WSRC-RP-89-715
~~Controlled by Receipt~~

36 1687

SRL Record Copy

SAFETY ANALYSIS
SAVANNAH RIVER SITE

EVALUATION OF ACCIDENT RISKS IN THE TRANSPORTATION OF HAZARDOUS MATERIALS BY TRUCK AND RAIL AT THE SAVANNAH RIVER SITE (U)

9/30/89

Vol. 1 of 1

Westinghouse Savannah River Company
Savannah River Laboratory
Aiken, SC 29808

SAFETY • RESPONSIBILITY • SECURITY
SRS
SAVANNAH RIVER SITE

PREPARED FOR THE U. S. DEPARTMENT OF ENERGY UNDER CONTRACT NO. DE-AC09-76SR00001
(NOW CONTRACT NO. DE-AC09-88SR18035)

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

LIST OF TABLES

LIST OF TABLES (Continued)

LIST OF FIGURES

LIST OF FIGURES (Continued)

LIST OF FIGURES (Continued)

LIST OF FIGURES (Continued)

1.0 INTRODUCTION AND SUMMARY

Transportation of hazardous materials at the Savannah River Plant (SRP) takes place on the onsite highways and railroads. Under the Westinghouse Savannah River Company (WSRC) contract the name of the site is now the Savannah River Site (SRS); the former reference to SRP is used interchangeably in this document. These arteries connect the SRP facilities to each other and to public transportation networks. The transported hazardous materials (commonly referred to as HMs in this document) consist of both radioactive and nonradioactive materials and include materials used by the facilities, products produced, and facility wastes. Flows of these materials and commercial flow on public access highways are illustrated in Figures 3-37, 3-38, and 3-39.

This report presents an analysis of the consequences and risks of accidents resulting from hazardous material transportation at the SRP. Radiation exposures during normal transportation operations are measured by personal dosimeters worn by the onsite population and are not included in this document. The analysis is based on the SRP transportation system design and operations data. The consequence and risk analysis methods used are consistent with those described in other SRP safety analysis reports (SARs) (1). However, because of the unique aspects of the transportation system analysis, additional methodologies and data sources, such as national transportation and occupational safety data, are included. The format and content of this report are consistent with guidelines presented in Savannah River Implementation Plans for U.S. Department of Energy (DOE) Order 5481.1A (2). The purpose of performing the safety analysis is to assess the risk of ongoing hazardous material transportation activities conducted in support of SRP operations within the confines of the SRP site. Specifically not included in the analysis are public transportation activities conducted on corridors that pass through the site. The transport onsite of materials packaged for offsite shipments is included but transportation past the SRS boundaries is not assessed.

Consequences are calculated in terms of exposures to hazardous materials resulting from accidents (e.g., person-rem for accidents involving radioactive materials or the number of people exposed to higher than health-effects-threshold values for nonradioactive materials). Risks are calculated as the products of consequences and accident frequencies.

The analysis is based on the facilities, equipment, and operations representative of transportation operations at the SRP during the 1982 to mid-1985. This time, during which three reactors operated at full power with production of Pu-238, Pu-239, tritium, and other special radionuclides represents bounding risks for current and future operations. Accident consequences and risks are summarized in this section and presented in detail in Chapter 5.0. Some changes have been made since collecting the information for this report. The most noteworthy changes significant to the risks of transporting hazardous materials onsite are:

- Low level waste (LLW) handling and disposal operations were changed significantly to improve the safety of operations and efficient use of Burial Ground space.

- Wherever possible, liquid chlorine, which is used in water purification, is being replaced by a much less volatile sodium hypochlorite solution.

The changes made in handling and disposal of solid LLW, if incorporated into the calculations of consequences and risk, are expected to result in lower risks for onsite transportation of these materials. For example, discontinuation of the use of skip-pans (load-lugger pans) in favor of metal burial boxes is expected to reduce the frequency of accidental failures of LLW packages and the amounts of radioactive materials released in transport accidents. Although these changes are significant for handling, transporting, and disposing of LLW, their incorporation into the analyses presented here do not significantly alter the overall results.

Although changes in onsite transportation equipment, facilities, and operations addressed above affect the conclusions of this report to a limited extent, future revisions will reflect these and other changes that modify the character or scope of onsite transportation. Specifically, future revisions will reflect recent developments in DOE Orders that govern transportation operations, both on- and offsite. In addition, future revisions will reflect the changes in onsite operations policies and practices arising from the change in management of the SRS by the E. I. du Pont de Nemours & Company to management by the WSRC. This change occurred in April 1, 1989, after this analysis was prepared.

This report has been revised in response to comments by the U.S. DOE, Savannah River Office. The comments and resulting responses are included as an attachment.

1.1 THE SAVANNAH RIVER SITE TRANSPORTATION SYSTEM

The Savannah River Site, which is managed by the Westinghouse Savannah River Company (WSRC) (previously by E. I. du Pont de Nemours & Company) for DOE, has operated since 1952. Since then the facilities have been operated primarily to produce radioactive material products for U.S. defense activities, energy activities, and other federal government programs. Roads and railways onsite were developed to provide safe and efficient transportation of personnel, supplies, products, and wastes in support of the facility operations. The roads, railways, and vehicles are well maintained. Transport activities for hazardous materials use many and varied vehicles and transport packagings. The vehicles include those operated by WSRC, DOE and its contractors onsite, as well as vehicles operated by vendors and commercial carriers transporting materials to and from the site. Old vehicles used on the site are being replaced with new ones that meet current highway and railway safety standards.

Packagings for hazardous materials transported at the site include U.S. Department of Transportation (DOT) specification packagings, including cargo vehicles that meet DOT Specifications; DOE and Nuclear Regulatory Commission

(NRC) certified Type B packagings for radioactive materials; and many SRP packagings designed for specialized applications.

Materials transported include radioactive materials in the forms of powders, bulk liquids, samples, solid billets, fabricated components, gasses, solid wastes, and contaminated equipment. Nonradioactive hazardous material forms that are transported at the SRP include bulk liquids, granular solids, liquified gasses, laboratory reagents, and janitorial supplies.

Transportation operations are controlled by established procedures and other administrative controls. Vehicles move between facilities and to and from points onsite, carrying out specified hazardous materials transportation activities with only infrequent flow modifications to accommodate special cargoes. Except for rail operations, vehicles move on the roads independent of other vehicular movements. Thus, except for the relatively low traffic density, onsite transportation has the appearance of general commerce transportation off the site. Onsite transportation of hazardous materials is normally conducted between shift changes when traffic density is low.

1.2 APPROACH TO ACCIDENT ANALYSIS

Consistent with the DOE requirements for SARs, the information presented here follows a logical order of first describing the site, system, and operations relevant to transportation safety. Based on these descriptions, the frequencies of accidents and subsequent releases of hazardous materials are then defined. The analytical methods employed to evaluate the consequences and risks of the accidents are described; accident consequences are estimated; and, finally, risk values are calculated.

This safety analysis uses transportation accident statistics presented in a recent report conducted for the U.S. Nuclear Regulatory Commission (NRC) by the Lawrence Livermore National Laboratory (LLNL) (3). The transportation of hazardous materials at the SRP is defined based on site specific characteristics such as the materials shipped, the types of containers and vehicles used, and the frequency and length of shipments. Because of the sparsity of site data, regional and national accident rate data (accidents/mi) were used with the site data to estimate the onsite accident frequencies (accidents/yr). Consistent with this approach, releases of materials resulting from accidents were estimated based on statistics for damage of similar transport packages in accidents in commerce and statistics for releases associated with a given level of damage. In view of the attention to safety in the Savannah River operations and the excellent safety record for the facility operations, the use of national commercial accident rate data to estimate SRP accident rates is regarded as a conservative approach (i.e., results in overestimates of the risks of accidents associated with hazardous materials transportation operations).

Analysis of accident consequences and risks for all hazardous materials being transported at the SRP is not practical. Therefore, the material commodities and associated shipments were screened to determine those with significant hazard potential (see Section 5.2.4 for a discussion of methods used to conduct the screening). Accident analyses were performed for those radioactive and nonradioactive materials of most concern which were selected in the screening process.

Impacts on the health and safety of workers and the public were estimated using analytical methods employed in other SARs for SRP facilities operations (1). Impacts in terms of consequences were determined for atmospheric and surface water transport pathways for released materials.

1.3 ACCIDENT ANALYSIS RESULTS

The principal risks associated with the transportation of hazardous materials at the SRP result from postulated releases of transuranic radionuclides, liquid chlorine, and bulk acids. Transuranic radionuclides are shipped in several forms, individually or combined with other radionuclides, and in many different kinds of packaging. However, the shipment commodity type with the predominant radiological risk is transuranic (TRU) wastes contained and moved in 55-gal drums. The estimated risk associated with all accidents involving the transportation of radioactive materials on site is $2.7x10^{-3}$ person-rem/yr to the offsite population, $7.8x10^{-4}$ person-rem/yr to the onsite population, and $7.5x10^{-6}$ rem/yr to the maximally exposed individual. In addition, on the basis of the analysis there are no accidents involving the transportation of radioactive materials on the SRP that will result in offsite consequences great enough to warrant designation of an offsite Emergency Planning Zone. **The greatest consequence is for a postulated accident in A-Area involving a high level waste trailer. The maximum offsite individual exposure resulting from this accident is estimated to be 0.69 rem.**

The risks are very small when compared to annual exposure to natural background radiation of the population in the 13 county area surrounding the SRP (approximately $6.8x10^{4}$ person-rem/yr). SRP onsite population exposure risks from onsite radioactive material transportation is also very small when compared to natural background exposures (approximately $1.6x10^{3}$ person-rem/yr from background radiation). An individual at the SRP or its surroundings is exposed to approximately 0.3 rem/yr from natural radiation sources. Thus, the calculated yearly risk to the hypothetical maximum individual is approximately three orders of magnitude below that from the annual normal background dose.

For nonradioactive hazardous materials, liquid chlorine transported in one-ton cylinders and bulk acids transported as concentrated liquids pose the greatest risk to onsite and offsite personnel. Risk values are $5.9x10^{-1}$ person/yr onsite and $8.8x10^{-3}$ person/yr offsite exposed above the toxic health-effects thresholds for these materials. The expected frequency of accidents involving releases of liquid chlorine is $1.1x10^{-3}$/yr.

For comparison, in the 13 county area surrounding the SRP (about 680,000 people) it is estimated that, on average, there will be one fatality each ten years attributable to the cargo in accidents involving commercial shipments of gasoline. This estimate is based on data compiled by Battelle Pacific Northwest Laboratories (4). Noteworthy is that the basis for the estimate attributes fatalities allocated to the hazardous nature of the cargo to fire and explosion hazards associated with gasoline transport and discounts hazards allocated to inhalation of gasoline vapors. In addition, 40% of the hazardous-cargo-caused fatalities in highway transportation of gasoline are those of truck drivers. Presumably a large fraction of the remaining commodity-related fatalities are persons in other vehicles who are involved in the accidents. Correspondingly, because fire and explosion were the only factors considered to be significant in the estimation of the risks, only persons directly involved in the accidents or in close proximity would be affected. Fatalities resulting from bodily harm due to vehicle collision during truck transport of gasoline are two to three times those attributable to the cargo. Traffic accidents in general, in the same area, can be expected to claim on the order of 170 lives each year. These comparisons were selected to help place into perspective risks associated with onsite transportation of nonradioactive hazardous material. However, the reader is cautioned that risks reported here for SRP transportation activities are those to uninvolved bystanders or members of the general public.

Consequences and risks for the hazardous commodities assessed to have the greatest hazard potential are summarized in Tables 1-1 and 1-2. Table 1-1 presents the results for radioactive materials; Table 1-2 contains results for nonradioactive hazardous materials.

1.4 REFERENCES

1. Beary, M. M., et. al. Safety Analysis - 200 Area Savannah River Plant H-Canyon Operations, Internal Report DPSTSA-200-10, SUP-5, for E. I. du Pont de Nemours & Co., Savannah River Laboratory, Aiken, SC, February 1986.

2. U. S. Department of Energy. SR Implementation Plans for DOE Order 5481.1A. Savannah River Operations Office. Aiken, SC, June 1982.

3. Fischer, L. E., et al. Shipping Container Response to Severe Highway and Railway Accident Conditions Main Report. NUREG/CR-4829-VI. Prepared for the Nuclear Regulatory Commission by Lawrence Livermore National Laboratory, February 1987.

4. Rhoads, R.E. An Assessment of the Risk of Transporting Gasoline by Truck PNL 2133, Battelle Pacific Northwest Laboratories, Richland, Washington, November 1978.

TABLE 1-1. Consequences and Risks to Onsite and Offsite Populations - Radioactive Materials

Accident	Location	Consequences: Max Ind rem	Consequences: Offsite pers-rem	Consequences: Onsite[a] pers-rem	Frequency of Release to Pathway[e]	Risk: Max Ind rem/yr	Risk: Offsite pers-rem/yr	Risk: Onsite[a] pers-rem/yr
Breach or Puncture of TRU Drum	Bur Gnd	1.9E-2[b]	1.3E+2	2.7E+1	1.5E-5	2.9E-7	2.0E-3	4.1E-4
	A-Area	5.5E-1	1.2E+2	3.3E+1	1.5E-5	8.3E-6	1.8E-3	5.0E-4
Basin Sludge Trailer Leak	F-Area	1.3E-7	4.4E-5	7.8E-5	5.0E-2	6.6E-9	2.2E-6	4.0E-6
	100-Area	1.2E-7	3.0E-4	7.2E-5	5.0E-2	6.2E-9	1.5E-5	3.6E-6
Product Waste Cask Accident	200-Area	2.3E-5	1.4E-1	3.4E-2	1.0E-5	2.3E-10	1.4E-6	3.4E-7
	A-Area	6.8E-4	1.2E-1	4.2E-2	1.0E-5	6.8E-9	1.2E-6	4.2E-7
UNH Trailer Leak (liquid)	UTRC[c]	3.6E-4	1.4E+1	_[d]	9.1E-7	3.2E-10	1.2E-5	_[d]
Low Level Waste Trailer Leak (atm rel)	200-Area	8.9E-8	3.0E-4	5.1E-5	5.0E-2	4.5E-9	1.5E-5	2.6E-6
	100-Area	8.1E-8	2.0E-4	4.7E-5	5.0E-2	4.1E-9	1.0E-5	2.4E-6
Low Level Waste Trailer Leak (liq rel)	UTRC[c]	8.0E-8	1.7E-4	_[d]	7.8E-8	6.3E-15	1.3E-11	_[d]
H-Area Sample Truck Accident	200-Area	1.7E-5	7.5E-2	1.8E-2	4.5E-5	7.7E-10	3.4E-6	8.1E-7
High Level Waste Trailer Accident (atm rel)	A-Area	6.9E-1	1.2E+2	4.2E+1	1.5E-9	1.0E-9	1.8E-7	6.4E-8
	200-Area	3.1E-2	1.0E+2	1.8E+2	1.5E-9	4.7E-11	1.5E-7	2.7E-7
High Level Waste Trailer Accident (liq rel)	UTRC[c]	5.6E-2	2.1E+3	_[d]	1.5E-10	8.5E-13	3.2E-8	_[d]

TABLE 1-1. Consequences and Risks to Onsite and Offsite Populations - Radioactive Materials (Continued)

Accident	Location	Consequences Max Ind rem	Consequences Offsite pers-rem	Consequences Onsite[a] pers-rem	Frequency of Release to Pathway[e]	Risk Max Ind rem/yr	Risk Offsite pers-rem/yr	Risk Onsite[a] pers-rem/yr
Rupture of D20 Drum	D-Area	2.1E-3	3.0E+0	1.5E-1	3.1E-5	6.8E-8	9.3E-5	4.7E-6
	100-Areas	5.4E-4	1.3E+0	3.2E-1	3.1E-5	1.7E-8	4.0E-5	9.9E-6
Totals						7.5E-6	2.7E-3	7.8E-4

a Does not include occupational dose and risk associated with recovery of radioactive materials in an accident. Also, does not include occupational dose and risks resulting from normal operations.

b Scientific notation - read 1.2E-2 as 0.012 or 1.2×10^{-2}

c Upper Three Runs Creek

d No onsite consumption of water from downstream areas

e P(A)/yr x P (L/R, A) from Table 5-10.

TABLE 1-2. Consequences and Risks to Onsite and Offsite Populations - Nonradioactive Materials

Released Material	Location	Tox. Lim. R (mi)[b]	Consequences: Peak Conc at Site Boundary (mg/m^3)	Consequences: Offsite Pop Exp > Limit (# pop)	Consequences: Onsite Pop Exp > Limit (# pop)	Frequency[d] of Release Pathway at Location	Risk: Offsite Pop Risk (pop/yr)	Risk: Onsite Pop Risk (pop/yr)
Liquid Chlorine	D-Area	1.4	7.4	0	3.0E2	2.1E-5	0	6.4E-3
	100-Area	2.1	3.4	0	1.55E2	2.0E-4	0	3.1E-2
	A-Area	0.9	4.5E1	4	1.47E3	2.7E-5	1.1E-4	3.9E-2
	200-Area	1.4	2.0	0	6.35E2	7.9E-5	0	5.0E-2
	Gate 7	1.0 est	—	4.0E2	2	1.1E-5	4.2E-3	2.1E-5
Gasoline and 1-1-1 Trichloro-ethane	All Areas	NE[c]	3.2E1	0	0		0	0
	Gates	NE	—	0	0		0	0
Sodium Hydroxide	All Areas	NE	2.0E-1	0	0		0	0
	Gates	NE	—	0	0		0	0
Hydrogen Fluoride (acqueous)	A-Area	NE	9.4E-2	0	0		0	0
	200-Area	NE	3.0E-2	0	0		0	0
	Gates	NE	—	0	0		0	0
Nitric Acid, Sulfuric Acid & Phosphoric Acid	A-Area	1.4	6.9E1	0	1.47E3	1.1E-4	0	1.6E-1
	200-Area	1.8	3.1	0	6.35E2	3.3E-4	0	2.1E-1
	D-Area	1.8	5.0E1	0	3.0E2	8.9E-5	0	2.7E-2
	Gate-7	1.0 est	—	0	2	4.5E-5	0	8.9E-5
Sodium[a] Hypo-chlorite	All Areas exc. Gates	See liquid chlorine for consequence estimates					5.9E-5	6.7E-2
	Gates						2.2E-3	1.1E-5

TABLE 1-2. Consequences and Risks to Onsite and Offsite Populations - Nonradioactive Materials (Continued)

			Consequences				Risk	
Released Material	Location	Tox. Lim. R (mi)[b]	Peak Conc at Site Boundary (mg/m^3)	Offsite Pop Exp > Limit (# pop)	Onsite Pop Exp > Limit (# pop)	Frequency[d] of Release Pathway at Location	Offsite Pop Risk (pop/yr)	Onsite Pop Risk (pop/yr)
Totals							6.6E-3	5.9E-1

[a] Sodium Hypochlorite solution contains approximately 12% chlorine by weight. Therefore, data for liquid chlorine are conservatively used here. The risk for "All Areas" is the sum of the Sodium Hypochlorite risks for areas listed in liquid chlorine.

[b] Tox. Lim R(mi) - The maximum calculated distance in miles from the accident at which concentrations could reach the Toxicological End Points presented in Table 5-4.

[c] NE - the threshold limit is not exceeded even near to the release.

[d] Probability per year of release

2.0 SITE EVALUATION

2.1 DESCRIPTION OF SAVANNAH RIVER SITE PHYSICAL ENVIRONMENT

The Savannah River Plant (SRP) reservation is an approximately circular tract of about 300 square miles within Aiken, Barnwell, and Allendale counties in southwestern South Carolina. The plant site is centered approximately 25 miles southeast of Augusta, Georgia; 100 miles from the Atlantic Coast; and is bounded on the southwest by the Savannah River (Figure 2-1). Other distances to locations of interest are shown in Table 2-1. The SRP Site Map, Figure 2-2, shows the major roadways and railways as well as the locations of all major facilities.

The 192,323 acres encompass a diversity of sandhills and coastal plain ecosystems which provide extensive timber and wildlife resources and various environmental research opportunities. Timber and wildlife resources are managed by the U.S. Forestry Service (USFS) through an interagency agreement with DOE. The initial agreement between the Atomic Energy Commission and USFS in 1952 called for establishing pine plantations on approximately 80,000 idle acres left behind by some 6000 former residents. Over the years, the Forest Management program has expanded to include timber sales, reforestation, wildlife management, deer hunt administration, soil stabilization, and secondary (unpaved) road maintenance and reconstruction.

Descriptions of the topographic, geologic, seismologic, hydrologic, meteorologic, and population characteristics of the site are found in References 1 and 2. These site characteristics are examined in Chapter 5.0 for situations in which transportation operations can be affected by natural phenomena.

2.1.1 Topography

The topography of the site is characterized by gently rolling uplands, with elevations ranging from 89 to 400 ft above sea level. The greatest relief is along south-westerly flowing streams which have incised asymmetric valleys into the uplands. These valleys are characterized by steep east slopes and relatively gentle west slopes. The steepest primary road gradient on the site is immediately east of the point where Road C crosses Upper Three Runs Creek. The road bed at this point drops approximately 100 ft in a quarter mile. The major site facilities are located on the relatively flat upland areas between creeks.

2.1.2 Geology

South Carolina is divided into two main geologic provinces: The Piedmont Plateau, which is underlain by igneous and metamorphic rock; and the Atlantic Coastal Plain, which is characterized by flat, mostly unconsolidated sediments of Cretaceous age or younger. The boundary between the two provinces, called the Fall Line, is not a sharp line of contact but a zone of transition from the typical land forms of one province to those of the other.

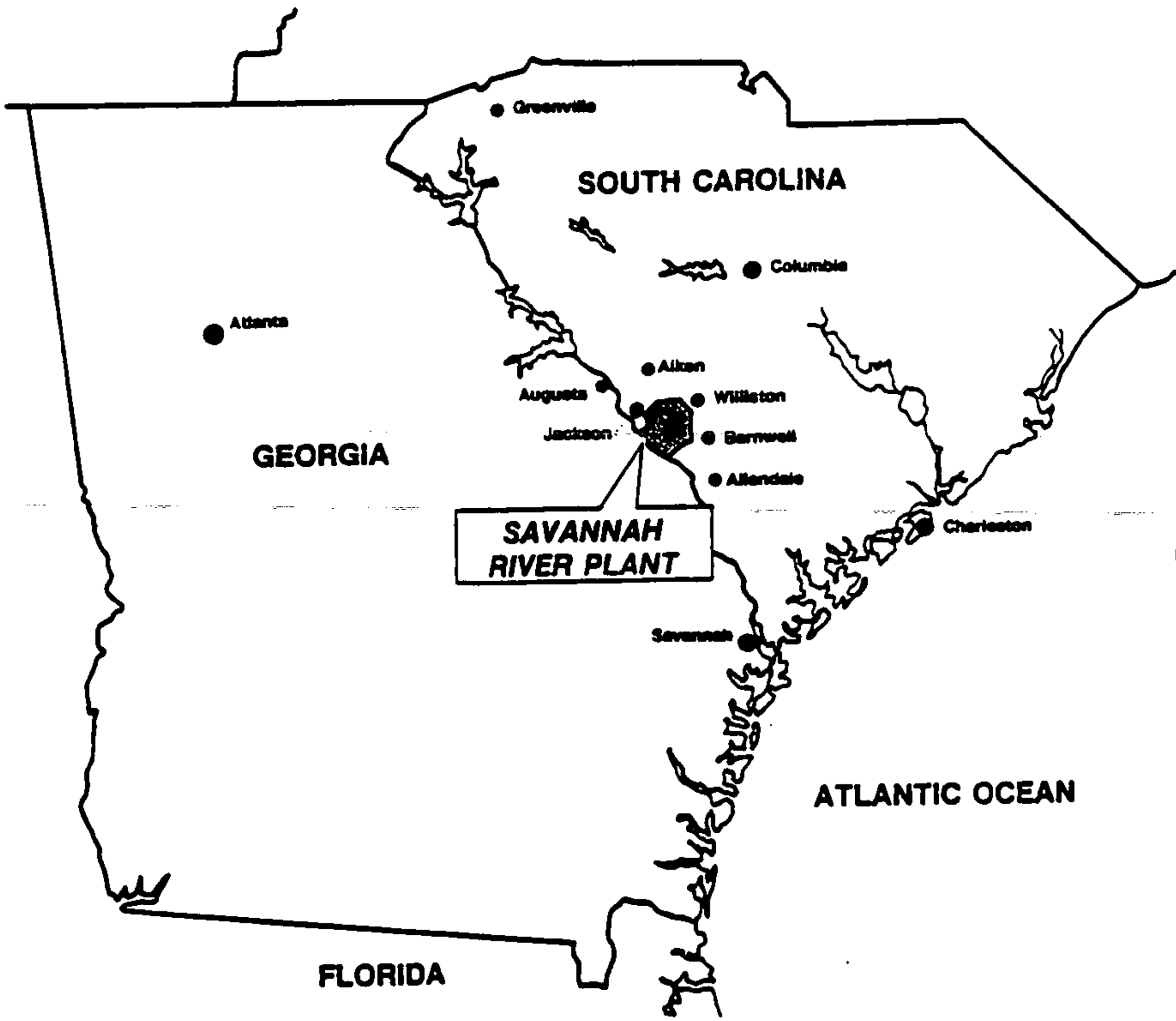


FIGURE 2-1. The Savannah River Plant Location

TABLE 2-1. Approximate Distances to Locations of Interest

From Center of Plant to	Distance (miles)
Greenville, SC	115
Atlantic Ocean	100
Charleston, SC	100
Savannah, GA	100
Columbia, SC	60
Augusta, GA	25
Aiken, SC	20
Barnwell, SC	15
Williston, SC	15

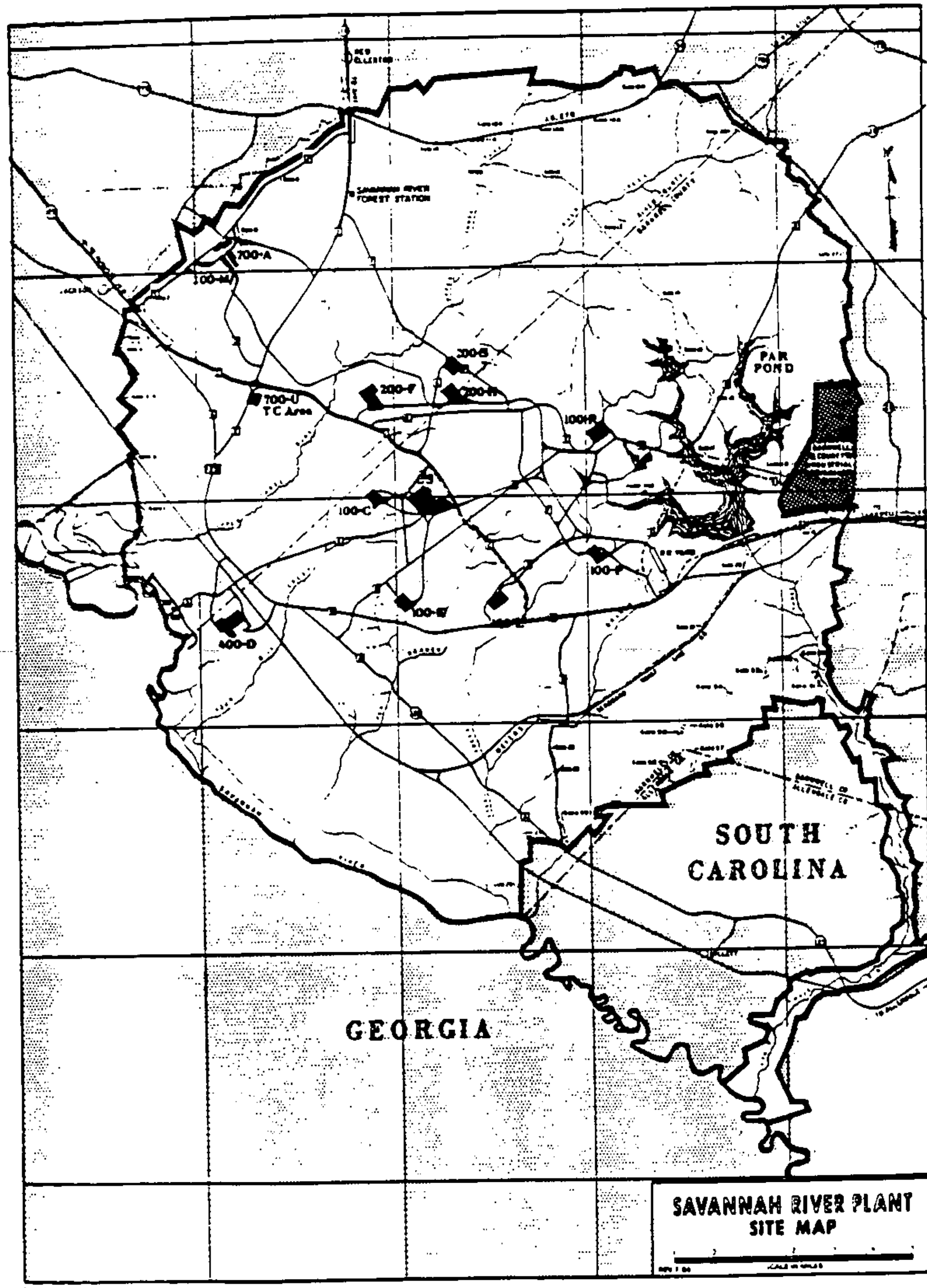


FIGURE 2-2. The Savannah River Plant Site

The SRP site is located on the upper Atlantic Coastal Plain in Aiken and Barnwell Counties, South Carolina. About 20 miles northwest of the site is the lower edge of the Piedmont Plateau (the other main geologic province in South Carolina).

The geologic layers of the plant site affect the migration rates and direction of groundwater flow. Geologic formations beneath the site are the Hawthorn, Barnwell, McBean, Congaree, Ellenton, and Tuscaloosa Formations, and bedrock (crystalline metamorphic rock and the Dunbarton Triassic Basin). Figure 2-3 is a profile of the geologic formations beneath the SRP. The sediments that constitute the formations above bedrock are in six distinct layers, average approximately 300 meters in thickness, and are either unconsolidated or semi-consolidated. The crystalline metamorphic rocks outcrop at the Fall Line and dip approximately 36 ft/mile to the southeast underneath the coastal plain sediments.

The major physiographic divisions in the site region are the Aiken Plateau and the Congaree Sand Hills. The Aiken Plateau is bounded by the Savannah and the Congaree Rivers and extends from the Fall Line to the coastal terraces. The surface of the Aiken Plateau is highly dissected and characterized by broad interfluvial areas with narrow steep-sided valleys. Relief is locally as much as 300 ft.

The site region, defined as the area within 200 miles of the site, contains elliptical depressions called Carolina Bays. These features, common throughout the Atlantic Coastal Plain, are most numerous in North Carolina and South Carolina.

The Congaree Sand Hills trend along the Fall Line northwest and north of the Aiken Plateau. The sand hills are characterized by gentle slopes and rounded summits, and are interrupted by the valleys of southeast-flowing streams and their tributaries.

2.1.3 Seismicity

The SRP is in an area of low seismic frequency. Based on three centuries of recorded history of earthquakes, an earthquake above Intensity VII on the Modified Mercalli Scale (MM) is not expected at the SRP. (See Reference 1, Appendix C for a description of the Modified Mercalli Scale.) Only two earthquakes of Intensity VII or greater have occurred within 200 miles of the site. They were the Charleston, South Carolina, event (epicenter 90 miles from the site) and the Union County, South Carolina, event (epicenter 100 miles from the site).

Available data indicate 18 events of Intensity VII or greater in the Central and Southern Appalachian Mountains and Atlantic Coastal Plain over the past two centuries (1). The largest event was the 1886 Charleston earthquake which was Intensity X. The next largest events were the Giles County, Virginia, earthquake (Intensity VIII) of 1897 and the Union County, South Carolina, earthquake (Intensity VII-VIII) of 1913. All other events were Intensity VII or less.

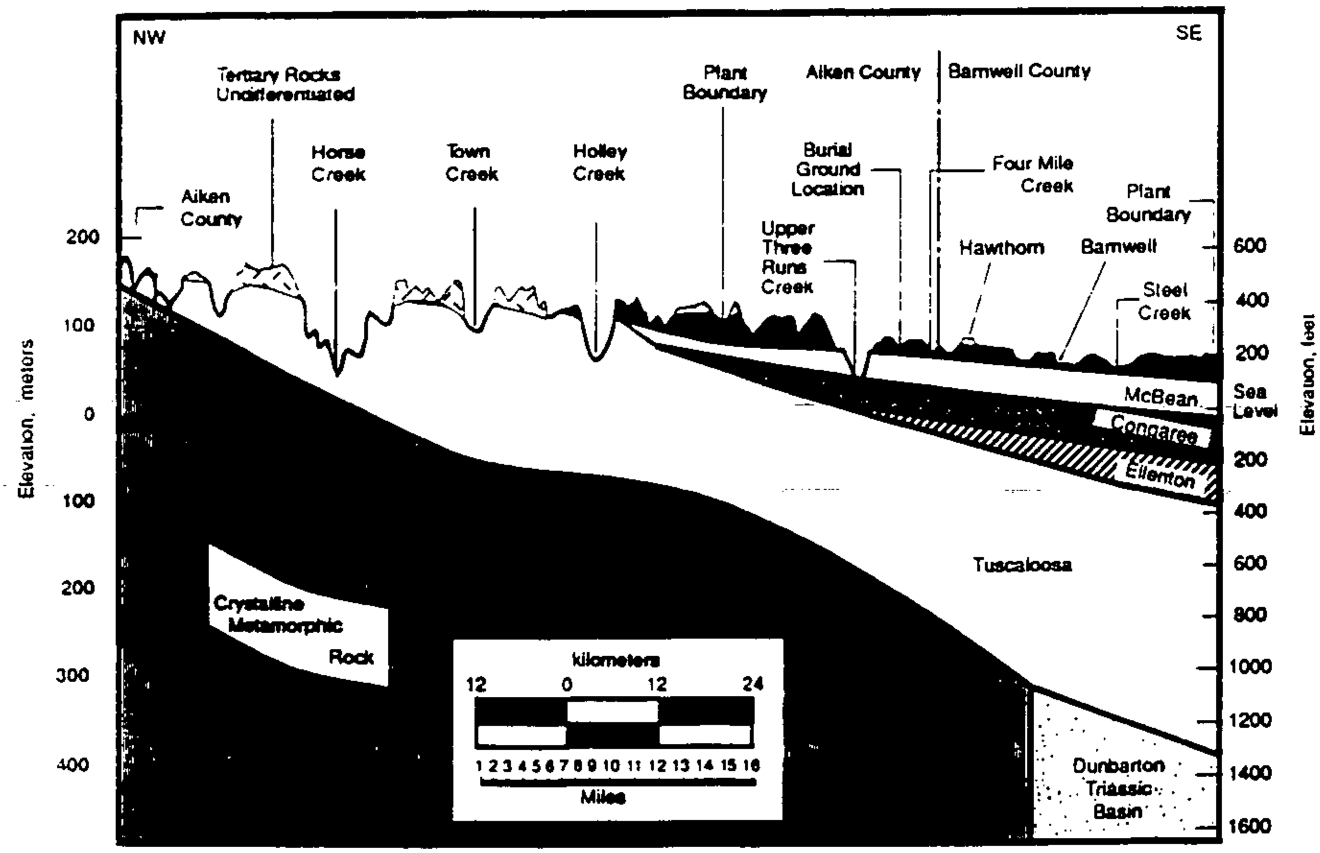


FIGURE 2-3. Profile of Geologic Formations Beneath the SRP

If data on the earthquakes in the vicinity of Charleston were omitted, South Carolina and Georgia would be considered to have relatively few earthquakes. The Charleston zone contains the epicenter of the 1886 Charleston earthquake, the 1912 Charleston earthquake, and hundreds of aftershocks of the 1886 event up to at least 1900.

The great Charleston earthquake of August 31, 1886, has dominated seismic activity in South Carolina for many years. This disturbance had dual epicenters, one at Woodstock (16 miles N 30° W from Charleston) and another 13 miles due west from Charleston. The epicenters were 14 miles apart. The Charleston quake, which was Intensity X, was felt 800 to 1000 miles away and affected an area of about 2,000,000 square miles. The epicentral region was broken by many fissures, through which water issued, but the fissures seldom attained a width of more than one inch. In the vicinity of Augusta, Georgia, just over 100 miles from the epicentral area, ground motion was estimated at Intensity VIII during the earthquake.

The Middleton Place - Summerville zone (25 miles northwest of Charleston, South Carolina) has experienced seismicity continually since the 1886 Charleston earthquake. This zone and the Jedburg (62 miles northwest of Summerville) and Adams Run (25 miles south southwest of Summerville) zones have had 36 shocks since 1974.

The Bowman area (16 miles southeast of Orangeburg, South Carolina) has experienced 12 shocks since 1974 from an apparent northeast-trending zone. The poorly determined foci are from 0 to 6.2 miles in depth, and other parameters cannot be accurately ascertained.

In western South Carolina, there have been 56 shocks since 1978, most of which are centered in the Piedmont Plateau. The most prominent activity was related to reservoir-induced seismicity (Lake Monticello and Clark Hill Lake).

Maximum earthquake intensities have been considered for three seismic source regions: the Appalachian Mountains, the Atlantic Coastal Plain, and the Charleston seismic zone. The maximum historical earthquake in the Appalachian Mountains was the Giles County, Virginia, event that occurred in 1897 with Intensity VIII. The maximum historical earthquakes in the Atlantic Coastal Plain (excluding the Charleston zone) were of Intensity VII. The Charleston seismic zone contains the 1886 event of Intensity X.

The Design Basis Earthquake for the SRP has been conservatively established as an earthquake with a Modified Mercalli Intensity of VIII and a corresponding zero-period peak horizontal ground acceleration of 0.20g.

Several fault systems occur in and adjacent to the piedmont and the valley and ridge tectonic provinces of the Appalachian System. The closest fault is the Belair, which is about 25 miles from the site. Evidence for the last movement of this fault is not conclusive, and it is not considered capable. There are no known active or capable faults within 200 miles of the SRP.

2.1.4 Hydrology

2.1.4.1 Surface Water

Most of the surface water at the SRP results from rainfall or from water pumped from the Savannah River and is used for secondary cooling for the plant reactors. The usage rate of the Savannah River water varies from about 300 cubic feet per second (cfs) to about 1000 cfs, depending on the number of reactors operating and the corresponding reactor power levels.* After use, the heated cooling water is returned to the river via one of the plant streams.

Almost all of the site is drained by tributaries of the Savannah River. Each tributary is fed by several small streams so that no location on the site is very far from a flowing stream. One small stream in the northeastern sector of the site drains to the Salkehatchie River instead of the Savannah River.

In addition to these streams, surface water is held in more than 50 artificial impoundments totaling over 3000 acres. Par Pond is the largest with an area of about 2700 acres. Water is retained intermittently in wetlands and in more than 200 natural basins, including some Carolina bays. A large swamp borders the Savannah River and is crossed by several of the streams.

The surface water bodies and their relationships to transportation routes are shown in Figure 2-2.

2.1.4.2 Groundwater

Groundwater, defined as that part of the water beneath the land surface that is free to move by gravity, occurs in the zone of saturation, in which all the interconnected openings or pores in the rocks of the earth's crust are filled with water under hydrostatic pressure. The number, size, and shape of the openings in porous rock and sediments and the degree of interconnection determine the amount of water that can be stored and yielded. The physiography of the area determines the location of groundwater gradients. Groundwater recharge is fairly uniform over the entire region. Groundwater gradients are determined by the location and depth of incision of the stream valleys.

Groundwater gradients in deeper aquifers are controlled by recharge and discharge areas that are farther removed from the point of interest. Shallow aquifers are controlled by nearby recharge and discharge areas.

---

*At the time of preparation of this report the SRP L-Reactor was being restarted. The statistics presented here do not include L-Reactor cooling water usage.

Three distinct geologic and hydrologic systems exist beneath the site:

- The coastal plain sediments, of Cretaceous and Tertiary age (Tuscaloosa and above), where water occurs in porous. unconsolidated to semiconsolidated sand and clays.

- The buried crystalline metamorphic basement rock, consisting of Chlorite-hornblende schist, hornblende gneiss, and lesser amounts of quartzite, where water occurs in small fractures.

- A buried Triassic basin, consisting mostly of red consolidated mudstone with some poorly sorted sandstones, where water occurs in the intergranular space but is very restricted in movement by the extremely low permeability.

The coastal plain sediments contain several prolific aquifers. The hydrology of buried crystalline metamorphic rocks and the Triassic mudstone beneath the site have been studied intensively as a result of an exploration program from 1961 to 1972 to assess the safety and feasibility of storing radioactive waste in these rocks (1-5).

2.1.5 Meteorology

Climate near the SRP is relatively temperate with mild winters and long summers. The average winter temperature in Augusta is 48°F, the average summer temperature is 80°F, and the annual average temperature is 63°F. This heavily wooded area, while subject to continental influences, is protected by the Blue Ridge Mountains to the north and northwest from the more vigorous winters prevailing in the Tennessee Valley. The terrain offers little moderating effect on the summer heat. As discussed above, the plant site and surrounding area are characterized by gently rolling hills with no unusual topographic features, except the Savannah River along the western boundary, to significantly influence the general climate.

Precipitation averages 47 in./yr, and ranges from less than 0.5 to 2 in./hr. The average wind speeds above ground level were determined by straight line extrapolation of data recorded at 37- and 90-m elevations. These data are given in Table 2-2.

Two types of storm winds occur in the area of SRP: tornadoes, and straight winds that include hurricanes. At an elevation of 37 m, wind speeds of 20 m/sec (45 mph) have been measured with a frequency of 6×10^{-5}/hr.

Many hurricanes that affect the South Carolina coast originate in the West Indies and Caribbean areas, turn northward along the west coast and panhandle of Florida. and then turn northwest following a track either across land to the south. or across water parallel to the Atlantic Coast. These storms lose much of their force before reaching South Carolina. Storms that enter the Atlantic Ocean after crossing land occasionally regain their strength and lash the coast of South Carolina with full hurricane force. Most hurricanes that originate far out in the Atlantic or in the East Indies curve away from the coast and stay over the ocean. Only a few of the hurricanes strike the

TABLE 2-2. Average Wind Speed

Elevation above Ground Level (meters)	Wind Speed (meters/sec)
8	3.0
15	3.2
30	3.6
61	4.5

mainland. Only 38 hurricanes caused damage to South Carolina during the 272 years of record between 1700 and 1972 (2). This is an average frequency of one every seven years. The hurricanes that affect South Carolina occur predominantly in the months of August (37% of total) and September (47% of total).

Since the SRP is located 100 miles from the Atlantic Coast, the occurrence of a hurricane along the coastal region does not necessarily mean that the SRP will be subject to hurricane-force winds. The high winds usually associated with hurricanes tend to decrease as the distance from the eye of the hurricane increases and as the storms move over the land. Winds of 75 mph were measured by anemometers (mounted at 200 ft) only once during the history of the SRP when Hurricane Gracie passed to the north of the plant site on September 29, 1959.

In South Carolina, the greatest percentage of tornadoes occur in April and May with a smaller maximum, about 20%, in August and September. The latter are mainly the result of spawning by hurricanes and waterspouts. One or two tornadoes can be expected in South Carolina during April and May, with one expected in each of the months of March, June, July, August, and September.

The Weather Bureau recorded 278 tornadoes in Georgia over the period of 1916 to 1958 and 258 tornadoes in South Carolina for the period 1950 to 1980 (2). The general direction of travel of confirmed tornado tracks in Georgia and South Carolina is from the southwest to northeast.

The SRP is in an area where occasional tornadoes are to be expected. Statistics for the period 1950 to 1978 for a rectangular region of Georgia and South Carolina including the SRP site show a total of 248 tornadoes or 8.5 per year. Of this average, there have been only four occasions (May 28, 1976; July 2, 1976; April 23, 1983; and August 26, 1985) on which tornadoes were confirmed on or in close proximity of the plant site. In all four cases, only light damage was reported, i.e., displacement of light sheet metal roofing, window breakage, trees snapped and uprooted, etc. On no occasion has there been tornado damage to any production facility on the plant site. There have also been several sightings of funnel clouds that did not touch ground or cause damage on the SRP site. Investigation of the confirmed tornadoes indicated wind speeds of 100 to 175 mph (1).

The Design Basis Tornado is defined as a tornado having a rotational speed of 230 mph at a radius of 230 ft and a maximum translational speed of 50 mph, and a total pressure drop of 1.5 psig at a maximum rate of 0.5 psi/sec. The combination of rotational and translational wind speed of 280 mph corresponds to a Fujita Intensity Five tornado.

2.2 ONSITE FACILITIES

The major facilities on the site include the 100-Areas Reactor facilities; the 200-Areas Separations (F and H) facilities; the Burial Ground (Building 643-G); the 300-Area Fuel Fabrication facility; the 400-Area Heavy Water facilities; and the 700-Area shops, Construction Central Shops, Administration buildings and Savannah River Laboratory facilities. The locations of the various facilities are identified in Figure 2-2. Table 2-3 presents the distances between these and other major SRP areas.

2.2.1 Production Facilities

2.2.1.1 Reactors (100-Areas)

The key production facilities of the SRP site are five nuclear production reactors, one (R-Reactor) of which is currently shut down (since 1964) and is in standby condition. Three of the original five reactors at the SRP (P, K, and C Reactors) were operating when this analysis was done. C-Reactor was shut down in June 1985 and since then has been placed in standby condition. L-Reactor, which had been on standby since 1968, was restarted October 31, 1985. Three reactors continue in operation after 1985.

The Savannah River reactor buildings (Figure 2-4) are large reinforced concrete structures originally designed to be blast resistant under enemy attack, and reinforced for earthquake protection. Although each building is slightly different, all contain four major process areas: reactor area, assembly area, disassembly area, and purification area. The reactor area is located in the central portion of the building and houses the rector, actuator system, heat exchanges, process pumps and piping, motors, crane and reactor control rooms, crane wash and maintenance areas, and auxiliary equipment and service facilities.

Water from the Savannah River or Par Pond (a man-made reservoir) is supplied to the reactor to remove heat. The water is pumped into a 25-million-gallon cooling water basin at the reactor area and pumped from the basin to the reactor building where it extracts heat from primary heat exchangers. The effluent cooling water flows from the heat exchangers back to Par Pond or the Savannah River. Nominal water flow of up to 400 cfs is established prior to reactor startup and is maintained during reactor operations.

2.2.1.2 Fuel and Target Fabrication (300-M Area)

The fuel and target fabrication plant manufactures elements to be irradiated in the reactors (Figure 2-5). Its major products are extruded, enriched uranium-aluminum alloy fuel, aluminum-clad depleted-uranium metal targets, and lithium-aluminum control rods and targets.

2.2.1.3 Separations Facilities (200-Areas)

Each of the two chemical separations plants (F and H) has a large shielded canyon building for processing irradiated materials (Figure 2-6). The plants dissolve the irradiated fuel and target materials and produce solutions containing the various products which have been decontaminated from fission products by solvent extraction and ion exchange processes. Further processing is performed in unshielded facilities where the products can be converted from solution to solid form for shipment offsite.

