV line I-77 I-70 I-270	I-77 N I-70 W I-270 S/W/N I-70 W	I-70 I-270 I-70 IN line	1993
	Ginna Plant to Dundalk Marine Terminal	NY line I-81	I-81 S I-83 S	I-83 MD line	1993
SC	Massachusetts Institute of Technology to Savannah River Project	NY line I-84 I-380 I-80	I-84 W I-380 S I-80 W I-81 S	I-380 I-80 I-81 MD line	1993/94
	Hope Creek to GE/Vallecitos	WV line I-79	I-79 N I-70 W	I-70 WV line	1993
TN	GE/Vallecitos to Dundalk Marine Terminal		(reverse of above route)		1994
	Massachusetts Institute of Technology to Savannah River Project (SRP)	NC line I-77 I-20	I-77 S I-20 W SC-19 S	I-20 SC-19 SRP	1993/94
UT	University of Virginia to Savannah River Project		(same as above route)		1993/94
	University of Missouri to Savannah River Project	NC line I-26 I-20	I-26 S I-20 SW SC-19 S	I-20 SC-19 SRP	1993/94
TN	University of Missouri to Savannah River Project	KY line I-24 I-65 I-40 I-640	I-24 SE I-65 S I-40 E I-640 E I-40 E	I-65 I-40 I-640 I-40 NC line	1993/94
	Babcock & Wilcox, Lynchburg to GE/Vallecitos	WY line I-80	I-80 W	NV line	1993
	Duane Arnold to GE/Vallecitos		(same as above route)		1993

Table 4.1 (Continued)

State	Shipment	Highway Shipment Route Segment			Shipments Completed
		From:	Route	To:	
UT (Cont.)	Hope Creek to GE/Vallecitos	(same as above route)			1993
	GE/Vallecitos to Dundalk Marine Terminal	(reverse of above route)			1994
	Quad Cities to GE/Vallecitos	WY line I-80 I-15	I-80 W I-15 N I-80 W	I-15 I-80 NV line	1993
VA	McGuire Plant to Babcock & Wilcox, Lynchburg	NC line I-77 I-81 Alt-220 US-460	I-77 N I-81 N Alt-220 S US-460 E VA-726 N	I-81 Alt-220 US-460 VA-726 B&W	1994
	University of Virginia to Savannah River Project	UVA Local Rds. US-250 US-29 I-64 I-81	Local Rds. US-250 W US-29 S I-64 W I-81 S I-77 S	US-250 US-29 I-64 I-81 I-77 NC line	1993/94
	Massachusetts Institute of Technology to Savannah River Project	WV line I-81 I-77	I-81 SW I-77 S	I-77 NC line	1993/94
	E. I. Hatch to Babcock & Wilcox, Lynchburg	SC line I-95 I-85 US-460	I-95 N I-85 W US-460 W VA-726 N	I-85 US-460 VA-726 B&W	1994
	Babcock & Wilcox, Lynchburg to GE/Vallecitos	Site VA-726 US-460 Alt-220 US-11 I-81	VA-726 S US-460 W Alt-220 N US-11 N I-81 N I-64 W	US-460 Alt-220 US-11 I-81 I-64 WV line	1993
WV	Massachusetts Institute of Technology to Savannah River Project	MD line I-81	I-81 S	VA line	1993/94
	GE/Vallecitos to Dundalk Marine Terminal	OH line I-470 PA line I-70 I-79	I-470 E I-70 E I-70 E I-79 S I-68 E	I-70 PA line I-79 I-68 MD line	1994
	Hope Creek to GE/Vallecitos	(reverse of above route)			1993
	Babcock & Wilcox, Lynchburg to GE/Vallecitos	VA line I-64	I-64 W I-77 N	I-77 OH line	1993

Table 4.1 (Continued)

State	Shipment	Highway Shipment Route Segment			Shipments Completed
		From:	Route	To:	
WY	Babcock & Wilcox, Lynchburg to GE/Vallecitos	NE line I-80	I-80 W	UT line	1993
	Duane Arnold to GE/Vallecitos	(same as above route)			1993
	Quad Cities to GE/Vallecitos	(same as above route)			1993
	Hope Creek to GE/Vallecitos	(same as above route)			1993
	GE/Vallecitos to Dundalk Marine Terminal	(reverse of above route)			1994

Table 4.1 (Continued)

State	Shipment	Railway Shipment Route Segment			Shipments Completed
		From:	Route	To:	
NC	Brunswick to Shearon Harris	Brunswick	Military Ocean Term. track	Leland	1993/94
			CSX	Hamlet	
			CSX (Shearon Harris)	Bonsal	
			CSX	Hamlet Bonsal (Shearon Harris)	
SC	Robinson to Shearon Harris	SC line Hamlet	CSX	Hamlet Bonsal (Shearon Harris)	1993
			CSX	NC line	

**BIBLIOGRAPHIC DATA SHEET**  
(See Instructions on the reverse)

**2. TITLE AND SUBTITLE**

Public Information Circular for Shipments of  
Irradiated Reactor Fuel

**1. REPORT NUMBER**  
(Assigned by NRC, Add Vol.,  
Supp., Rev., and Addendum Num-  
bers, if any.)

NUREG-0725, Rev. 10

**3. DATE REPORT PUBLISHED**

MONTH	YEAR
April	1995

**5. AUTHOR(S)**

**4. FIN OR GRANT NUMBER**

Regulatory

**7. PERIOD COVERED (Inclusive Dates)**

01/01/79 to 12/31/94

**8. PERFORMING ORGANIZATION - NAME AND ADDRESS** (If NRC, provide Division, Office or Region, U.S. Nuclear Regulatory Commission, and mailing address; If contractor, provide name and mailing address.)

Division of Industrial and Medical Nuclear Safety  
Office of Nuclear Material Safety and Safeguards  
U.S. Nuclear Regulatory Commission  
Washington, DC 20555-0001

**9. SPONSORING ORGANIZATION - NAME AND ADDRESS** (If NRC, type "Same as above"; If contractor, provide NRC Division, Office or Region, U.S. Nuclear Regulatory Commission, and mailing address.)

**10. SUPPLEMENTARY NOTES**

Updates expected to be issued annually

**11. ABSTRACT (200 words or less)**

This circular has been prepared to provide information on the shipment of irradiated reactor fuel (spent fuel) subject to regulation by the Nuclear Regulatory Commission (NRC), and to meet the requirements of Public Law 96-295. The report provides a brief description of NRC authority for certain aspects of transporting spent fuel. It provides descriptive statistics on spent fuel shipments regulated by the NRC from 1979 to 1994. It also lists detailed highway and railway segments used within each state from January 1, 1993, through December 31, 1994.

**12. KEY WORDS/DESCRIPTORS** (List words or phrases that will assist researchers in locating the report.)

spent fuel shipment routes  
spent fuel shipment statistics

**13. AVAILABILITY STATEMENT**  
Unlimited

**14. SECURITY CLASSIFICATION**  
(This Page)

Unclassified  
(This Report)

Unclassified

**15. NUMBER OF PAGES**

**16. PRICE**