TABLE 2-3. Distances Between Areas (from the SRP Map)

Trip Description	Distance (miles)
100-K Area to Burial Ground	8-1/2
100-C Area to 100-K Area	4
100-C Area to 100-P Area	8-1/2
100-C Area to 100-L Area	6-3/4
100-K Area to 100-P Area	8
100-K Area to 100-L Area	2-3/4
100-K Area to Building 232-H	6-3/4
100-C Area to Building 232-H	4-1/2
100-P Area to 100-L Area	4-1/2
100-P Area to Building 232-H	8-1/4
100-L Area to Building 232-H	7-3/4
F Area to 100-K Area, 100-L Area, 100-C Area, and 100-P Area	3/4 > to Building 232-H
300-M Area to 100-P Area	15-1/4
300-M Area to 100-C Area	10-1/2
300-M Area to 100-K Area	13
300-M Area to 100-L Area	11
Building 241-F to 100-C Area	5-3/8
400 Area to 100-P Area	13-1/4
400 Area to 100-C Area	9-1/2
400 Area to 100-K Area	7
Maximum trip 100-K Area to 100-C Area to 100-P Area to 100-L Area to 400 Area	25

TABLE 2-3. Distances Between Areas (from the SRP Map) (Continued)

Trip Description	Distance (miles)
UNH Trailer to weigh station	10
Building 773-A trailers to Building 221-F	7-3/4
Building 772-F to Building 773-A	7-1/2
200-H Area to Building 772-F; samples, etc., also 200-F Area to 200-H Area, neptunium solution	2-1/2
200-H Area to Building 235-F	2-3/4
Building 221-F to Building 217-F	0.7
Building 235-F to Building 321-M	7-1/2
Building 777-M to 400 Area	11
Building 777-M to Building 710-U	4
Building 773-A to 200-H Area	9-3/8 RBOF 9-3/4 south loading dock
Plant Boundary toward Jackson, SC by highway	
100-P Area	13-3/4
100-C Area	9
100-K Area	11-1/2
100-L Area	13-1/2
200-F Area	9-1/4
200-H Area	9-1/4
3/700 Area	3-3/8

TABLE 2-3. Distances Between Areas (from the SRP Map) (Continued)

Trip Description	Distance (miles)
Solvent Trailers	
200-F Area to Burial Ground	2-1/4
200-H Area to Burial Ground	1-3/4
TRU Wastes	
Building 773-A to Burial Ground	8
Building 773-A to Building 221-F	7-1/4
200-F Area to Burial Ground	2
200-H Area to Burial Ground	1-1/2
Building 773-A to Building 221-F to Building 221-H to Burial Ground	12
200-F Area to 200-H Area to Burial Ground	5
Rail	
100-C Area to 200-H Area	10-1/2
100-C Area to 200-F Area	13-1/4
100-K Area to 200-H Area	11-1/2
100-K Area to 200-F Area	14-1/4
100-P Area to 200-H Area	9-1/2
100-P Area to 200-F Area	12-1/4
100-L Area to 200-H Area	7-1/2
100-L Area to 200-F Area	8
Average of the three areas to 200-H Area	10-1/2
Overall average of rail trips	12

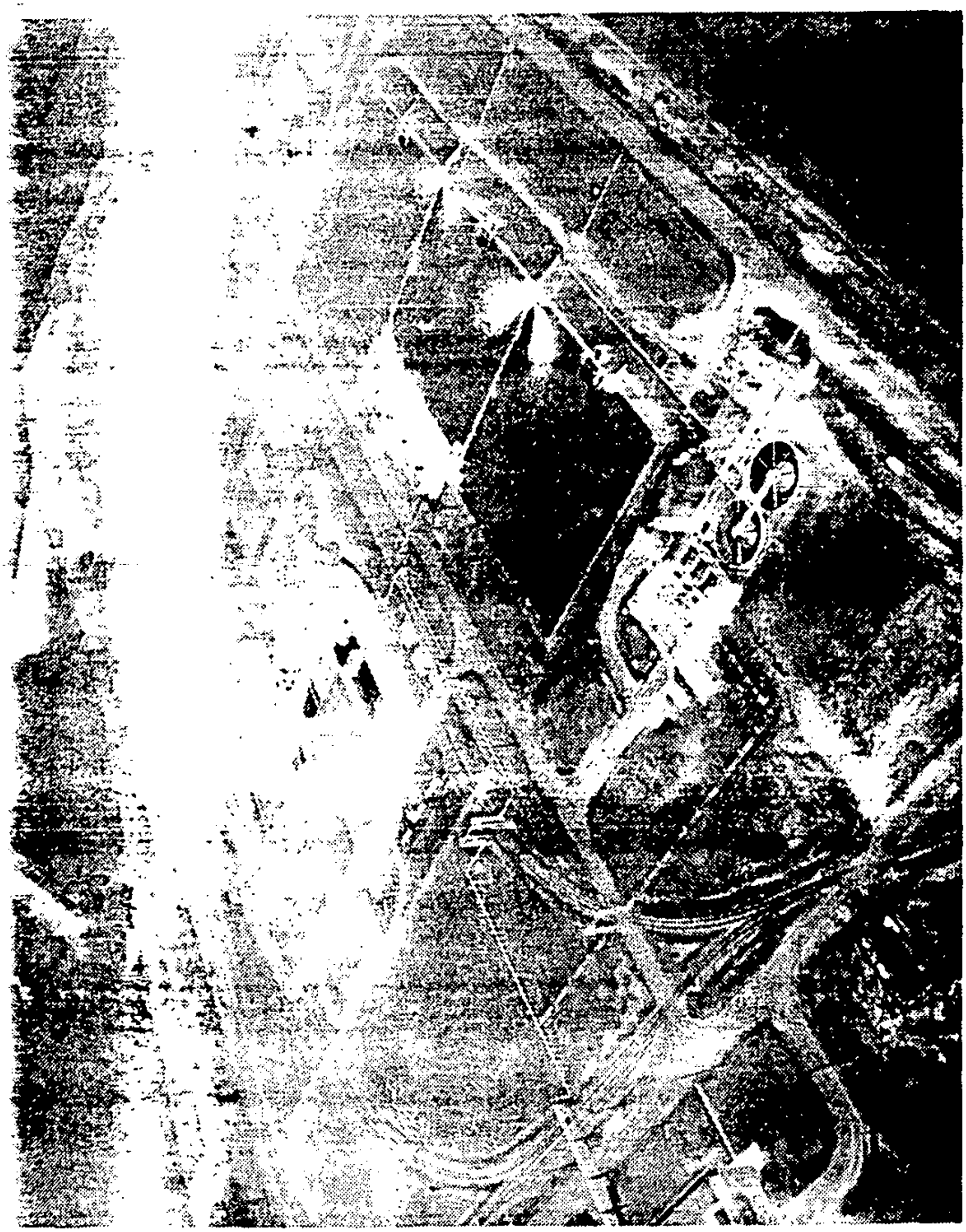


FIGURE 2-4. Reactor Area

FIGURE 2-5. Administration and Fuel and Target Fabrication Areas

FIGURE 2-6. Separations Area

2.2.1.- Heavy Water Plant (400-Area)

At present, the rework unit of what formerly was the heavy water plant (this plant is no longer operational) is operating to rework and purify reactor moderator. A large coal-fired power plant is also located in the 400-Area (Figure 2-7).

2.2.2 Waste Facilities

The SRS has been operating since 1953 to produce special nuclear materials, primarily plutonium and tritium, for defense purposes. This type of operation necessarily produces two forms of radioactive waste: high-level radioactive liquid waste, which is stored in large underground tanks, and solid radioactive waste, which is buried and/or stored in the Burial Ground. The solid waste is segregated as to whether it is contaminated primarily with beta-gamma-emitting radionuclides or alpha-emitting radionuclides.

Potential releases of stored wastes are minimized by multiple barriers such as steel tanks and concrete containers, by procedural controls, and by converting the wastes to less soluble and less mobile forms for storage.

2.2.2.1 Solid Radioactive Waste

One centrally located solid radioactive waste storage site (Figure 2-8) is used to store all radioactive solid waste produced at the SRS as well as occasional special DOE shipments from offsite (6). This storage site occupies 195 acres between the F and H Separations Areas, approximately six miles from the nearest plant boundary. The original area of 76 acres, which began to receive waste in 1953, was filled in 1972, and operations were shifted to a 119-acre contiguous site. A paved road to its entrance and many unpaved roads inside the fenced area provide access for trucks, the usual transportation mode for solid waste. Three railroad spurs permit shipments of large pieces of contaminated process equipment from the plant's operating areas.

The average annual volumes of waste generated and buried during 1981, 1982, and the first four months of 1983 are (7):

Type of Waste	Volume, ft^3/yr
Low-level beta-gamma	566,000
Intermediate-level beta-gamma	115,600
Low-level alpha	99,500
Total	781,100

2.2.2.2 High-Level Liquid Waste

Since plant startup, and continuing through 1982, over 72-million gallons of highly radioactive liquid waste have been generated at the SRS. Currently, about 2 million gallons is being produced annually. These wastes are stored

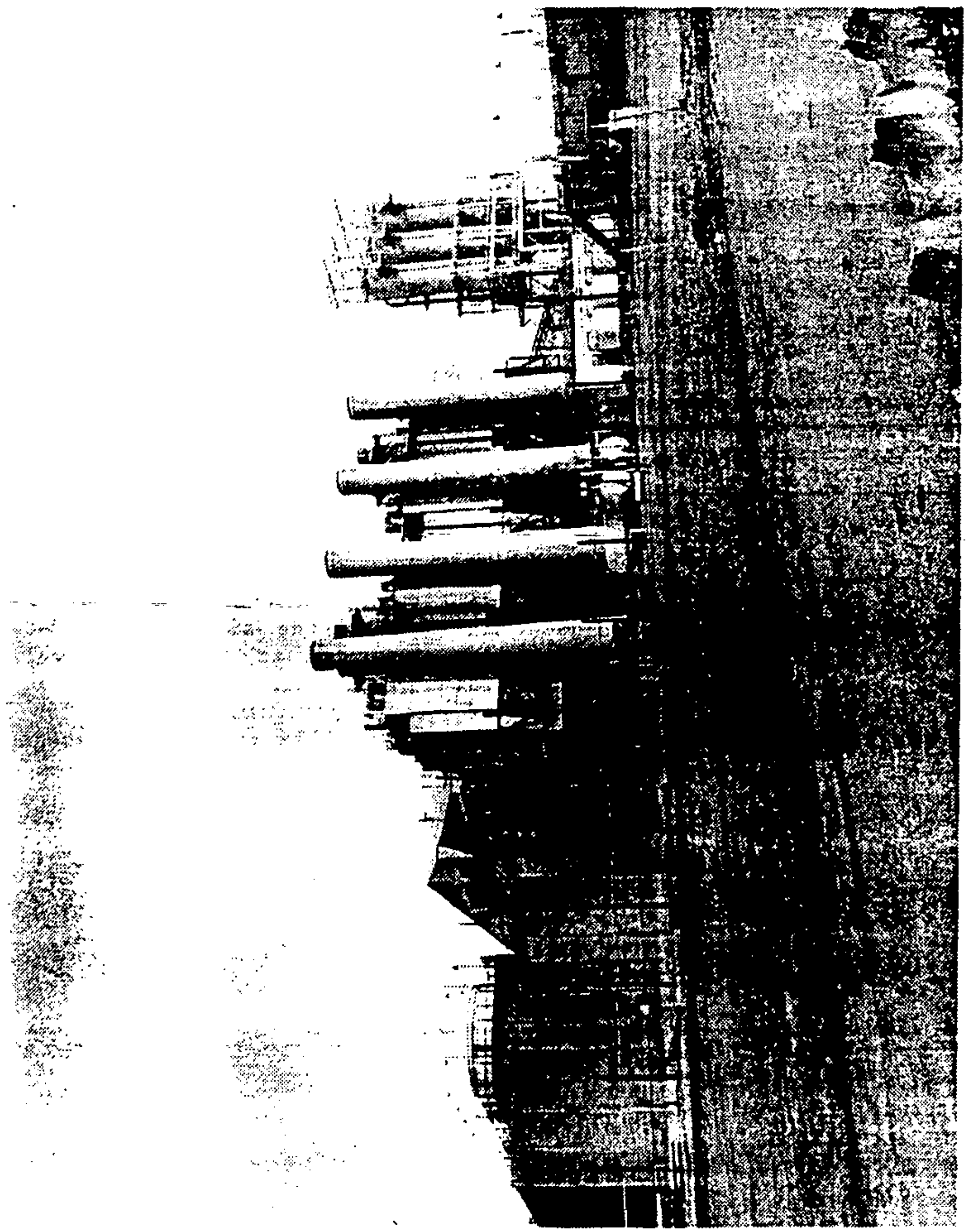


FIGURE 2-7. Coal-Fired Power Plant (400-Area)

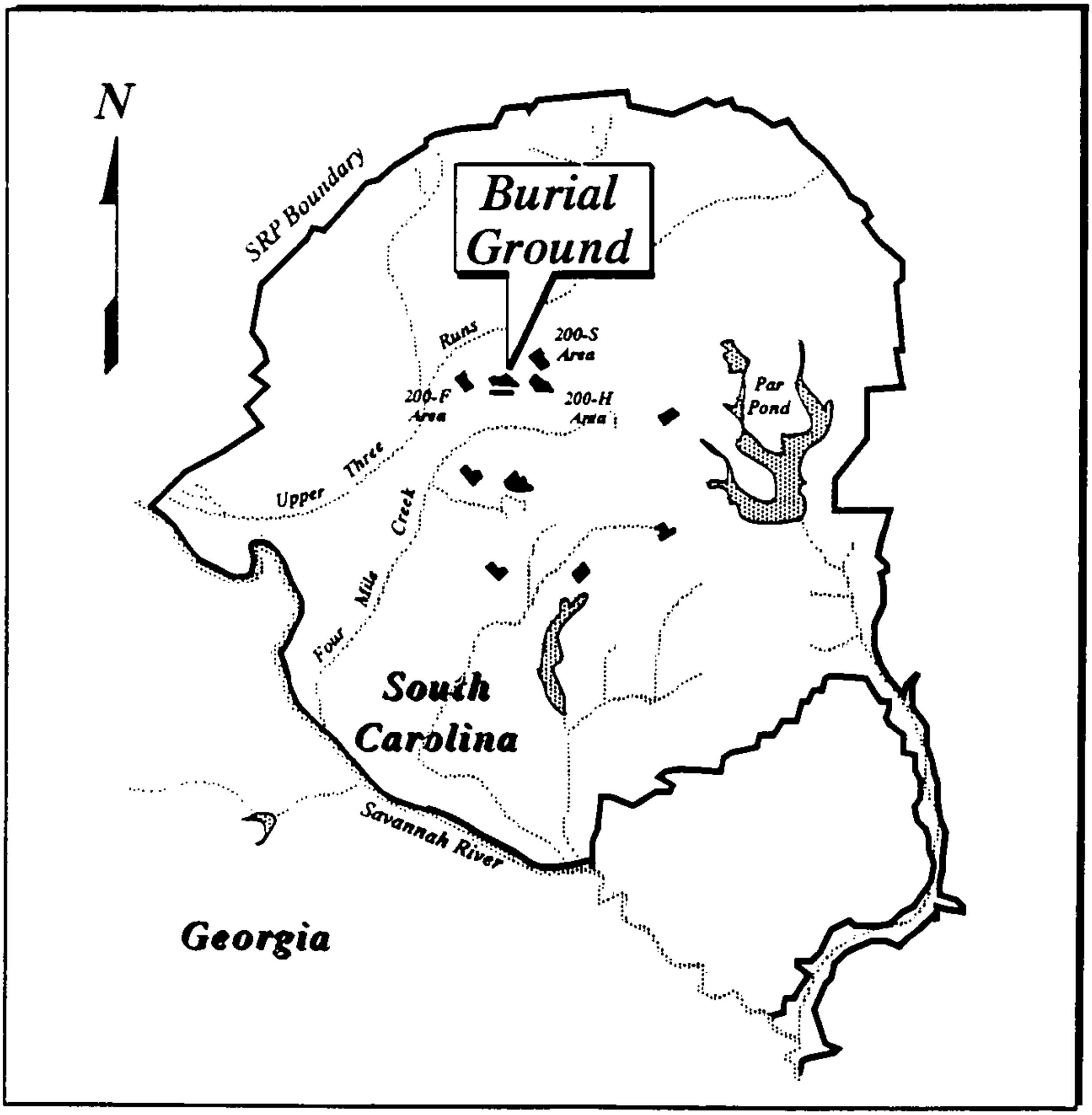


FIGURE 2-8. Burial Ground Location

in large (250,000- to 1,300,000-gal) tanks that are surrounded and covered by earth in F- and H-Areas where most of the waste is generated (Figures 2-9 and 2-10). Fifty out of 51 available tanks are in use, however, many tanks are not full because the waste volume has been reduced by evaporation to about 30 million gallons.

The tanks are of four different designs. These designs, along with control in waste handling, ensure against any boiling of the liquid wastes. All of the waste tanks are built of carbon steel and reinforced concrete. Three designs have double steel walls and bottoms and forced-water cooling systems and are used primarily for high-heat waste and waste concentrate; the fourth design has a single steel wall directly supported by the encasing reinforced concrete, has no forced cooling, and is used primarily for low-heat waste and concentrate.

2.2.3 Other SRP Facilities

The other SRP facilities consist of:

- The Savannah River Laboratory (SRL) which performs research and development work related to plant changes, upgrades, improvements, and waste management. The main building contains offices, laboratories, shielded high-level cells, a fabrication laboratory, and a modern scientific library. In addition to this building, the SRL operates a semiworks facility (TNX-CMX) located near the Savannah River. This facility is used to run tests on plant equipment prior to installation or to experiment with new designs.

- The Administration Area (A-Area) which provides office and work space for SRP and DOE personnel in supervisory, administrative and support assignments. Within the A-Area, the SRP Stores Facility (Building 713-A) provides for the majority of the receiving, departure, and storage of hazardous materials for the site.

- The Construction Administration Area and Central Shops. This area receives construction supplies including certain hazardous materials such as gasoline, diesel fuel, paints, etc.

- Building 618-G, Classification Yard provides an interface for the onsite rail system with the Seaboard Coast Line railroad. The Classification Yard provides for the receipt and acceptance of shipments from offsite. It is here that the onsite railroad dispatching and releasing of shipments to the CSX Railroad system are conducted. Railroad machinery maintenance is also performed at the Classification Yard.

In addition, the Savannah River Ecology Laboratory (SREL) and offices of the USFS are located at the SRP. The SRP production and support facilities occupy less than five percent of the site's 192,323 acres. About 900 acres are reserved for environmental research and/or natural areas, while reservoirs

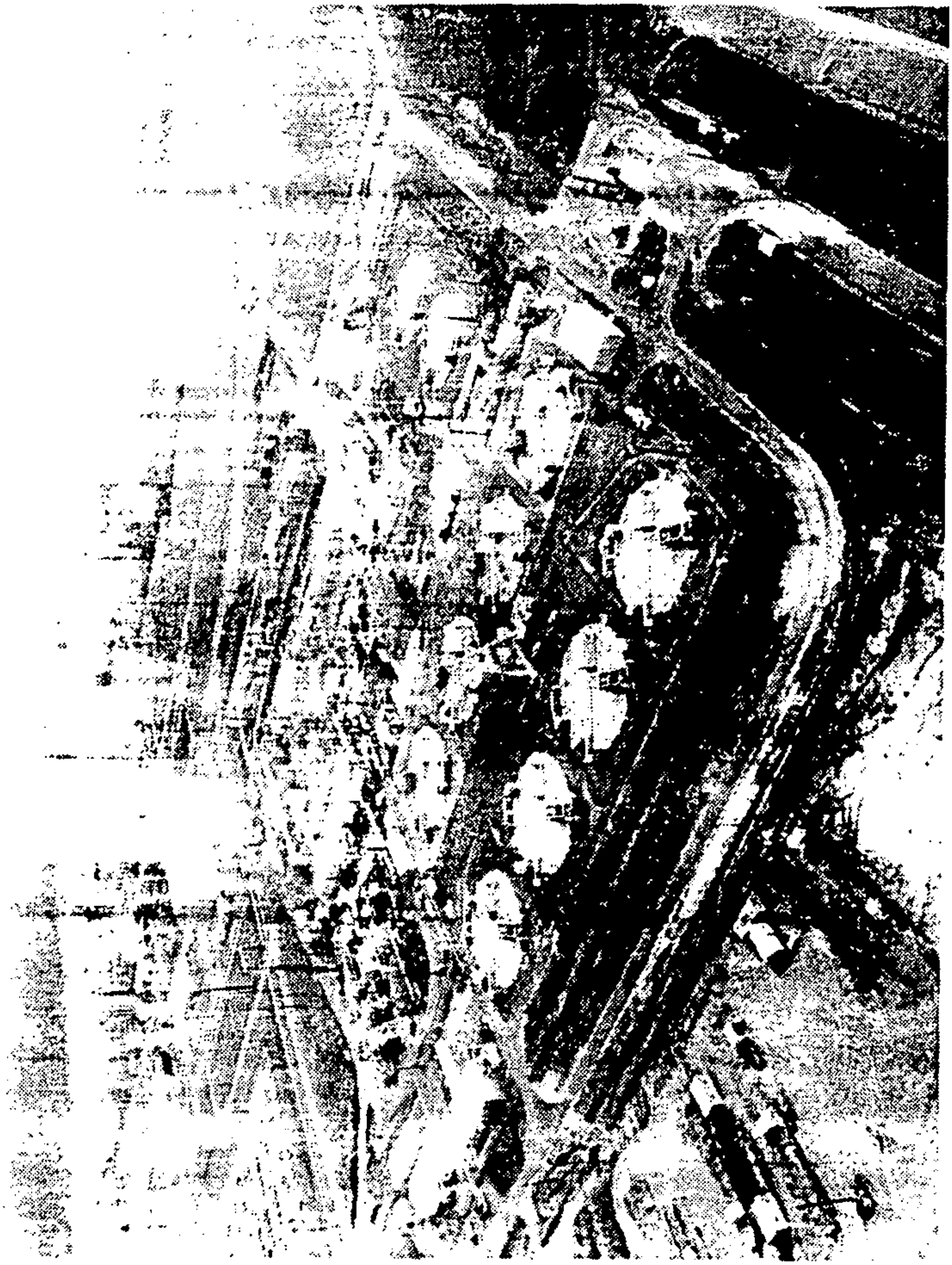
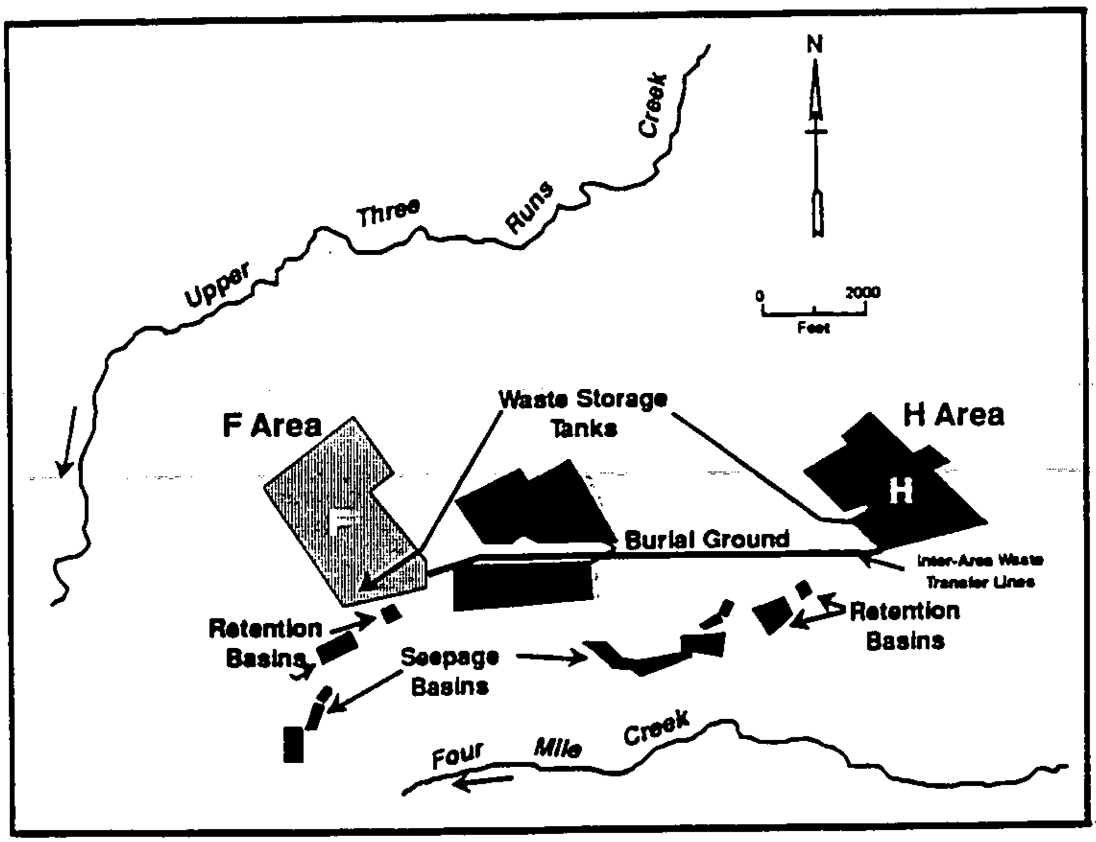


FIGURE 2-9. Tank Farm



FA 078024

FIGURE 2-10. Relative Locations of Tank Farms and Separations Areas and ponds occupy another 3000 acres. Except for wetlands, the remainder of the site is a forest managed by the USFS under a cooperative agreement with DOE.

2.3 POPULATION CHARACTERISTICS

The population potentially affected by any accidents related to transportation activities includes personnel on the SRP reservation and the general public in the nearby areas.

2.3.1 Onsite Population

The SRP is a security controlled area, and access by the general public is limited. Table 2-4 shows the number of onsite personnel by assignment. At the end of June 1987, the official DOE records indicated there were more than 15,000 people working at the site.

2.3.2 Offsite Population

The offsite population for the 13 counties surrounding the SRP is shown in Table 2-5 and Figure 2-11. The two largest population centers located close to the plant are Augusta (25 miles west-northwest) and Aiken (20 miles north). Also shown in Table 2-5 is the 1980 population for major population centers within about 25 miles of the plant boundaries. Figure 2-12 shows the major population centers within a 150-mile radius of the SRP.

2.4 DESCRIPTION OF SRP ROADWAYS AND RAILWAYS

The network of SRP roadways and railways is presented in Figure 2-2. The network provides the transportation passageways interconnecting the various onsite facilities as well as providing the offsite transportation linkages.

Access to the site is provided at various points of entry through gates or barricades. The various gatehouses are identified in Figure 2-13. At these gates, the security contractor, Wackenhut Services Inc., provides access control for the site.

Figures 2-14 through 2-29 are selected photographs of typical road and rail scenes on the SRP site. Discussions of both roadways and railways are presented below.

2.4.1 Roadway Description

The SRP roadway systems consists of over 200 miles of primary roads and over 1000 miles of unpaved, secondary roads. These roadways are maintained by the Railroad, Roads and Ground, and Field Services Division (RR&FS) of the Central Services Works Engineering Department (CSWE), with the USFS providing secondary road maintenance management. For the purposes of this report, the

TABLE 2-4. Onsite Personnel, November 1985

Assignment	Number of Personnel
Savannah River Plant	6,852
Savannah River Laboratory	1,108
Construction	5,279
DOE Savannah River	303
Forest Service	24
Cafeteria	75
Janitorial	237
Savannah River Ecology Laboratory	136
Laundry	25
Wackenhut	922
Corp. of Engineers	13
Other Du Pont Subcontracts	286
Total	15,260

TABLE 2-5. 1980 Population Counts

Counties

South Carolina		Georgia	
County	1980 Population	County	1980 Population
Aiken	105,625	Burke	19,349
Allendale	10,700	Columbia	40,118
Bamberg	18,118	Richmond	181,629
Barnwell	19,868	Screven	14,043
Edgefield	17,528		
Hampton	18,159		
Lexington	140,353		
Orangeburg	82,276		
Saluda	16,150		

Major Population Centers Within About 25 Miles

City	Distance (miles)	Direction from Plant	1980 Population
Augusta, GA	25	West-Northwest	47,532
N. Augusta, SC	25	Northwest	13,593
Aiken, SC	20	North	14,978
Williston, SC	15	Northeast	3,173
Barnwell, SC	15	East	5,572
Allendale, SC	26	Southeast	4,400
Waynesboro, GA	28	Southwest	5,760

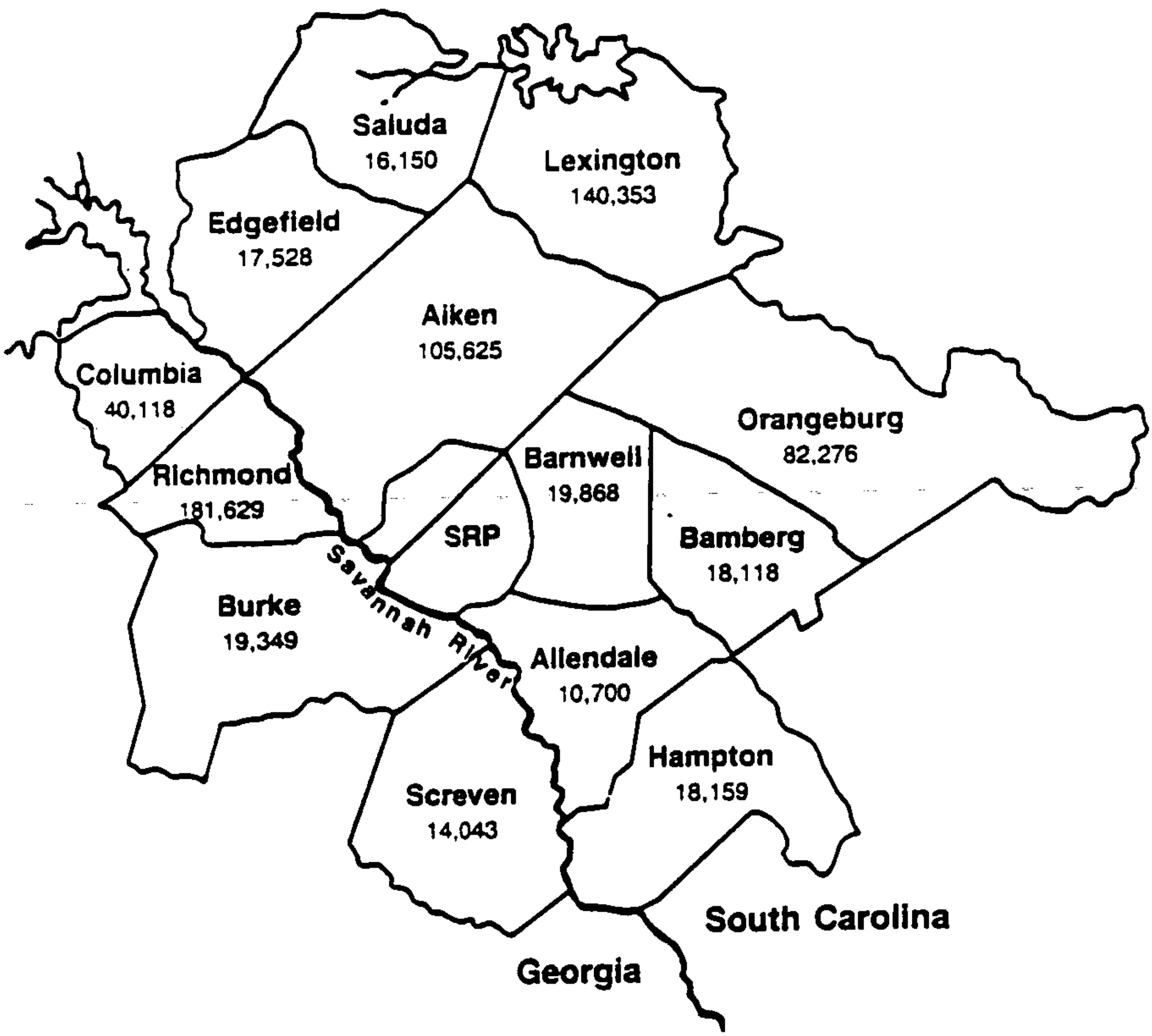


FIGURE 2-11. Population of Surrounding Counties, 1980 Census

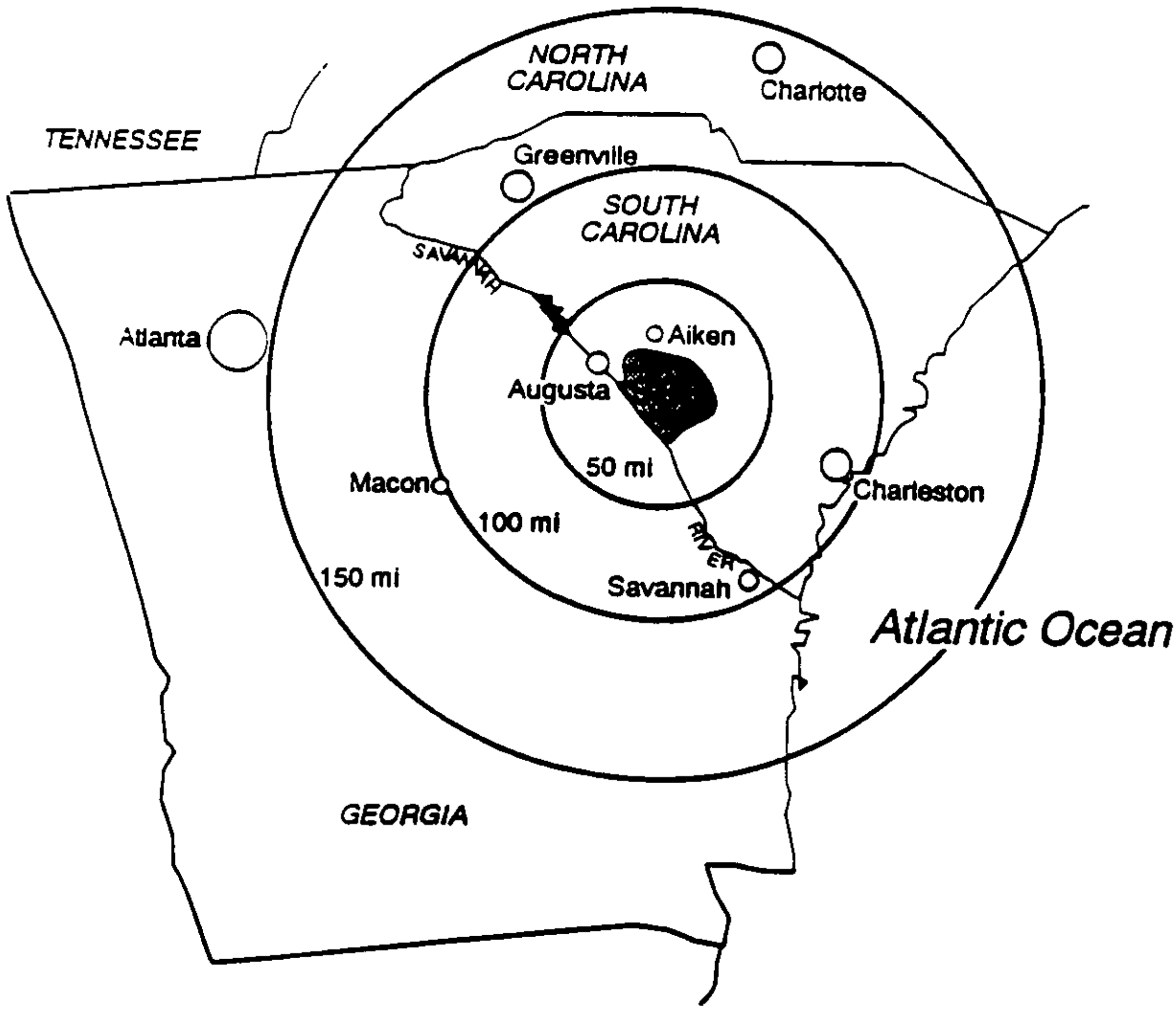


FIGURE 2-12. Location Relative to Surrounding Population Centers

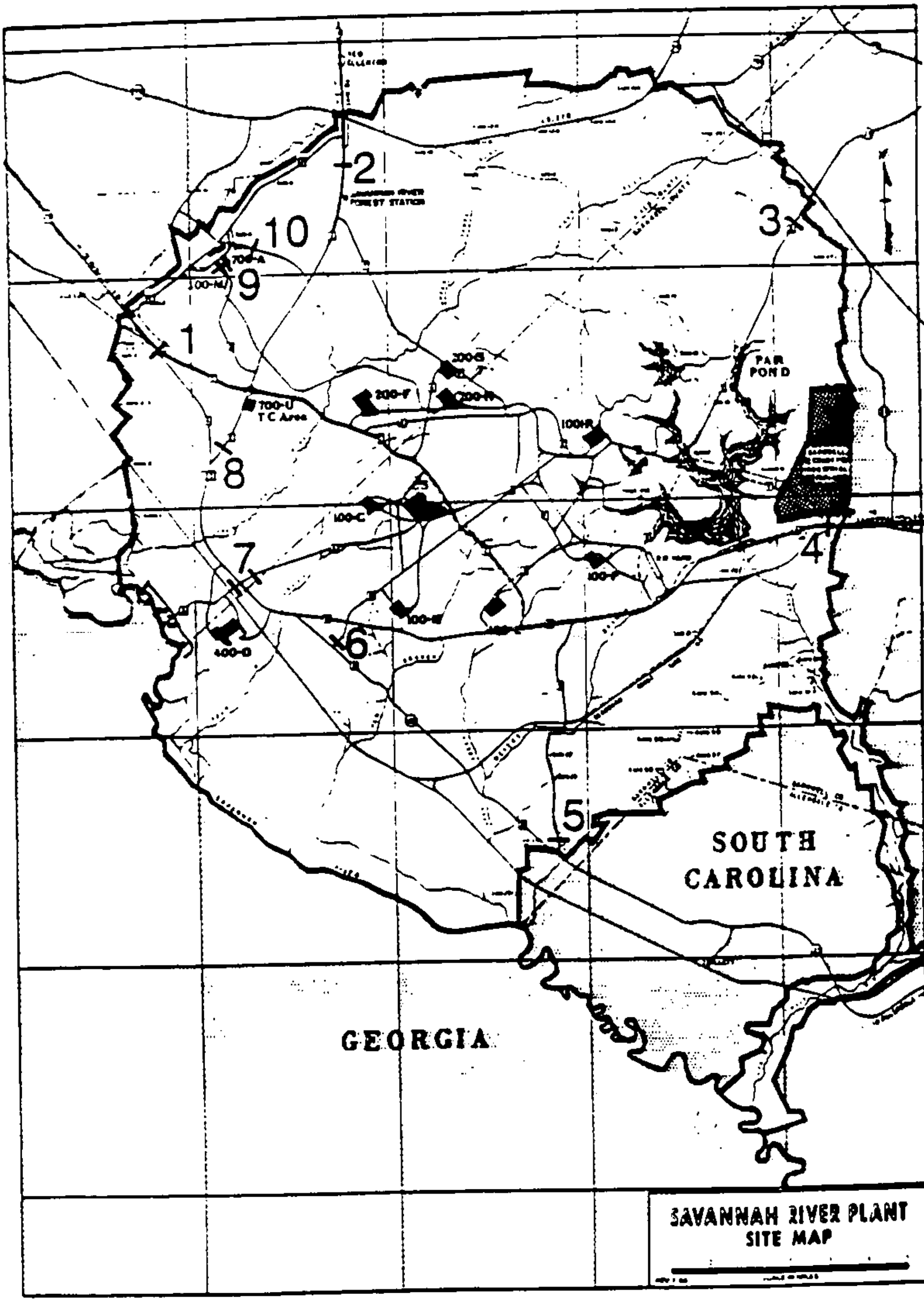
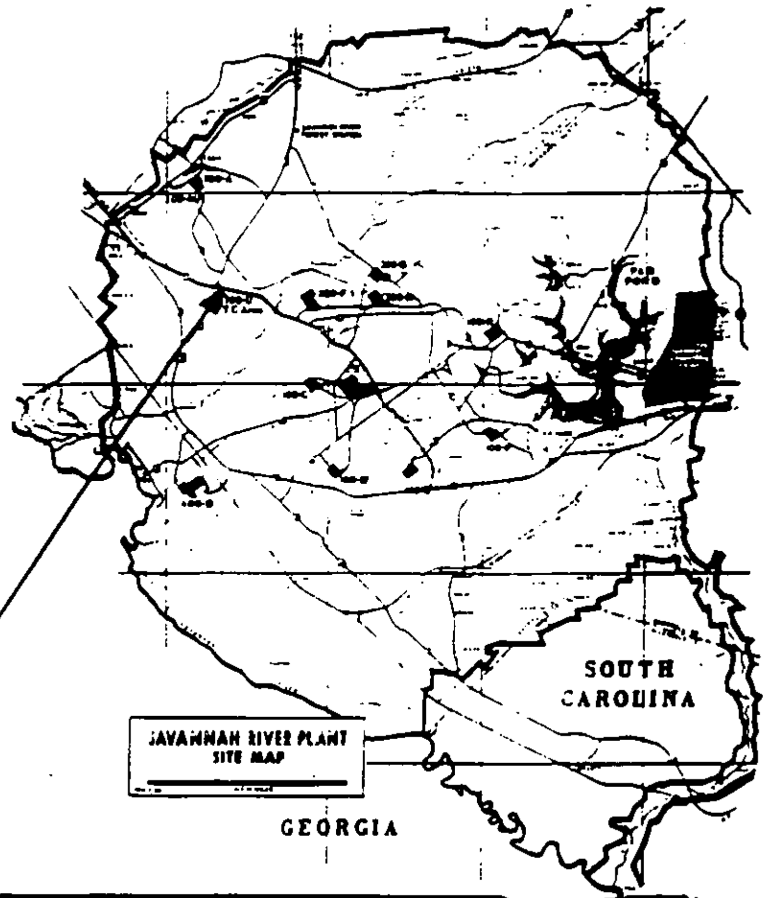


FIGURE 2-13. Gate Numbers for the SRP

Eastward View From Overpass on Road C at Intersection With Road 2. The 200-Areas are in the Background.



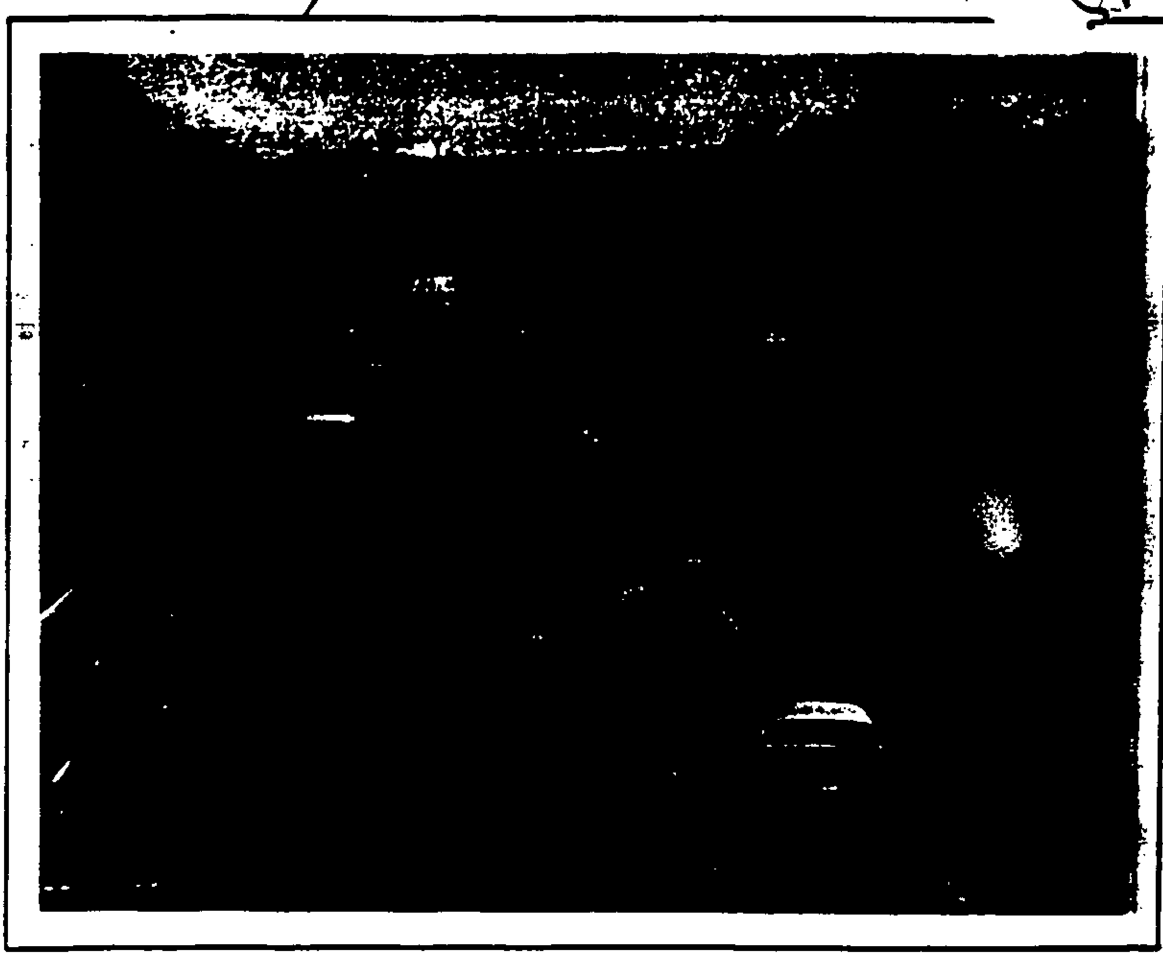
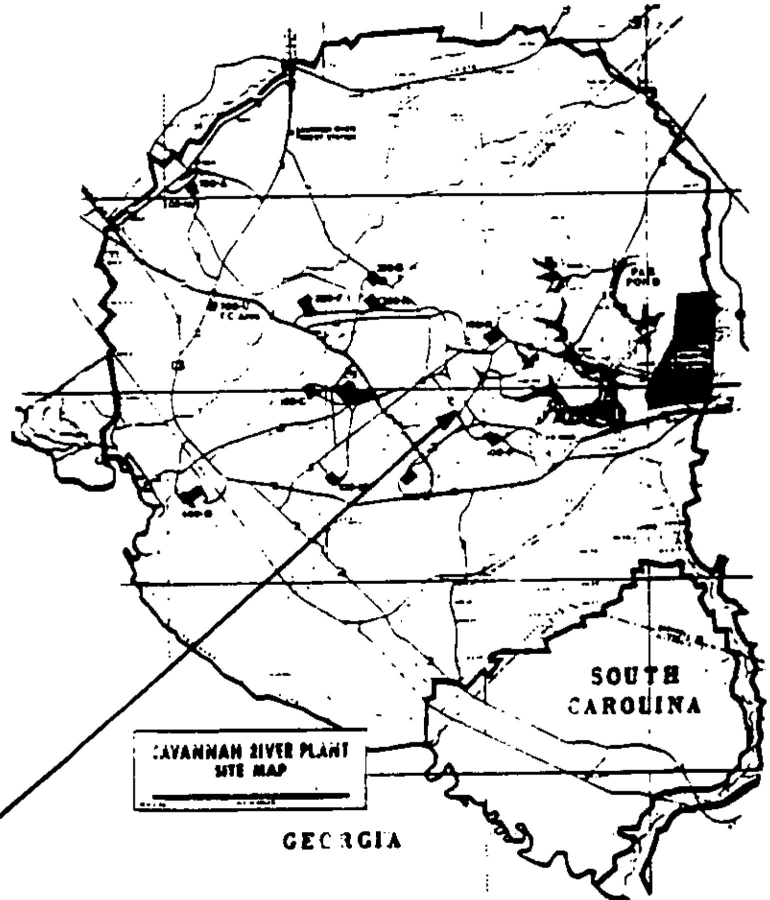


FIGURE 2-14. View of Road C With 200-Areas in Background

Road F Southeast of 100-P
Reactor, Looking Northwest
(Note: Wide, Firm Shoulders)



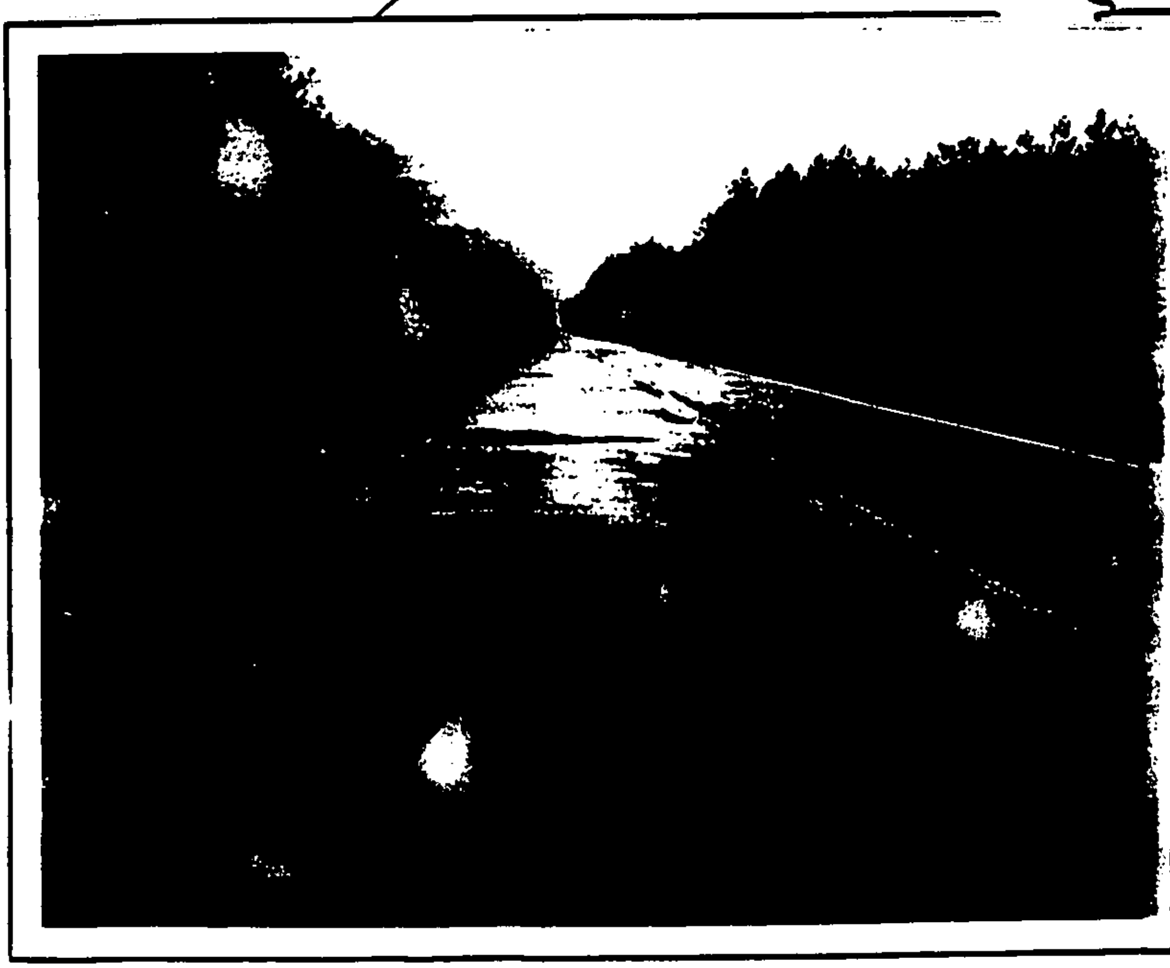


FIGURE 2-15. Road F

Curve on Road D South of 3/700
Area (Note: Railing on Curve)

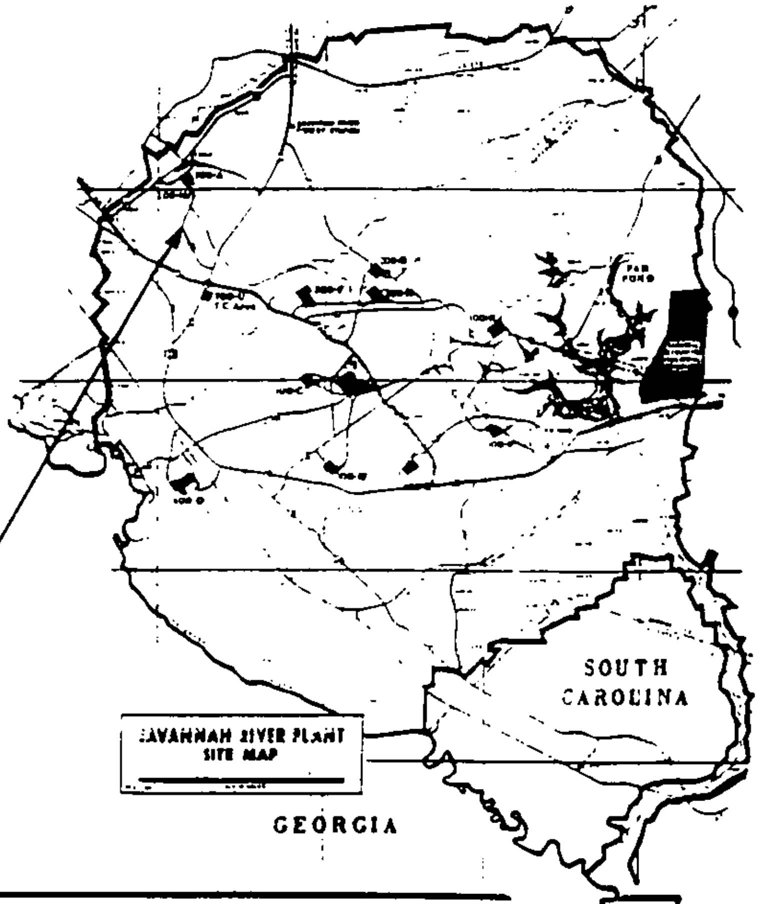


FIGURE 2-16. Road D

Intersection of Road F and SRP Road 6 Looking Northwest (Note: Cleared Area Typical of SRP Intersections)

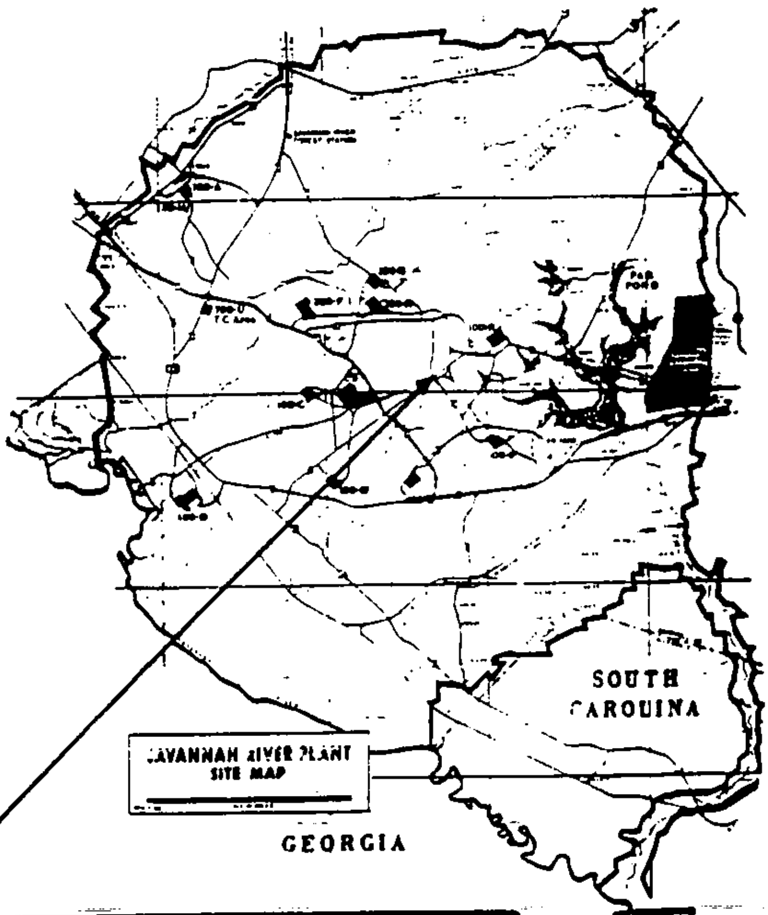
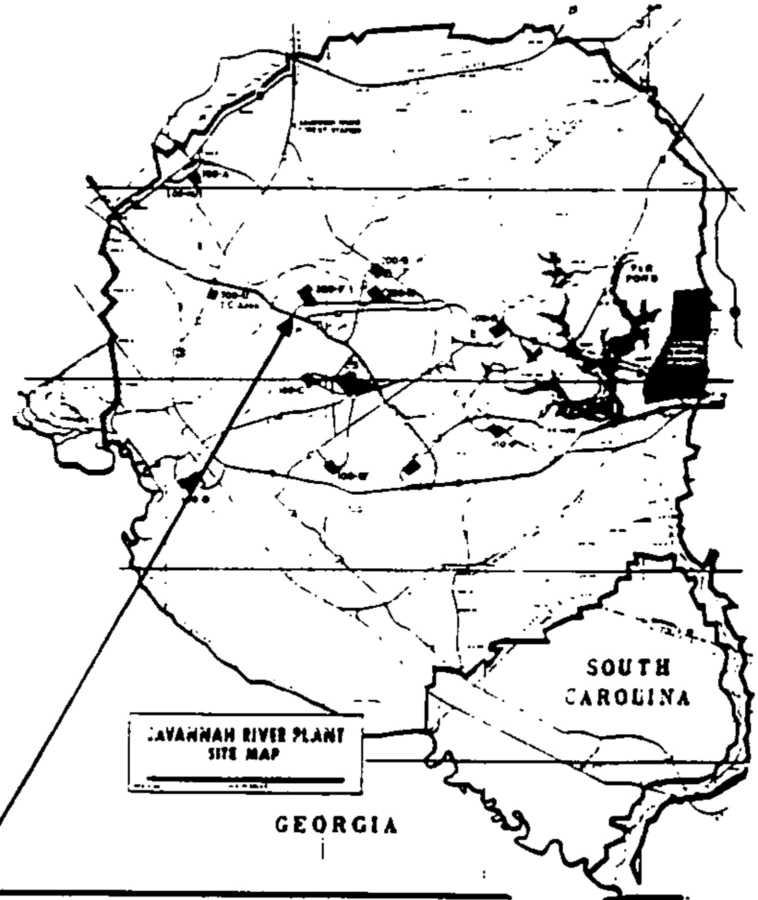


FIGURE 2-17. Intersection of Road F and Road 6

Intersection of Road C with F-Area Access Road (Note: Traffic Control Measures)



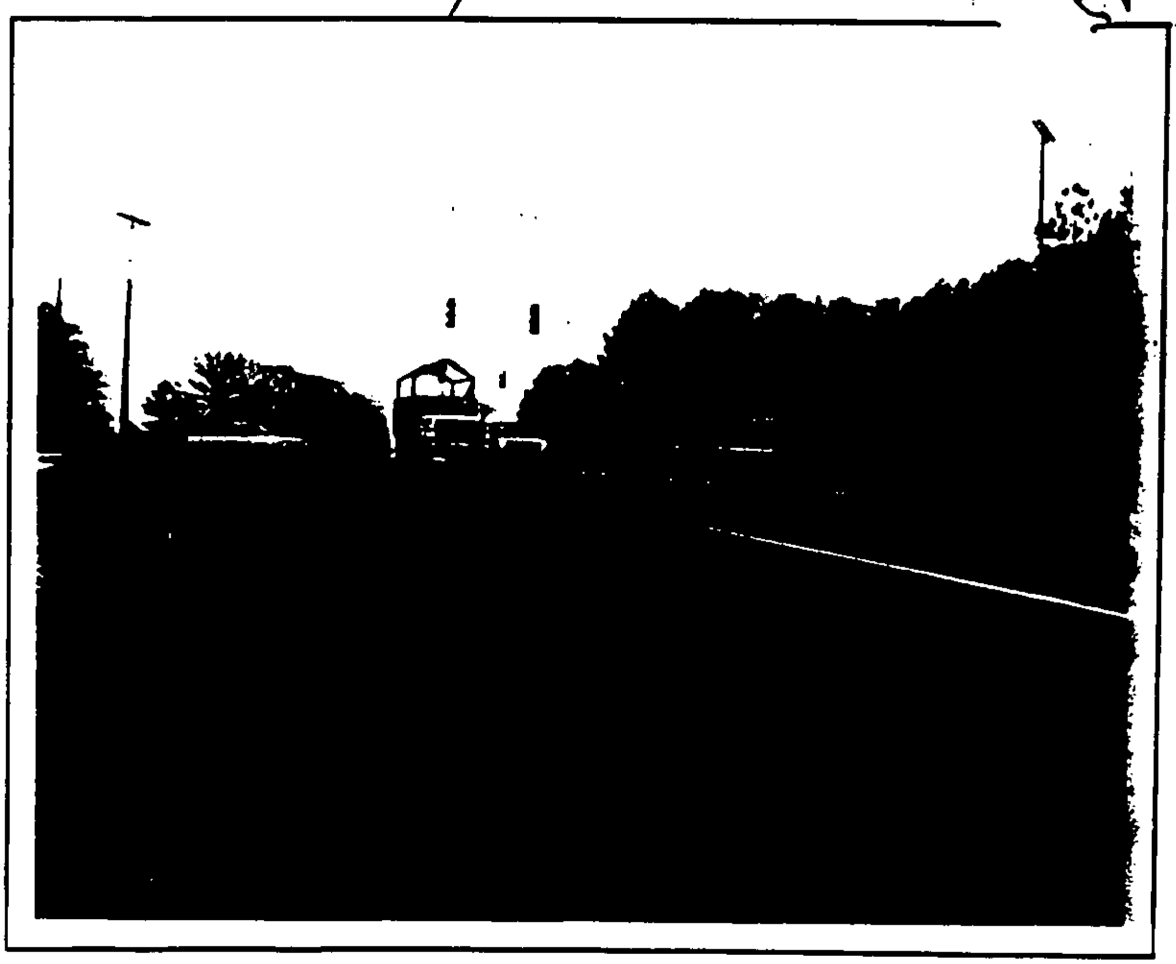


FIGURE 2-18. Intersection of Road C and F-Area Access Road

Intersection of South Carolina Rt. 125 and SRP Road 3 Looking Northwest Down Rt. 125

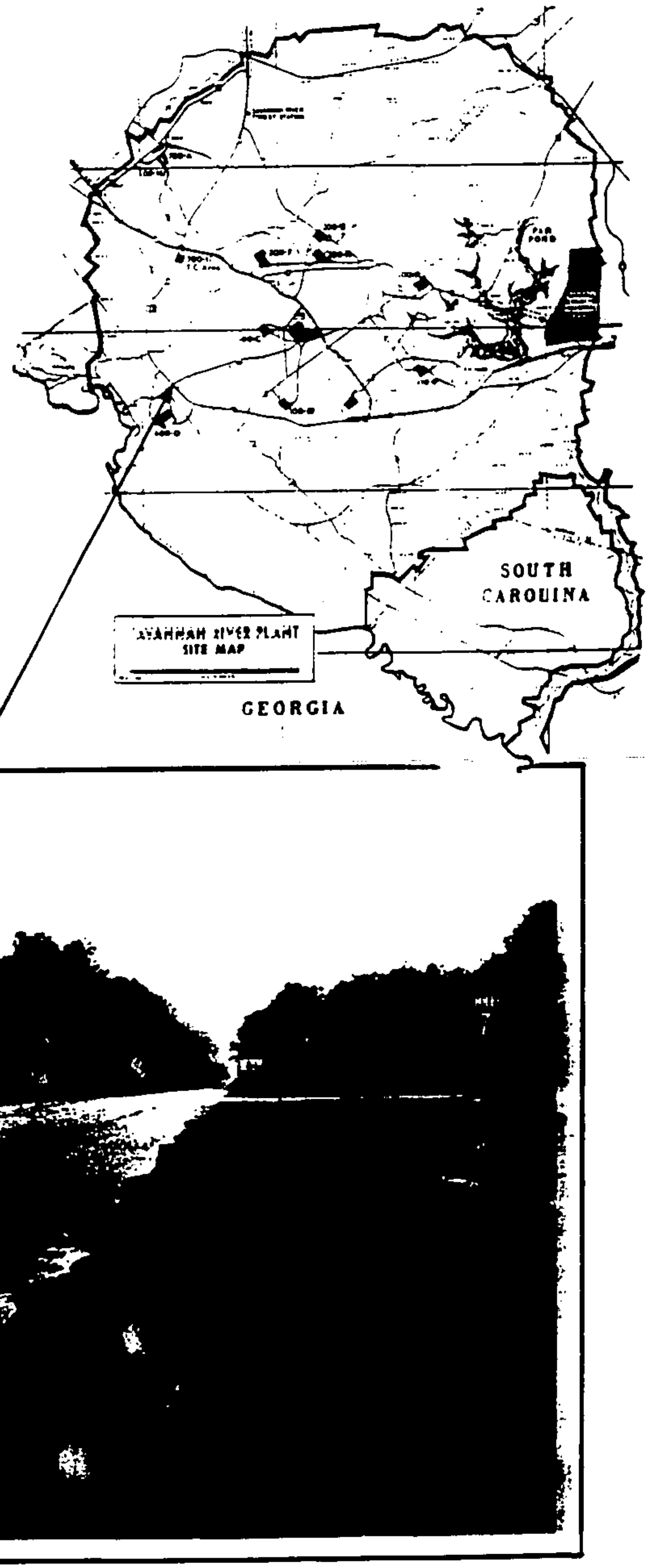
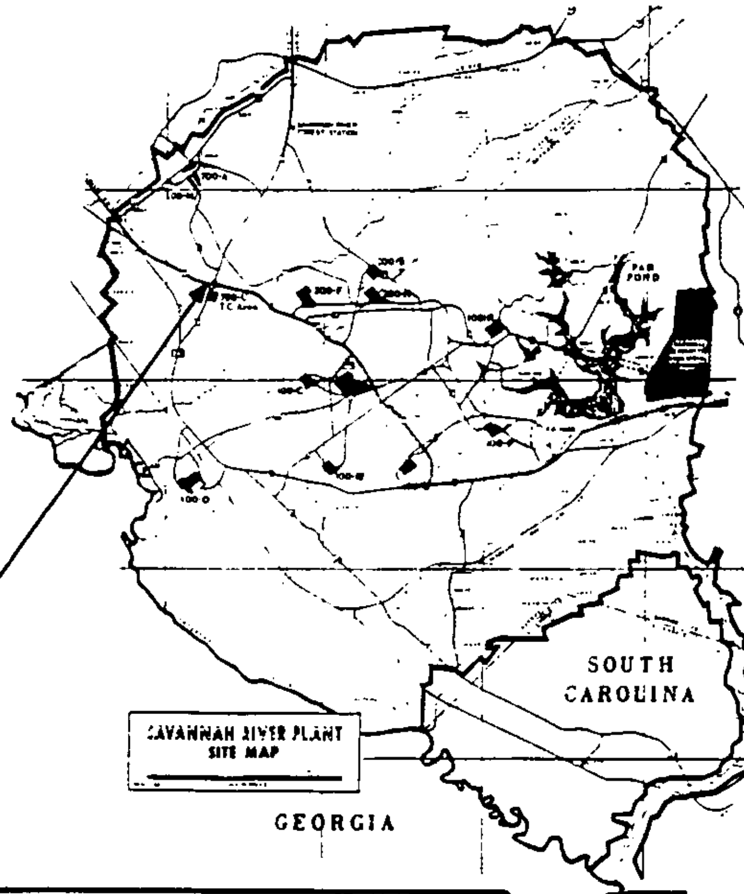


FIGURE 2-19. Intersection of South Carolina Route 125 and Road 3

Road 2 Overpass Over Road C at
Cloverleaf Looking East



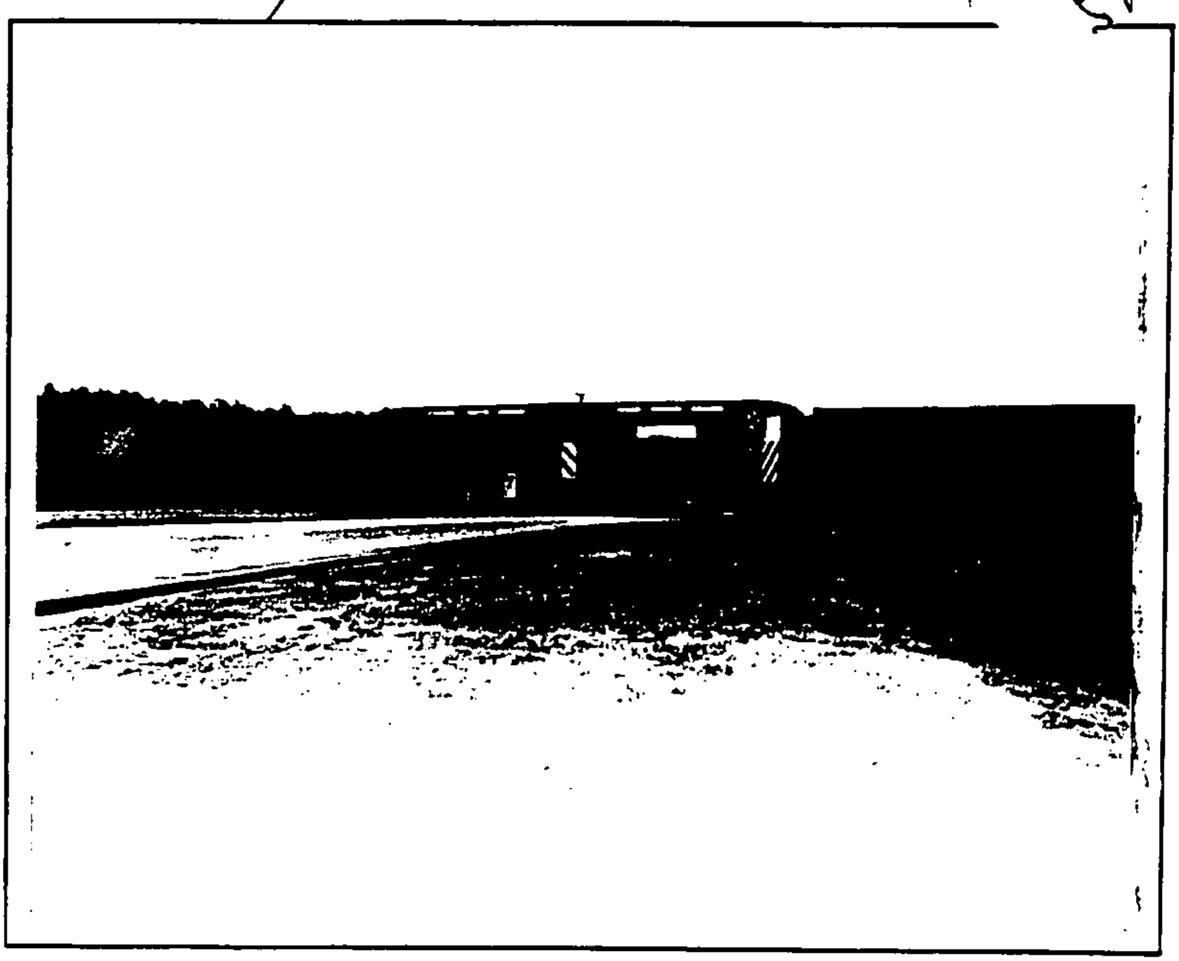


FIGURE 2-20. Road 2 Overpass at Road C

Road E Crossings Over
Tributary of Four-Mile
Creek Near F-Area

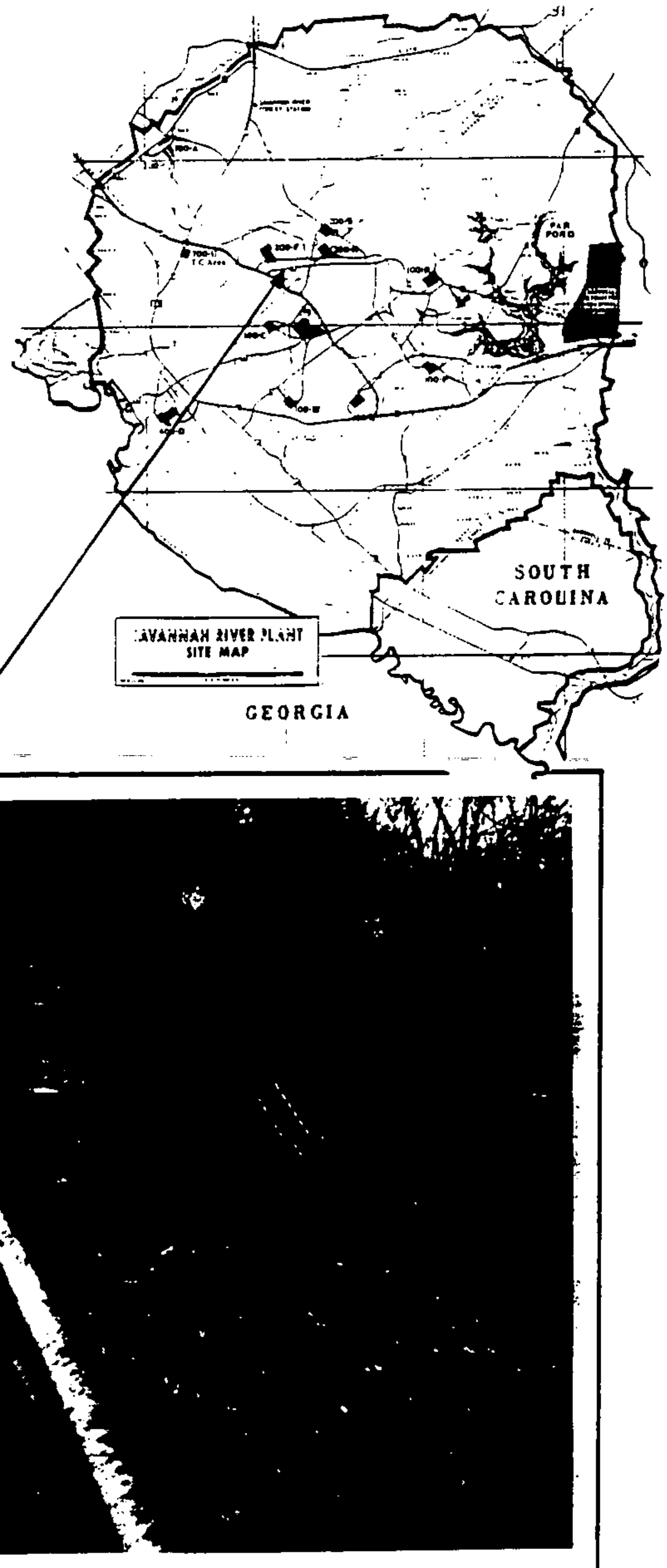
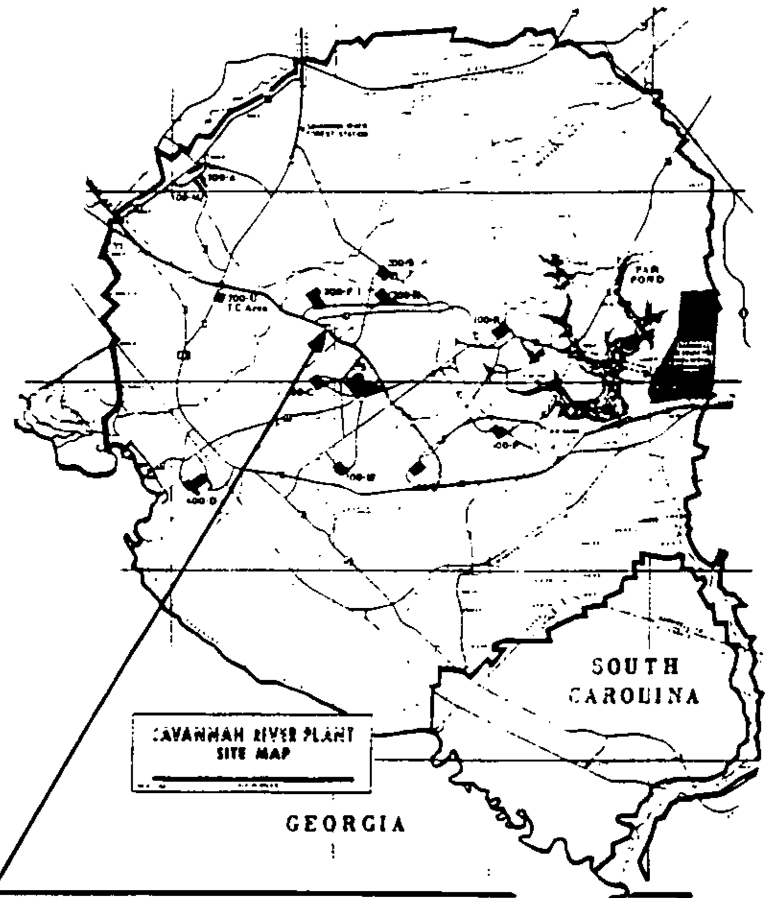


FIGURE 2-21. Road E at Four Mile Creek

Road C Bridge Over Four-Mile Creek Looking North



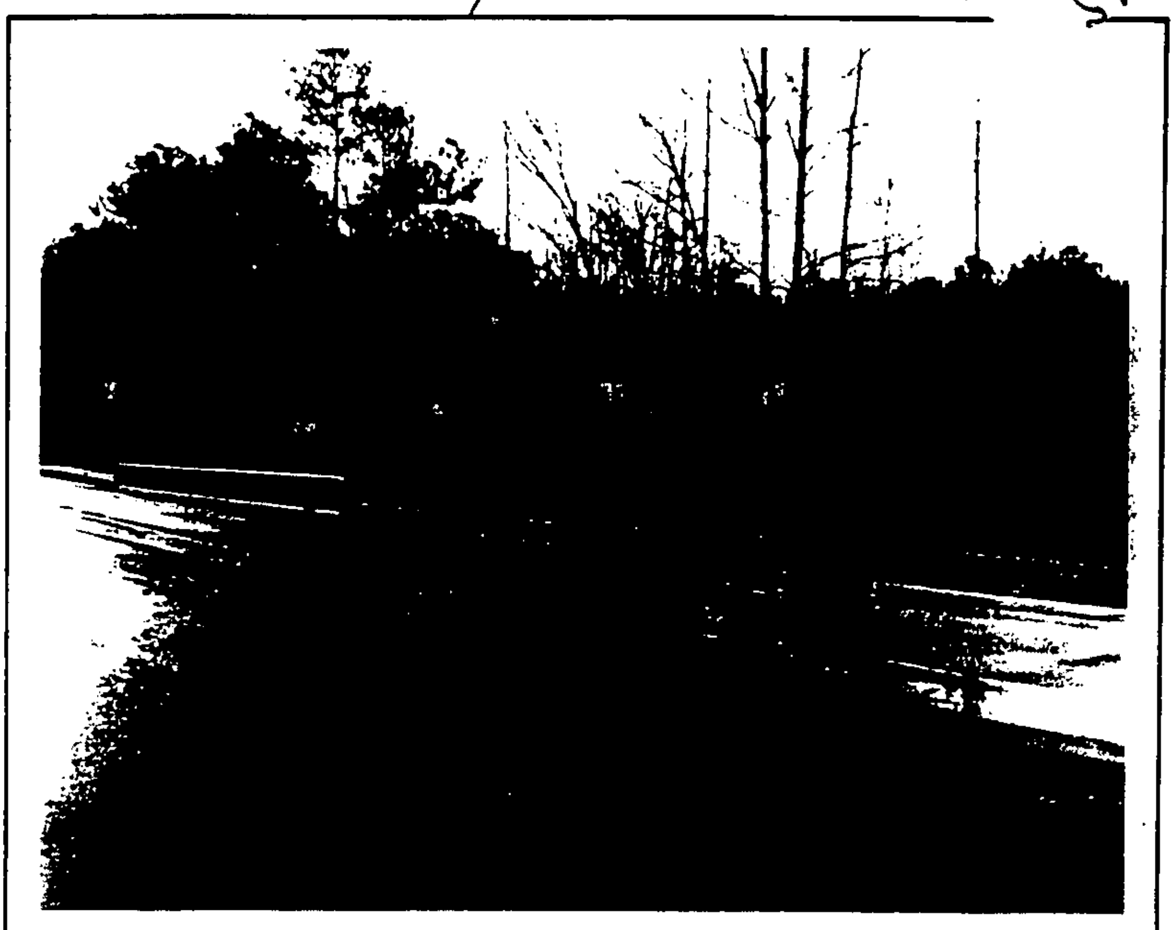


FIGURE 2-22. Road C at Four-Mile Creek

Road C Bridge Over Four-Mile
Creek Looking North-West

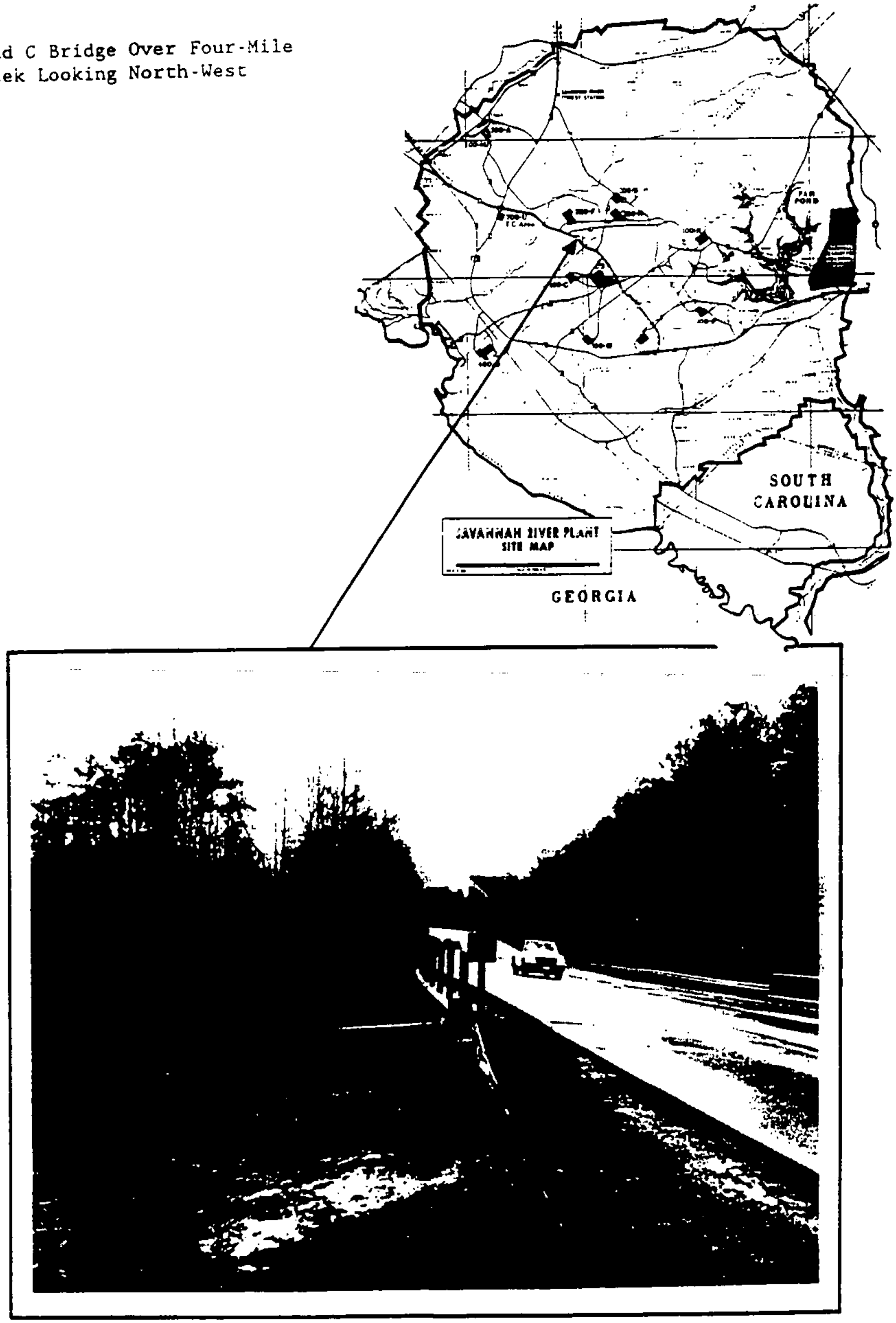


FIGURE 2-23. Road C at Four-Mile Creek

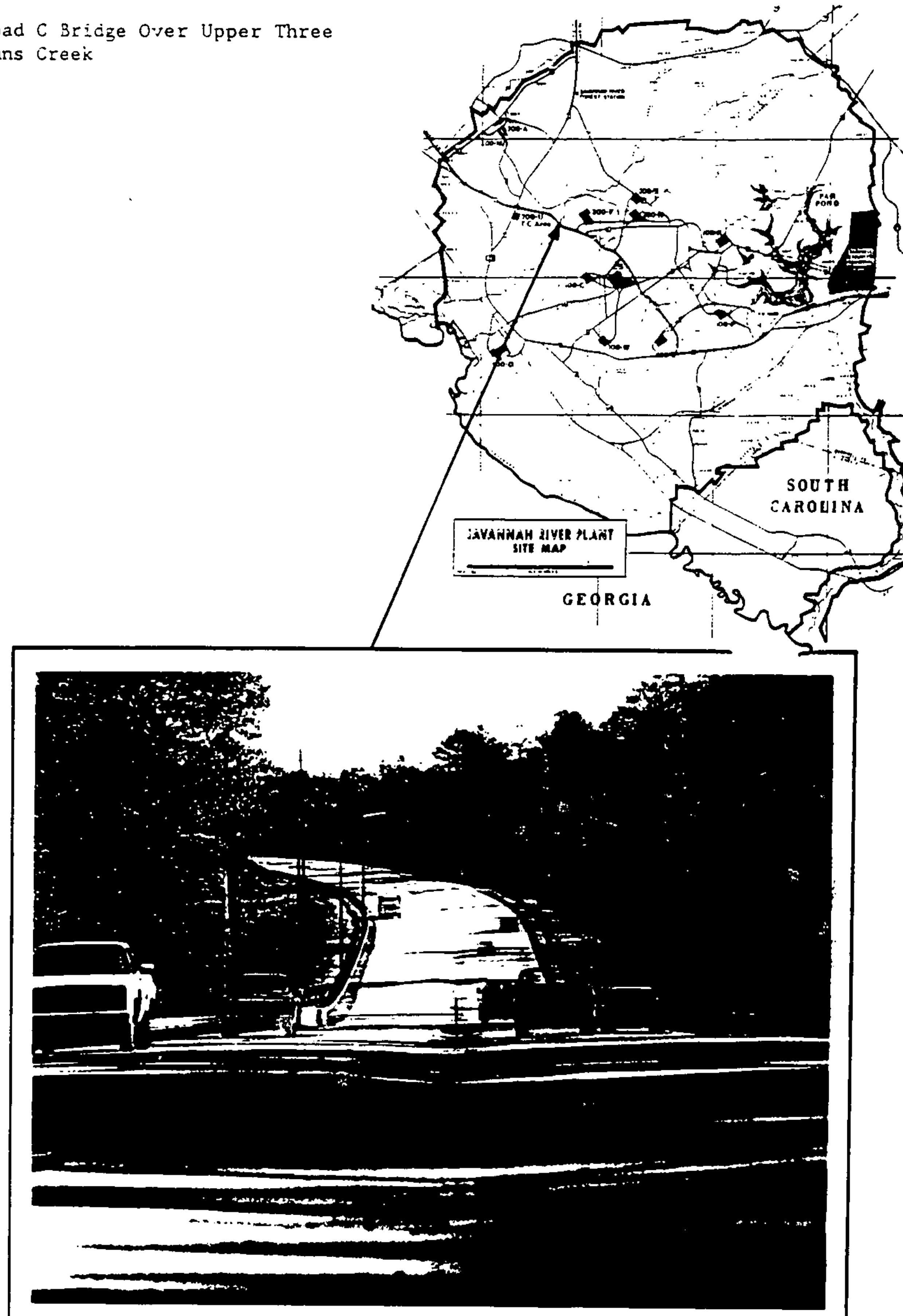


FIGURE 2-24. Road C at Upper Three Runs Creek

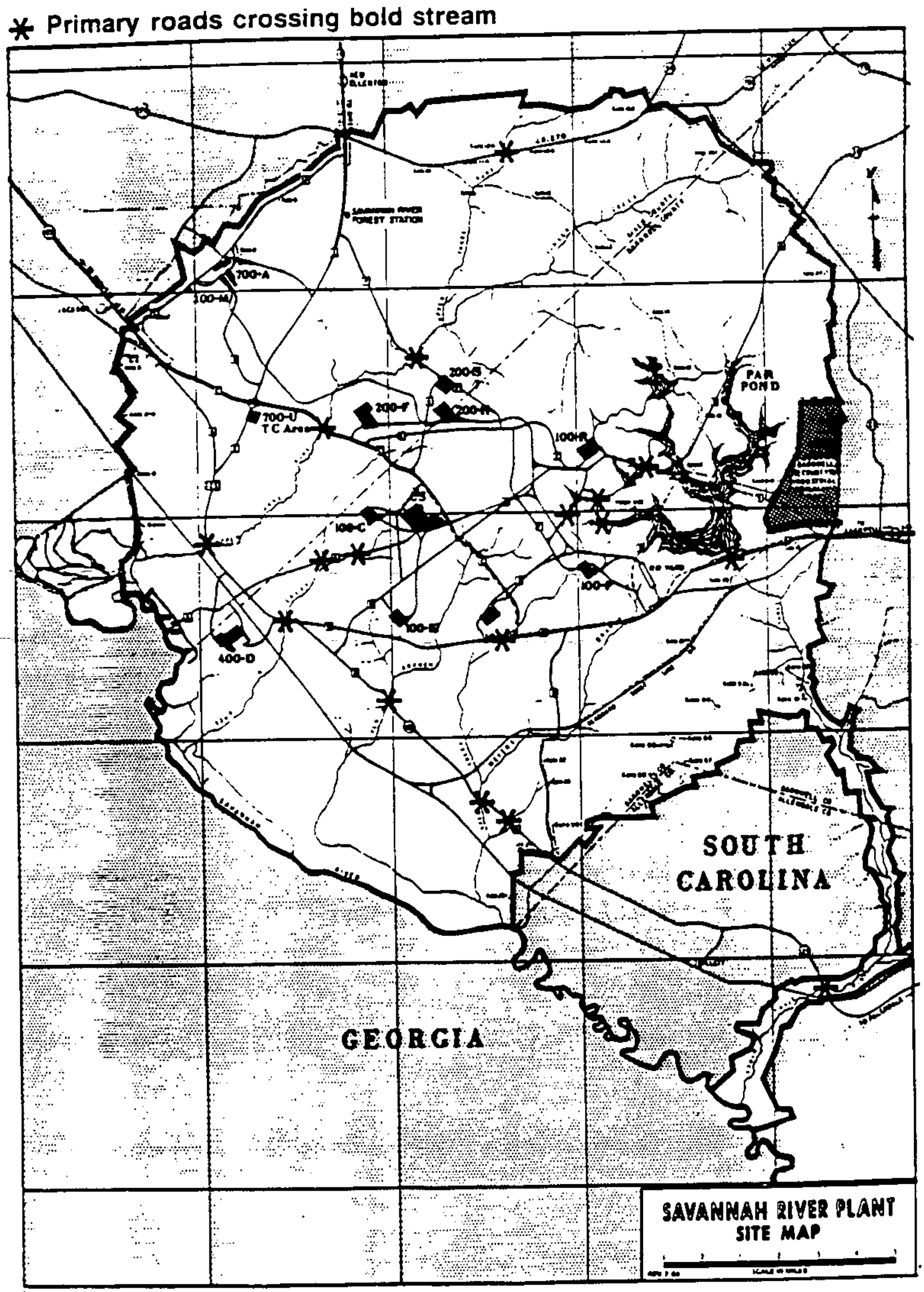


FIGURE 2-25. Primary Roads Crossing Bold Streams

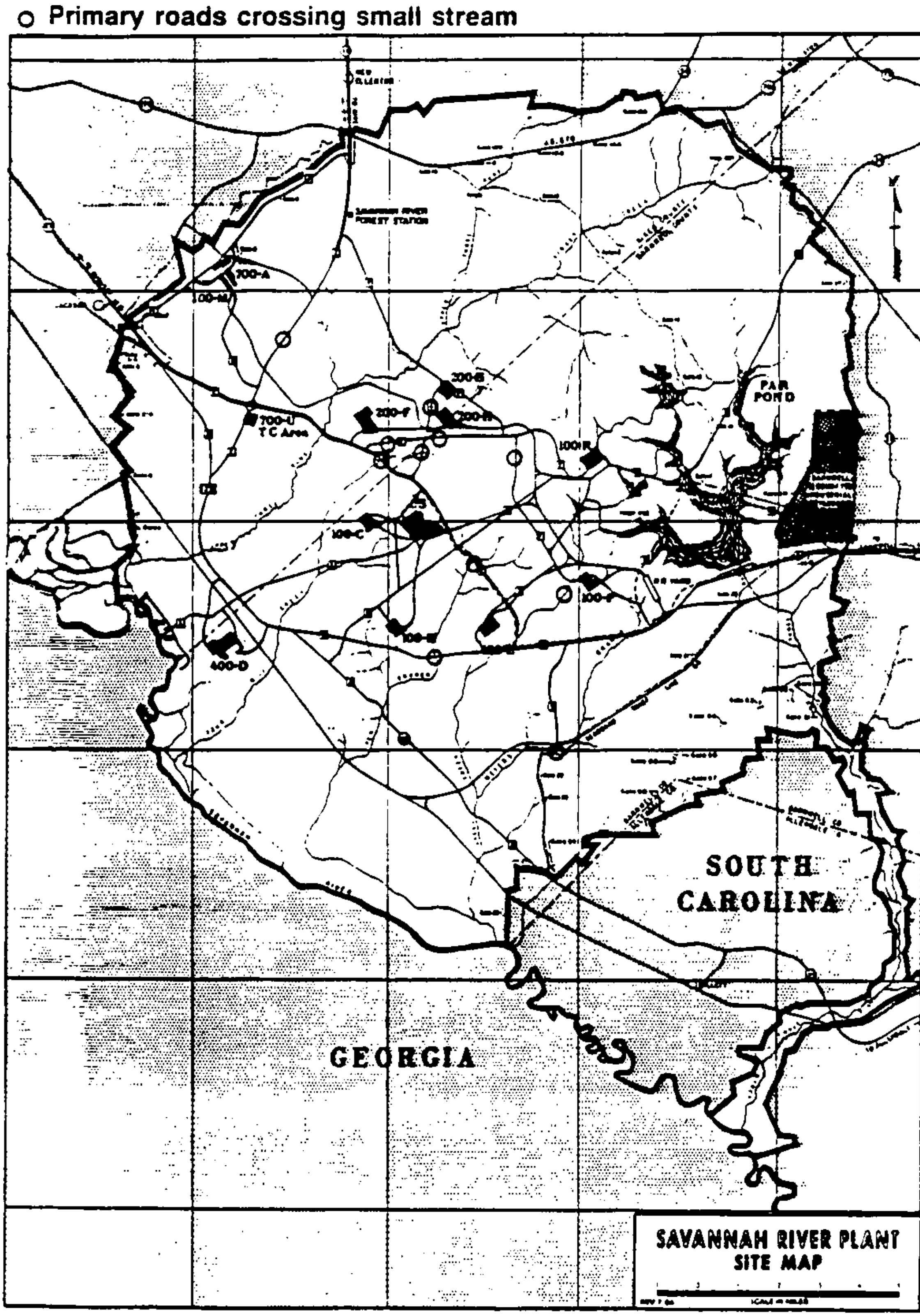


FIGURE 2-26. Primary Roads Crossing Small Streams

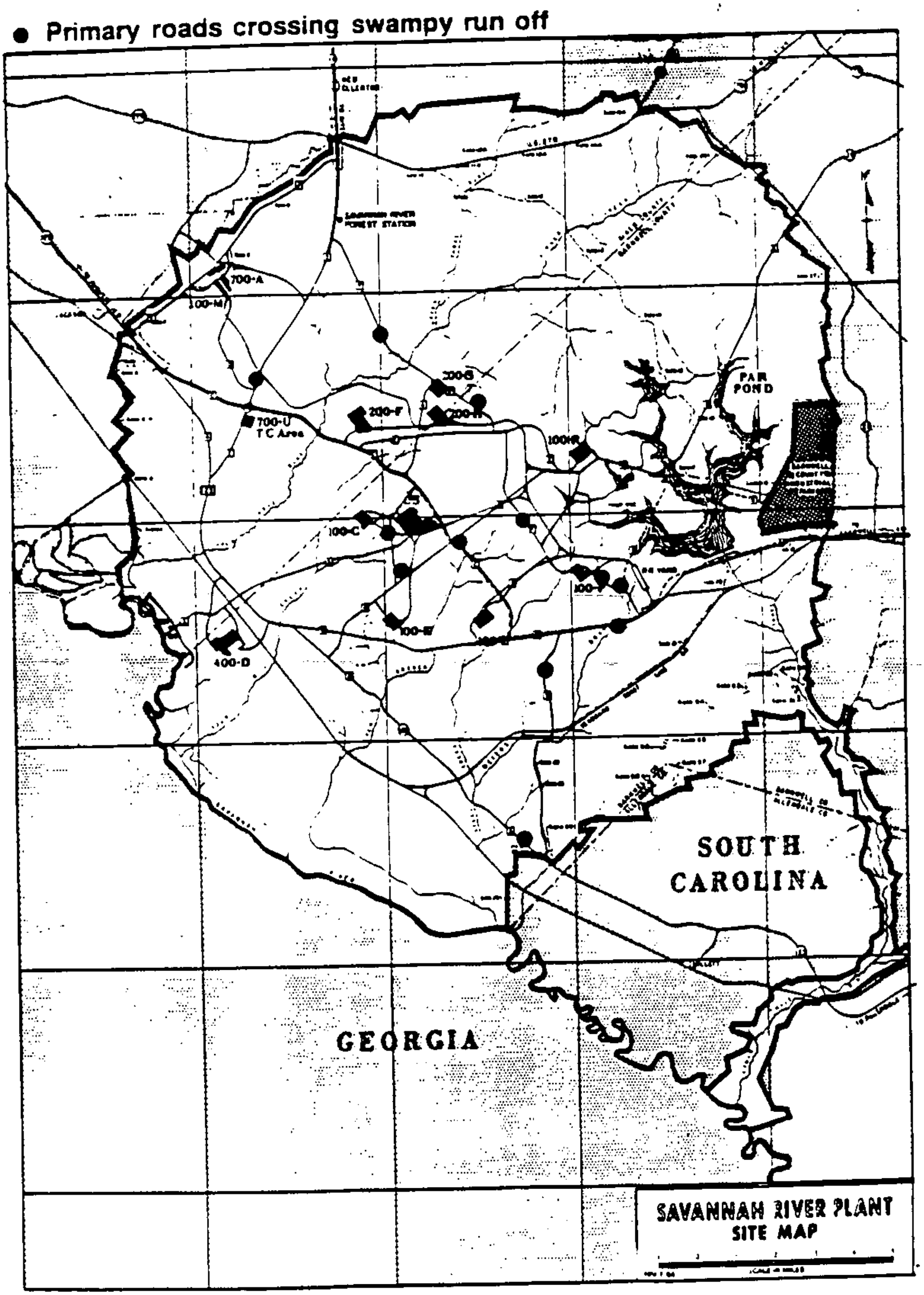


FIGURE 2-27. Primary Roads Crossing Swampy Run-Offs

H-Area Rail Crossing

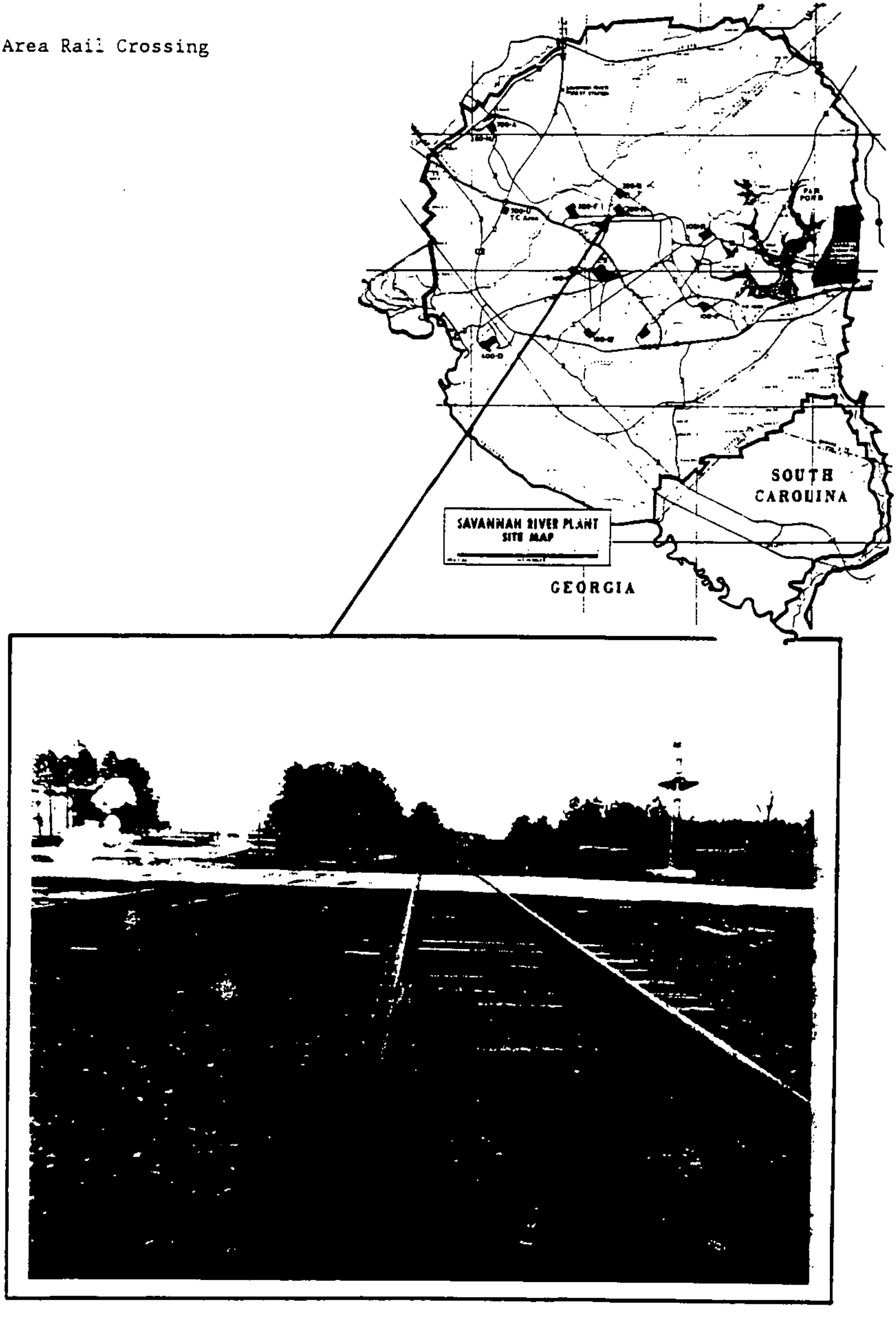


FIGURE 2-28. H-Area Rail Crossing

Seaboard Coastline Railroad
(Now CSX)
Near 400-D Area

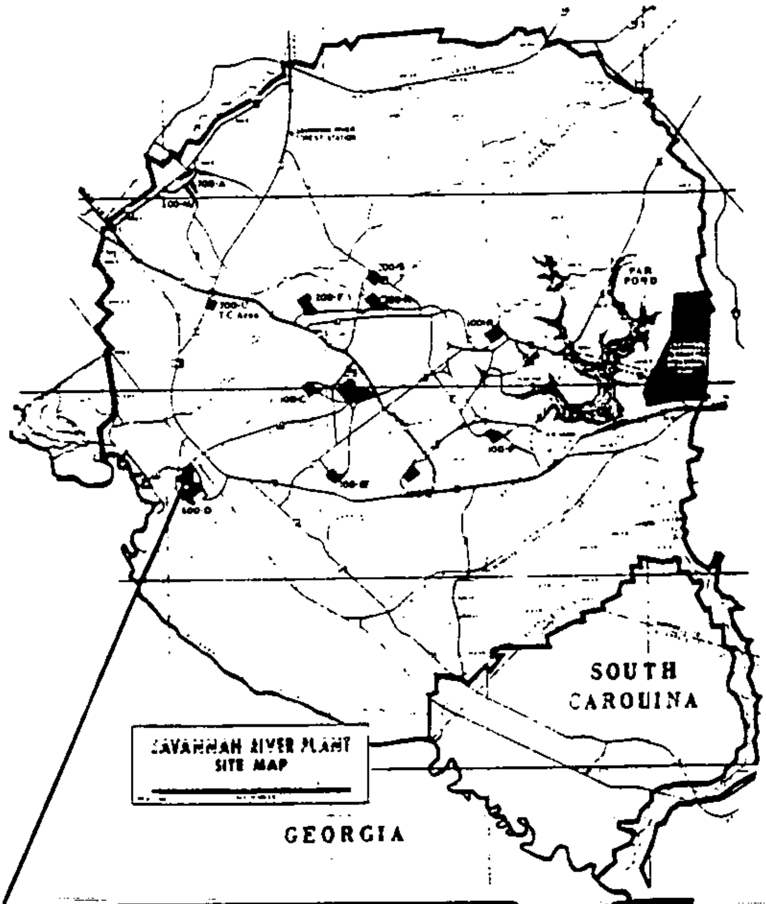


FIGURE 2-29. Seaboard Coastline Railroad

discussion of roadways focuses on the network of primary roads shown in Figure 2-2.

Two major public highways traverse the site, South Carolina Highway 125 and U.S. Route 278. Highway 125 connects the site to Augusta to the northwest and to Allendale to the southeast. U.S. Route 278 also leads westward into Augusta.

The SRP primary roadways are generally in good condition. The roads are smooth and free of pot-holes. Typically, the roadways are bordered by wide, firm shoulders (Figures 2-14 and 2-15) and are either straight or have wide, gradual turns (Figure 2-16). Intersections are generally well marked for both traffic safety and identification purposes and are sufficiently cleared of trees and brush which might obstruct the driver's view of oncoming traffic (Figures 2-17 through 2-19).

The speed limits onsite are consistent with those of the surrounding areas; posting of the limits is sufficiently well done. Railings alongside the roadways are provided at appropriate locations, offering protection to the vehicle from drop-offs or other hazards. The roadways are generally unlighted, except at the gate areas and in the vicinity of the major facilities.

The roadway lanes, edges, and traffic zones are clearly delineated by highway striping. This striping is done in accordance with the Du Pont striping procedures, and are consistent with normal roadway markings.

On the site there are two overpasses. Figure 2-20 shows the overpass located in the cloverleaf intersection of Road 2 and Road C. Also, South Carolina Highway 125 overpasses the CSX railroad tracks in the southern section of the site. Of the various bridges on the site, fifty-one were inspected and evaluated in 1981. Safe weight limits were determined for each bridge. Ten structures are adequate to carry the 200-ton heat exchanger crane and accessories under controlled conditions. Thirty-six are adequate to carry a 40-ton log truck with no restrictions and five can accommodate the 40-ton load if speed is reduced to 15 mph and traffic is limited to a single lane. Forty-four are adequate for 20-ton loads imposed by fire fighting equipment. One bridge can also accommodate a 20-ton load under controlled conditions. Some of the bridges on the site are shown in Figures 2-20 through 2-24.

The crossings of the primary roads with the various streams and water bodies are depicted in Figures 2-25, 2-26, and 2-27. These figures present the crossing of bold streams, small streams, and swampy run-offs, respectively.

As discussed above, the steepest roadway gradient on the SRP site is located on Road C at the east bank of Upper Three Runs Creek. At this point, the road drops more than 100 feet over 1/4 mile. At the base of the drop-off is the bridge over the creek and an immediate turn in the road. This area of the site presents a relatively hazardous roadway condition. Figure 2-24 presents a photograph of a truck descending the slope on Road C and approaching the bridge over Upper Three Runs Creek where a spill would be difficult or impossible to contain.

Road Traffic. In general, heavy traffic is found in the following instances: A surge of private vehicles brings workers into the site in the early morning. Most of these vehicles remain parked throughout the day, and official vehicles comprise the major portion of the traffic during the work day. At the end of the day, many of the official vehicles are parked, and the private vehicles depart in a surge of outbound traffic. After a traffic count in October 1985, estimates for 2-hr peaks were:

Gate	Vehicles
1	2570
2	1680
3	265
4	510
5	275
1 to 5	5300

As opposed to private vehicles, official vehicles are relatively inactive from 4:00 PM to 8:00 AM, and are then used throughout the day. Hence, the best indicator of official vehicle traffic is in the number of vehicles in service.

The above traffic does not include a large number of vehicles operated eastward on Highway 125 and South Highway 19 that park near SRL and 700-Area administrative buildings without going through a gate. It was also estimated that over 7300 private vehicles were parked at SRP in a normal work day.

There are several small fleets of official vehicles which individually constitute a minor part of the traffic picture, but collectively require consideration. Of these fleets, the USFS is one of the most important (even excluding logging trucks, which will be discussed later). The USFS has 22 vehicles in service.

Logging trucks are important, not only because of their number, but because they tend to interfere with traffic flow. At any one time, there will be from 10 to 30 logging trucks operating on the SRP; the average is estimated by the USFS as 15 trucks in service.

The Savannah River Ecology Laboratory operates 26 pickups. Southern Bell maintains a fleet of 7 panel trucks. In addition, AT&T maintains a fleet of about one-half dozen sedans. Other contractors, such as Diversico and the food service contractor, maintain relatively small fleets.

One of the major fleets of official vehicles is operated by the security contractor, Wackenhut (based in the TC area). The Wackenhut fleet consists of 107 vehicles. Of these, 32 are in constant use; 18 are staff, administration, etc., with limited use (estimated as 25% of the time on the road); and 57 are in use about 90% of the time. The total Wackenhut fleet logs about 200,000 miles per month.

DOE itself has 14 sedans, 9 pickup trucks, and 3 large trucks (greater than 24,000 lbs gross vehicle weight (GVW)).

The Du Pont Construction Division operates 22 sedans and 294 pickups. Du Pont (exclusive of construction) operates 240 sedans and 542 pickups. Also included in this fleet are about 30 trucks in the 12,500-24,000 lb GVW class, 58 trucks rated above 24,000 lb GVW, and 66 special purpose vehicles. These special vehicles include fire trucks, dump trucks, welding trucks, and other dedicated-use trucks. Du Pont Central Trucking dispatches an average of around 425 moves per month on large trucks.

2.4.2 Railroads Description

Railroads include onsite DOE owned rolling stock and trackage which is operated by the Railroads Division of Du Pont operations as well as CSX trackage. The CSX distribution system has two routes that run through the site: a line between Florence, South Carolina, and Augusta, Georgia, and a main line between Yemassee, South Carolina, and Augusta, Georgia. The two lines join within the site boundary (Figure 2-2). Early in 1989 CSX discontinued service on the line from this SRS junction to Florence, South Carolina.

There are approximately 63 miles of railway in the SRP railroad system. The railroads are well maintained. The rails and crossties are in good condition and the track lines are kept clear of vegetation and debris. Figure 2-28 clearly depicts the general condition of SRP railways. Significant clear areas border the tracks on both sides as shown in Figure 2-29.

The SRP railroad classification yard is located to the east of the 100-P Facility and is shown in Figure 2-30. Rail spurs and side tracks are provided as appropriate at various locations around the site.

Intersections of railways and roadways on the site are marked by railroad crossing signs, with lights where appropriate. Figures 2-28, 2-31, and 2-32 show typical railroad crossings.

The crossings of the railroads with the various streams and water bodies are depicted in Figures 2-33 and 2-34. These figures present the crossing of bold streams and small streams, respectively.

Rail Traffic. Normal traffic on the CSX tracks to and from Augusta through the site is up to 8 trains per day in 1985. Most shipments to SRP (9-10 per week) come in on east-bound trains, with empties being picked up by west-bound trains. Shipments destined for the 400-D Area (generally coal, acid, or caustic) are left on the Ellenton siding near 400-D (in the southwest portion of the plant area); outbound empties are picked up at the same location. Shipments for other areas of the plant are left on the Dunbarton siding at the east end of the SRP rail system; empties are picked up from the same location.

Shipments will generally come in to Ellenton (400-D) about five or six times per week. Most of these shipments are coal, with some tank cars and a very

Rail Classification Yard

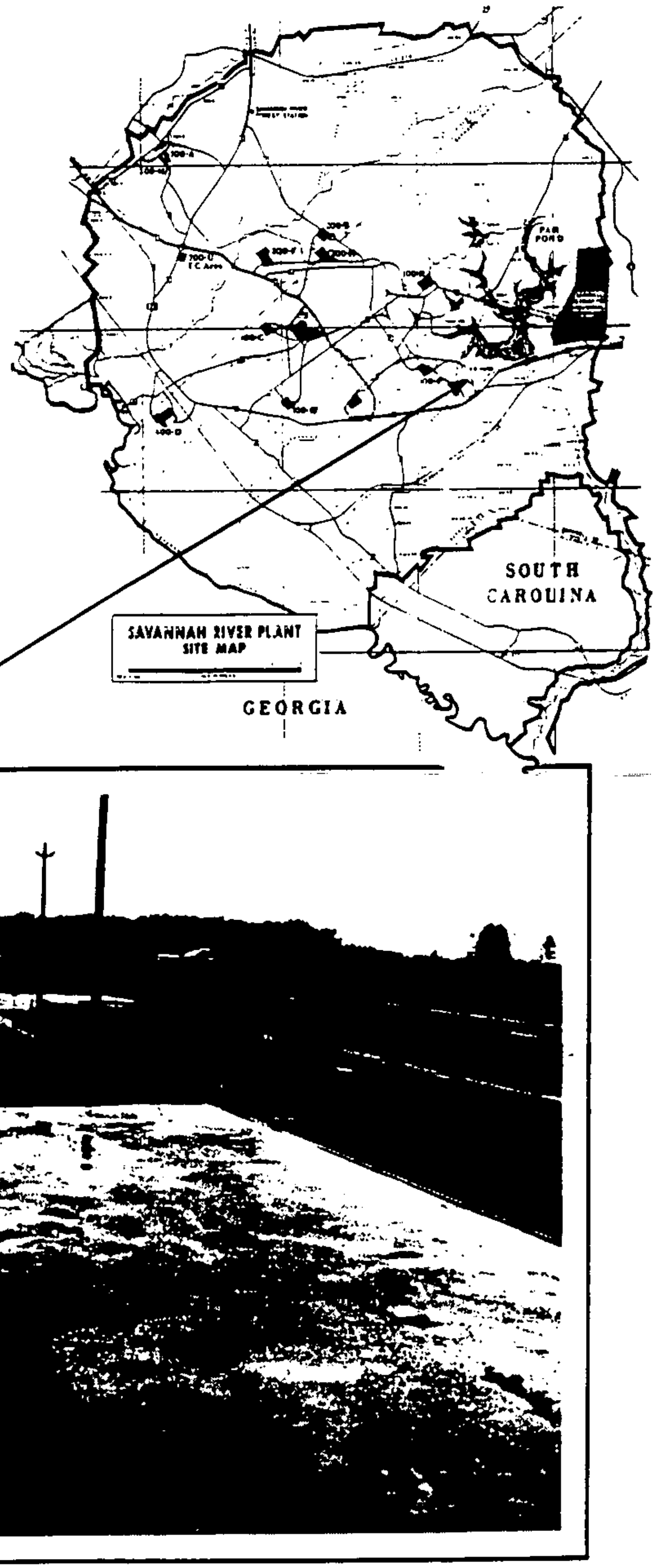


FIGURE 2-30. Rail Classification Yard

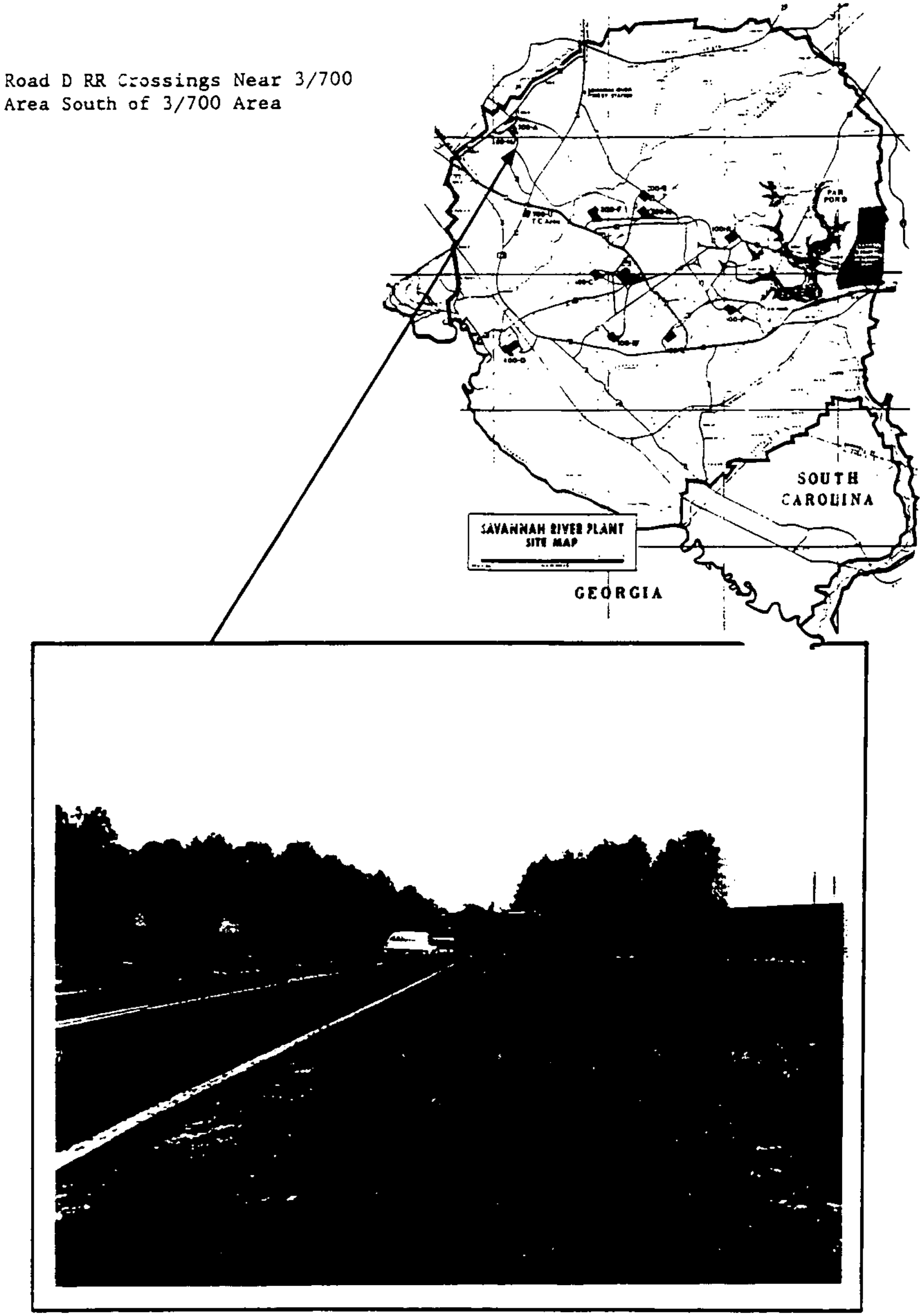


FIGURE 2-31. Road D - Rail Crossing

Road D Railroad Crossing South of 3/700 Area (Note: Typical Highway Signs and Signals)

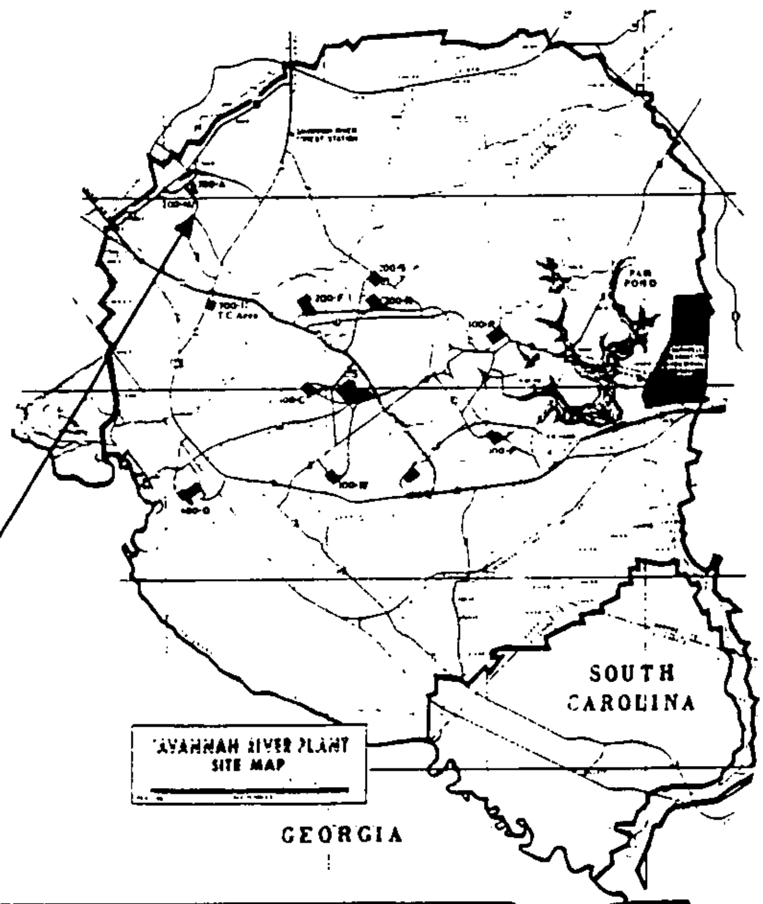


FIGURE 2-32. Road D - Railroad Crossing

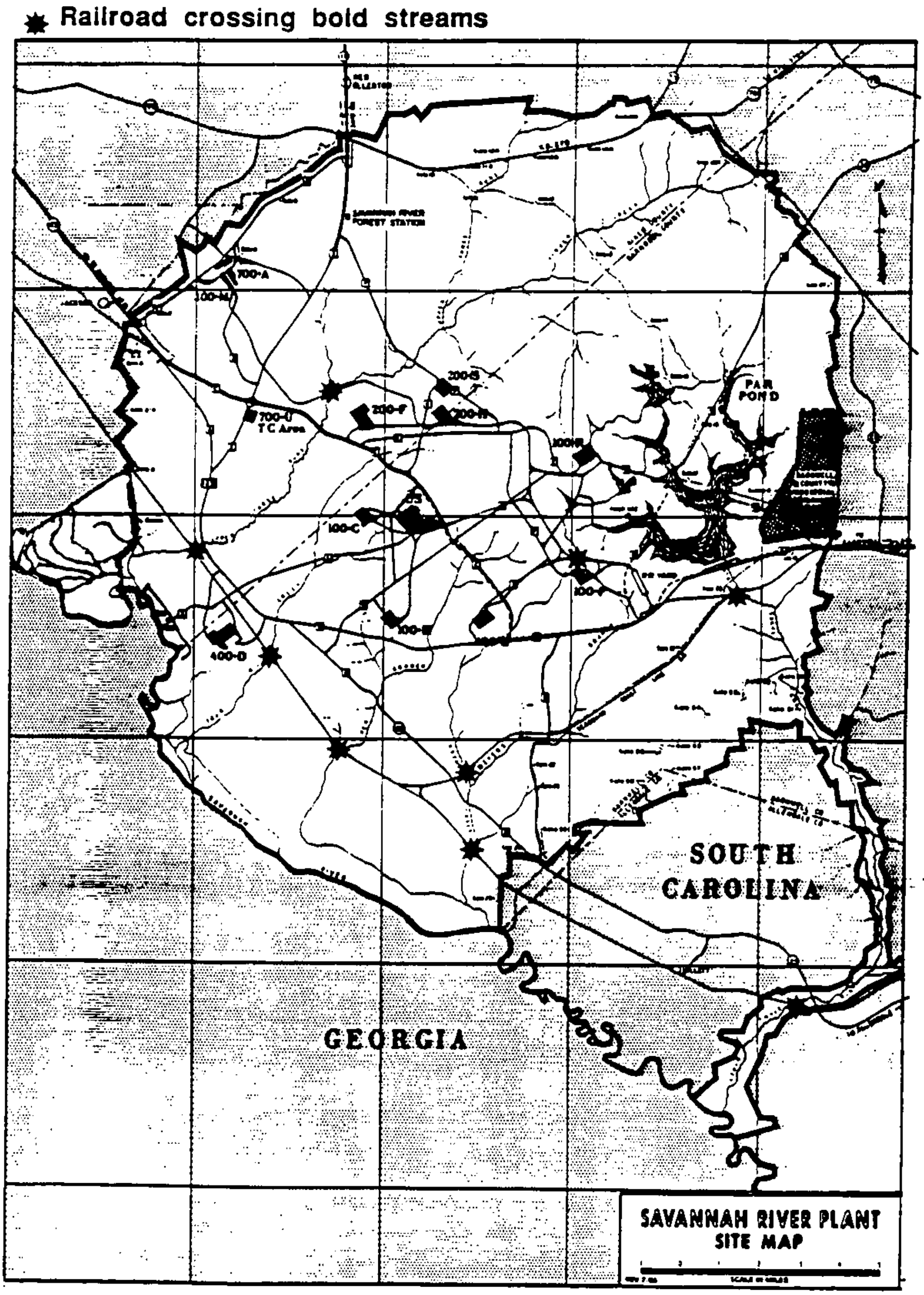


FIGURE 2-33. Railroad Crossing Bold Streams

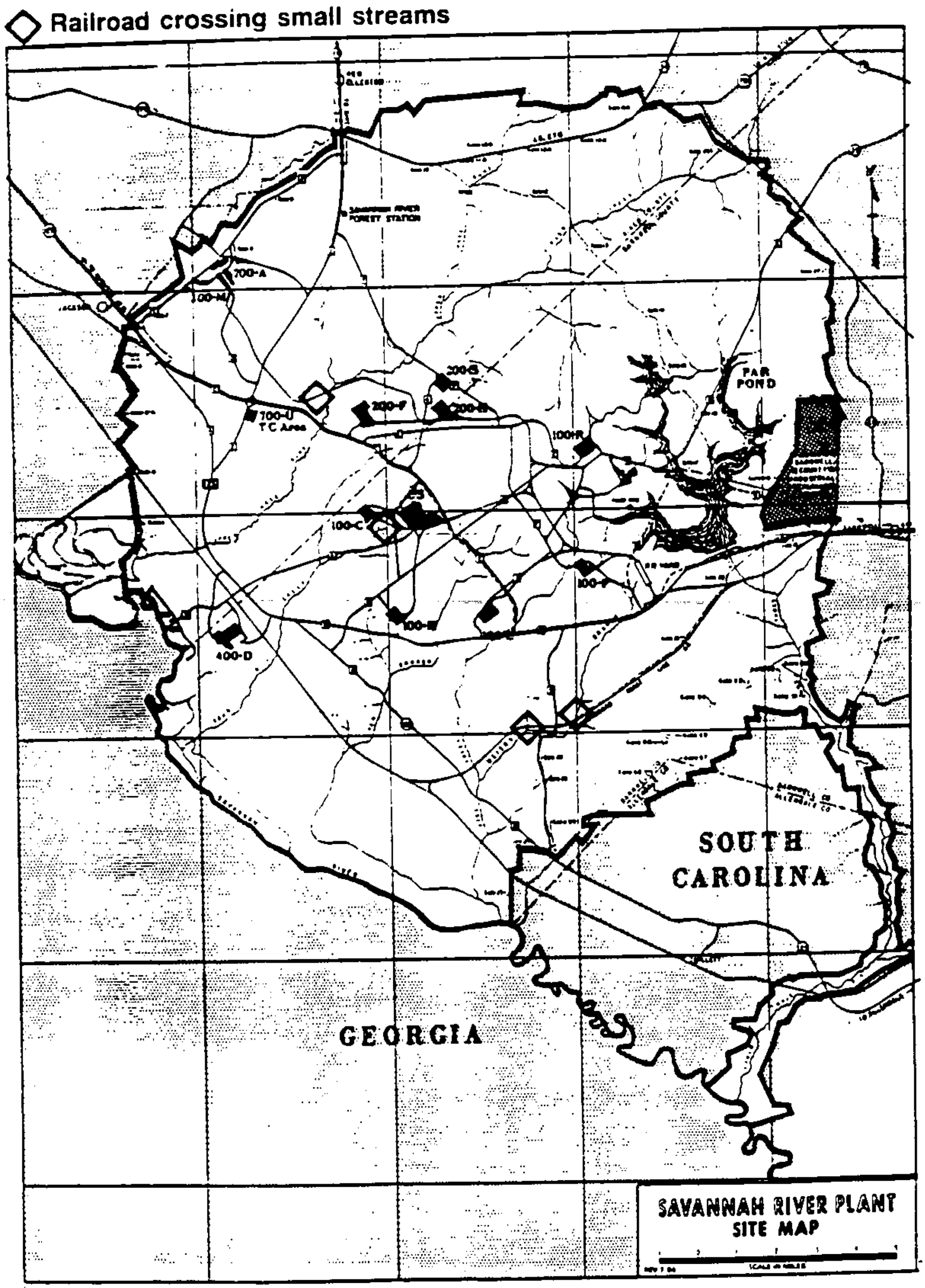


FIGURE 2-34. Railroad Crossing Small Streams

occasional flat car or box car with a piece of heavy equipment (such as a large transformer). Tank cars will have sulfuric acid or sodium hydroxide (caustic). In one eleven-month period (January through November, 1985), 9 cars of acid and 14 cars of caustic were delivered to SRP at Ellenton. In that time, the maximum was 4 tank cars, and the following month was the only month with no tank cars at Ellenton.

At Dunbarton, shipments come in about six times per week. Again, most of these are coal, with some cars carrying various chemicals, and an occasional flat car or box car with heavy equipment. The "various chemicals," with approximate annual receiving rates, are: sodium hydroxide, 72 cars (ranging from 0 to 11 cars per month in a recent 12-month period); aluminum nitrate, 2 cars; helium, 10 cars; an organic chemical (a normal paraffin), 2 cars; trichlorethane, 4 cars; and sodium nitrate (in bags), 6 cars.

On the SRP site cask cars (flat cars adapted for use in onsite transportation of casks) are used for shipping irradiated materials from reactors to the 200-Area. During May of 1985 there were 102 cask car moves. Some of these do not show on official records. For example, if the CD-3 car is to be moved from F-Area to K-Area, it is counted as a single move ("respot"); however, if it was moved from the F-Area to the classification yard and then later moved to K, these were recorded as two moves. Allowing for this, there were 93 complete cask car moves in May 1985. Cask cars are the major contributor to "cars moved in intra-plant service" shown in Table 2-6. A significant portion of intra-plant moves is flat car and tank car "respots".

As mentioned earlier, coal cars constitute the bulk of inbound loads, with tank cars accounting for most of the remainder. To illustrate this, Table 2-7 shows detailed records of inbound loads for May 1985 for both Ellenton (400-D) and Dunbarton (remainder of plant). Table 2-7 also shows the variability of incoming material. The total number of SRP rail car movements for a period of fifteen consecutive months ending in January 1986 is identified in Table 2-6.

TABLE 2-6. SRP Car Movements

Report Month	Inbound Loads	Outbound Empties	Outbound Loads	Cars Moved in Intra-Plant Service	Total Cars Handled
November 1984					1633
December	629	917	2	180	1728
January 1985	459	372	10	59	900
February	176	271	6	111	564
March	104	101	6	132	343
April	342	295	0	77	714
May	219	247	1	95	562
June	491	493	0	69	1053
July	59	49	0	109	217
August	324	285	0	106	715
September	437	473	0	70	980
October	247	250	0	48	545
November	205	214	0	74	493
December	404	373	0	84	861
January 1986	651	655	0	86	1392

TABLE 2-7. Seaboard Coast Line Releases to SRP, May 1985

Date	Ellenton		Dunbarton	
	Coal Cars	Other	Coal Cars	Other
5-01-85	35	--	24	1
5-03-85	20	--	--	--
5-04-85	1	--	7	--
5-05-85	3	--	9	1
5-06-85	5	--	1	--
5-07-85	--	1	3	--
5-08-85	--	1	8	--
5-10-85	--	--	--	3
5-14-85	--	--	12	--
5-15-85	--	--	6	1
5-16-85	--	--	--	2
5-17-85	1	--	--	--
5-18-85	--	--	2	3
5-19-85	15	--	--	--
5-20-85	--	--	19	--
5-22-85	--	--	5	--
5-23-85	9	--	11	--
5-24-85	36	--	--	--
5-25-85	28	--	--	--
5-27-85	16	--	--	--
5-28-85	37	--	19	3
5-30-85	10	1	--	--

2.5 REFERENCES

1. Dukes, E. K. The Savannah River Plant Environment. DP-1624, E. I. du Pont de Nemours & Co., Savannah River Laboratory, Aiken, SC, June 1984.

2. Final Environmental Impact Statement, L-Reactor Operation. DOE/EIS-0108, Volumes 1-3, U.S. Department of Energy, Savannah River Plant, Aiken, SC, May 1984.

3. Christensen, E. J. and Gordon, D. E., Eds. Technical Summary of Groundwater Quality Protection Program at Savannah River Plan; Volume I - Site Geohydrology and Solid and Hazardous Wastes. Internal Report DPST-83-829 (Vol. 1), E. I. du Pont de Nemours & Co., Savannah River Plant, Aiken, SC, December 1983.

4. Stone, J. A. and Christensen, E. J., Eds. Technical Summary of Groundwater Quality Protection Program at Savannah River Plan: Volume II - Radioactive Wastes. Internal Report DPST-83-829 (Vol. 2), E. I. du Pont de Nemours & Co., Savannah River Plant, Aiken, SC, December 1983.

5. Radioactive Waste Management at the SRP: A Technical Review. National Research Council, National Academy Press, Washington, DC (1981).

6. Final Environmental Impact Statement, Waste Management Operations, Savannah River Plant, Aiken, South Carolina. U.S. Energy Research and Development Administration, ERDA-1537 (1977) and DOE/EIS-0062, Supplement to ERDA-1537. Available from National Technical Information Service, Springfield, VA (1980).

7. Environmental Assessment L-Reactor Operation, Savannah River Plant, Aiken, SC. DOE/EA-0195, U.S. Department of Energy Assistant Secretary for Defense Programs, Office of Nuclear Material Production, Washington, DC (1982).

3.0 DESCRIPTION OF THE SRP TRANSPORTATION SYSTEM

Chapter 2.0 of this Safety Analysis Report describes the features and characteristics of the Savannah River Plant site including activities, facilities, and engineered improvements relevant to hazardous materials transportation operations and safety. Chapter 4.0 describes the operations of the SRP transportation system and discusses administrative controls that augment the safety features that are designed into the system. This section details the transportation system that moves hazardous materials (HMs) within the boundaries of the site. Included are descriptions of interfaces between transportation and facility components of the system; the focus is on the equipment and facilities used in transportation and on the hazardous materials being transported. This chapter is divided into four major sections. Section 3.1 presents the policies, standards, and criteria being applied to regulate the safety of transportation of hazardous materials on the site. The features of the SRP transportation system are described in Section 3.2. Section 3.3 identifies Engineered Safety Features of the onsite transportation system. Section 3.4 discusses future plans and decommissioning considerations.

3.1 TRANSPORTATION SAFETY POLICIES, STANDARDS, SPECIFICATIONS, AND CRITERIA

As will be discussed in Chapter 4.0, the Safe Distribution Subcommittee of Du Pont's SRP Management Committee is responsible for ensuring development and implementation of policies, standards, specifications, and criteria that are essential to the safety of transportation of hazardous materials on the SRP site. These onsite requirements are developed and implemented in conformance with requirements of 1) the contract agreement between the U.S. DOE and Du Pont for operation of the SRP, 2) the policies of E. I. du Pont de Nemours & Co., and 3) the applicable statutes and regulations of the U.S. Government, the State of South Carolina, and local legal jurisdictions.

Currently, specific statutory or regulatory requirements do not exist to regulate the safety of the transportation of hazardous materials on the site. However, State and Federal environmental and public and occupational health standards impose overall plant safety requirements. These are met by imposing management controls on SRP operations practices, plant equipment and facility designs, and safety performance.

In addition, the contractual agreement between the DOE and Du Pont requires that transportation of hazardous materials on the SRP site be conducted in a manner that provides for the protection of public health and safety equivalent to protection afforded by compliance with U.S. Department of Transportation regulations (1). Additionally, all onsite operations, including loading, unloading, and transportation, are required to conform to safety requirements specified in applicable DOE Orders (2, 3).

Given the general guidance provided by the Contract, the applicable DOE Orders, and the omnibus requirements of public and occupational health and safety and environmental laws and regulations, Du Pont has established procedural requirements to regulate onsite, inter-area transportation safety.

These requirements, which are presented in DPSOP 170 "Interarea Shipments" (4), address equipment and facilities, packaging, inspections and maintenance, and special controls.

In addition, all shipments of nonradioactive hazardous materials originating onsite for delivery to offsite receivers are made in accordance with U.S. DOT regulations and other applicable rules and regulations. The U.S. DOE Savannah River Operations Office (DOE-SRO) acts as the shipper of record for shipments of radioactive materials from the SRP. Du Pont procedures require that radioactive materials delivered to the DOE-SRO for shipment be prepared and packaged in accordance with DOT regulations and with DOE Order 5480.3 requirements.

Du Pont assumes that all hazardous materials delivered to the SRP are packaged and shipped in full compliance with DOT regulations. Notwithstanding this assumption, Du Pont personnel inspect arriving shipments of hazardous materials to assess compliance of these shipments with applicable regulations. Du Pont makes necessary reports to the DOT and effects other corrective actions with the responsible shippers and carriers.

Specific requirements that govern inter-area transportation safety for hazardous materials on the site are summarized below.

3.1.1 Packaging for Hazardous Materials

At a minimum, hazardous materials packaging should provide containment for the materials during normal conditions of transportation. The packaging should remain intact from origin to destination and provide a level of containment consistent with the characteristics of the material.

Hazardous Materials Packaging for Transport on Public Access Roads. South Carolina Highway 125 and SRP Road 1 are open to unrestricted public access. If a hazardous material under SRP control (see Reference 1, 49 CFR 172.101) must be moved on or across one of these roads, it must be packaged in accordance with 49 CFR 173. Note: if hazardous material not packaged according to 49 CFR 173 must be moved across one of these roads, traffic will be stopped by security inspectors and will not be allowed to resume until after the vehicle has passed and it is determined that no hazardous material was released during the transit.

Packagings for Nonradioactive Hazardous Materials Including Waste. Materials contained in their original vendor packaging, provided the packaging is not damaged or deteriorated, are considered suitable for onsite transportation. If materials are repackaged, the packaging must be compatible with the particular hazard and other characteristics of the specific material. The packaging selected should provide protection and containment of the material not only during transit, but also during an extended storage period that may occur after delivery.

Packaging for Nonfissile Radioactive Material, Including Waste. Packaging for radioactive materials should preclude release during the normal conditions encountered in transportation. Also, packaging should be selected to provide a minimum reasonably achievable radiation exposure of handling and transporting personnel.

All radioactive packages must bear labels indicating the nature of the radiation hazard.

In addition, radioactive waste must be packaged in accordance with requirements specified by Burial Ground supervision.

Packagings for Fissile Radioactive Material. Fissile materials may be transported in only DOT specification or certified packages or in packaging for which criticality potential has been determined to be within acceptable safe limits by a prior competent nuclear safety study at SRP.

Each package of fissile material must be labeled on opposite sides with standard DOT radioactive material labels.

Packages may not be stored or transported in groups whose cumulative transport index (TI) (see Reference 1, 49 CFR 173.403) exceeds 100. This level is consistent with that allowed in the DOT regulations for exclusive use shipments by commercial carriers where the additional levels of administrative control are provided.

3.1.2 Vehicles and Mobile Equipment

Vehicles and equipment used to transport and handle hazardous materials on the site are maintained to ensure their safe operating condition. Vehicles and equipment that are no longer considered safe or cannot be adequately maintained are replaced. When procured, new vehicles and equipment conform to current applicable national safety standards.

3.1.3 Tiedowns and Other Transportation Load Restraints

For normal transport conditions, hazardous material packages are secured to transport vehicles to prevent damage to the package or to limit accident potential due to load shift. Tiedowns or restraining devices shall be designed to retain packages on vehicles except in extreme accidents.

3.1.4 Lifting Devices (Hoists, Slings, Yokes, etc.)

Lifting devices used to handle hazardous material packages are selected and/or designed, inspected, and maintained to assure the safe handling of hazardous material packages.

3.1.5 Roads and Rails

SRP roads and rails are periodically inspected and maintained to ensure safety in transportation. Inspection and maintenance are performed in accordance with the American Association of State Highway and Transportation Officials (AASHTO) and the American Railroad Association Class III Guidelines. Roads, railroads and bridges are constructed in accordance with engineering standards effective at the time of construction. Service limitations (e.g., load limits, speed limits) are consistent with current safety standards, the condition of the roadway or railway, and the construction standards originally used.

3.1.6 Special Controls

From time to time, hazardous materials are transported on the site using special administrative controls procedures. These controls are applied whenever the nature of the transported material, in combination with the characteristics of its packaging, is such that it is necessary to provide additional measures to limit the potential for in-transit accidents or to limit the release consequences should an accident occur.

Special administrative controls also apply to all interarea movements of special nuclear material (SNM) and high level radioactive waste within the SRP boundaries performed under the prime operating contract with the U.S. Department of Energy.

3.1.7 General

Du Pont Engineering Standards were used for the design and construction of all SRP facilities, ensuring the use of standard, reliable, and economical materials with quality workmanship. The Du Pont Engineering Standards provide specific, detailed, instructive information for the designer. They refer to portions of national standards where applicable.

Du Pont Engineering Standards are updated frequently and are reviewed and revised, or reaffirmed every five years. The standards provide design information and specifications in the following general areas:

Architectural	Lubrication
Civil	Machine Design
Concrete	Piping
Drafting	Plumbing
Electrical	Power
Environmental Protection	Process Equipment
Fire Protection	Safety
Heating and Ventilation	Steel
Instruments	

The operations and features of transportation facilities, systems and equipment are also designed and controlled to comply with SRP (DOE and Du Pont) policies governing the safe handling and transport of hazardous (including radioactive) materials. The policies are as follows:

1. Managing Quantities of Waste Produced: The generation of hazardous and environmentally polluting wastes, including radioactive, hazardous and mixed wastes, in gaseous (or airborne particulates), liquid, and solid forms, shall be limited to quantities as low as are economically practical using available and feasible technologies and methods.

2. Managing Releases of Hazardous Wastes: The goal for the design and operations of systems used to confine or otherwise prevent the release of hazardous materials shall be that there will be no unmanaged release of hazardous material to the environment or to the work place.

3. Characterization, Classification and Segregation of Hazardous Wastes: The designs and operations of facilities, systems and equipment that produce hazardous wastes shall provide for characterization, classification and segregation of the waste to enhance public and worker health and safety and protection of the environment in handling, transportation, treatment, storage and final disposal.

3.2 ONSITE TRANSPORTATION SYSTEM

This section describes functions, characteristics, and principal safety considerations relevant to the SRP hazardous material transportation system. Section 3.2.1 is a summary description of the transportation system, is followed by sections providing details of system functions, material flows, and a general description of how the system's components respond to hazardous conditions that might exist during transportation.

3.2.1 Summary Description

This section addresses topics concerning the physical elements of the SRP onsite hazardous materials transportation system; organizational elements of the system are addressed in Chapter 4.0. Site-related features of the highways and railways components of the system are described in Chapter 2.0.

3.2.1.1 Facility Interfaces

The physical elements or components of the transportation system include hazardous material transportation package-handling equipment and transportation interface features (e.g., hose connectors, loading docks, etc.) at shipper and receiver facilities; vehicles and tiedowns or restraining devices provided by carriers; transport packagings; and the materials being transported. Figure 3-1 illustrates typical transportation interface features for a shipping and receiving facility; also shown are outdoor chemical storage tanks which are loaded directly from tank trucks and typical out-of-use storage arrangements for hazardous material (radioactive) packagings and for transport vehicles. Figure 3-2 shows a typical rail off-loading area. Loading dock and material handling equipment interfaces are illustrated in Figures 3-3 and 3-4. A liquid chlorine storage area (prior to constructing a storage building in 1987) is illustrated in Figure 3-5.

FIGURE 3-1. Typical Transportation Interface for a Shipping and Receiving Facility

FIGURE 3-2. Typical SRP Hazardous Material Rail Off-Loading Area

FIGURE 3-3. Stores Shippir Dock, Building 713-A

FIGURE 3-4. Stores Shipping Dock, Building 713-A

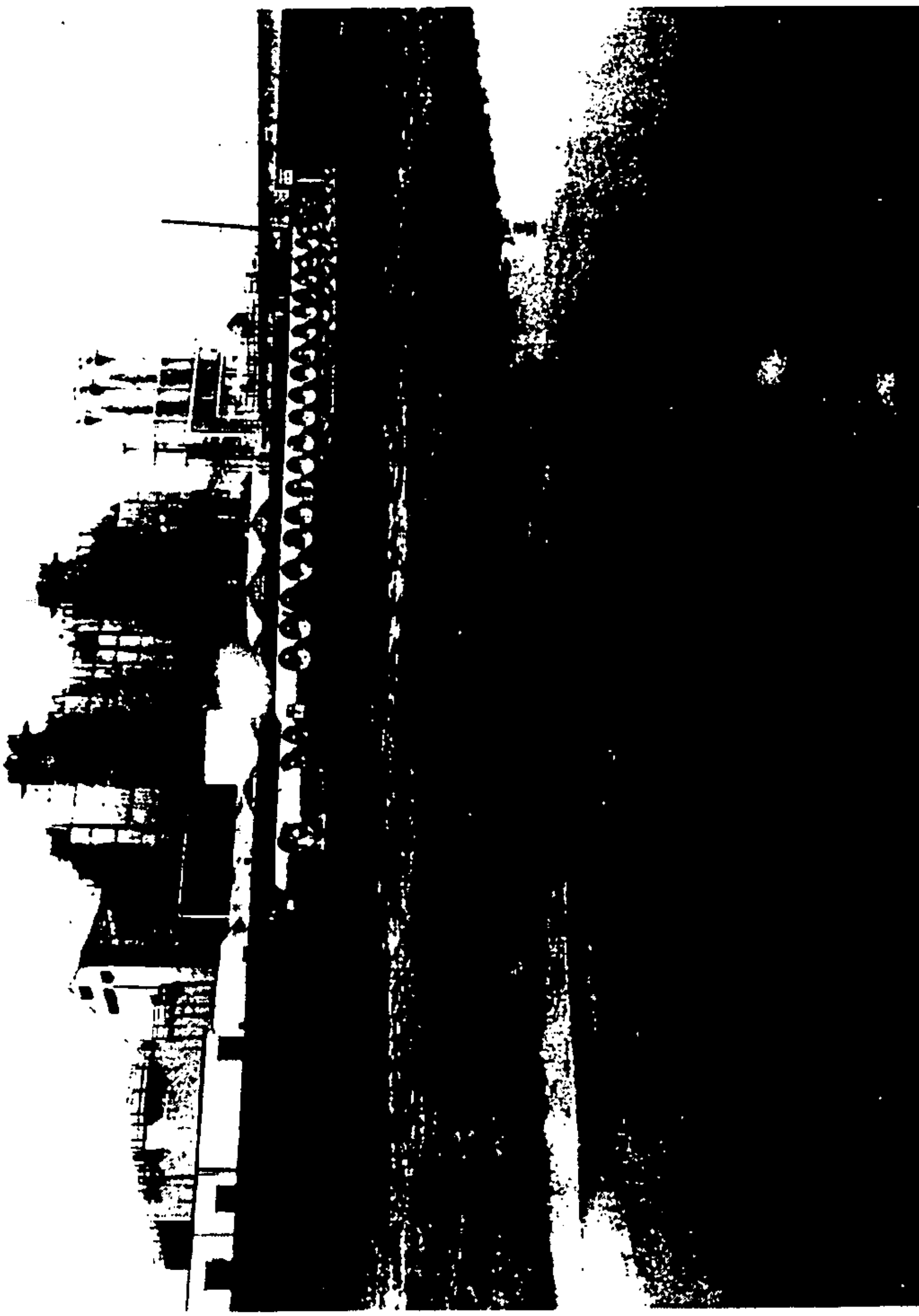


FIGURE 3-5. 400-Area Liquid Chlorine Storage

3.2.1.2 Road and Highway Vehicles

Examples of road and highway vehicles used in onsite transportation of hazardous materials are shown in Figures 3-6 through 3-14. Figure 3-6 shows a typical commercial carrier making a delivery to the Stores area on the site. Many commercial vehicles of all types make deliveries to destination points on the site. Vehicles used to make Stores Department deliveries are shown in Figure 3-7. An SRP gasoline and diesel fuel tanker operated by the Equipment Maintenance and General Services Division is shown in Figure 3-8. Similar tankers are also operated by Du Pont Construction Management.

A Stores Department cylinder-gas truck is shown in Figure 3-9. Clearly illustrated are the special truck bed design features provided to secure gas bottles for safe transport. A standard DOT hazardous material placard is displayed on the vehicle's cab door. The cylinder-gas storage area shown is where most of SRP's cylinder-gases are received and stored prior to delivery to operations facilities on the site. There is a similar cylinder-gas storage area at the Construction Central Shops area.

Figure 3-10 shows a typical heavy equipment tractor-trailer rig operated by the Roads, Railroads, Grounds and Field Services Division. Figure 3-11 shows the enclosed area of the H-Area sample truck with the payload restraint feature and easily-decontaminated stainless steel liner in the body. The walls of this truck have added shielding to limit the radiation exposure of drivers and personnel who may be near the vehicle when highly radioactive samples are being transported. A Load Lugger truck is shown in Figure 3-12. The arms extending above the load bed are hydraulically activated devices used to pick up containers from ground-level surfaces and to load the containers onto the truck bed.

Figures 3-13 and 3-14 show typical forklift vehicles used to handle materials in shipping and receiving areas. These vehicles are also used to short distance transfers of hazardous materials, e.g., between the Stores Department (713-A) and other nearby facilities in the 3/700-Area.

3.2.1.3 Railroad Equipment

Figures 3-15 through 3-18 show the typical railroad equipment used on the SRP site. Figure 3-15 shows the CD-4 rail car with its 70 ton spent fuel element cask payload. A typical nitric acid tank car is shown in Figure 3-16. The car shown, which was being prepared for shipment to an offsite destination for refilling, meets current DOT and AAR specifications for shipment of corrosive liquids.

Figure 3-17 shows the 400-D Area switching locomotive used to shuttle rail cars between the Seaboard Coast Line switch point and the 400-D Area Facilities. Four, larger, 1000 HP locomotives are used to move rail cars around areas of the site. One of these is seen in Figure 3-18, which is a view looking north at the Rail Classification yard.

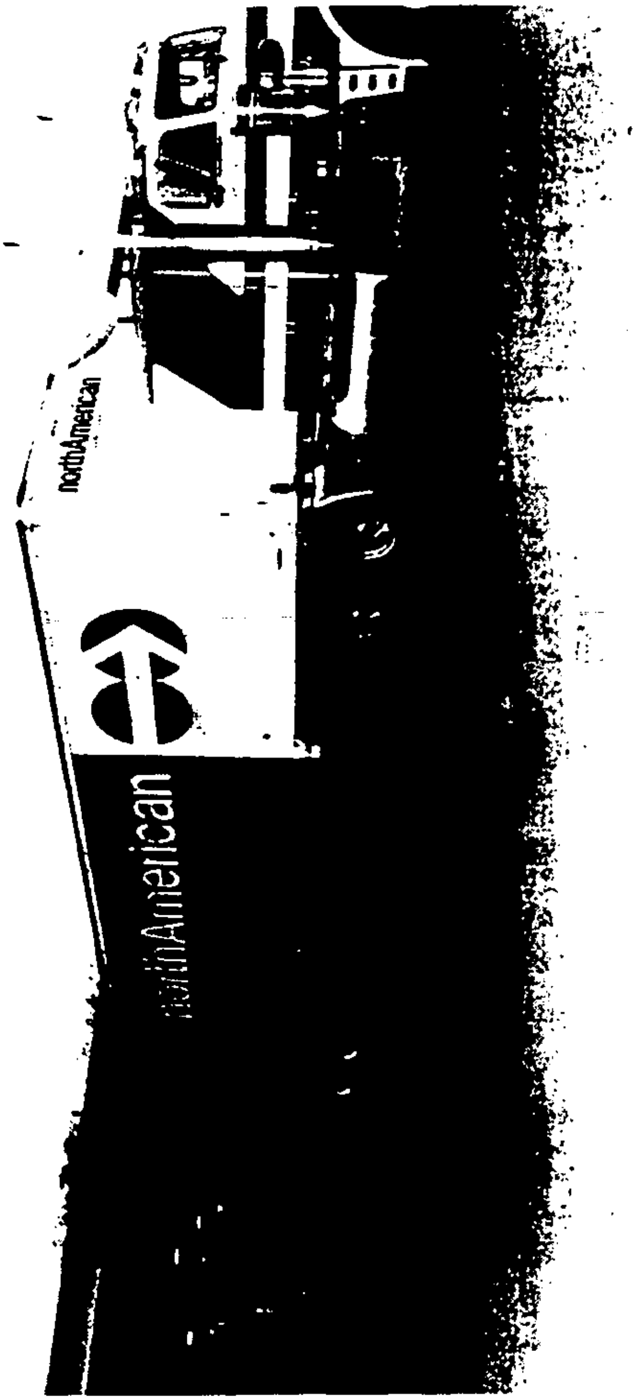


FIGURE 3-6. Typical Commercial Carrier Delivery to Stores, Building 713-A

FIGURE 3-7. Stores Department Delivery Vehicles

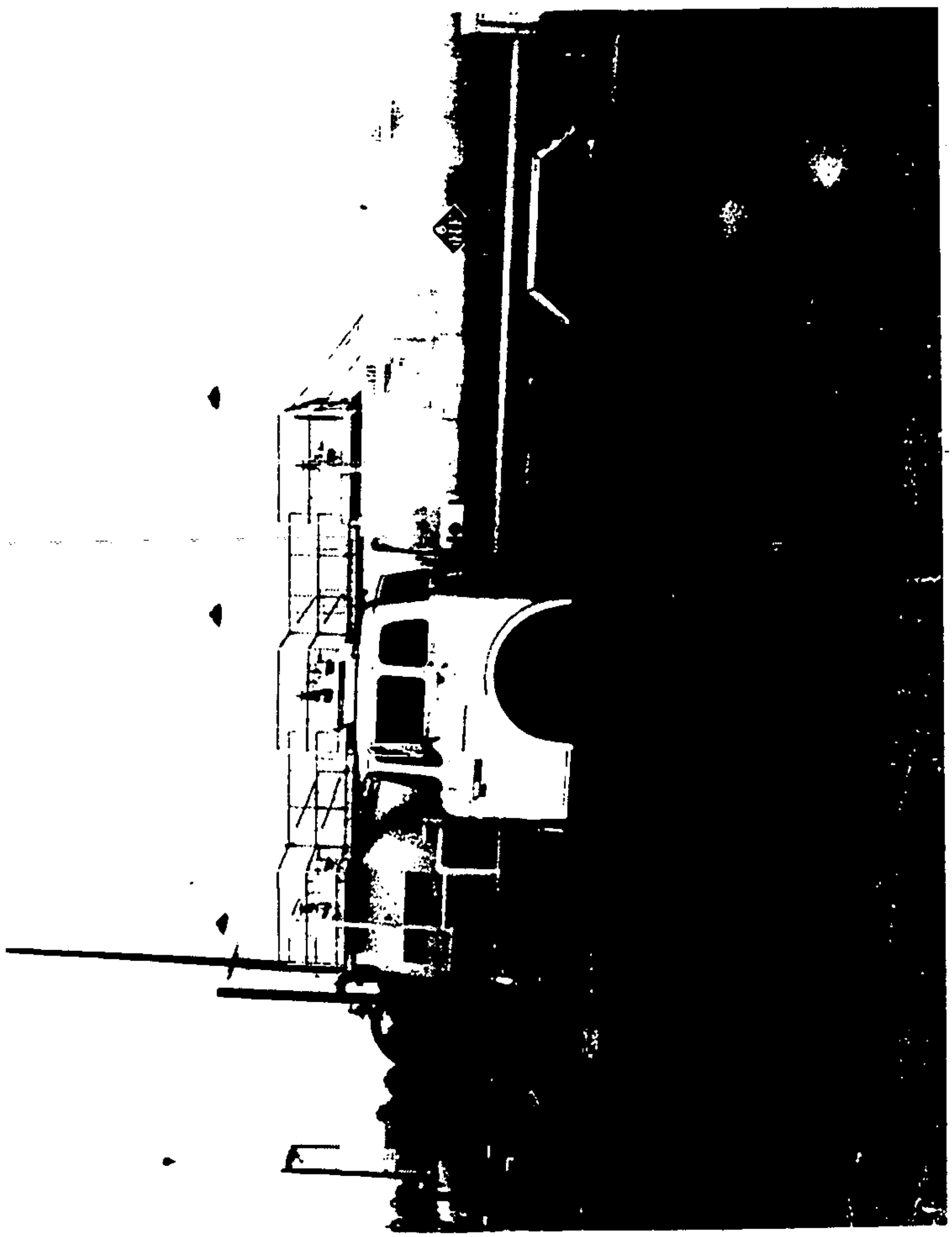


FIGURE 3-8. Gasoline and Diesel Tank Truck

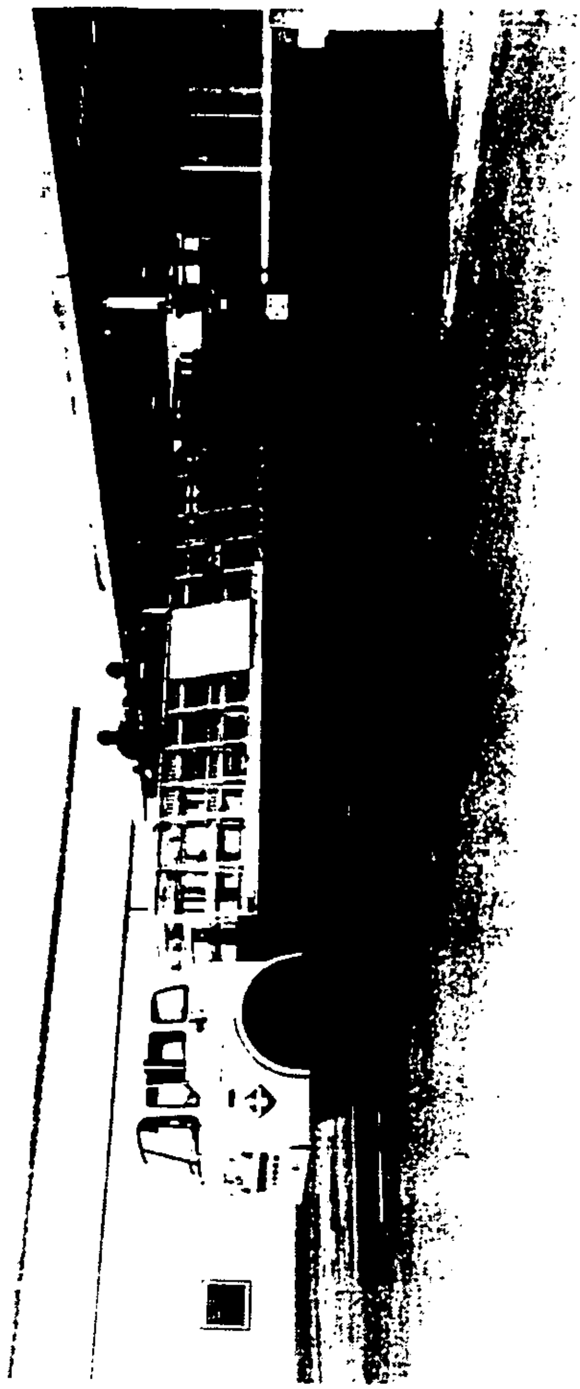


FIGURE 3-9. Stores Department Cylinder Gas Delivery Truck

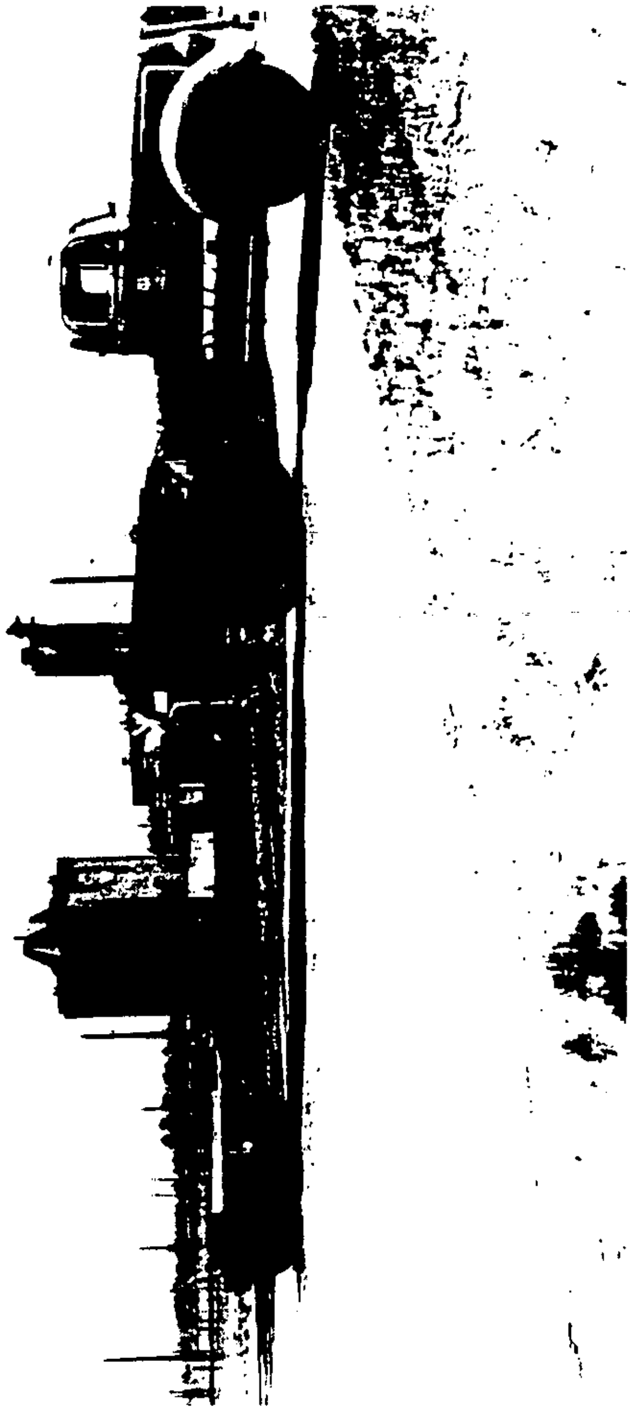


FIGURE 3-10. Heavy Equipment Tractor and Trailer Operated by RR&FS Division

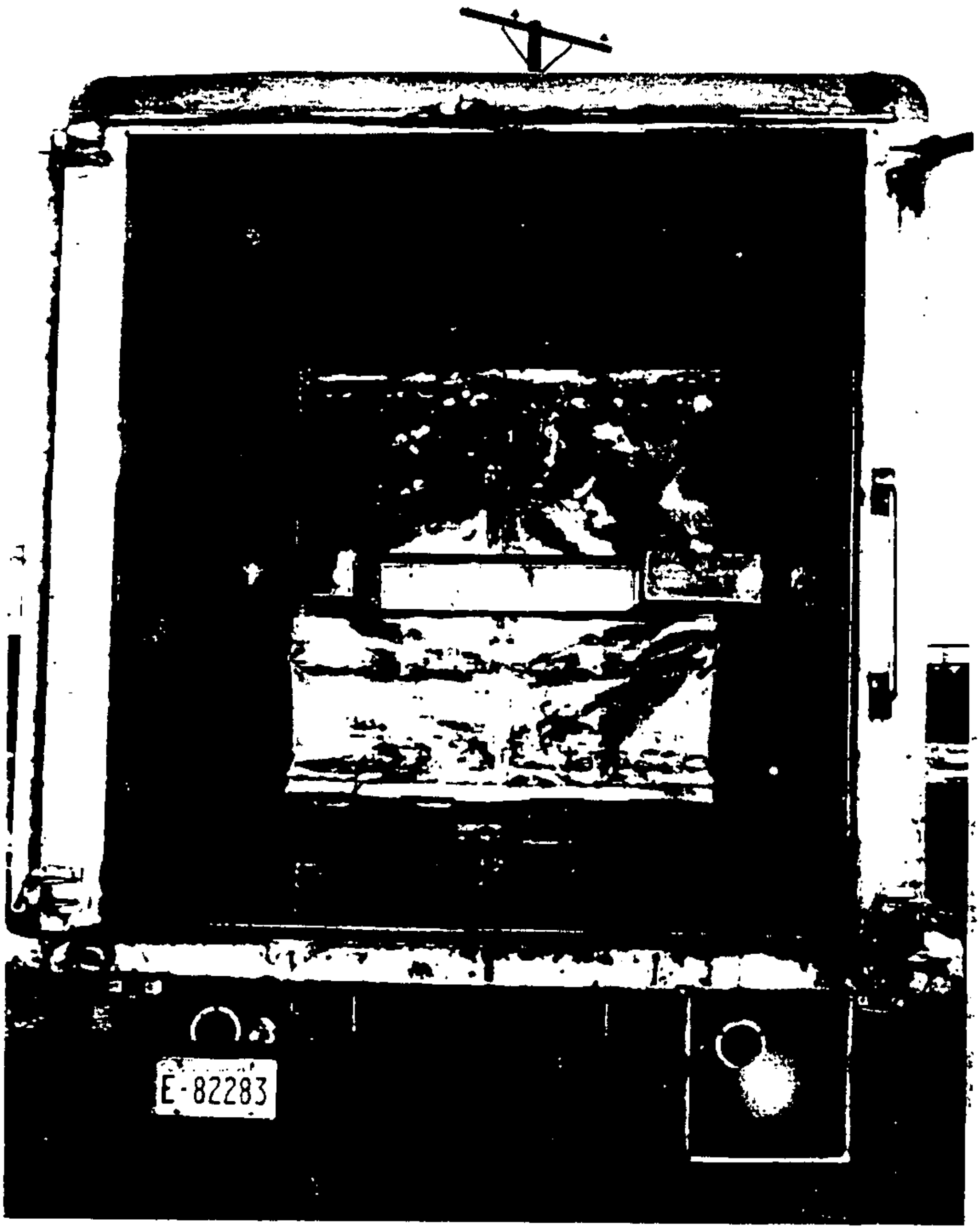


FIGURE 3-11. H-Area Sample Truck

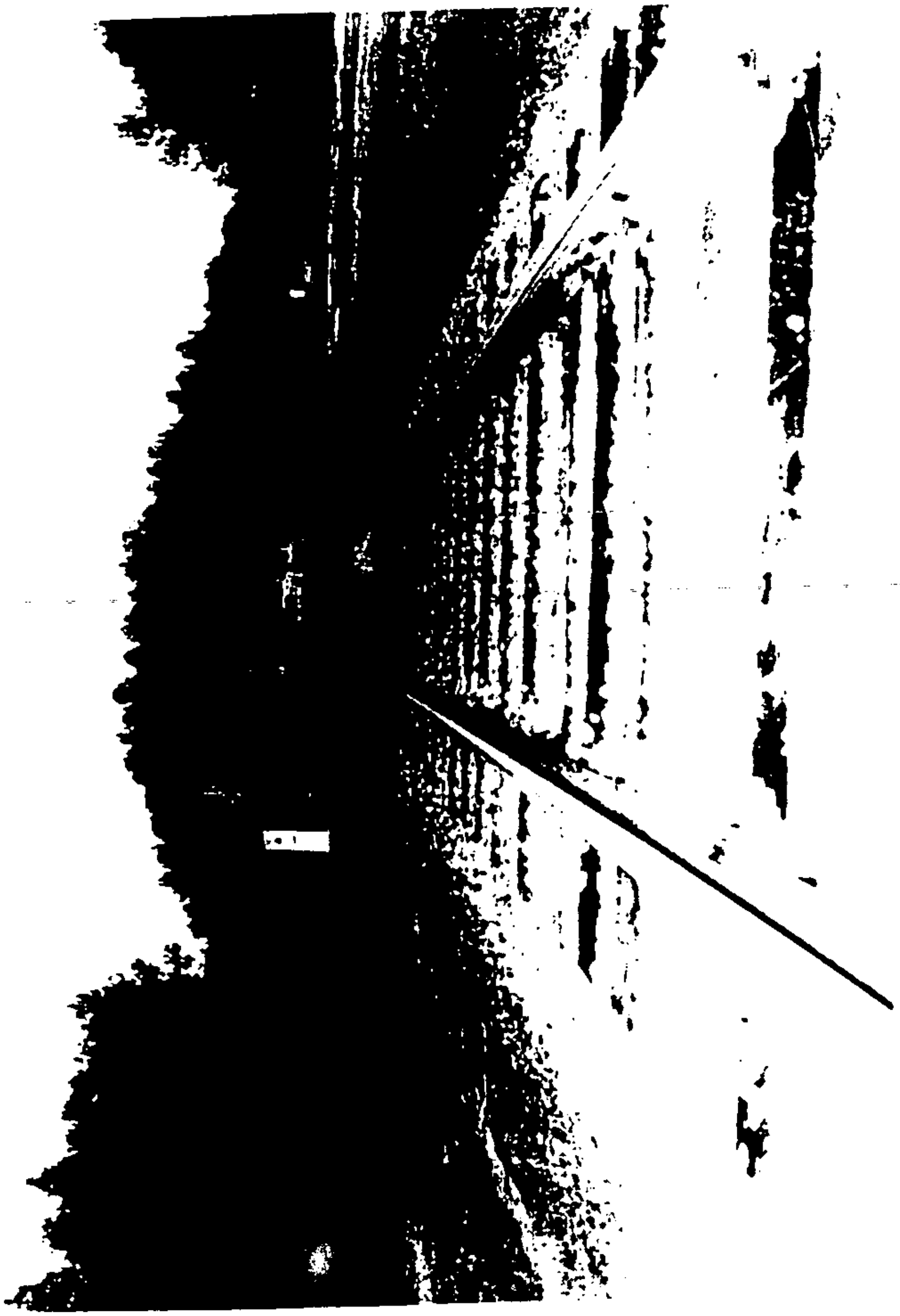


FIGURE 3-12. Load Lugger Truck at Railroad Crossing Near 3/700-Area

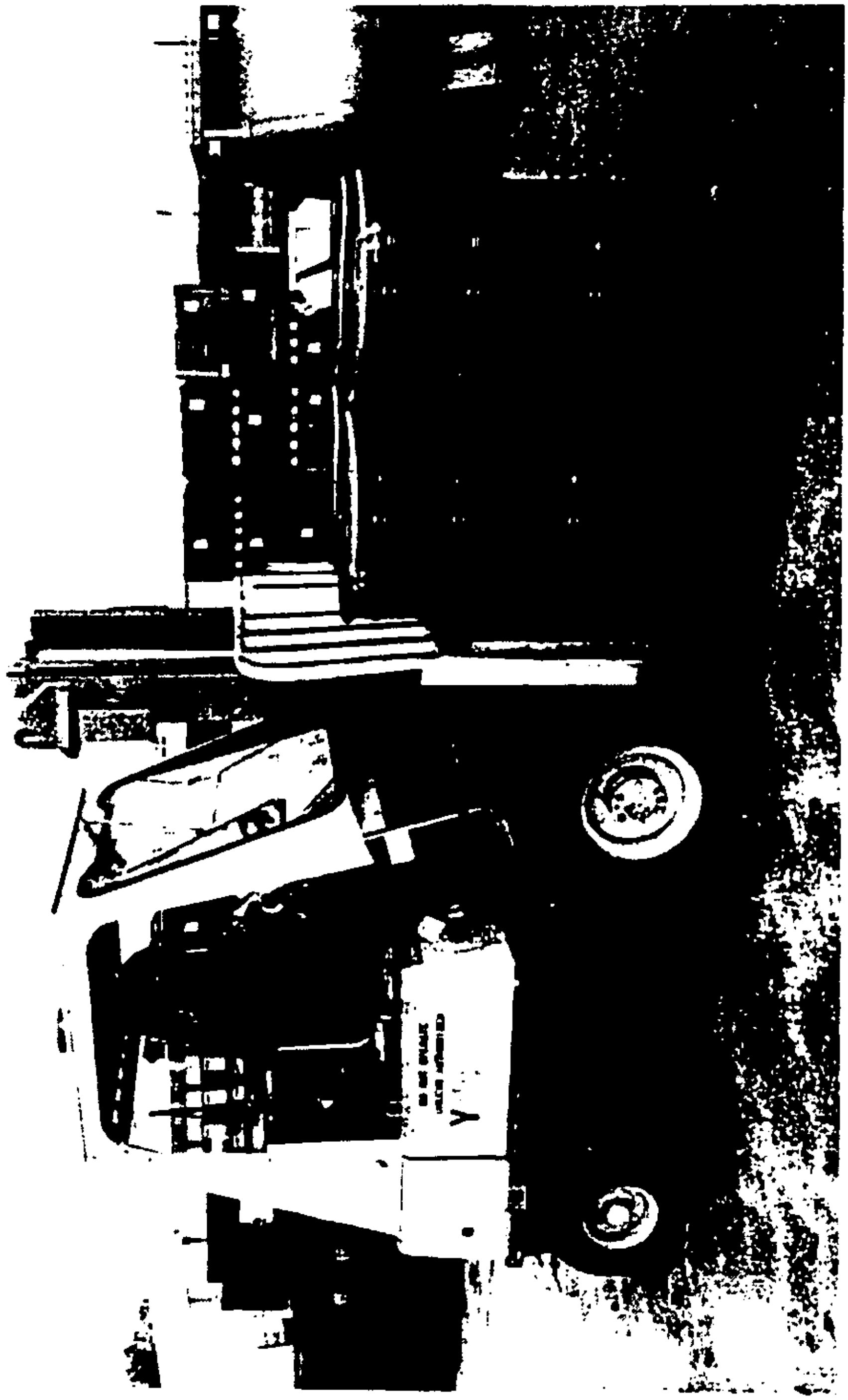


FIGURE 3-13. Small Forklift - Typical of Use at SRP

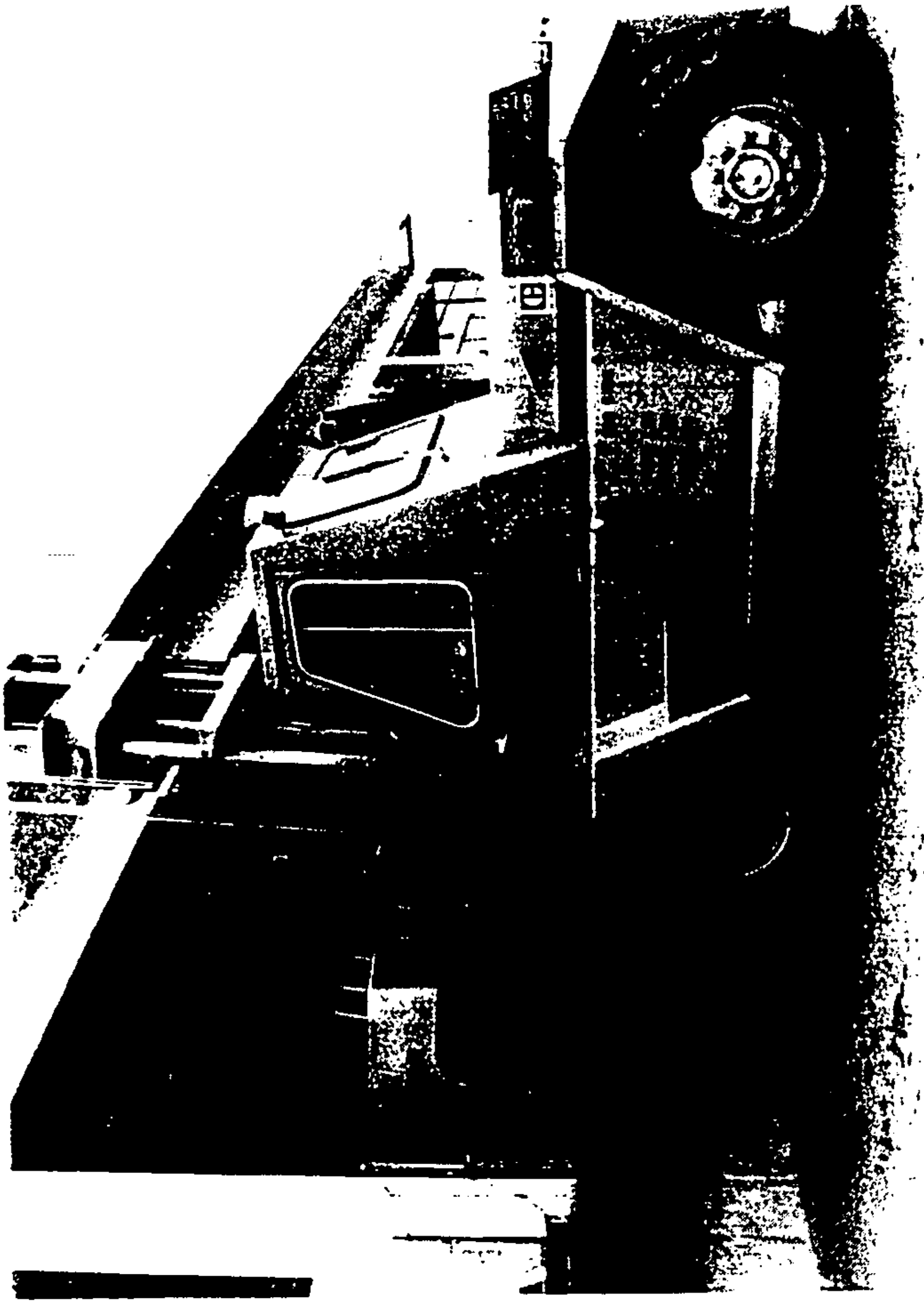


FIGURE 3-14. Large Forklift Vehicle Used in Stores and 3/700-Area

FIGURE 3-15. CD-4 Rail Car with 70-Ton Rail Cask for Moving Irradiated Fuel and Targets from 100-Areas to 200-Areas

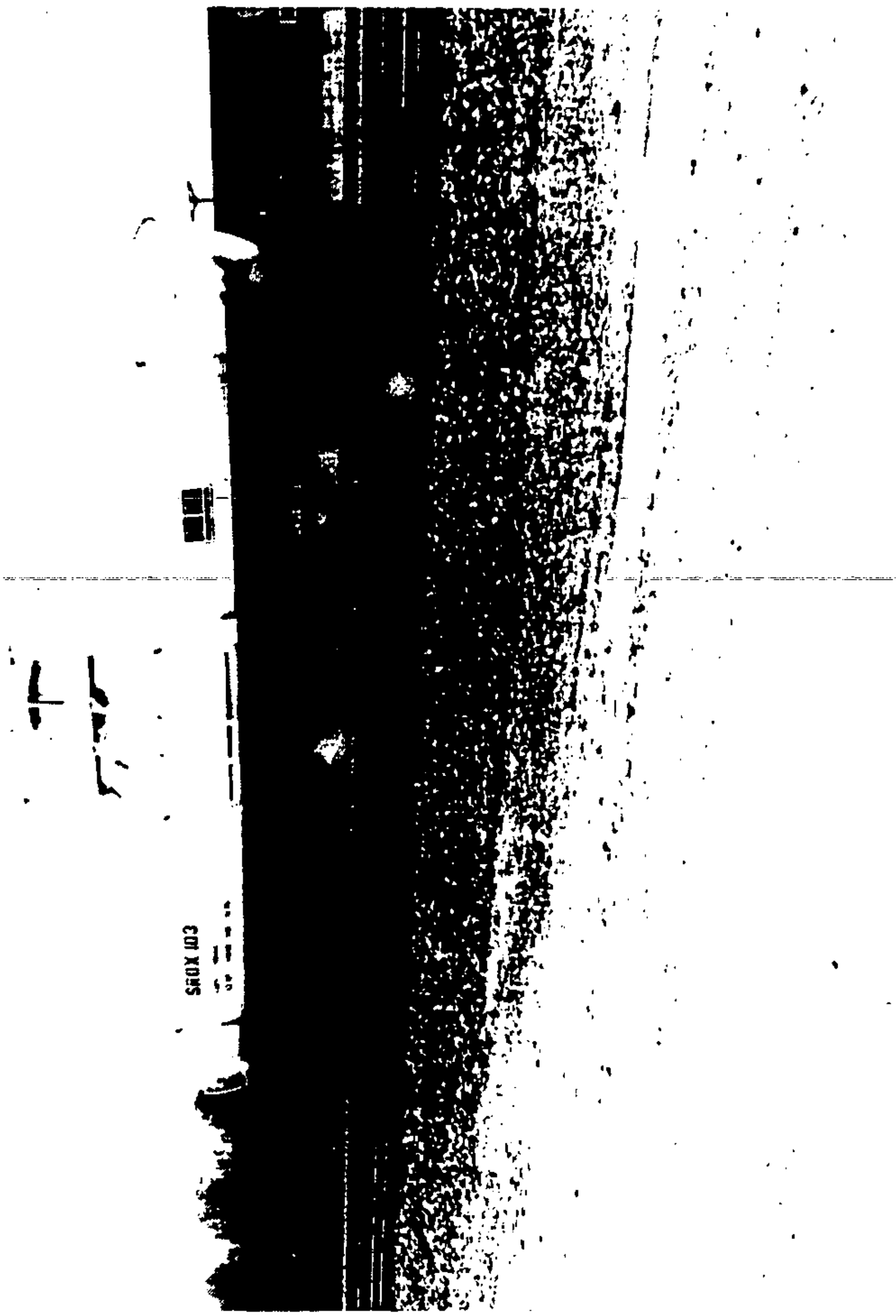


FIGURE 3-16. Typical Tank Car Used for Delivery of Nitric Acid

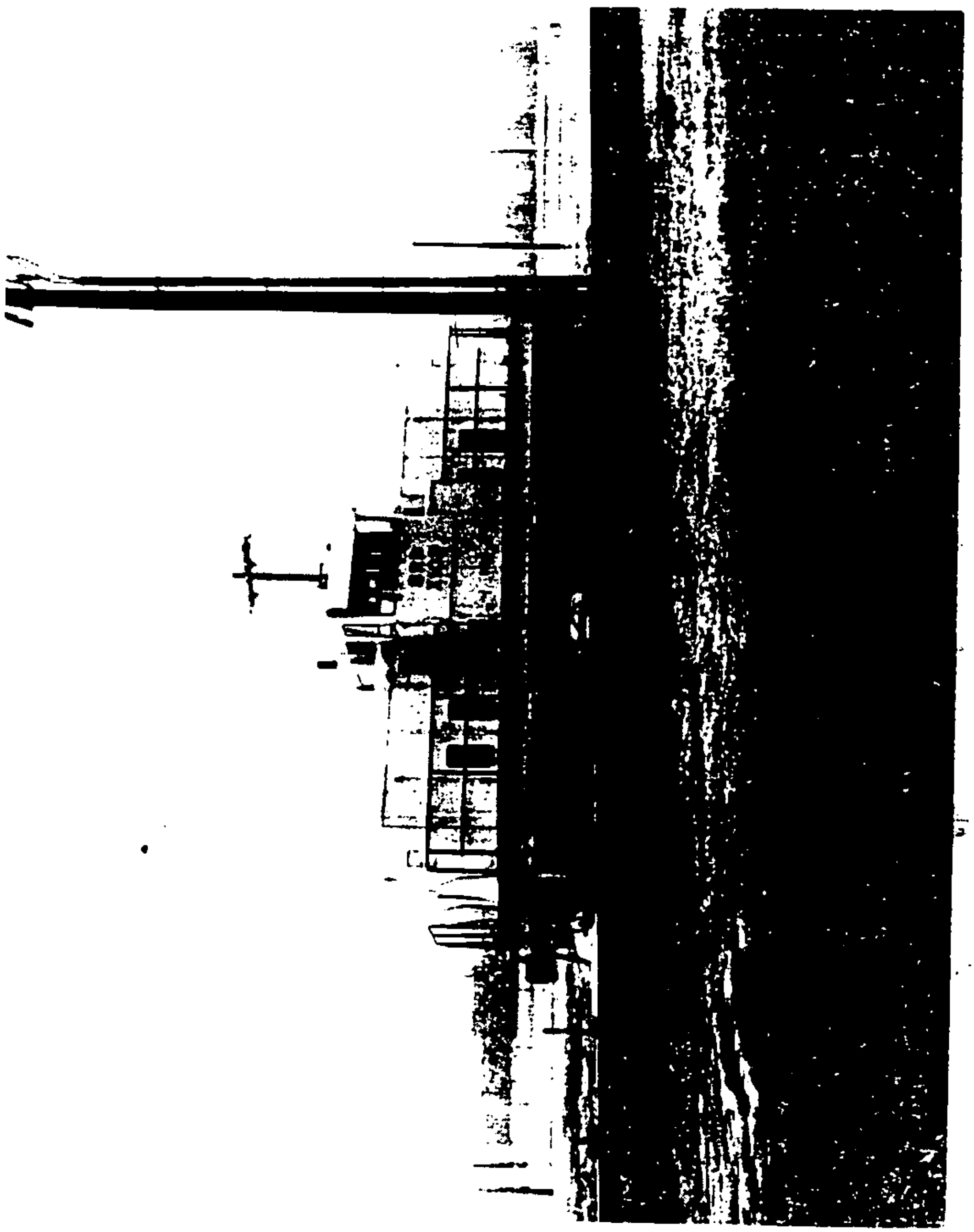


FIGURE 3-17. 400-D Area Switching Locomotive

FIGURE 3-18. Central Site Areas ! omotive in Classification Yard

The remaining rolling stock consists of:

- Seven cask cars, used for transporting materials from the reactors to the separations areas
- Eight tank cars
- Two gondola cars
- Thirteen flat cars

The gondola and flat cars are used to transport large equipment pieces and to act as "spacers" which provide separation between the locomotive and a radioactive load.

A Hy-Railer, a vehicle capable of traveling on road or rail, is used to make safety inspections in any kind of weather and to transport personnel and portable derailers to work locations anywhere in the rail system.

3.2.1.4 Tiedowns

Figures 3-19 and 3-20 show examples of tiedown restraints used to secure hazardous material packages to vehicles for onsite transport.

3.2.1.5 Packagings and Containers

A variety of packages, containers, casks, boxes, tanks, protective overpacks, etc. are used to transport HMs onsite and offsite. Packages used for offsite transport of radioactive materials are rigorously tested and evaluated. For example, testing for Type A packages has been carried out by Mound Laboratories. For Type B and fissile radioactive materials packages, other than DOT specification packages, a Safety Analysis Report for Packaging (SARP) is prepared before a package may be used in offsite transportation of radioactive material cargo. For packages that are not DOT specification packages, the DOE or NRC issues a certificate of compliance prior to a package being placed in service (5).

Packages used for onsite transport are usually designed for a particular shipping need and, if used repetitively, may be modified during extended usage. The designs and associated administrative controls, which are reviewed and approved for safety then tested by use and experience, satisfy production needs and other plant requirements. Packages for onsite unrestricted transport on roads with public access must meet DOT packaging regulations (6).

The types of packages vary with production and experimental activities and range from cardboard cartons to 70-ton fuel element casks. Some of the designs have been in use for 20 years or more. For radioactive materials packages, recent changes in the mix of products from SRP plant operations have increased requirements for containers that provide neutron shielding in addition to gamma shielding and containment.

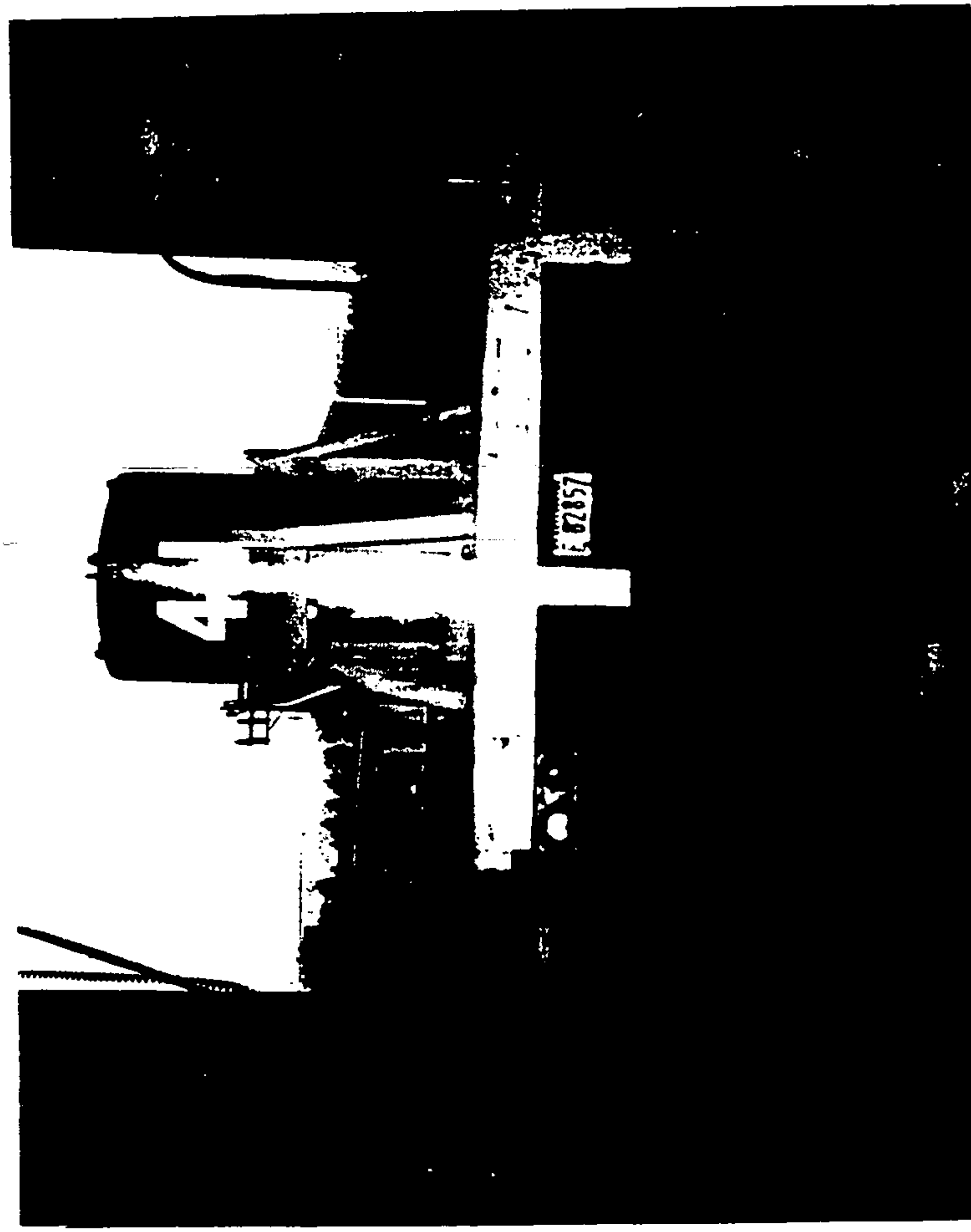


FIGURE 3-19. Eight-Ton Cask Shown with Transport Restraint

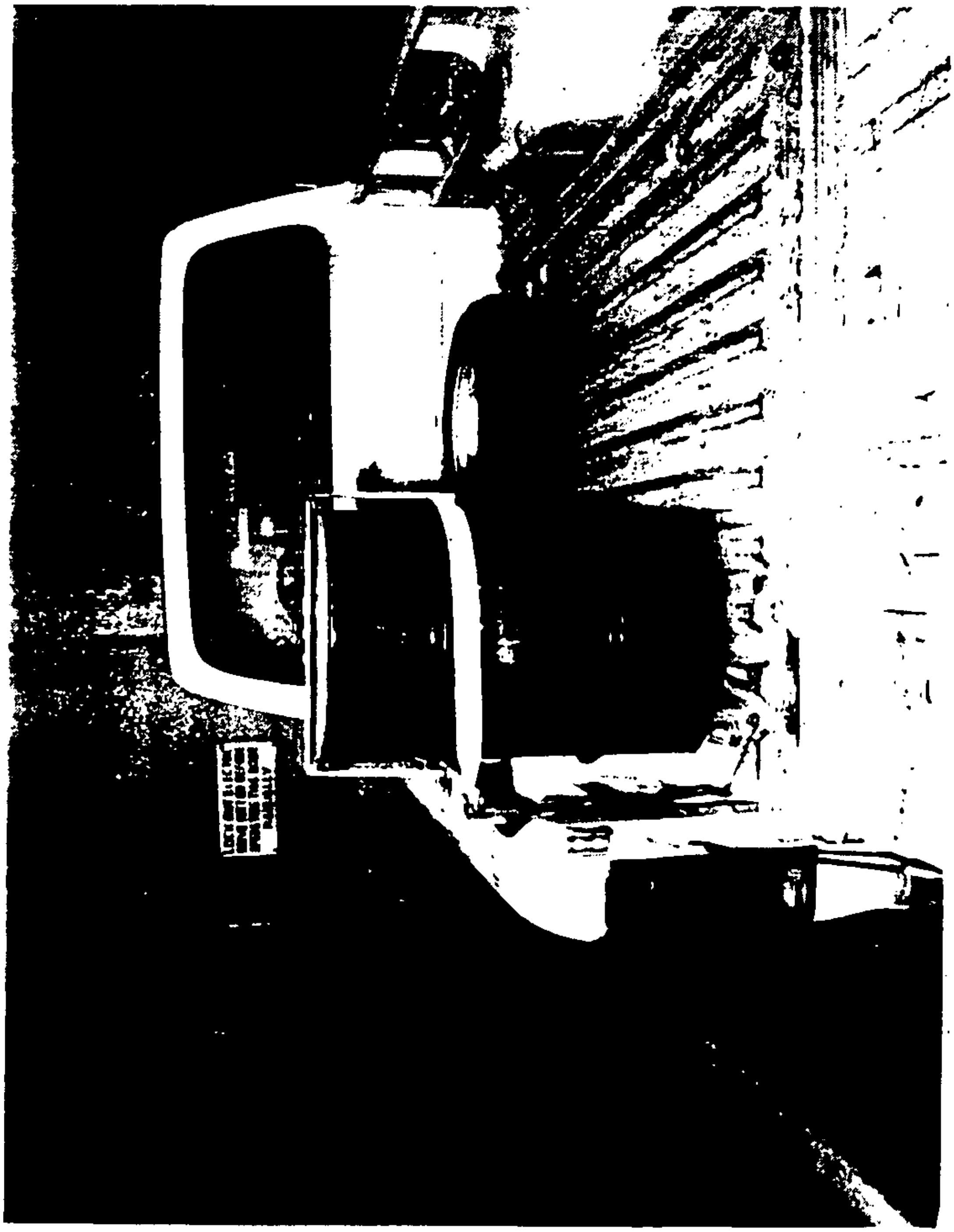


FIGURE 3-20. DT-7 Drum with Transport Tiedown on Pickup Truck

Figures 3-21 through 3-35 illustrate packagings and containers used for onsite transport of radioactive materials. Figures 3-5, 3-8, 3-9, 3-12, and 3-16, discussed above, show transport packagings used for nonradioactive hazardous materials. Vehicles such as those seen in Figures 3-1, 3-8, 3-16, and 3-32 through 3-35, are considered to be transport packagings. These vehicles are tank type carriers for bulk liquids or other bulk materials, e.g., ion exchange resin. Not shown are four DOT specification MC312 cargo tankers (UNH tank trailers) assigned to H-Area canyon and outside facilities which were used for use as shipping containers for uranyl nitrate hexahydrate. The UNH trailers are no longer authorized for shipment offsite.

Figures 3-21 through 3-25 are examples of inner containers and packagings used for the transport of radioactive samples. Figure 3-22 shows typical placement of low activity samples in the bed area of a pickup truck. Although shipping of HMs using pickups, shuttles, and sedans is generally discouraged, some materials are transported in this way. Figure 3-24 illustrates a shielded Door-Stop cask used for process samples from the plant's 200-Area. Figure 3-25 illustrates the general arrangement of components in the T-50 packaging used for transporting tritium standards.

Figures 3-26 through 3-28 show three kinds of packagings used to transport radioactive and hazardous wastes on the site. Figure 3-26 illustrates the efficient use of space that is possible with metal waste burial boxes. These boxes are typically moved to the Burial Ground area of the site on load lugger or flat-bed vehicles (see Figure 3-12). A typical SRL concrete waste box is shown in Figure 3-27. This type of box is used as a transport and burial container for radioactive laboratory wastes that have radiation levels too high for normal handling in 55-gal drums.

DOT Specification 17-C 55-gal drums on wood forklift pallets are shown in Figure 3-28. Large numbers of drums of this or similar types are used onsite for hazardous material storage, handling, transportation, and burial. Drums for solid materials at the SRP typically employ the heavy duty bolted clamp ring closure shown on these drums. Drums for liquids have integral heads with screw plug fill and vent ports.

Figures 3-29 and 3-30 illustrate three medium-sized packagings used for transportation of transuranium and fissile radioactive materials on the site. A DOT Specification 7A, Type A (see Reference 1, 49 CFR 178.350) packaging for Californium is shown in Figure 3-29. Other requirements for Type A packagings include routine process water samples from the 100-Areas (105-Buildings) which contain sufficient tritium to require Type A packaging for shipment on public access roads. Each sample truck has a DOT specification 7A drum approved as a Type A package mounted on the truck bed. A cutaway view of a DOT Specification 6-M (see Reference 1, 49 CFR 178.104) fissile material package used for onsite plutonium transports is shown in Figure 3-30. In general, and wherever applicable and practical, DOT specification packagings are replacing older packagings for onsite hazardous material transportation activities (see Appendix A).

Figures 3-15, 3-16, and 3-31 through 3-35 show some of the larger packagings used on the site. These packagings are designed for unique applications. As

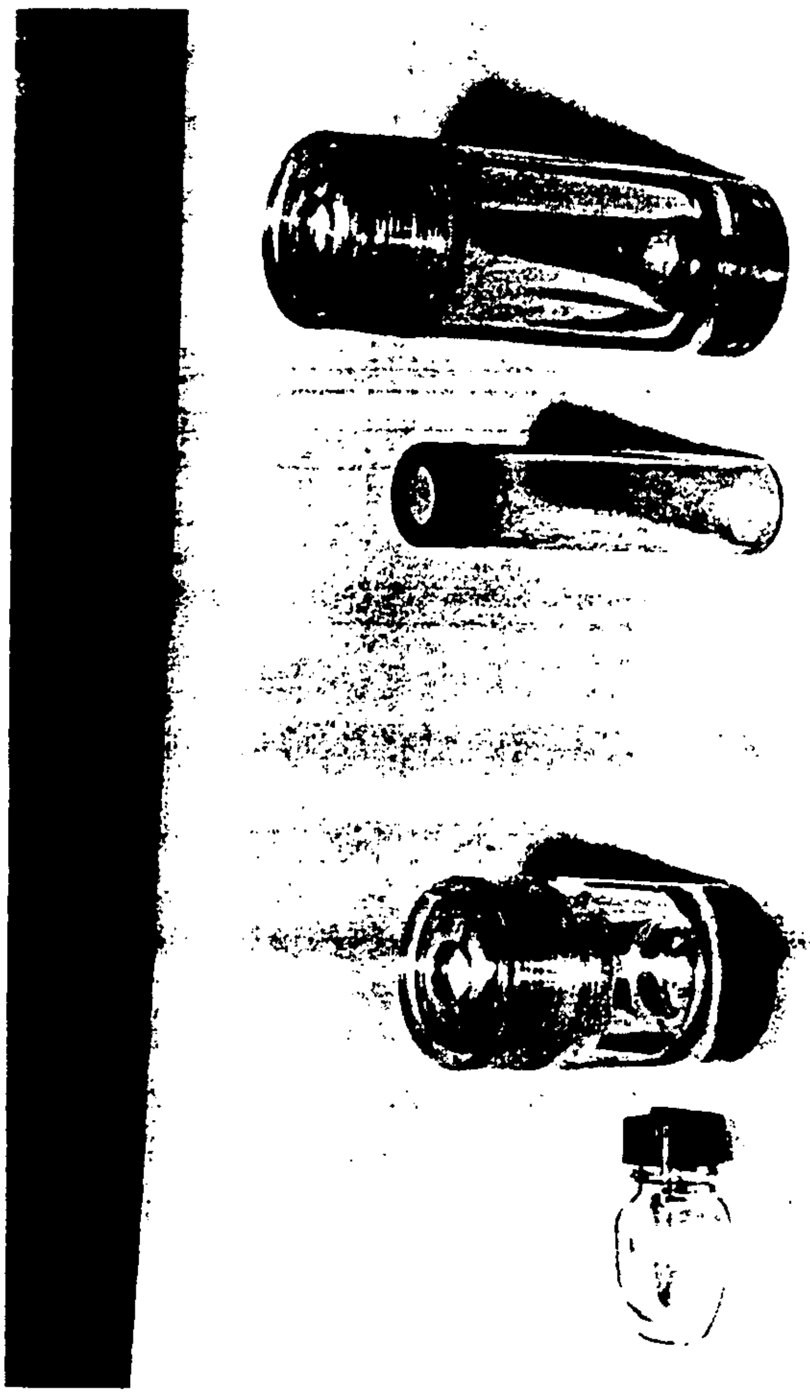


FIGURE 3-21. Containers for Radioactive Process Samples

FIGURE 3-22. Low Activity Samples in Pickup Truck Bed

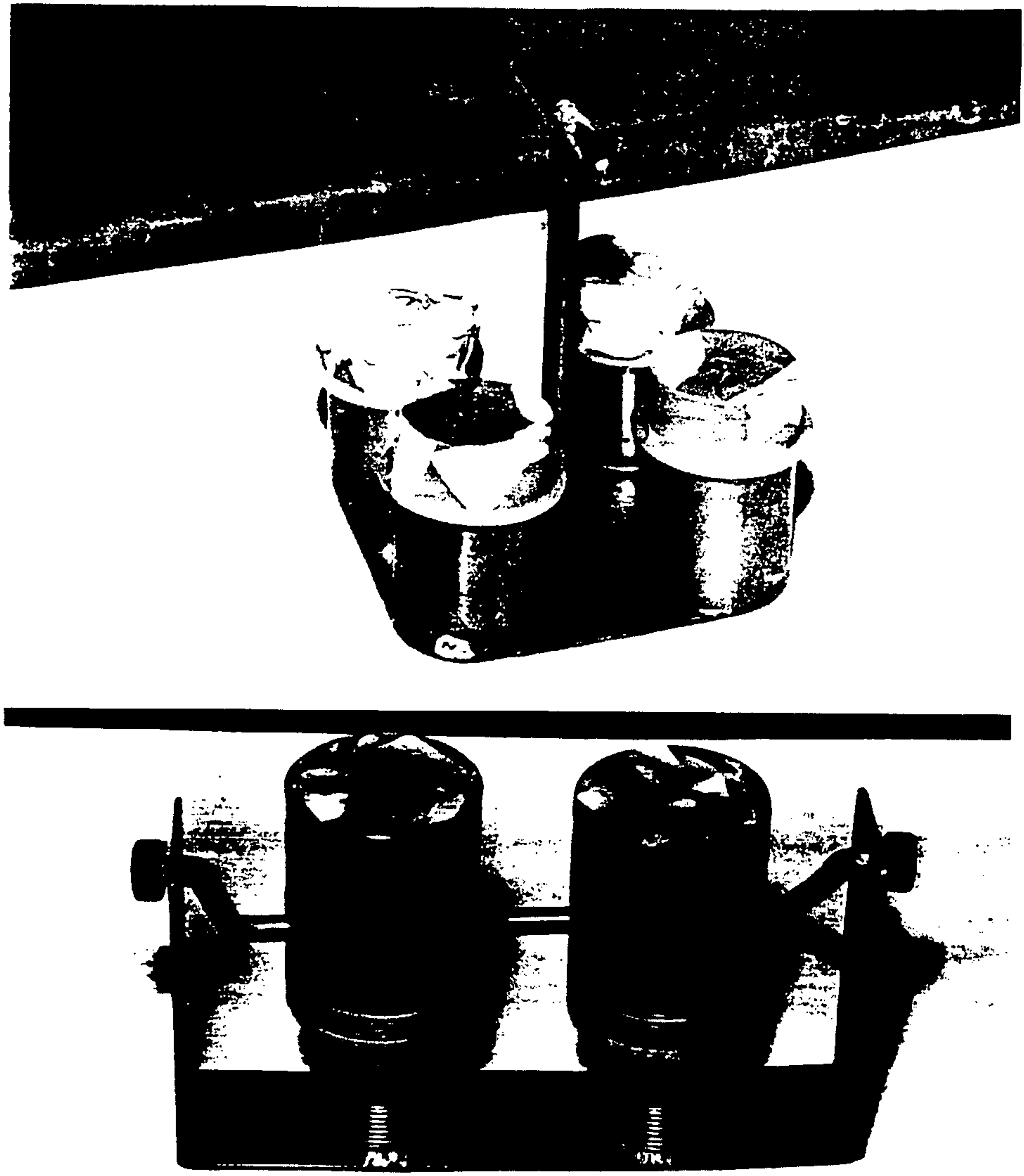


FIGURE 3-23. Transfer Packagings for Production Process Samples

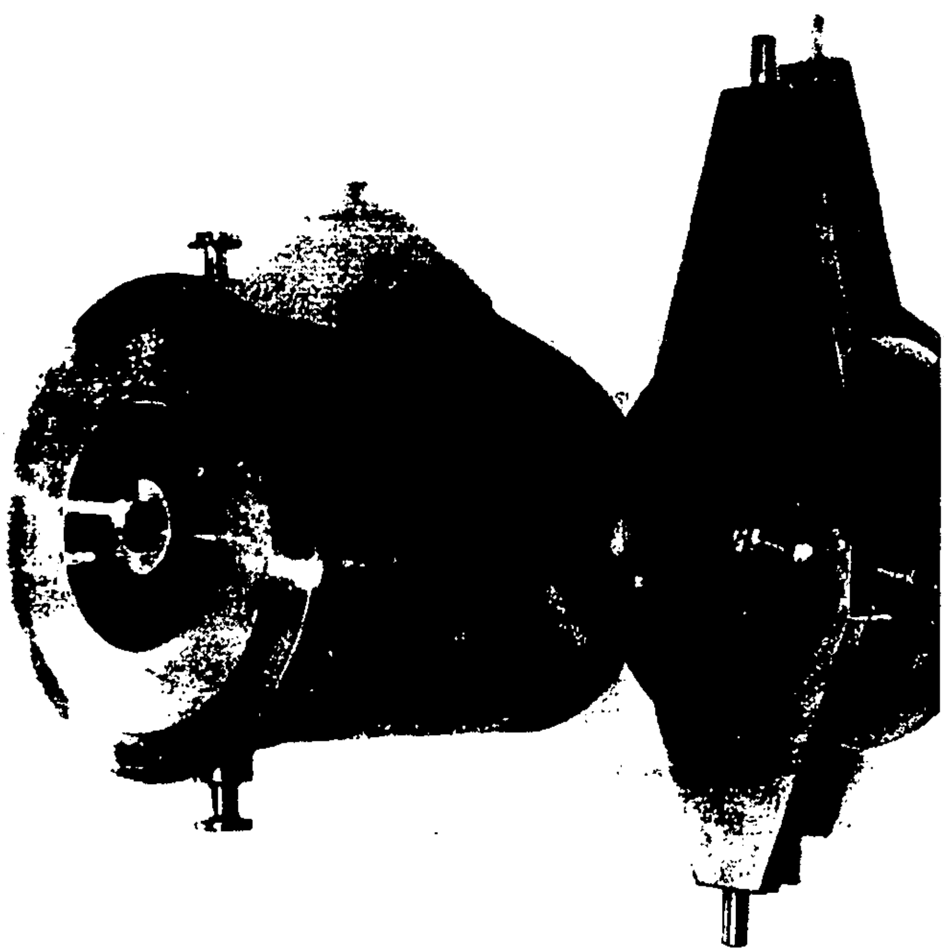


FIGURE 3-24. Shielded Doorstop Cask for 200-Area Process Samples

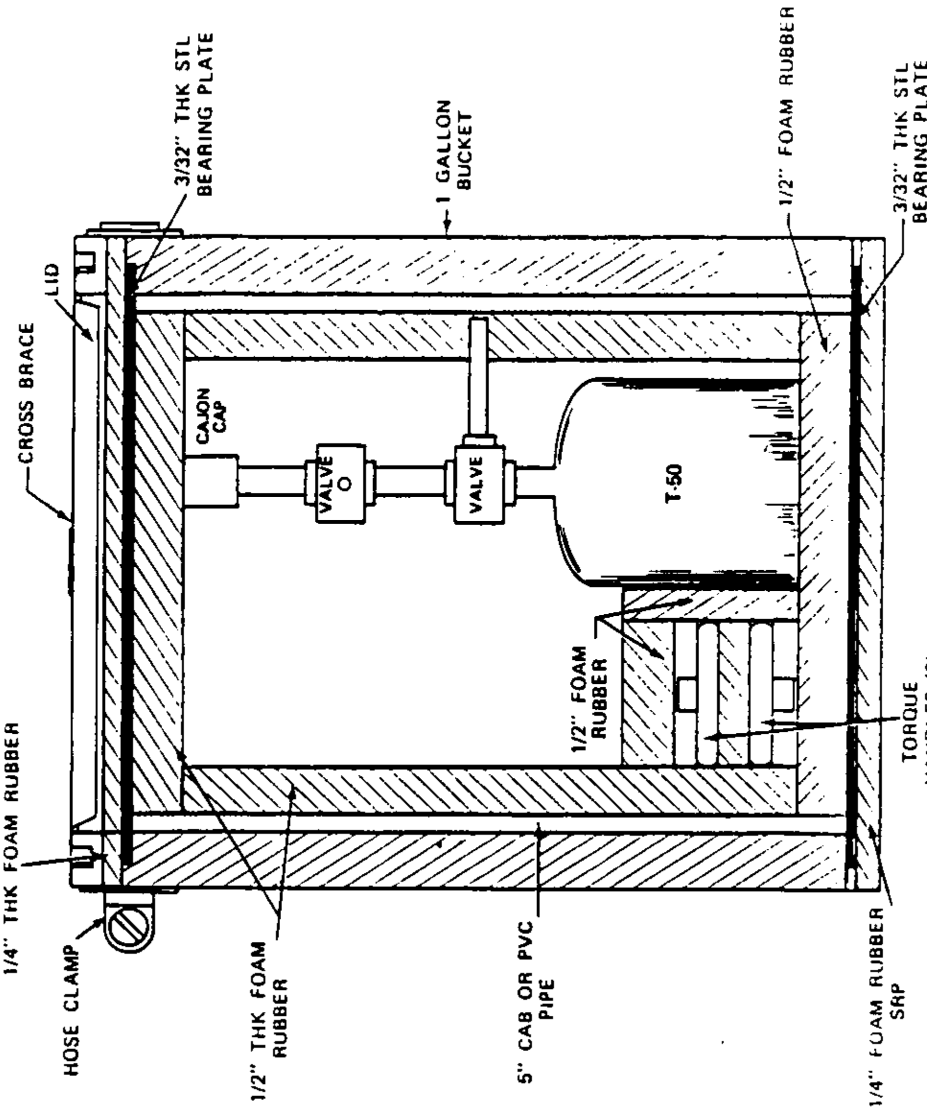


FIGURE 3-25. T-50 Tritium Standard Package

FIGURE 3-26. Ninety Cubic Foot Metal Waste Box

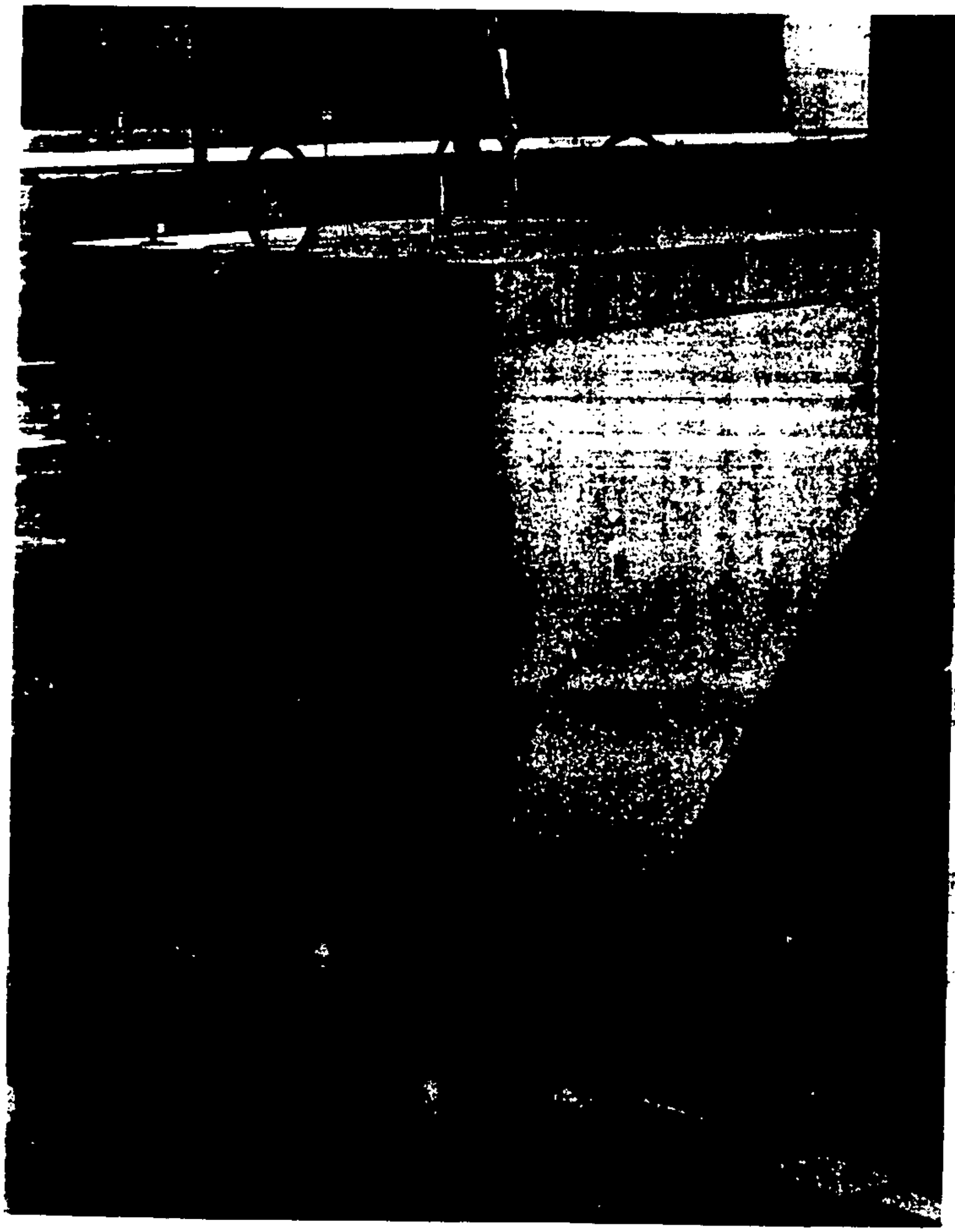


FIGURE 3-27. SRL Concrete Waste Box

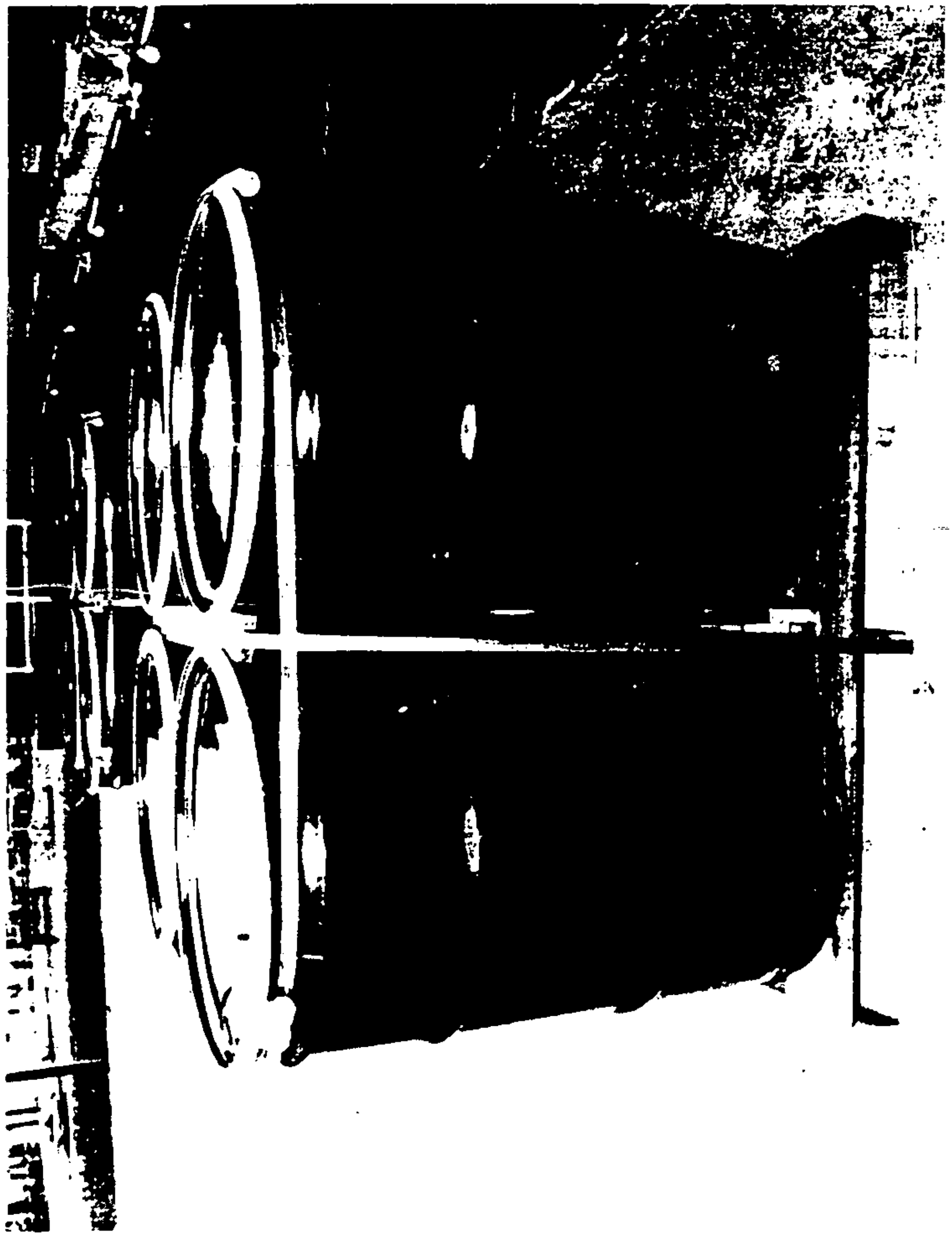


FIGURE 3-28. 55-Gal Drums Used at SRP for Containing Radioactive and Hazardous Wastes

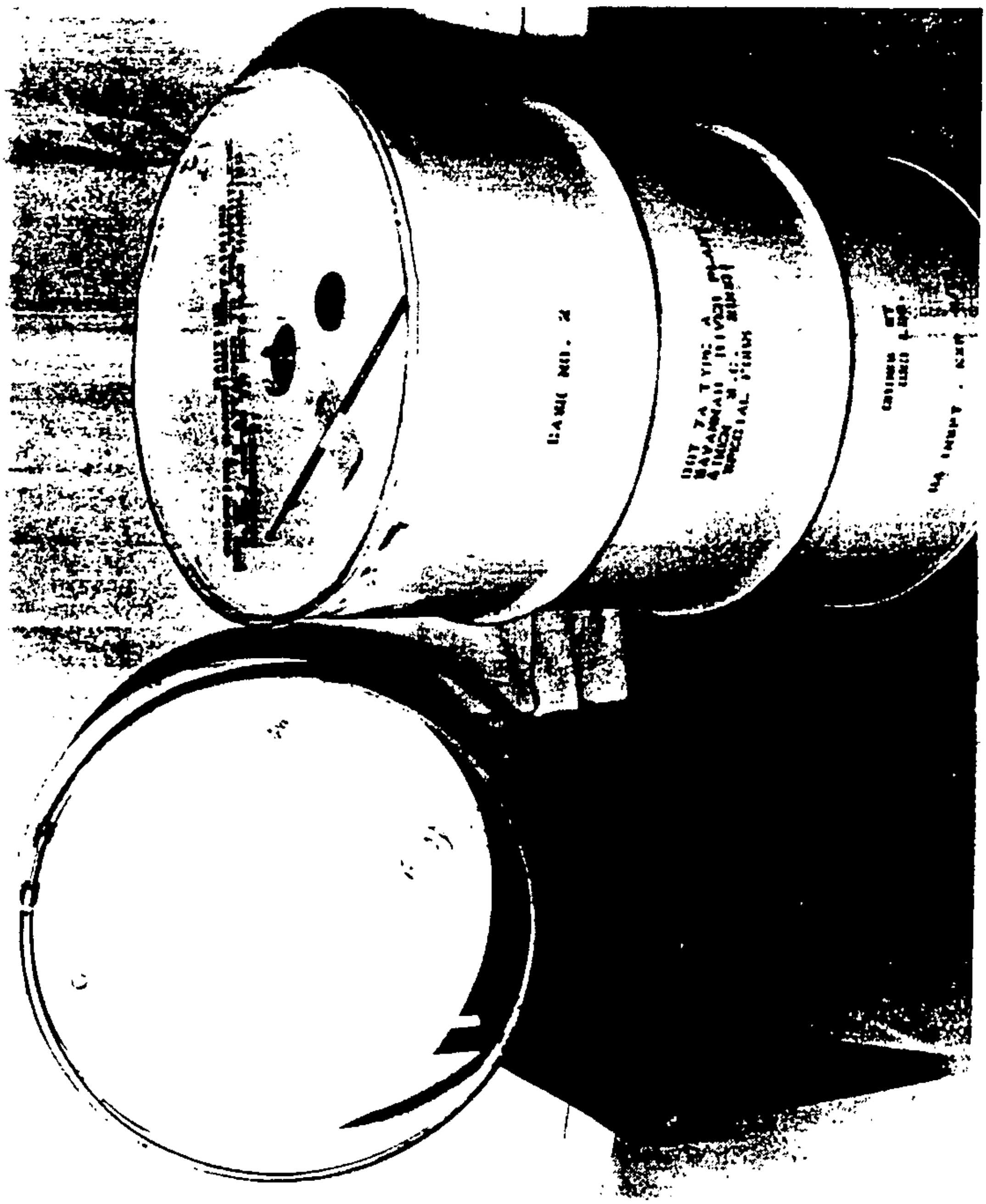


FIGURE 3-29. DOT Specification 7-A Packaging for Type-A Quantities of Californium-252

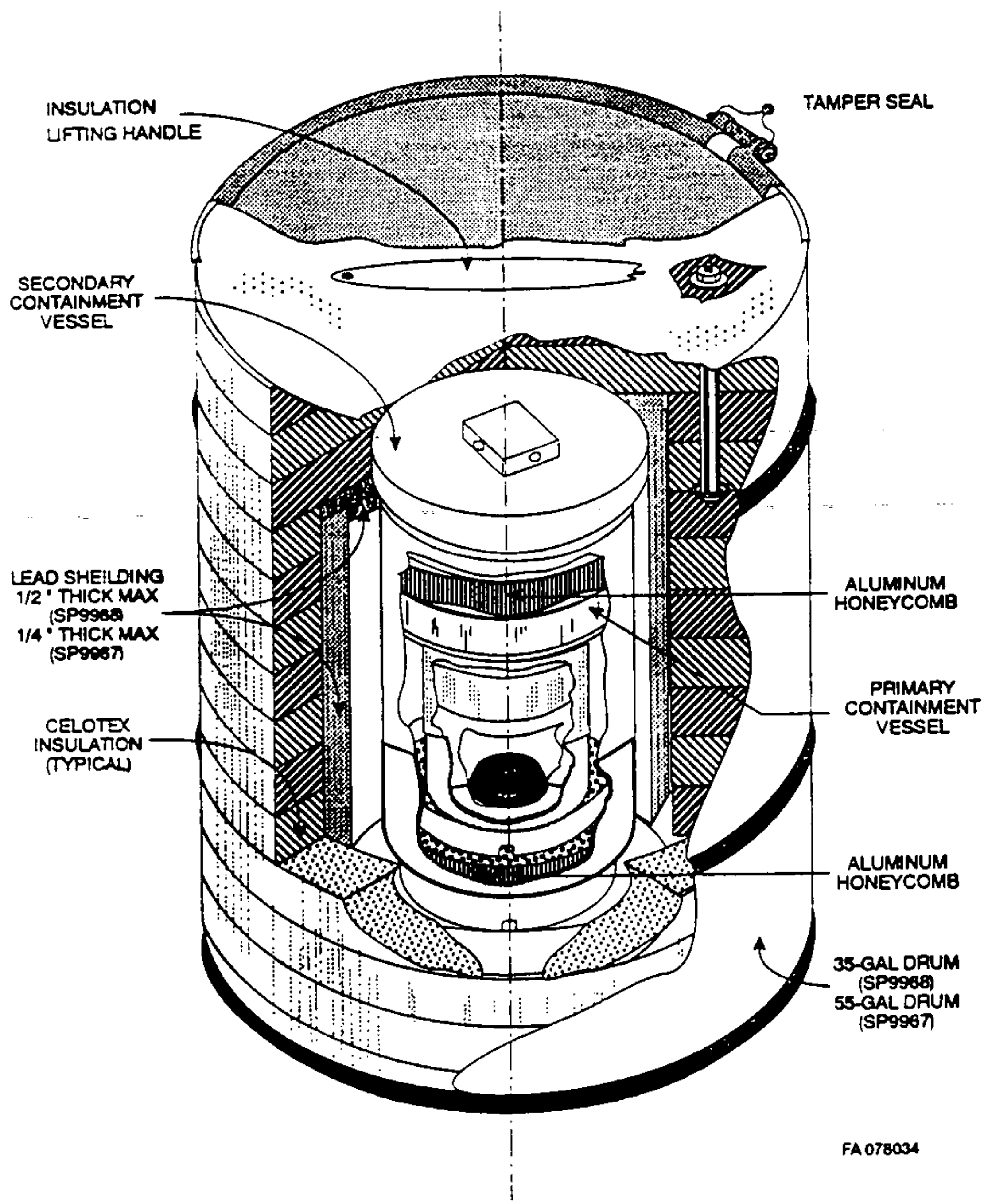


FIGURE 3-30. DOT 6-M Packaging

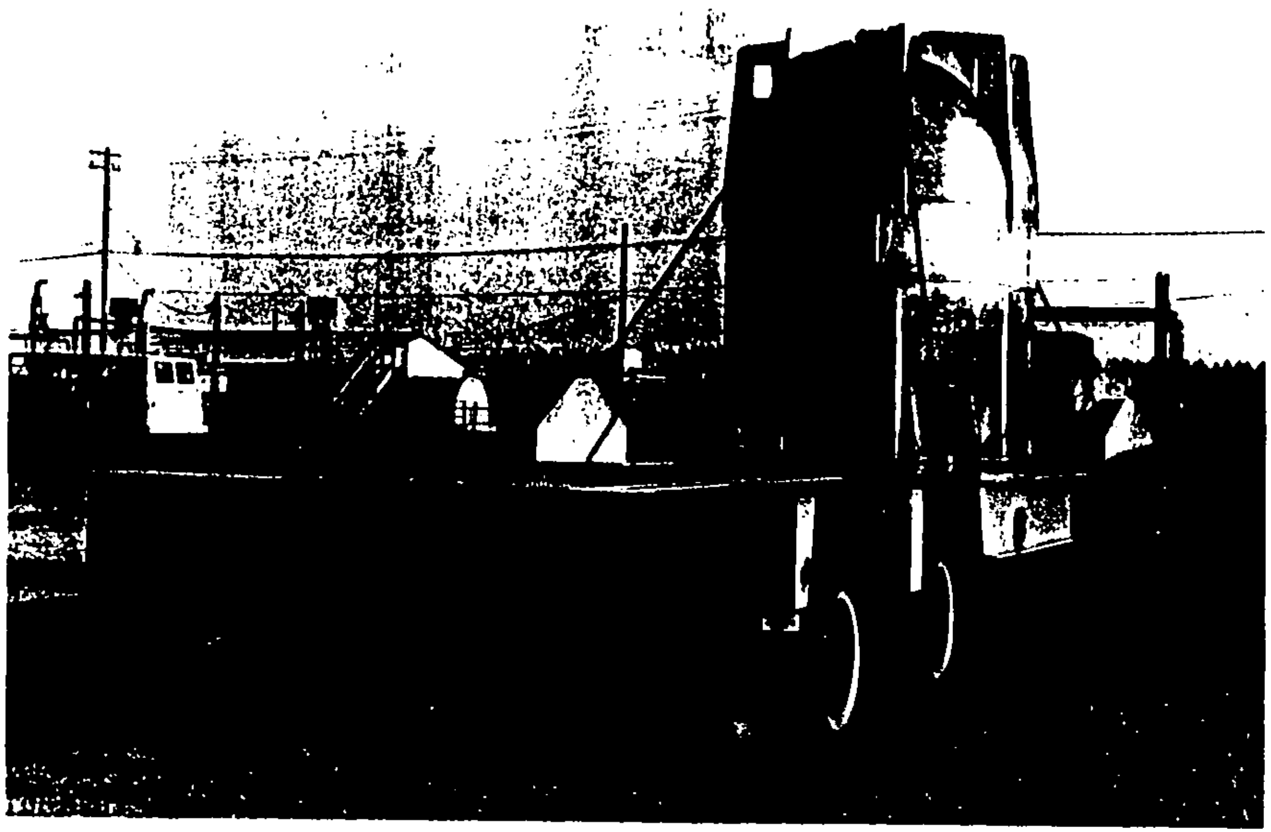


FIGURE 3-31. Californium-252 Cask

FIGURE 3-32. 100-Area Low Level Waste Tank Trailer

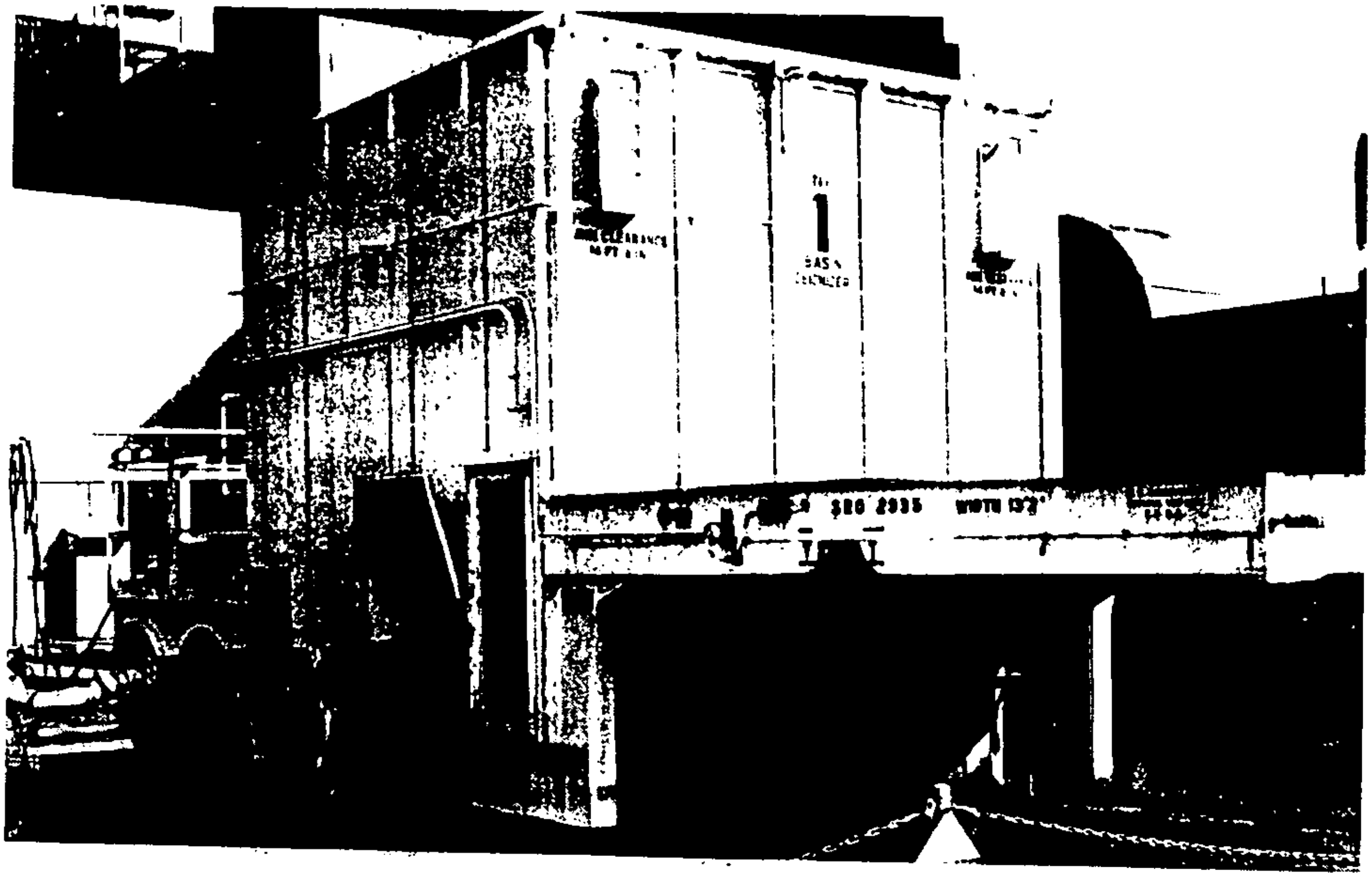


FIGURE 3-33. No. 1 Mobile Deionizer

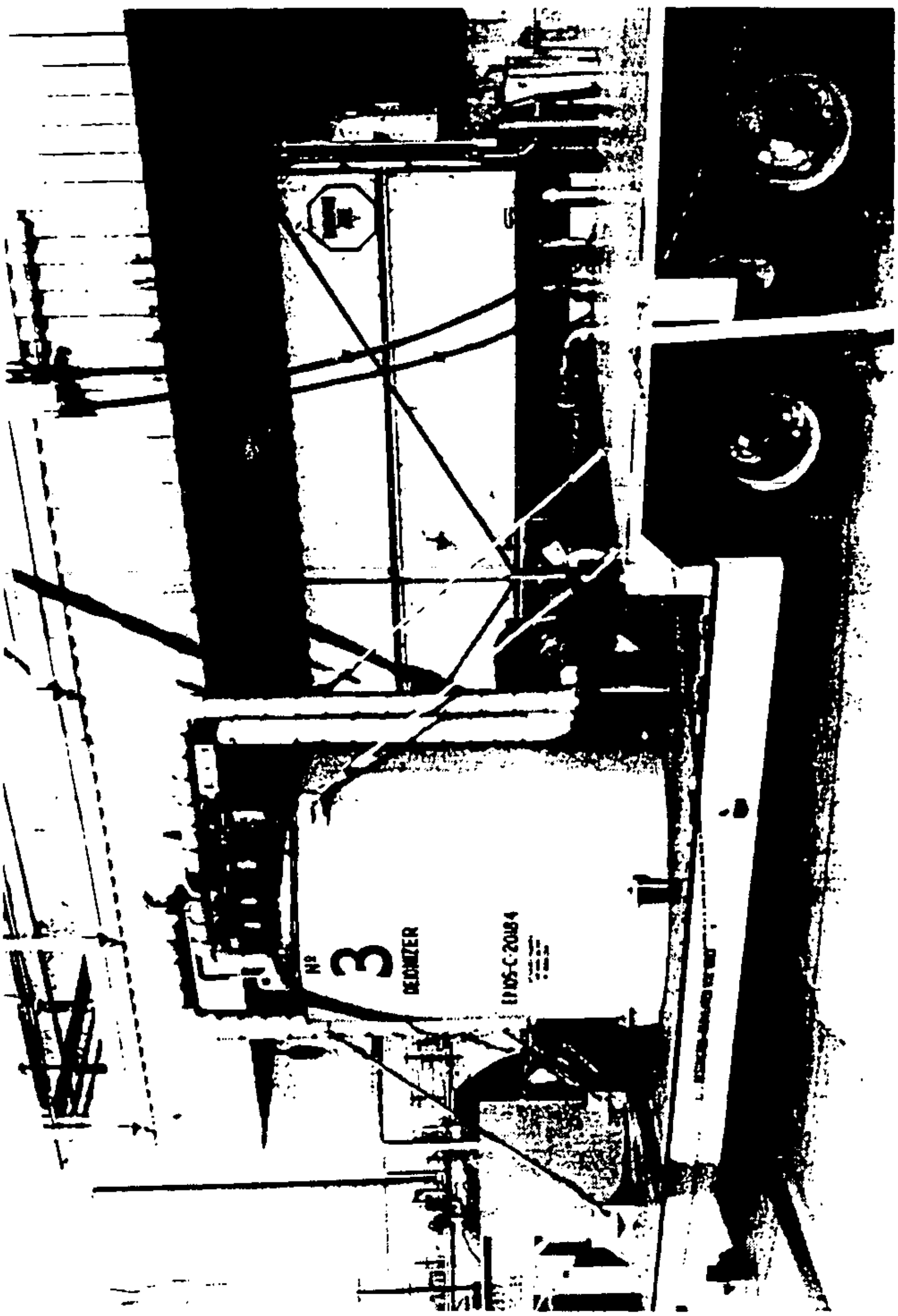


FIGURE 3-34. No. 3 Mobile Deionizer

FIGURE 3-35. SRP High Level Waste Trailer

shown, many are integrated with transport trailers. In general, the packaging designs incorporate features that:

- Provide health and safety protection for SRP workers during loading, unloading, handling, and transport,
- Ensure containment of the hazardous material contents under conditions that are expected (considering onsite administrative controls) during operations including transport, and
- Contribute to the effectiveness of facility operations which the packagings are designed to support.

The packaging, or cask, shown in Figure 3-31 is a Type B packaging used to transport Californium-252. The tank vehicle shown in Figure 3-32 is used to transfer contaminated liquids from reactor areas to low level liquid waste tanks in the 200-Area. Mobile packages incorporating vessels that contain ion exchange media (deionizers) are used on the site primarily to support reactor facility operations. The ion exchange media are transported in these packages to the 200-Area for regeneration. Figures 3-33 and 3-34 show two of the mobile deionizers. Figure 3-33 illustrates a typical piping interface between the package and a facility. Figure 3-34 shows typical tiedowns that hold a package to its transporter.

Figure 3-35 shows the SRP high level waste trailer used to transport highly radioactive liquids from the 3/700-Area to the 200-Area. This trailer and towing tractor, when loaded and with the water shielding in place, weighs approximately 85 tons. The gamma ray shielding and an enclosed stainless steel liquid tank accounts for most of the weight. Figure 3-36 shows the special designed 5-inch king pin used on the high-level-trailer. The king-pins on several SRP operated hazardous materials trailers have been redesigned to have greater strength than conventional king-pins. In addition, king pins on all SRP hazardous material trailers are periodically subjected to nondestructive examinations which provide additional insurance against failures during hazardous material transports at the SRP.

Small primary containers containing HMs that are separated at the SRP Stores facility from DOT-specification packaged lots are placed in spill prevention bins for onsite transportation on tractor-trailers and van bodied trucks operated by the Stores Division. These bins are intended to confine any leakage that might occur in handling and transportation.

Liquid propane, argone, hydrogen, and nitrogen are delivered in bulk by tank truck to large storage tanks near Stores (Building 734-A) and at other onsite facilities. The storage tanks at Building 734-A are used to fill small propane bottles and dewars of liquid nitrogen for delivery in the field. Liquid propane, nitrogen, argon and hydrogen are also delivered in bulk by tank truck to cryogenic storage tanks at other facilities on the site.

FIGURE 3-36. 5-Inch King Pin for the High Level Waste Trailer

3.2.1.6 Hazardous Materials Spill Containment at Loading and Unloading Points

Plans have been made to provide or improve spill containment at locations where such containments do not currently exist or where improvements are needed.

Measures being implemented at the various locations where HMs are stored include:

- Improving storage facilities (i.e., replacing substandard storage tanks); providing or improving containment dikes or catch basins; providing building enclosures with concrete floors; improving drains, valves, sumps and sump pumps; providing chlorine leak detectors and other detection systems; providing remote alarms and forced ventilation; and making other engineered improvements that help prevent or mitigate spills.

- Improving railroad tank cars by providing for collection of spills in collector pans.

- Protecting storage facilities with guard posts and chains.

Procedures have also been established to deal with spills at each location.

As part of the above measures, there are plans to minimize hydrocarbon spill impacts by improving spill containment at locations where the following materials are stored: diesel fuel, diesel fuel oil, gasoline, multigrades of oil, waste oils, asphalt emulsions, hydraulic oil, and transformer oil.

3.2.2 Design Considerations for the Hazardous Material Transportation System

The hazardous materials transportation system on the site functions to:

- Deliver essential raw materials to facilities and construction sites where they are used.

- Transfer product materials between onsite facilities and from onsite facilities to the site boundary and subsequently to offsite destinations.

- Transfer hazardous waste materials from facilities where they are generated to hazardous waste storage/disposal areas on the site.

The systems requirements, which incorporate safety functions, were discussed in Section 3.1 above. The characteristics of the operational functions of the system are presented here. Section 3.2.2.1 discusses the hazardous materials that are transported at the SRP. Section 3.2.2.2 presents a summary of the material flows that are major contributors to transportation risk as have been determined in this safety analysis. Section 3.2.2.3

summarizes the transport environmental factors and their effects on the transportation systems performance.

3.2.2.1 Hazardous Materials

Hazardous materials transported on the SRP site are listed in Appendix B. The material names in the appendix are DOT Proper Shipping Names listed in Reference 1, 49 CFR 172.101. Materials that are of greatest safety concern are summarized in Tables 3-1 and 3-2. The risks associated with transporting these materials are analyzed in Section 5.0 which also presents the rationale used to screen the large list of materials to determine those that are of greatest risk. Tables 3-1 and 3-2 contain brief descriptions of the characteristics of the materials, containers used for transport, and the amount of each used annually at the SRP.

3.2.2.2 Flows of Materials

Hazardous material flows to and from each onsite facility can be grouped into three categories: essential materials, products, and wastes. Essential materials are raw materials, process chemicals, and other supplies that are the feed stocks used in SRP facilities to produce products. Products of a facility may be feed stocks for one or more other facilities. Flow is illustrated in the following example.

Uranium fuel assemblies are produced in the 3/700 Area from raw material feed stock received from offsite sources. The assemblies are transported to the 100-Area reactors where they are loaded into the reactor core and contribute in nuclear chain reactions that produce neutrons for irradiating targets. The irradiated fuels that are subsequently discharged from the reactors are then transported to the 200-Area for chemical processing. One of the products from processing of uranium fuels in the 200-Area facilities has been neptunium-aluminum billets. These billets are transported to the SRP 3/700-Area where they are used to fabricate targets. The targets in turn are transported to the 100-Area reactors for irradiation to produce Pu-238. The irradiated targets are transported to the 200-Area where the Pu-238 is recovered and incorporated into product capsules. These radioactive source capsules are subsequently shipped to outside users. Figure 3-37 illustrates the complex flows of radioactive materials at the SRP.

In support of such interrelated activities, essential materials other than the radioactive materials are also transported at the SRP. Nitric acid, sodium hydroxide, liquid chlorine, petroleum distillates, and more than 100 other hazardous materials are transported to the facilities where they are used. Table 3-1 identifies the most significant of these materials from a risk perspective. This list was developed through a screening analysis of all HMs shipped at the SRP. Figure 3-38 illustrates the flows of essential materials at the SRP.

As inevitable byproducts of its function, each facility also generates wastes. Although some wastes are chemical only, others are mixed radioactive-chemical wastes. For the most part, the wastes are low level radioactive wastes that

TABLE 3-1. Summary List* of Nonradioactive Materials Transported on the SRP Site

Nonradioactive Material	Characteristics	Containers Used	Annual Amount Shipped	Annual Shipment Miles on SRP (1985)
Chlorine (liquid)	Highly volatile liquid evaporates to dense gas; poisonous; corrosive when mixed with water	DOT Specification 1-ton cylinders	700,000 lb (includes transshipments) 170 cylinders 57 shipments (includes transshipments)	570 highway
Gasoline and other light petroleum distallates	Flammable liquids	DOT Specification tank trucks	4.7 million gal in 1300 truck loads (includes onsite distribution)	25,000 highway
			128,000 gal n-paraffin in 2 rail tank cars	24 rail
Sodium Hydroxide (caustic soda)	Corrosive liquid	DOT Specification tank truck or rail car	1.5 million lb 59 tank trucks (includes onsite distribution)	590 highway
			13.4 million lb 106 rail cars	1,272 rail
Hydrogen Fluoride (aqueous solution)	Corrosive; highly volatile liquid; poisonous	DOT Specification plastic bottle	20,000 lb 400 bottles 7 truck shipments	70 highway
Nitric Acid	Corrosive liquid	DOT Specification tank truck	8.7 million lb (51%) 124 truck loads	1,240 highway
			5.7 million lb (64%)	1,170 highway
Sodium Hypochlorite (see Note)	Corrosive liquid	DOT Specification tank truck or 15-gal drums	33,000 gal (15 gal drums) 77 truck loads	770 highway
			24,000 gal (tank truck) 11 truck loads	110 highway
			117 truck loads	

TABLE 3-1. Summary List* of Nonradioactive Materials Transported on the SRP Site (Continued)

Nonradioactive Material	Characteristics	Containers Used	Annual Amount Shipped	Annual Shipment Miles on SRP (1985)
Phosphoric Acid	Corrosive liquid	DOT Specification 55-gal drums	98,000 lb 4 truck loads	40 highway
Sulfuric Acid	Corrosive liquid	DOT Specification 55-gal drums	12,000 lb (drums) 2 truck loads	20 highway
		tank truck	290,000 lb (tank truck) 26 truck loads	260 highway
		rail car	1.2 million lb (rail car) 10 rail cars	120 rail
Trichloroethane	Volatile, noxious liquid (ORM-A)**	DOT Specification rail tank car	50,000-gal 6 rail cars	72 rail

* This summary lists the nonradioactive materials assessed to present the greatest risk to public and worker health and safety when in transportation at the Savannah River Plant.

** ORM-A - Other Regulated Material, category A. See Reference 1, 49 CFR 172.101

Note: To the extent practical, sodium hypoclorite solution is being substituted for liquid chlorine for process uses at the SRP. At the time of preparation of this SAR the available data did not reflect the full extent of conversions. Thus the quantities of liquid chlorine (reflecting 1985 data) are high estimates of current usage whereas the quantities of sodium hypochlorite are low estimates.

TABLE 3-2. Summary List* of Radioactive Materials Transported on the SRP Site

Radioactive Material	Characteristics	Containers Used	Annual Amount Shipped	Annual Shipment Miles on SRP (1985)
Irradiated Reactor Fuel and Production Material Targets 100-Areas (reactors) 200-Areas (Canyons) and shipments from Offsite.	Highly radioactive solid, engineered assemblies.	Onsite Transport casks and offsite certified transport casks.	Approximately 350 onsite rail car trips per year containing large quantities of radioactive materials. Approximately 100 truck shipments reveived from offsite.	4,200 rail 1,000 truck
Product Materials for Fabrication of Targets and Experiment Assemblies; 200-Areas.	Uranium-Aluminum Billets, Plutonium-Al and Neptunium-Al billets; Neptunium Oxide, Plutonium Oxide (238 and 239) powder; Californium in special form capsules.	Various onsite packagings; e.g., DOT 6M, Offsite shipments in DOE certified packages.	Approximately 350 truck shipments of multi-kilogram quantities of these materials.	3,500 highway
TRU Waste in drums; mostly 200-Areas to Waste Burial Grounds for storage.	Slightly radioactive TRU contaminated laboratory and process equipment, filters, consumables, protective clothing, etc.	55-gal poly-lined DOT 17C galvanized drums	Approximately 100 truck shipments - 15 drums each total average load is estimated to be 300 Ci***	700 highway
Beta Gamma Wastes (Solid) and contaminated equipment mostly 100-Areas to Waste Burial Grounds	Beta-Gamma contaminated laboratory and process equipment, filters, consumables, protective cloting, construction debris, etc.	55-gal 17C drums, metal burial boxes, concrete boxes, special containers load lugger pans** for debris.	Approximately 1000 load lugger pans per year, 10,000 metal burial boxes (90 ft^3) per year and 300 100-Area scrap metal shipments per year.	30,000 highway

TABLE 3-2. Summary List* of Radioactive Materials Transported on the SRP Site (Continued)

Radioactive Material	Characteristics	Containers Used	Annual Amount Shipped	Annual Shipment Miles on SRP (1985)
Analytical Samples and Test Specimens between all areas	Range in radioactivity from high (irradiated fuel specimens) to low (e.g. uranyl nitrate solution samples and blanket gas samples). However, most samples are low in activity activity.	Various onsite packagings ranging from the 8 ton specimen cask to small sample containers	Approximately 4000 truck shipments. Sample activities vary up to a few tens of curies; fuel speciment have high levels of fission product activity. Fuel specimens are shipped infrequently (i.e. about 2 times each year on average).	40,000 highway
Low Level Waste Liquid 100-Areas and 3/700 Area to 200 Area.	Aqueous solutions and sludges with dissolved and suspended radioactive contaminants	Onsite tank trailers or tanks mounted on flat bed trailers	Approximately 150 truck shipments per year. Average radioactive contents per shipment is less than 20 Ci.	1,500 highway
High level waste liquid 700-Area to 200-Area.	Aqueous solution with dissolved and suspended radioactive contaminants	Onsite high level tank trailer	Approximately 30 truck shipments per year. Average radioactive contents per shipment is 100 Ci Alpha and 200 Ci Beta-Gama	300 highway
Contaminated ion-exchange media 100-Areas to 200-Areas	Ion exchange resin contaminated by radionuclides including free liquid contaminated with 10 uCi/gal Beta-Gamma	Deionizer vessels mounted on flat bed trailers.	Approximately 120 truck shipments per year. Average radioactive contents per shipment is 0.5 Ci Alpha and 50 Ci Beta-Gamma.	780 highway

TABLE 3-2. Summary List* of Radioactive Materials Transported on the SRP Site (Continued)

Radioactive Material	Characteristics	Containers Used	Annual Amount Shipped	Annual Shipment Miles on SRP (1985)
Liquids for Recycling, D_2O from 100-Areas to D-Area, Neptunium solution from 200-F Area to 200-H Area.	Aqueous solutions	D_2O in 55-gal drums Np solution in double wall tank container.	Approximately 200 shipments per year for D_2O. Average of 20 drums per shipment with approximately 3000 Ci Tritium per drum. Approximately 200 shipments per year for Np solution. Average of 0.1 Ci Alpha per shipment.	2,500 highway

* This summary lists the radioactive materials assessed to present the greatest risk to public and worker health and safety when in transportation at the Savannah River Plant.

** Load lugger pans are similar in construction and use to commercial outdoor trash dumpsters.

*** Mostly Pu-238 from operations at 235-F. The Pu-238 production program has been discontinued.

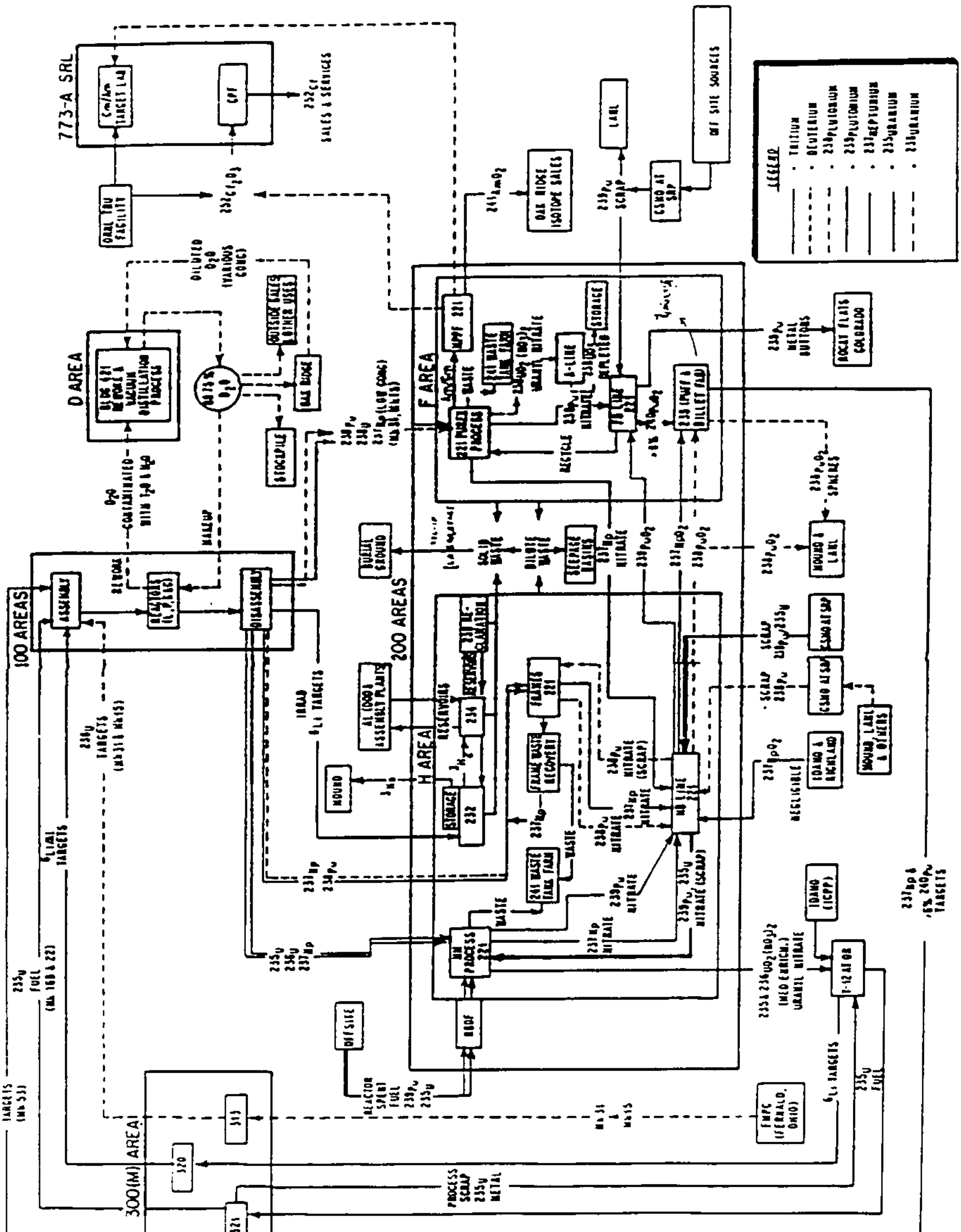
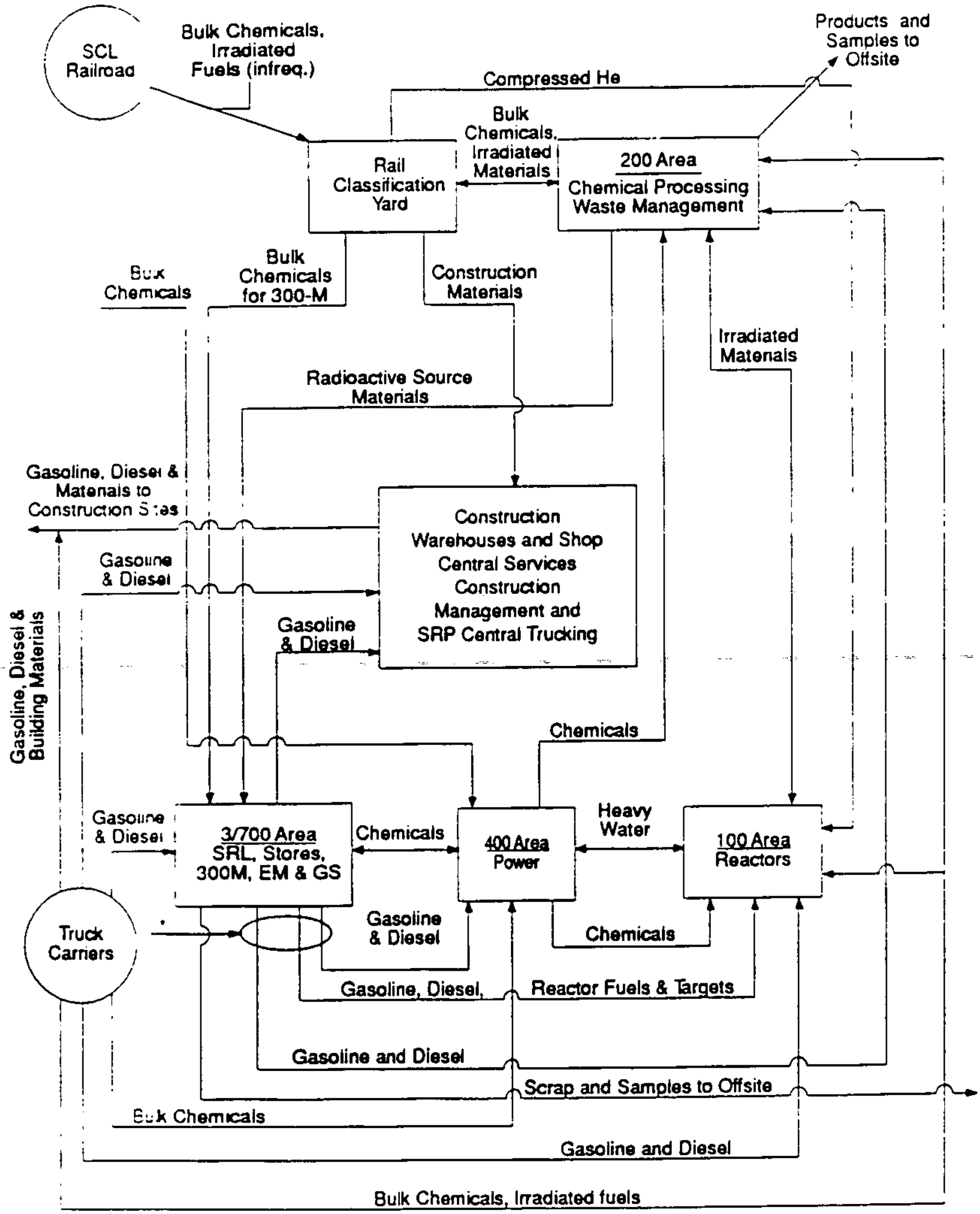


FIGURE 3-37. SRP Materials Flow Diagram (1985)



* Direct delivery of gasoline and diesel to storage tanks located near areas of fuel use on the SRP.

FIGURE 3-38. Flows of Essential Materials in Bulk and Bulk Construction Supplies (HMs Only) are transported to the SRP Burial Ground (643-7G) in the 200-Area. The flows of waste materials are illustrated in Figure 3-39. Tables 3-3 and 3-4 give examples of flows of radioactive wastes to the Burial Ground. Table 3-5 lists the flows of nonradioactive hazardous waste to onsite storage at the SRP during 1985.

Examples of regulated wastes transported in boxes are low level radioactive wastes in metal burial boxes that are routinely transported to the Burial Grounds (at a rate of about 800 boxes per month). Non-regulated wastes include trash which is transported to onsite land fills. Nonradioactive hazardous materials that are moved include waste oil in 500-gallon containers by load-lugger from 716-A to the SRP power plant in the 400-Area for BTU recovery (about twice per year). About 40 shipments of waste oil are made from the 100-Areas to the 400-Area each year. Other materials such as asbestos are also transported.

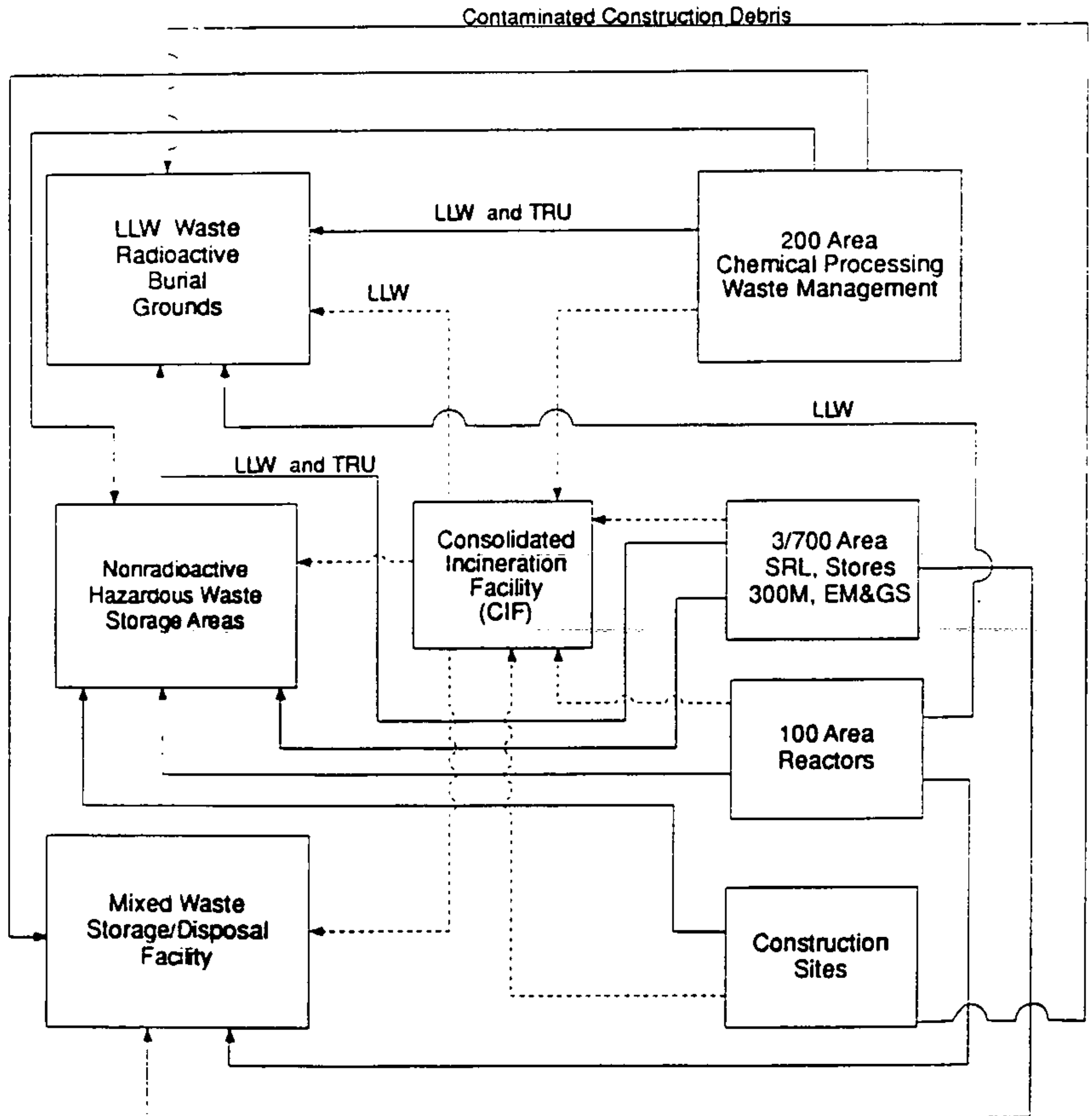
Tables 3-6 and 3-7 summarize the flow of all hazardous materials at the SRP. Gasoline and other light petroleum distillates are the most frequently moved nonradioactive hazardous materials that are shipped by truck. These shipments account for 78% of nonradioactive hazardous materials shipments by truck. Nitric acid is next, with 11% of the shipments.

The bulk of the rail traffic is coal and cask car movements. Cask car movements for the month of May, 1985, are illustrated in Figure 3-40. Coal cars are moved from the Seaboard Coastline interchanges at Dunbarton and Ellenton to area powerhouses for use in steam generating boilers. Cask cars are moved between the reactors and the 200-F and 200-H separations buildings. Other cargo, such as tank cars, steel, utility poles, bulk chemicals, helium cars, and a variety of other goods are moved from the Seaboard Coast Line Railroad at the changes to the SRP Railroad then to areas on the plant site. Occasionally, cargoes are moved between areas at SRP. Approximately 14,150 cars were moved during the 1984 calendar year.

For shipments by rail, sodium hydroxide accounts for 85% of the nonradioactive hazardous material moves. Sulfuric acid is next in frequency (8%), followed by Trichloroethane (5%) and n-paraffin included with light petroleum distillates (2%).

For radioactive materials shipped by truck, low level beta-gamma wastes and analytical samples comprise the majority of shipments. These are about equal in number and account for 86% of shipments. With exception of very infrequent receipts of rail shipments of radioactive materials from offsite, all rail shipments are of irradiated fuel and targets from the 100-Area reactors to the 200-Area chemical processing facilities.

About 400-500 shipments are made from Stores offsite each month (usually overage, incorrect-material etc). Eight to 10% contain HM; about 1% contain radioactive materials.



NOTE:

- Consolidated Incineration Facility startup is planned for 1992.
- The Beta-Gamma Incinerator was in operation when this diagram was initially developed. The Beta-Gamma Incinerator is no longer operating.

FA 078004

FIGURE 3-39. Flows of Hazardous Waste

TABLE 3-3. TRU Waste to Burial Ground, 1982*

Area	Trips	#Drums	Ci	Avg. Drums Load	Avg. Ci/ Load	Miles Travelled	Ci-Miles
221F	56	215	300	4	5.4	145	870
235F	60	369	30,900	6	515	180	84,500
772F	27	655	2,300	24	85	80	6,950
221H	32	336	24,150	11	755	50	36,200
773A**	17	106	25.5	6	1.5	160	215
TOTALS	110	1,681	57,675	15	525	406	1.29×10^5

* This table summarizes SRP onsite transuranic waste shipments to the Burial Ground during 1982. Significant amounts of these waste shipments were associated with a Pu-238 isotope production program which was ongoing at that time. The Pu-238 program has since been discontinued.

** There were 4 drums >.5 Ci content shipped from 773-A to the Burial Ground in 1982.

*** The total number of shipments from the 5 buildings is not equal to the sum of the individual building shipments because of co-mingling of shipments. For example, 22 of the 27 shipments from 772-F were co-mingled with shipments from one or more of the other buildings. In all 53 of the 110 total shipments involved co-mingling of shipments from two or more of the facilities. Other consequences of the co-mingling of shipments for this table are: a) that the reported total for average drums per load is higher than the average of the drums shipped from the five facilities (15 vs. 9), b) the overall average number of curies per load is proportionately higher (525 vs. 300), c) the total miles traveled is less than the sum of miles traveled by the individual facility shipments, and d) the total Ci-miles reported is less than would be calculated by multiplying average curies per load by total load miles from each area then summing these products (1.29×10^5 vs. 1.38×10^5).

TABLE 3-4. Reactor Scrap Metal Shipments

Year	Reactor	Shipments	Volume	Curies
1979	C	59	2,065	1,578
	K	55	1,925	4,376
	P	74	2,590	25,038
1980	C	39	1,365	4,696
	K	81	2,835	1,791
	P	77	2,695	3,324
1981	C	101	3,535	1,190
	K	52	1,820	1,308
	P	111	3,885	11,413
1982	C	86	3,010	443
	K	87	3,045	5,282
	P	117	4,095	4,479
1983	C	58	2,030	5,054
	K	65	2,275	2,568
	P	78	2,730	1,200

TABLE 3-5. Shipments* of Nonradioactive Hazardous Waste, 1985

Waste Type	Shipped From	Shipped To	# of 55-gal Drums
Lithium-Aluminum	320-M	709-G	16
Methyl Ethyl Ketone	717-A	709-G	89
Paint Solvents/Water	709-G	709-G	1
Spent Blanket Wash Soln.	703-A	709-G	3
Paint Solvents	8309-Z	709-G	148
Xylene/Toluene Mix.	735-A	709-G	1
Spent Polyester Varnish	722-4A	709-G	5
Alcohol/Toluene Mix.	773-A	709-G	11
Soil and Xylene Mix.	772-F	709-4G	1
Acetone Soln.	704T/676-9T	709-4G	2
Benzene and Oil Dri	704T/676-9T	710-U	2
Toluene/Hexane/Xylene	735-A	709-4G	2
Glass Frit Waste Slurry	773-A	709-G	1
Lab Pack	773-A	709-G	1
Machine Coolant	717-A	709-4G	8
Lead And Oil	321-M	709-4G	155
Neutralized Nitric Acid	CAB	709-4G	**3
Mercury Contaminated Equip.	400-D	710-U	33
Trim-sol Coolant Waste	773-A	709-4G	4
Mercury/Soil Mix.	284-8F/676-9T	710-U	7
Trichloroethane and Oil Dri Mixture	321-M/320-M/313-M	710-U	60
F101 Safety Solvent	320-M	709-4G	1
Kerosene/Water Mix.	676-9T	709-4G	2
Perclene	***CMP PITS	709-4G	14

* Depending on the size of the waste shipments, drums are shipped to the storage facilities via stakebody trucks, covered vans, or semi trailers.

** Neutralized nitric acid from Construction is stored in high density polyethylene 55-gal drums; all other waste is stored in 55-gal carbon steel drums.

*** One hundred and ninety-six (196) drums of CMP Pit waste are in storage at Buildings 710-U and 709-4G. This waste was shipped one time only from the CMP Pits site to the buildings (14 drums shipped in 1985; all others shipped in 1984).

Four hundred and seventy-seven (477) 90-cubic foot boxes of contaminated soil are in storage at Building 709-4G. This waste was shipped one time only from the CMP Pits site to Building 709-4G (boxes shipped in 1984).

TABLE 3-6. Hazardous Material Flows - Nonradioactive Materials

Material	From	To	Annual Amount	Annual Shipments	
				Truck	Rail
Chlorine	Savannah, GA	683-D	340,000 lb	15	-
	683-D	681-1,2,3,5,6	124,000	8	-
		100-C,K,P	194,000	18	-
		200-F	12,000	6	-
		400-D	24,000	9	-
				57	0
Gasoline & Other Light Petroleum Distillates	Sweetwater or Augusta, Ga.	D-Area	329,000 gal	41	-
		100-C,K,L,P	823,000	101	-
		200-F,H	435,000	53	-
		Central Shops	393,000	112	-
		Construction Sites	750,000	36	-
		618-G	30,000	4	-
		715-A	1,081,000	141	-
	Seaboard Coast-line Railroad	200-F,H	128,000	-	2
	715-A	Field Equiment and Fixed Storage Tanks	564,000	806	-
	Central Shops	Construction Sites	250,000	500 est.	-
				1,794	2

TABLE 3-6. Hazardous Material Flows - Nonradioactive Materials (Continued)

Material	From	To	Annual Amount	Annual Shipments	
				Truck	Rail
Sodium Hypochlorite	Charlotte, NC	100-C,K,L,P	39,000 gal	40	-
		200-F,H	9,500	22	-
		400-D	735	6	-
		Central Shops	2,550	9	-
		700-A	4,800	11	-
				88	-
Phosphoric Acid	Charlotte, NC	300-Area	70,000 lb	2	-
		200-Area	28,000	2	-
				4	-
Sulfuric Acid	Columbia, SC	300-Area	12,000 lb	2	-
	Copper Hill, TN	400-Area	1,164,000	-	10
				2	10
	400-Area	100-C,K,P,	189,000	17	-
		200-F,H	100,000	9	-
				28	10
Trichlorethane	Augusta, GA	300-Area	50,000 gal	-	6
				-	6

TABLE 3-6. Hazardous Material Flows - Nonradioactive Materials (Continued)

Material	From	To	Annual Amount	Annual Shipments	
				[illegible]	[illegible]
Sodium Hydroxide	Augusta, GA	300 Area	147,000 lb	5	
	Savannah, GA	400-D	1,989,000	-	16
		200-Area	11,454,000	3	90
		Central Shops	579,000	11	-
				19	106
	400-D	100-C,K,L,P,	315,000	22	-
		200-F,H	338,000	18	-
				40	0
Hydrogen Floride	Morristown, NJ	Stores	20,000 lb	***	-
				-	-
	Stores	200-Area	20,000	7	-
				7	-
***N/A - Not Available					
Nitric Acid	Augusta, GA	300-Area	728,000 lb	16	-
		200-Area	13,634,000	225	-
				241	-

TABLE 3-7. Hazardous Material Flows - Radioactive Materials

Material	From	To	Annual Amount		Annual Shipments	
					Truck	Rail
Irradiated Reactor Fuel & Production Material Targets	Offsite	200-Area	100	Cask loads	100	-
	100-Area	200-Area	350	Lg. Quant. RAM	-	350
					100	350
Product Materials	200-Areas	3/700-Area	Pu-Al & Np-Al Billets	150	150	-
			U-Al Billets	2	2	-
			Pu-239 Oxide	10	10	-
			Pu-238 Oxide****	45	45	-
	HB-Line	235-F	Np Oxide*	36	36	-
			Pu-239 Oxide	4-5	4-5	-
	200-Areas	Offsite	Pu-239 Buttons	15-20**	15-20**	-
			Pu-238 Oxide		N/A	-
			GPHS Fuel Forms	36 pkgs	36	-
			Tritium		N/A	-
			Uranyl Nitrate Solution		50-100	-
					348-404	-
TRU Wastes	200-Area 3/700-Area	643-7G Burial Ground	1,600 55-gal drums 60,000 Ci/yr		100+	-
					100+	-

TABLE 3-7. Hazardous Material Flows - Radioactive Materials (Continued)

Material	From	To	Annual Amount	Annual Shipments Truck	Annual Shipments Rail
Beta Gamma Wastes	200-Area 3/700-Area	643-7G Burial Ground	10,000 B-25 Boxes (90ft^3)	2,000-3,000	
	Construction Sites		1,000 Load Lugger Pans	1,000	-
	100-Areas		Scrap metal w/Lg. Quant. RAM	300	-
	Offsite		---------------------------	-	-
			Total -- 100,000 Cy/yr.	3,000-4,000	-
Analytical Supplies	Between all areas	Between all areas	2 Irradiated Fuel specimens w/Lg. Quant. of RAM. Other samples up to few 10's of Ci per shipment. Est. 10,000 Ci/yr.	4,000	-
Liquid Low Level Waste	100-Areas 3/700-Areas	200-Area	3,000 Ci	150	-
Liquid High Level Waste	3/700-Area	200-Area	3,000 Ci Alpha 6,000 Ci Beta-Gamma	30	-
Contaminated Ion Exchange Media	100-Areas	200-Area	60 Ci Alpha 6,000 Ci Beta-Gamma	120	-

TABLE 3-7. Hazardous Material Flows - Radioactive Materials (Continued)

Material	From	To	Annual Amount	Annual Shipments	
				Truck	Rail
Liquids for Recycling	100-Areas	D-Areas and return	12 Million Ci Tritium	200	-
(D_2O and Np-Solution)	200-F	200-H	20 Ci Np	200	-

* Np-Oxide production campaign discontinued

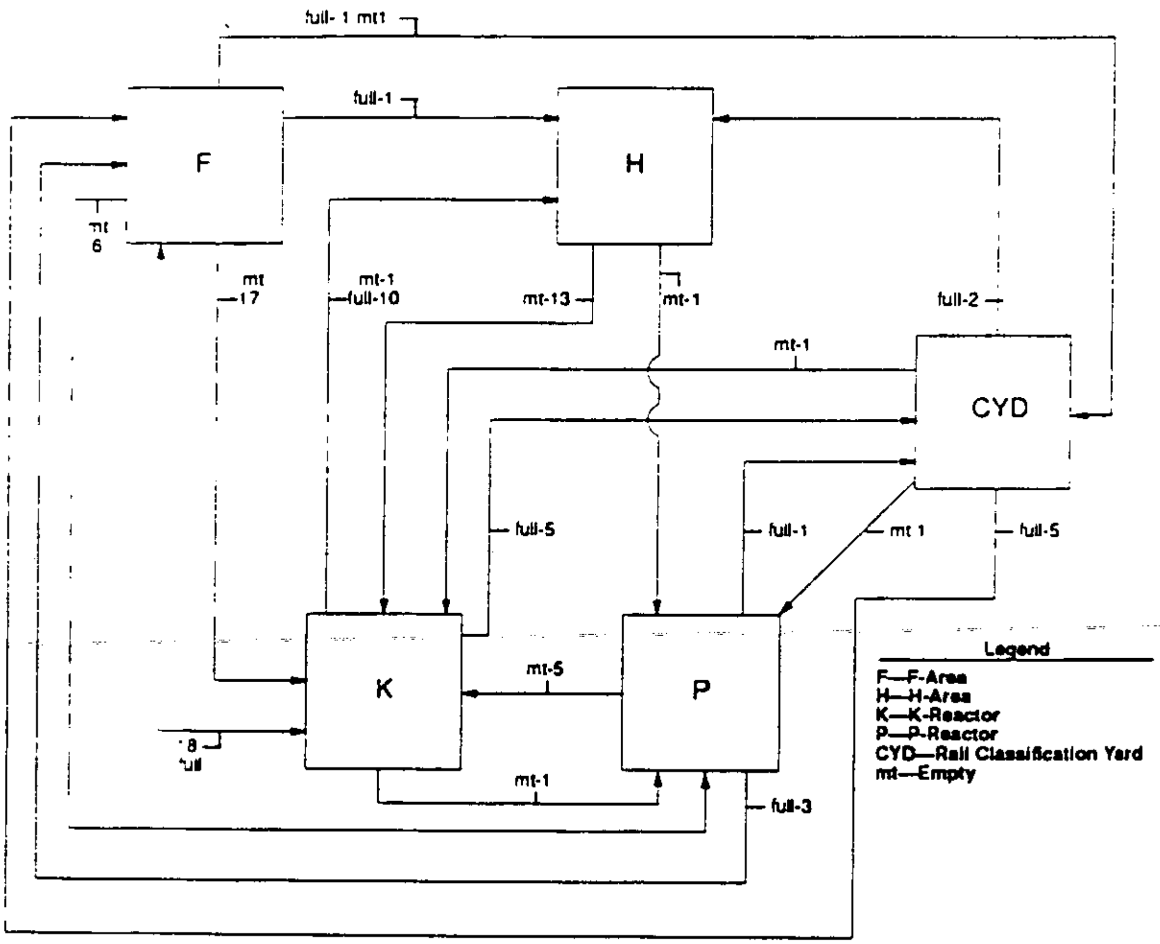
** Shipments in a campaign, no. per year is classified

*** N/A - Not Available

**** Pu-238 program in operation

RAM: Radioactive Material

Lg. Quant.: Large Quantity - The term "large quantity," in this table and elsewhere in this document, has been replaced by "highway route controlled quantity" for compatibility with the latest international standards for transport of radioactive materials across the public highway. The differences between the two quantities are not significant and does not affect the transportation of hazardous materials onsite.



Total Moves

From	To	Full	Empty
F	H	1	0
	CYD	1	1
	P	0	6
	K	0	17
H	CYD	0	0
	P	0	1
	K	0	13
	F	0	0

Total Moves

From	To	Full	Empty
CYD	P	0	1
	K	0	1
	F	5	0
	H	2	0
P	K	0	5
	F	3	0
	H	0	0
	CYD	1	0

Total Moves

From	To	Full	Empty
K	F	18	0
	H	10	1
	CYD	5	0
	P	0	1

FA 078014

FIGURE 3-40. Cask Car Moves - May, 1985

3.2.2.3 Environmental Factors and Effects

The transportation of hazardous materials at the SRP has been conducted since plant operations began in 1952 with a good record of safe operations. This safety record has been achieved in large part because the SRP transportation system, in terms of safety features, closely resembles the general offsite transportation system used by the public and because the transportation safety environment onsite is relatively benign when compared to that offsite (see Section 4.2.2.3 for a discussion of the SRP safety record). The specific dimensions of the environmental factors that affect onsite transportation safety and the transportation system's responses are discussed below.

Road and Rail Conditions. As discussed in Chapter 2.0, roads and rails at the SRP are well maintained. Roadways are wide with wide berms and along road cleared areas have gradual turns, generally shallow grades (except for the hill on the Road C highway northwest of the 200-Area), few embankments, and few areas with elevated road beds. Well-marked intersections are centered in large cleared areas affording good visibility to intersecting traffic. There is one overpass where the Road 2 highway crosses the Road C highway. The clearance under this overpass is 14 ft 3 in. The Road C highway is four lanes wide at the overpass but the road width clearance through the underpass is narrow because of narrow berms. Highway bridges are short over the narrow streams and have low guard rails.

Weather Conditions. Weather at the SRP is representative of weather in the Atlantic coastal areas in the southeast. A key discriminating characteristic of this weather relevant to transportation safety is the relatively few days in each year where icy road conditions are encountered. In addition, there are proportionally a greater number of clear weather days when compared to the upper midwest and northeast where large amounts of hazardous materials are transported.

Traffic Conditions. Except for rush hours when work shifts are changing, highway traffic at the SRP is light. Rail traffic on the site is limited to through, commercial traffic on corridors established for the SCL Railroad and to SRP-only rail traffic in the central and D-Areas of the site. The SRP Railroad operates on its own track system separate from the SCL track but is connected to the SCL at the Dunbarton and Ellenton interchanges. The SRP traffic is low density, slow and controlled by an onsite dispatcher.

Administrative Controls. Administrative controls exercised by SRP management are important in limiting the likelihood and consequences of onsite transportation accidents. Specific controls include:

- Employee screening, selection, orientation, and training;
- RHYTHM (see Section 4.1) Committee activities and oversight;
- Established procedures and safety practices;

- Accident and incident reporting, investigation, and corrective actions;
- Safety compliance audits;
- Periodic inspections and maintenance of equipment and facilities;
- Restricted site access;
- Restrictions on transport operations for certain high hazard materials; and
- Established accident response plans and teams.

Transportation System Response. The benign nature of the transportation environment discussed above does not preclude accidents. It does, however, affect the severity and frequency of accidents. Based on the environmental factors, the frequency of accidents should be much less than that in general commercial transportation on public highways and over commercial railways. In addition, accident severities should, at a minimum, not exceed those expected for commerce. The established onsite emergency response capabilities can be expected to contribute to low consequences for onsite accidents when compared with those of accidents in commerce.

3.2.3 Instrumentation and Control

Packagings. Packagings used at the SRP for transporting hazardous materials are passive containment systems. Active controls and instrumentation are used in these transportation system components.

Vehicles. Vehicles used in the transport of hazardous material packages are equipped with standard instruments and controls commonly installed in similar vehicles used in commerce. The exception is for the high-level waste trailer used to transport liquid high-level waste from the 3/700-Area to the 200-Area. This trailer is equipped with eight fail-safe brake systems (two wheels per system) that close to brake position if compressed air pressure is lost.

Roadways and Railways. Traffic control signals are of the same type used on public roadways and commercial railways.

3.2.4 Electrical Power Distribution

Except for traffic control signals, the transportation system at the SRP does not rely on electrical power distributed from fixed power stations. Traffic control signals are inoperative during electrical power supply disruptions.

3.2.5 Auxiliary Systems and Support Facilities

There are no auxiliary systems in the transportation system. Fires in transportation are responded to by the SRP Fire Department using appropriate equipment. Many different kinds of equipment are used in responding to transportation accidents or incidents having the potential for releases of hazardous materials.

3.3 ENGINEERED SAFETY FEATURES

The engineered safety features of the SRP hazardous material transportation system include features of roadways and railways, vehicles, packages, and loading and unloading facilities.

Roadways and Railways are engineered in conformance to national standards as interpreted in Du Pont specifications. These standards provide for road and railway design, along with route signs and signals, markings, and accident mitigation features (e.g. guardrails for highways, derailers for railroads) that are provided for safety in use.

Vehicle designs conform to applicable national safety standards at the time of procurement for use at the SRP. Vendor or commercial carrier vehicles are presumed to comply with applicable current safety standards. As discussed above, the high-level waste trailer brake system is augmented to provide fail-safe function. In addition, several trailers have improved king pin designs to ensure the integrity of the coupling to tractors.

Packagings for offsite shipments of radioactive materials are specification packagings prescribed by DOT regulations (Reference 1, 49 CFR 173.400-478) or are packages certified by the DOE to comply with applicable standards specified in the DOT regulations. Packagings used for offsite shipments of other hazardous materials comply with applicable requirements of 49 CFR 173. The DOT regulations specify safety features and/or safety performance requirements. DOT regulatory requirements for radioactive material packages are discussed in Appendix C.

Packagings for onsite transportation of hazardous materials include DOT specification packagings (e.g., Specification 6M, see Reference 1, 49 CFR 178.102) and other packagings engineered for specified uses. The specially engineered packages provide levels of containment and health protection consistent with the type of service, nature of the contained materials, and the anticipated hazards considering administrative controls that are applied. The packages and associated ancillary features, e.g., tiedowns, also incorporate features that permit safe handling, ease of decontamination, and verification of proper assembly. The packagings along with the administrative transportation controls are required to incorporate features that provide for the public a level of safety equivalent to what is provided by packagings that comply with DOT regulatory requirements during transportation by common carriers on public highways.

Packaging engineered safety features include: containment and isolation; ionizing radiation shielding; thermal protection; pressure indication and relief; impact and puncture protection; handling features; testing and inspection features; nuclear criticality safety features; and liquid absorption. Not all of these features are necessarily embodied in any one packaging.

3.4 DECOMMISSIONING CONSIDERATIONS

On occasion, SRP transportation equipment is removed from service. Equipment that is contaminated by beta-gamma emitting radionuclides may be disposed by burial at the Burial Ground. Alpha contaminated equipment may be placed in an appropriate container and stored with other TRU wastes. Alternatively, if there is a potential for future use, equipment contaminated by radioactive materials may be stored at the Burial Ground with other contaminated equipment. Equipment that is no longer useful and is contaminated by nonradioactive hazardous materials may be cleaned then declared to be excess or it may be stored with hazardous wastes at the SRP.

3.5 REFERENCES

1. Code of Federal Regulations, Title 49, U.S. Department of Transportation (1983).

2. DOE Order 5480.1, Environmental Protection, Safety, and Health Protection Program for DOE Operations, Chapter XI - Requirements for Radiation Protection, U.S. Department of Energy (1981).

3. DOE Order 5480.5, Safety of Nuclear Facilities, U.S. Department of Energy, September 1986.

4. Interarea Shipments. Internal Report DPSOP 170, E.I. du Pont de Nemours & Co., Savannah River Plant, Aiken, SC (1987).

5. DOE Order N5480.3, Safety Requirements for the Packaging and Transportation of Hazardous Materials, Hazardous Substances, and Hazardous Wastes, U.S. Department of Energy, March 1988.

6. DOE Order SR1540.1, Materials Transportation and Traffic Management, U.S. Department of Energy.

APPENDIX A

SP9965, SP9966, SP9967, AND SP9968 PACKAGES

FOR SURFACE SHIPMENT OF FISSILE AND

OTHER RADIOACTIVE MATERIALS

(Appendix to Chapter 3.0)

APPENDIX A. SP9965, SP9966, SP9967 AND SP9968 PACKAGES FOR SURFACE SHIPMENT OF FISSILE AND OTHER RADIOACTIVE MATERIALS

The SP9965, SP9966, SP9967, and SP9968 packages are designed for surface shipment of fissile and other radioactive materials where a high degree of containment (either single or double) is required. Provisions are made to add shielding material to the packaging as required. The package was primarily tested to demonstrate that it meets the criteria specified in U.S. DOE Order No. 5480.1, Chapter III, dated 5/1/81, which invokes Title 10, Code of Federal Regulations, Part 71 (10 CFR 71), "Packaging of Radioactive Material Under Certain Conditions," and Chapter I, Interstate Commerce Commission, Subchapter A, Title 49, Parts 171-179.

These packages have been assessed for transport of up to 14.5 kilograms of uranium, excluding uranium-233, or 4.4 kilograms of plutonium metal, oxides, or scrap having a maximum radioactive decay energy of 30 watts.

This quantity and the configuration of uranium or plutonium metal cannot be made critical by any combination of hydrogenous reflection and moderation regardless of the condition of the package. For a uranium-233 shipment, a separate criticality evaluation for the specific package is required.

Package Descriptions

SP9965 Package

The SP9965 package has a nominal gross weight of 193 lb and a maximum gross weight of 200 lb (Table A-1). The various components of the package are shown in Figure A-1. They include the drum, insulation, bearing plates, primary containment vessel, and aluminum honeycomb spacers as discussed in the following paragraphs.

The drum is fabricated as a 30-gal removable head drum per DOT Specification 6C or 17C. It is fabricated of 18 gage (0.048 in.) carbon steel. The drum and cover are galvanized and passivated with zinc chromate for outdoor protection. Four 1/2-in.-diameter holes are drilled, approximately 90° apart, 1-3/4 in. below the top curl and are covered with a weatherproof tape or fusible plug. The holes prevent rupture of the drum during a fire by venting the gases from the insulation. A locking ring with dropped-forged lugs, installed with a 5/8-in.-high strength steel bolt, provides closure by securing the cover to the drum. The steel bolt, which threads into the dropped-forged lug, must be provided with a lock nut or equivalent device to prevent loosening during transit. A 1/8-in.-diameter hole is drilled through both drop-forged lugs for insertion of a wire seal which will show evidence of tampering.

The insulation material which cradles the primary containment vessel is "Celotex" (trademark of the Jim Walter Corp.); "Celotex" meets the requirements of 49 CFR 178.104-3. Physical and thermal properties are discussed in detail in Table A-2. The "Celotex" insulation, which normally comes in 1/2 to 5/8-in.-thick sheets, is cut into disks which are cemented

TABLE A-1. Maximum Gross Weights and Overall Dimensions

Package Type	Nominal Capacity,[a] Size, gal	Containment Vessels	Overall Diameter, in	Overall Height, in	Normal Gross Weight, lb	Maximum Gross Weight, lb	Drum Weight, lb
9965	30	Single S5-2-11037	19.6	29.1	193	200	400
9966	30	Double S5-2-11037 & S5-2-11038	19.6	29.1	236	250	480
9967	55	Double S5-2-11037 & S5-2-11038	23.9	34.8	327	627[b]	640
9968	35	Double S5-2-13097 & S5-2-13098	19.6	35	265	406[b]	

a Maximum weight authorized by DOT in 49 CFR 178.104.3.

b When extra lead shielding is added.

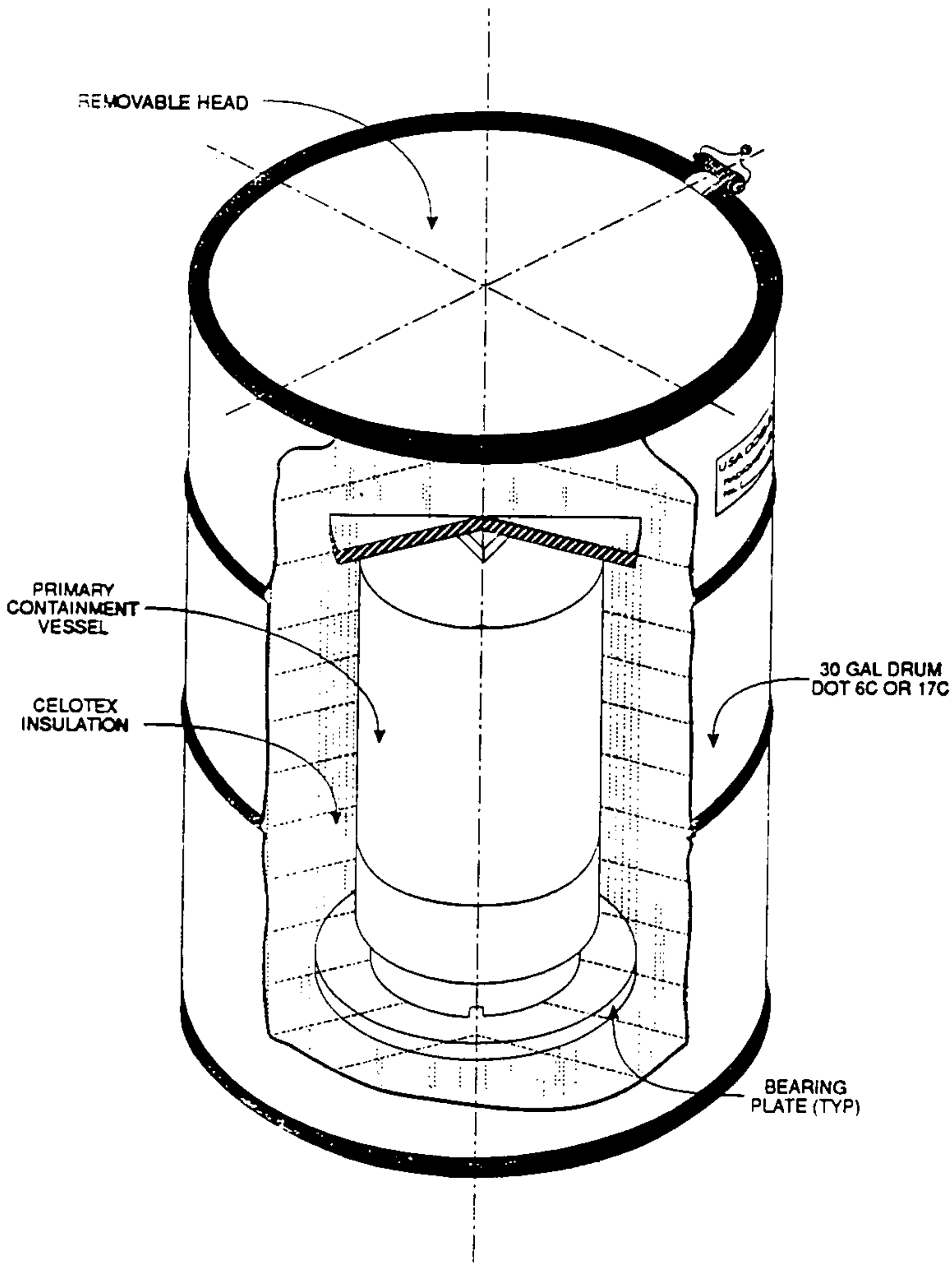


FIGURE A-1. SP9965 Package

TABLE A-2. Maximum Fuel Loading For SP9965 Package (Without Lead Shield)

Material	Form	Total kg	H:X of PCV contents, max
Plutonium[a]	Metal	4.4	3.75
	Compounds	4.4	4.23
Uranium (U-235)	Metal	14.5	1.20
	Compounds	14.5	1.67

[a] Pu-240 content must equal or exceed Pu-241 content.

4.0 DESCRIPTION OF OPERATIONS

Transportation operations are conducted according to documented operating procedures which are revised periodically. These procedures are established to assure that the transportation system functions effectively to support plant operations while providing for the protection of operating staff, the public, and the environment. Operations are administered under Du Pont management controls to ensure their continuing safety and effectiveness.

The primary administrative control document is the contract (DE-AC09-76SR00001) between Du Pont and DOE. The contract explicitly describes certain obligations with regard to safety on the part of both the contractor (Du Pont) and the contracting officer (DOE). While SRP process facilities are operated by Du Pont, DOE is ultimately responsible for the safety, effectiveness, and environmental compliance of operations.

4.1 ORGANIZATIONAL STRUCTURE

The SRP is operated by the Atomic Energy Division (AED) of the Petrochemicals Department of E. I. du Pont de Nemours & Co. (1). The structure of the AED, for purposes of this Safety Analysis, is shown in Figure 4-1. The two major divisions are the Technical Division, which includes the Savannah River Laboratory (SRL) and the Manufacturing Division, which includes SRP. The Departmental Engineer's Office reports separately to the AED in Wilmington.

The Savannah River Laboratory provides technical support to SRP. The SRP organization has two major divisions: Operations; and Plant Facilities and Services. The Manager of Operations has custodial and operating responsibilities for all production facilities. The Manager of Plant Facilities and Services has responsibilities for nonproduction facilities and central services. The SRP organization (2) is shown in Figure 4-2.

Several SRP departments are responsible for transportation of hazardous materials at the site. The operations are conducted under authority and within guidelines delegated to Plant Facilities and Services, and to Operations.

Onsite, interarea transportation of hazardous materials (HMs) is handled mainly by the Stores Division of the Procurement and General Services Department and by the Central Services Works Engineering Department (CSWE). The organization of CSWE is shown in Figure 4-3, with emphasis on the Railroad, Roads and Grounds, and Field Services Division (RR&FS), as shown on the right side of the figure.

Centralized Trucking, which is a part of the Roads and Field Services group of RR&FS, has the primary responsibility for interarea road transport (except from Stores) and the Railroads Division the primary responsibility for rail transport at the SRP site. Stores delivers all store-stocked material and material received at the plant except for bulk materials, consigned shipments, and large and heavy materials that must be handled by Centralized Trucking or Railroads. Excepting bulk deliveries, it is estimated that 95% of materials

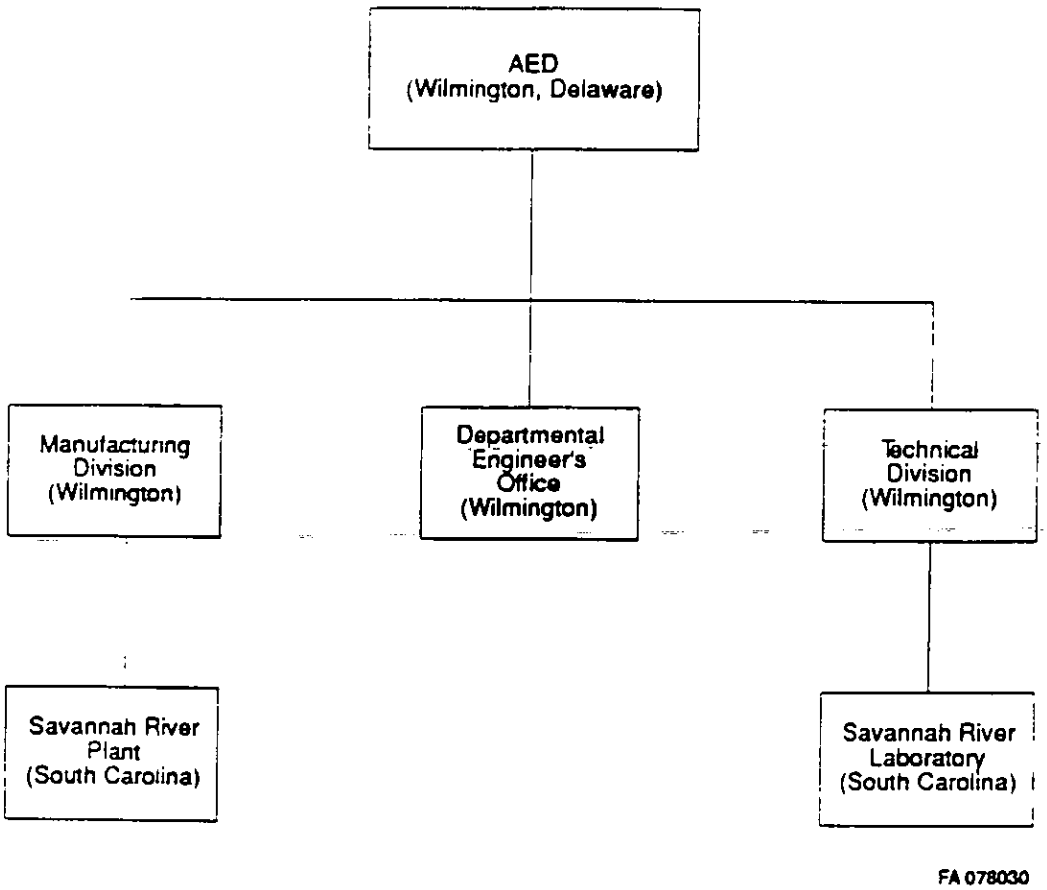


FIGURE 4-1. Atomic Energy Division Management

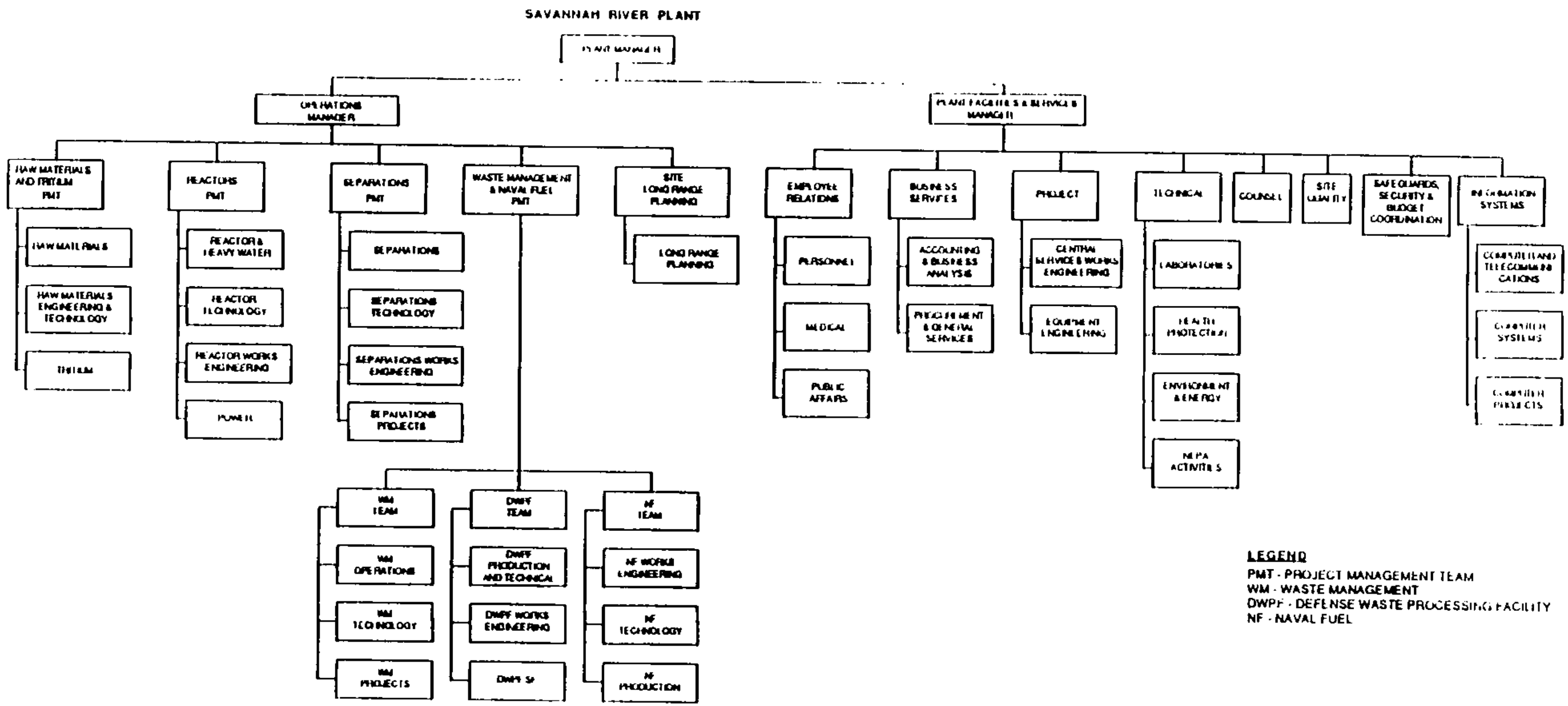


FIGURE 4-2. Organization of Savannah River Plant (1985)

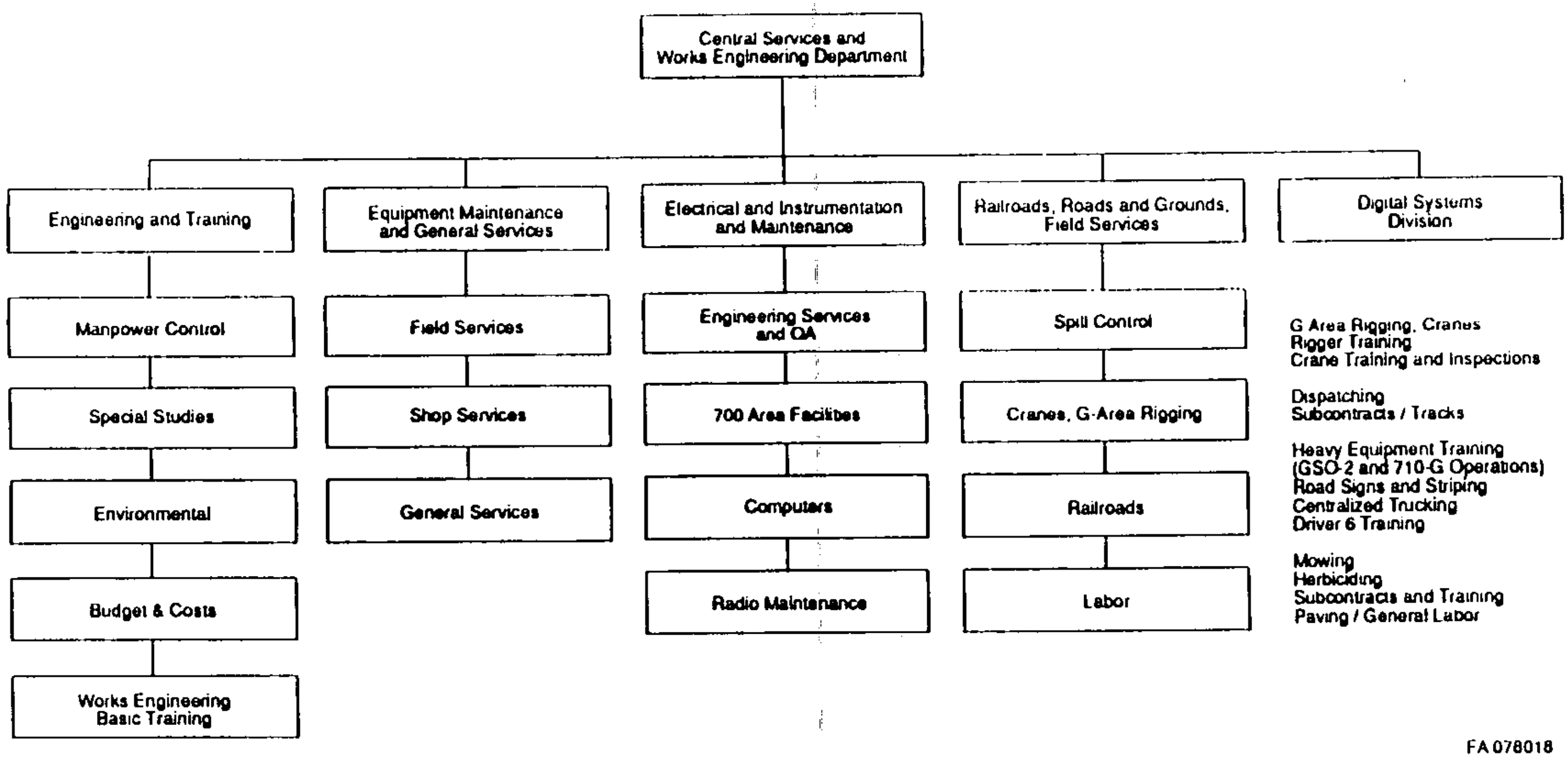


FIGURE 4-3. Organization of CSWE with Emphasis on Railroads, Roads and Grounds, and Field Services

items are handled through Stores. Any of these loads may be solids, liquids, or gasses, and may be hazardous or non-hazardous.

Stores, Centralized Trucking, and Railroads all work closely with departments who have responsibilities for shipping and receiving materials, particularly hazardous materials. Each type of material must be packaged, secured, and transported in accordance with standard shipping practices.

The Equipment Maintenance and General Services Division (EM&GS) of the CSWE is organized as shown in Figure 4-3. The division is generally responsible for the maintenance of road and rail equipment. It is also involved in some transport activities, such as trash hauling and onsite deliveries of gasoline and diesel fuel. Since Centralized Trucking does not work the third shift (midnight to 8 am), EM&GS attends to transportation needs on this shift, such as the movement of deionizer casks.

In November 1984, SRP operations were reorganized around Project Management Teams, so that each area now has a full complement of functional capabilities, such as rigging, transportation, maintenance etc. Thus, loading and unloading operations at an area may involve riggers and/or transportation personnel assigned to the area as well as the transportation personnel assigned to, for example, Centralized Trucking.

As part of the technical group (Figure 4-2), the Health Protection Department (HP) (or Occupational Health Protection (OHP) personnel in SRL facilities) concerns itself with radiation and contamination control. The HP (Figure 4-4) has many functions. Some of these functions are listed in Table 4-1.

The Plant Central Safety Committee which reports to the SRP Manager is composed of top level managers, Chairmen of Area Central Safety Committees, and Safety and Fire Protection supervision. This body establishes policy and plant-wide procedures. Ten permanent subcommittees are shown in Figure 4-5. The primary functions of each subcommittee are listed in Table 4-2.

Although the safe distribution of hazardous materials is a line-organization responsibility, the RHYTHM* Committee was established in 1981 to assist in fulfilling this responsibility. The RHYTHM Committee, which meets at least once a month, provides a centralized communication, coordination, training, and audit forum for matters of mutual interest to committee member organizations, particularly in the preparation of hazardous materials for shipment in compliance with DOT regulations and DOE orders. The committee is primarily concerned with shipments to offsite destinations.

The RHYTHM Committee reports to management through the chairman of the Safe Distribution Committee of the Plant Central Safety Committee. Members of the RHYTHM Committee are appointed by SRP and SRL management. Assignments are in addition to members' regular functions. Each member represents a facility and/or activity where hazardous materials are handled.

---

*RHYTHM is a registered trademark of Du Pont: Remember How You Treat Hazardous Materials

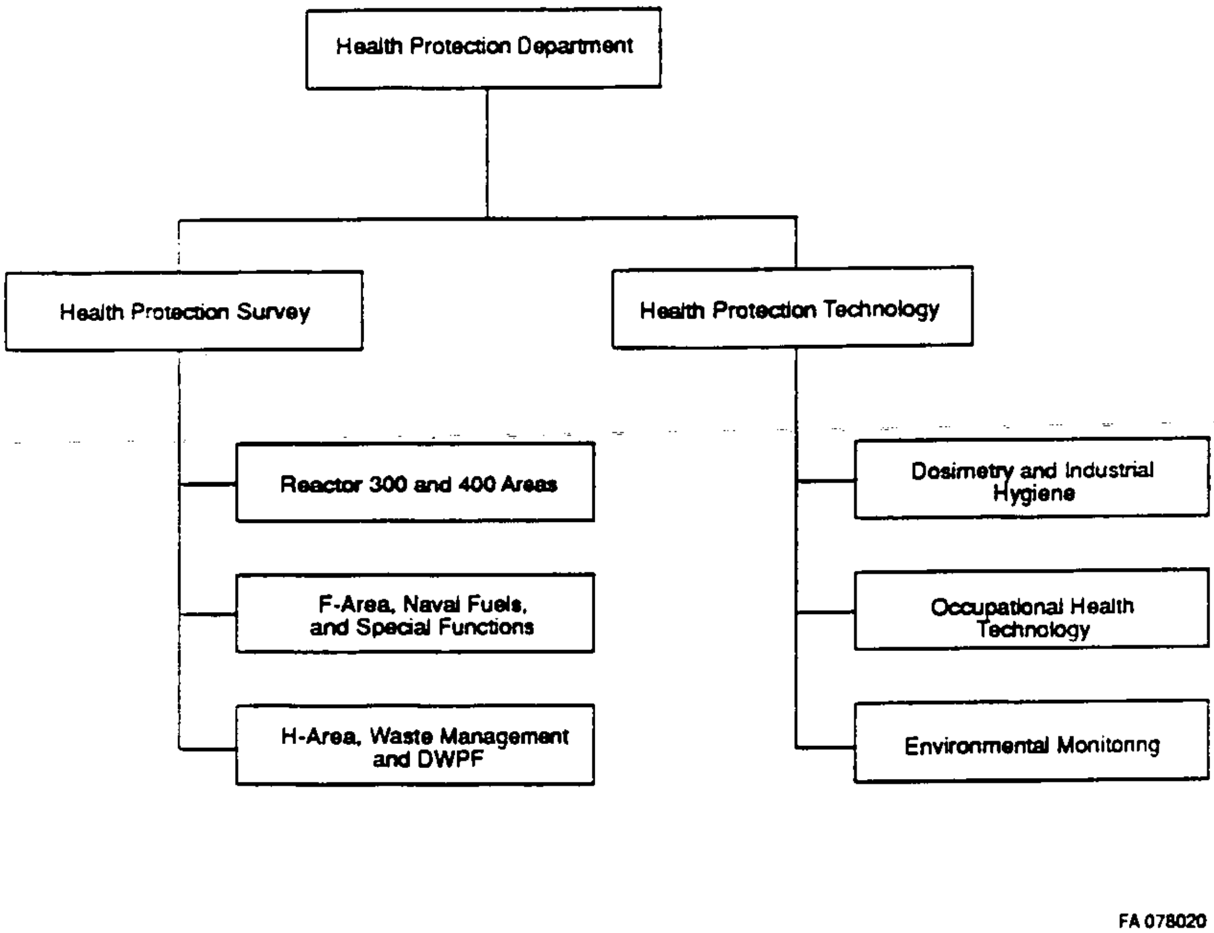


FIGURE 4-4. Health Protection Department Organization

TABLE 4-1. Health Protection Department Organizational Responsibilities

Group	Responsibilities
Area Survey	Radiation and Contamination Surveys
	Industrial Hygiene Surveys
	Minimize personnel radiation exposures (ALARA)
	Minimize skin contamination
	Minimize facility contamination
	Minimize environmental releases
	Prevent internal assimilations of radioactive materials
	Train plant personnel in Health Protection aspects of jobs
	Coordinate Personnel Protective Clothing and Equipment Programs
	Audit work and procedures
Dosimetry and Industrial Hygiene	Distribution, collection, and evaluation of personnel dosimeters
	Maintain bioassay records
	Collection and quantitative analysis of excreta for contaminants
	Count individuals and estimate body burdens
	Maintenance, calibration, and distribution of survey and monitoring instruments
Environmental Monitoring	Quantitative analysis of air, water, milk, flora, fauna
	Evaluation and publication of environmental samples
	Instrumental analysis of of environmental monitoring data
	Investigation of releases
Occupational Health Technology	Technical support for area surveys, dosimetry, and environmental monitoring

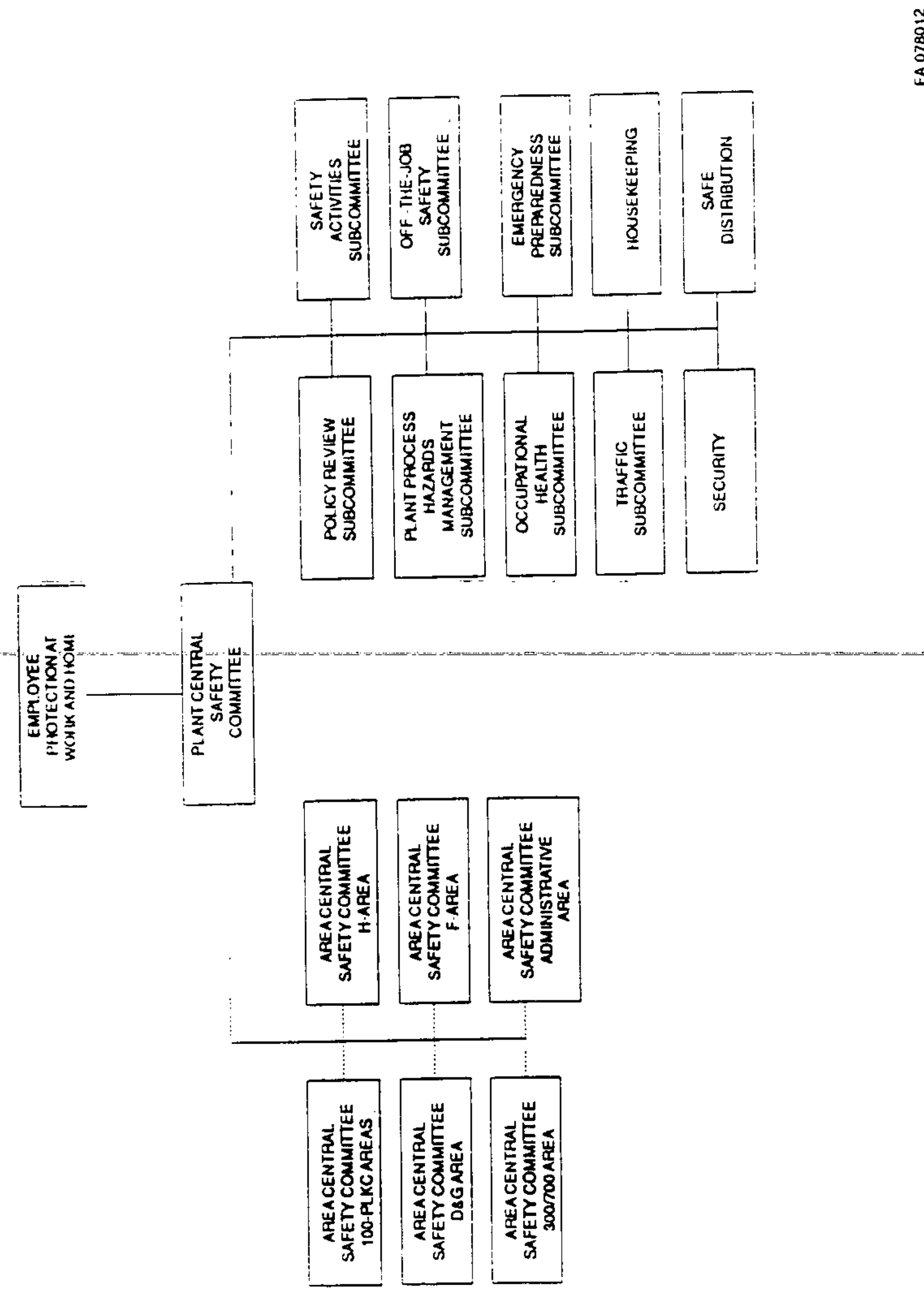


FIGURE 4-5. SRP Safety Committees

TABLE 4-2. Subcommittee Primary Functions

Policy Review	Reviews and approves changes in Safety Manual. Reviews and approves injury and unusual incident investigation reports.
Safety Activities	Devotes itself to increasing the involvement in and expanding efforts in the planning of in-plant safety programs.
Process Hazards Management	Coordinates and audits process hazards management programs.
Off-the-Job Safety	Reviews off-the-job injuries and develops programs to improve the performance.
Occupational Health	Devotes itself to special hazards involving industrial hygiene, heating conservation, handling of radioactive and toxic materials.
Emergency Preparedness	Devotes itself to the ability of plant forces to respond to emergency situations.
Traffic	Devotes itself to traffic problems, road hazards, and vehicle accidents.
Housekeeping	Reviews plant housekeeping standards and develops programs and procedures to improve housekeeping performance.
Security	Directs the security program.
Safe Distribution	Coordinates and directs the receiving, handling, and shipment of hazardous materials ("RHYTHM").

There are presently 90 members (30 in 1985), including representatives, from Railroads, Centralized Trucking, and Stores. The training function of the RHYTHM Committee is discussed in Section 4.4.3.1 and the safety function is considered in Section 4.8.4.3.

The SRP Spill Team, which reports to the RR&FS Division of CSWE (see Figure 4-3), is responsible for containment and control of spills of Hazardous Materials at the SRP. This team is called into action whenever the magnitude or nature of a release requires actions exceeding the capabilities of the cognizant operation's area response team. For a major transportation accident involving a potential release of hazardous material, the Spill Team is called into action by the Emergency Operations Coordinator (EOC) (now renamed Technical Support Center (TSC)). The EOC is assigned to the SRP Security Division and, in addition, is a member of the Emergency Preparedness Subcommittee of the Plant Central Safety Committee.

4.2 OPERATIONAL DESCRIPTION

This section describes the operations of the transportation system. Included are the following:

- Description of transport activities
- Discussion of operating experience

4.2.1 Transport Activities

4.2.1.1 Vehicles

The EM&GS purchases trucks and tractors for general-purpose hauling, for specific loads, and for courier service on the behalf of DOE-SR. Several sizes of tractors are operated, and generally more than one is available for any trailer with a dedicated load, such as an assigned shielded container. All heavy equipment and most trucks used to transport radioactive materials are operated by Centralized Trucking operators. Exceptions include pickups assigned to radioactive service and sample trucks. For convenience, a number of trailers are assigned to operating departments because each trailer is assigned to a specific task.

Containment and shielding requirements for a proposed shipment determine the size and weight of the shielded container, tank, or shielded tank. The trailer or truck is then selected to accommodate the container. Generally, vehicles with excess capacity are selected.

Special precautions are exercised for moves involving liquids containing large amounts of radioisotopes. Large vehicles and rail equipment are operated exclusively by CSWE personnel. Cars, pickups and some enclosed trucks are assigned to, and operated by, other groups, including DOE carriers.

Forklift trucks of different sizes are distributed widely onsite. The larger units are occasionally used for moving packaged radioactive materials within or between buildings at speeds of 5 to 10 mph. Many units are assigned to an operating group for use by trained and certified personnel for short hauls within or outside a building.

Most vendors vehicles make deliveries to Stores in the 700-Area, but bulk materials (about six per day), consigned shipments, and construction materials are transported directly to their destination on the site. Consequently, there are usually a considerable number of vendor vehicles on the site, not directly under the control of SRP. Such vehicles and their contents are required to meet applicable DOT regulations and standards.

4.2.1.2 General Responsibilities

It is the shipper's responsibility, regardless of the destination of the consignment, to ensure all materials are properly packaged according to the nature of the material. The shippers are also responsible for loading, including any special arrangements required, and for arranging any escorts, security, or safeguard measures required during transport. The shipper is responsible for arranging emergency response to any incident involving an HM during transit.

The transporter is responsible for seeing that the material is properly loaded and secured before movement begins, for avoiding any unnecessary delays in transit, and for operating the vehicle safely. SRP transporters perform these functions in accordance with SRP safety requirements and applicable procedures. If a vehicle is involved in an incident, the transporter is responsible for corrective action, unless the incident involves HM, in which case the transporter is responsible for notifying the shipper promptly of the incident.

The receiver is responsible for determining the condition of the material received, notifying the shipper of any discrepancies, and unloading the material, including any special arrangements that must be made.

4.2.1.3 Scheduling

Shipments using Centralized Trucking are scheduled by calling the area foreman and asking him or her to schedule the shipment. Information given includes a brief description of the material to be shipped, pickup and delivery points, and the form (Stores Order, Move Ticket, or Transportation Work Request) to be used.

Shipments from Stores-Receiving are generally handled by the Stores delivery supervisor in Building 713-A, who requests assistance from Centralized Trucking if necessary.

Shipments using an assigned vehicle are scheduled with the driver of that vehicle. A list of forms for the control of hazardous materials is shown in Table 4-3.

TABLE 4-3. Forms for Control of Hazardous Materials

Form Identification	Title
Offsite Shipments	
OSR-12-95	Radioactive Shipment Receipt
OSR 1-53	Shipping Order
OSR 7-554	Radioactive Shipment Report
OSR 7-655	Deviation from Standard Shipping Practice
DOE-AD 60	Courier Receipt
Onsite Shipments	
OSR 6-1	Stores Order
OSR 12-80	Move Ticket
OSR 12-57	Transportation Work Request
OSR 6-27	Receiving Report
OSR 8-25	Plant Equipment Transfer
OSR 7-375	Radioactive Solid Waste Burial Ground Record
OSR 7-375A	Radioactive Solid Waste Burial Ground Record (Accountable Materials)
OSR 7-24	Alloy Delivery Receipt
OSR 7-102	Cask Car Release Record
OSR 16-69	Hazardous Materials Shipment - Public Access Roads

4.2.1.4 Dispatching

For road transport, the request and information is relayed by the area foreman to the Centralized Trucking dispatcher in Building 706-G. The dispatcher then assigns a driver with suitable equipment to transport the materials and supplies him or her with the necessary paperwork (e.g., three copies of form OSR 12-57 if this form is used). In addition to scheduling vehicle moves, the dispatcher maintains radio contact with the vehicle.

In the case of fissile materials, a driver who has special training in the handling of fissile materials is assigned. If the shipment contains special nuclear materials, the dispatcher reminds the driver that if there is a delay enroute, the dispatcher must be notified immediately.

For rail shipments, the shipper notifies the train dispatcher in Building 618-G, who assigns by radio a crew to move the material. Details are given in Section 4.2.2.11, Railroad Activities.

4.2.1.5 Shipping

Offsite shippers are required to meet DOT regulations regarding the vehicle, containment, labeling, etc. Interarea shipments are not governed by DOT regulations, even though they often comply with these. The interarea shipments are governed by Du Pont procedures and practices. The discussion of transport activities in this section is primarily concerned with interarea shipments.

The shipper is responsible for proper packaging and labeling of the package. For interarea shipments at the SRP, the appropriate Stores Order, Delivery Ticket, or Move Ticket is attached to each item to be shipped.

Nonradioactive hazardous materials are packaged and sealed either in the vendor's original container or in a DOT-approved container, which in either case must be in good condition and properly sealed. Additionally, wastes must be identified as such. The shipper is responsible for properly completing shipping papers, loading the material onto the vehicle, arranging for emergency response to any incident during transit, and arranging for any escorts, security, or safeguard measures required in transit.

Radioactive hazardous materials are categorized according to whether they are nonfissile or fissile materials. Nonfissile materials are packaged according to local area procedures for that material and are labeled appropriately. If the material does not require close administrative control, form OSR 12-57 (Transportation Work Request) is used by the Centralized Trucking foreman; additional information required on this form includes the hazard class, the safety precautions the driver must know, and whether water can be used to extinguish a fire. Other OSR forms may also be required. The shipper must approve the job description, safety precautions, and hazard class selection on form OSR 12-57 before the material is loaded, and complete any of the other

OSR forms which are to accompany the shipment. After loading, the shipment is surveyed by HP or OHP in the Technical Division.

Fissile materials, whether irradiated or nonirradiated, are identified and shipped according to established procedures. Only a supervisor can request shipment of fissile material. He or she is responsible for the packaging, loading and tie-down, as well as for nuclear safety during transit, and until accepted by the receiver. A single unit (e.g., small box) of unirradiated fissile material or samples containing less than 15 g U-235 total may sometimes be shipped in a non-specification container. Otherwise, an approved DOT specification container is required. There are limitations to shipping natural uranium, depleted uranium, heavy water, or beryllium with any fissile material. The necessary forms are prepared and the proper radioactive labels affixed to the package. The procedures are similar to that for nonfissile materials; in addition, the supervisor directly supervises the loading of the truck and tells the driver he or she will be handling fissile material.

4.2.1.6 Transporting

Hazardous materials are transported by vendors, couriers, and onsite organizations, such as Centralized Trucking, Stores, EM&GS, and other organizations using various facility-operated vehicles.

Centralized Trucking. For interarea shipments the driver inspects the assigned transportation equipment according to established procedures and ensures that it functions properly, before driving to the pickup point. The material to be shipped is identified by checking against the appropriate Stores Order, Receiving Report, Move Ticket, or Transportation Work Request.

After loading, the driver ensures the material is properly secured and moves it to the delivery point. Upon arrival at the destination, the driver contacts the receiver, if necessary, and distributes the forms as required.

Any hazardous material (as defined in 49 CFR 172.101) which will be transported on or across a road with unrestricted public access, such as SC Highway 125 and SRP Road 1, must be packaged as prescribed in 49 CFR 173. The hazard class of the material must be identified on form OSR 12-57 provided to the driver, in addition to other forms which may be required.

If the HM is not packaged according to 49 CFR 173 and is to be moved onsite across public access roads, traffic is stopped during passage of the vehicle. If necessary, the road is surveyed by HP to verify that no hazardous material has leaked onto the road and, therefore, to assure safe use before public access is resumed. In the case of heavy water drums for example, Centralized Trucking notifies Wackenhut Services 30 minutes prior to the scheduled crossing of Highway 125; Wackenhut provides two vehicles and stops traffic on both sides of the intersection while the vehicle on the SRP road crosses the public highway.

If the HM is radioactive but nonfissile (or fissile but containing less than 15 g of fissile material), additional precautions are required. For instance, radioactive waste must be appropriately marked. HP surveys which comply with departmental requirements (or appropriate radiation and contamination control procedures in the Technical Division) are required. The material is loaded using approved methods. The load is then inspected to ensure that it has been properly secured to the transport vehicle. If the material is taken to the Burial Grounds, it is unloaded by the driver under the supervision of the Burial Grounds supervisor; HP personnel are required to continuously survey while alpha waste is being placed in concrete containers or when the radiation intensities are above 300 mrads/hr or 50 mR/hr at 3 in. from the package. On completion of the job HP surveys the vehicle.

Radioactive fissile materials are only moved when there is documented authorization signed by the shipper, together with any other documents which are to accompany the shipment. The driver discusses with the shipper any special precautions to ensure they are understood. When leaving, the driver informs the dispatcher, so that he or she can notify the receiver that the shipment is enroute and what the expected time of arrival is. The driver remains continuously with the shipment until delivered; if it is necessary for the driver to leave the truck for any reason, another qualified employee is designated to stand by the shipment. Unloading takes place under the direct supervision of the receiver.

Deliveries by Stores. For nonradioactive, bulk shipments to destinations outside the 3/700-Area, the Stores Division makes deliveries using a flat-bed (open) truck. Bulk materials (items weighing more than 100 lb in a single unit, e.g., a bag) are secured on a pallet and loaded onto the truck for delivery. A Delivery Ticket accompanies the delivered materials. For non-radioactive, bulk shipments to destinations within the 3/700-Area, Stores delivers primarily by forklift, but also by flat-bed truck. Materials are secured on a pallet for delivery and are accompanied by Delivery Ticket documentation.

For packages of radioactive materials weighing less than 5000 lb to destinations within the 3/700-Area, Stores makes deliveries using its own equipment (e.g., forklift truck). However, packages of radioactive materials weighing more than 5000 lb and all radioactive materials to destinations outside of the 3/700-Area, are moved by Centralized Trucking.

Delivery is made daily to designated drop points in each area during normal working hours (7:45 a.m. - 4:15 p.m.). Emergency deliveries are made at other times by coordinating with the Stores delivery supervisor.

Stores material is moved with a Stores Order, Delivery Ticket, or Move Ticket. At the drop point the Delivery Ticket or Move Ticket is signed by the custodian or the driver to verify delivery. Drivers are responsible for securing vehicle loads, even if loaded by another group, and for the safety and condition of the load until it is delivered. Drivers are not provided with manifests of the materials to be delivered.

Stores-delivered cylinders are transported to all areas on approved cylinder trucks; small propane bottles and dewars of liquid nitrogen filled from the large tanks near to Stores are delivered to the field using Stores vehicles.

Intra-area shipments of cylinders, however, are transported by Centralized Trucking.

Stores also provides a service to package HM shipments for delivery to offsite destinations, as follows:

- On request from other SRP and SRL groups, Stores prepares HM packages (except for radioactive materials) and shipping documents in compliance with DOT regulations. HM shipping documents are filed separately from other documents in Stores Division files. Most (95%) HMs (other than radioactive) shipped from SRP are prepared for shipment by Stores. Many of these shipments involve laboratory samples. Packaging of the shipments is done at the 713-A facility. Materials are transported to 713-A by various means from other locations on the SRP reservation.

- Stores provides a service to DOE-SR by preparing Bills of Lading for radioactive material shipments originating from SRP (except shipments that use DOE Safe Secure Transport (SST) tractors or SST tractors and trailers). DOE is the shipper of record for all radioactive materials shipped from SRP per the Du Pont contract.

  Receipts of HMs at the SRP from offsite are preceded by the development of purchasing documents. Cross references to these documents are subsequently recorded on Delivery Tickets which are retained in the Stores Division files.

Sample Trucks Assigned to 200-Area. Two 1-1/2-ton trucks with van-type bodies are assigned to Building 221-H for use primarily as sample delivery trucks. The sample trucks are used for delivering samples from H-Area facilities and Building 235-F to Building 772-F laboratory; neptunium product containers from the H-Area B-line to Building 235-F; and samples from H-Area, Building 772-F laboratory, Building 235-F and JB-Line to SRL at Building 773-A.

The driver assumes responsibility for the samples when he signs the appropriate form and the receiver accepts custody when he signs the same form at the destination. For security reasons, samples may not be left unattended in the sample truck.

Sample Trucks Assigned to Reactor Areas. Each of the Reactor Areas is assigned a vehicle (modified pickup truck) used primarily to transport process samples to the laboratory in Buildings 772-D and 772-F. The Reactor Department is the shipper and the transporter. The samples are removed from the vehicle by Reactor Department personnel and hand-delivered to the laboratory. Standard procedures are followed.

Routine process water samples from the 105 Buildings contain sufficient tritium to require Type A packaging for shipment on public access roads.

Each sample truck has a DOT specification 7A drum approved as a Type A package mounted on the truck bed.

When moderator samples are transported to Building 772-D, the shipper is responsible for documentation and/or following procedures to properly package the samples for shipping and unloading. The shipper is responsible for properly preparing the DOT 7A drum for the return trip.

When samples are transported, departmental and HP requirements are followed for 1) radiation and contamination control during transport and at destination, 2) packaging, identifying and separating samples, 3) receiving samples in the vehicle, and 4) minimizing radiation exposure for the driver. Samples are delivered to laboratory personnel.

High Level Waste Trailer. The high level waste trailer is a lead-shielded, stainless steel vessel used for transporting high level radioactive liquid waste from SRL to Building 211-F for processing. The trailer contents activity level, which is controlled administratively by limiting discharges to the holding tanks from which the trailer is filled, is generally between 10^5 d/m/ml and 10^6 d/m/ml. Criticality control of the waste is administered by SRL.

When the trailer has been filled and decontaminated according to SRL procedures, Centralized Trucking delivers a tractor to Building 776-A for transport of the trailer to Building 211-F. SRL notifies the operating foreman in Building 211-F when the trailer leaves Building 776-A. An escort is provided by Centralized Trucking and the maximum speed allowed is 35 mph.

An OHP survey report and a high level waste shipment form are prepared by SRL and accompany the trailer. SRL is responsible for the condition of the trailer, contents, and shipping. Centralized Trucking is responsible for delivering the load and the Separations Department is responsible for unloading.

Waste Handling. With the exception of construction wastes, which are handled by a group reporting to the Construction Department, routine transportation of regulated and non-regulated wastes on the SRP site is handled by EM&GS.

Regulated wastes contain radioactive materials. Examples of regulated wastes transported include metal burial boxes containing low level radioactive wastes that are routinely transported to the Burial Grounds (at a rate of about 800 boxes per month). Non-regulated wastes include trash which is transported to onsite land fills. Non-radioactive hazardous materials that are moved include waste oil in 500-gal containers by load-lugger from 716-A to the SRP power plant (about twice per year). About 40 shipments of waste oil are made from the 100-Areas to the 400-Area each year. Other materials such as asbestos are also transported by EM&GS.

Work requests are not used for routine trash hauling and, because they take place almost every day, shipments are not coordinated with shippers and receivers. For hazardous materials, however, the standard procedures are followed.

Deliveries of Gasoline and Diesel Fuel. Gasoline and diesel fuel used by field equipment (other than Construction Management's equipment) on the SRP site is delivered by EM&GS tank trucks nightly. These trucks function as mobile service stations.

Pickups, Shuttles, and Sedans. Shipping radioactive or other hazardous materials via pickups, sedans, or shuttles at the SRP is discouraged. However, if material must be transported by this mode the shipper is responsible for packaging, loading, and transporting the HM.

4.2.1.7 Receiving

The receiver has various responsibilities depending on the type of material shipped.

In the case of nonhazardous materials, the Stores Order may be retained but all move tickets are discarded; however, if there is any discrepancy in the material, packaging, or loading the receiver notifies the shipper immediately and does not unload the truck unless agreed upon by the shipper.

With HMs, the receiver ensures that the quantity of material is accounted for when received and that it is safely contained. If a difference is detected that cannot be easily resolved or if the integrity of the package is compromised, the receiver reports this to the shipper for any necessary corrective action. The receiver is responsible for making any special arrangements for unloading and for supervising the unloading unless corrective action by the shipper is called for.

With fissile materials, the receiver has the additional responsibility of directly supervising the unloading of the material and signing and distributing any accountability forms.

If any discrepancies are noted in the material, packaging, or loading of radioactive materials, the shipper is requested to direct the unloading. Otherwise the shipper is informed that the shipment has been received.

If a survey is required, the receiver notifies HP or OHP. HP or OHP performs the necessary health physics checks of the shipment.

4.2.1.8 Escorting

In compliance with safeguards requirements, all vehicles used to transport reactor fuel are radio-equipped. Also, stake-body trucks that are used to transport other products and wastes are radio-equipped (for efficiency purposes rather than because of occasional radioactive loads). Escorts with radio-equipped vehicles accompany some wide loads, very high loads, loads over

40 ft in length, and other special equipment such as the high-level waste trailer and the No. 1 deionizer cask. The availability of radio communication permits rapid assistance if needed.

The locomotives are equipped with radios for communications with the dispatcher in Building 618-G. Train crews are instructed to stop the train if they observe leaks from 70-ton casks during transit from the 100-Areas to the 200-Areas. If leaks are observed, the dispatcher is called for assistance. Locomotives moving cask cars travel at 25 mph except at highway crossings where the trains slow down to 3 to 4 mph.

4.2.1.9 Reporting and Recording of Shipments

Documents used in the control of movements of materials are listed in Table 4-3. Radioactive sources are supplied by many different vendors and are usually shipped via Federal Express to assure traceability in case of loss in transit.

4.2.1.10 Special Controls and Safeguards

Safeguards for Special Nuclear Materials. Special nuclear material (SNM) is defined as: plutonium, uranium enriched in the isotope U-233 or in the isotope U-235, and any other material which has been determined to be special nuclear material, but does not include source material; or any material artificially enriched by any of the foregoing, but does not include source material (source material is uranium or thorium or any combination thereof). Table 4-4 shows the categories of SNM. Categories I and II are shipped in radio-equipped cars or trucks and require an escort of armed couriers or security inspectors in a vehicle equipped with a two-way radio. At least two such couriers or security inspectors are required for Category I shipments and at least one such courier or security inspector is required for Category II shipments. Category III quantities of SNM require no escort.

In general, all SNM transferred between areas at the plant site is handled by Centralized Trucking. Special procedures have been established for transporting, escorting, and tracing shipments that are delayed or lost enroute.

Any SNM prepared for offsite shipping is stored in a vault in the operating area or is transferred to the custody of DOE in a vault in H-Area. Upon transfer of custody, DOE couriers are responsible for safeguards during transport onsite and offsite. Incoming offsite shipments of classified materials or SNM are safeguarded by DOE couriers until the package is delivered to a processing facility.

When the SNM is not readily separable from other radioactive material and the combination of the SNM and other radioactive material delivers an external radiation dose of 100 rem/hr or more at 1 m from any accessible surface without intervening shielding material, it is exempt from these requirements. SNM that has been declared as waste is also exempt.

TABLE 4-4. Categorization of Nuclear Material*

Special Nuclear Material	Category** I, kg	Category** II, g	Category+ III-A, g	Category III-B, g
Plutonium	2 or more	400 to 1999	220 to 399	1 to 219
U-235	2 or more	400 to 1999	220 to 399	1 to 219
U-235 contained in uranium enriched to 20% or more	5 or more	1000 to 4999	350 to 999	1 to 349
U-235 contained in uranium enriched to less than 20%	-	-	-	All quantities above 0.99 g

*Source: DOE Order 5632.2 Physical Protection of Special Nuclear Material. Also see DOE Order 5632.1 Physical Protection of Classified Matter.

** If plutonium or U-233 is combined with U-235, the amounts of plutonium or U-233 are multiplied by 2.5 to arrive at the limits shown.

+ A plutonium or U-233 content of less than 400 g may be combined with U-235 when the total content is less than 1000 g.

UNH Trailers. Four DOT specification MC312 cargo tankers (UNH trailers) are assigned to H-Area canyon and outside facilities which were used as shipping containers for uranyl nitrate hexahydrate (UNH). The trailers are no longer authorized for shipment offsite.

Onsite movements of the trailers are performed by Centralized Trucking drivers using SRP tractors.

The DOE Safeguards and Security Branch arranges for pickup of the UNH trailer by the driver and the couriers of the DOE Transportation Safeguards Division (TSD) at an appointed time. The solution temperature has to be 50°F or above when delivered to the carrier.

Loaded trailers are always either under surveillance by Separations Department personnel who perform the loading operation, parked in a protected area under surveillance of security inspectors, attended by Q-cleared drivers escorted by security inspectors, or under control of DOE couriers.

4.2.1.11 Railroad Activities

System and Equipment. The onsite rail system is interfaced with the commercial railroad at the Dunbarton Wye near the Building 618-G Classification Yard and at the Ellenton Wye near 400-D Area. The SRP line is operated by Railroads within RR&FS. Cars received from offsite rail lines and SRP-owned cars are moved within and between areas.

Under special circumstances, a piece of SRP rolling equipment, such as a car or a switch engine, must be moved between 400-D and some other area. The portion of the move on Seaboard Coastline (SCL) track must be made by SCL. The procedure is: SRP spots the equipment on the siding (at Dunbarton or Ellenton), SCL couples it to its train, delivers it to the other siding, decouples, and then SRP completes the move.

The bulk of the rail traffic is coal and cask car movements. Coal cars are moved from the SCL interchanges at Dunbarton and Ellenton to area powerhouses for use in steam generating boilers. Cask cars are moved between the reactors and the 200-F and 200-H separations buildings. Other cargo, such as tank cars, steel, utility poles, bulk chemicals, helium cars, and a variety of other goods are moved from the Dunbarton and Ellenton interchanges to areas on the site. Occasionally, cargoes are moved between areas at SRP. Approximately 14,150 cars were moved during the 1984 calendar year.

All SRP train movements are closely monitored and strictly controlled by the shift supervisor located in Building 618-G. There is constant radio communication with the train crew and the location of each train is known at all times. Train crew members are outfitted with a radio transceiver which allows constant communication between crew members. This has improved safety, especially during switching and pushing tasks. Rail services are provided seven days per week, from 7:45 a.m. to 12:00 midnight.

Cars carrying radioactive materials in the central site areas (excludes D-Area) are handled by any of the four locomotives and are not mixed with cars carrying other cargo. Special trains hauling spent fuel casks or equipment contaminated with radioactive materials are operated at speeds of less than 25 mph and are slowed to less than 4 mph at railroad-highway crossings; they travel about 40,000 mi/yr. In the 200-Areas, the cask cars are uncoupled outside the railroad tunnel, and a small battery-powered locomotive (dinky) is used by Separations personnel to position the car in the railroad tunnel for unloading.

The dispatcher in Building 618-G maintains radio contact with the SRP locomotive crews, including crews operating the D-Area locomotive. He also maintains a log sheet containing information on the location of all locomotives and cars and the status of operations, including repairs and decontamination, that are in progress.

Responsibilities of Railroads Organization. Specific responsibilities of the Railroads organization include: maintenance of track, roadbed, and rail crossings on the site; safety of rolling stock assigned to Railroads; higher operation of the railroad in support of SRP operations; acceptance of offsite originating rail cars; and pre-release inspection of SRP-originated rail shipments.

Railroads personnel are not necessarily qualified to judge the proper function or safety of transport packagings; however, if a train crew observes an unusual condition, such as fluid leakage or an unattached tie-down, this condition is reported to the shipper for resolution. Onsite and offsite shippers are responsible for proper documentation of shipments. All radioactive material shipments released for shipment to offsite destinations and received from offsite are surveyed for compliance with DOT regulations regarding radiation levels and surface contamination by HP prior to being moved by SRP Railroads.

Procedures. For intraplant movements of regulated rail cars (a "regulated" vehicle is one that is specifically designated for the transport of radioactive materials), the shipper fills out a Cask Car Release Record and leaves it in the box provided on the car. He then notifies the train dispatcher that the car is ready to move.

After assignment by the train dispatcher and before coupling the car, the conductor examines the forms in order to ensure the correct car is to be moved and that the forms are properly signed. The train crew then moves the car to the receiving location and leaves the form in the box provided. The conductor writes down the car number, location, and destination on his switchlist and, at the end of the day, forwards all documents to the dispatcher.

Movements of non-regulated cars are made by verbal request, as are inbound cars from common carrier railroads. All inbound cars, other than open top cars, are inspected according to set procedures. When the cars are ready (either empty or loaded), the receiver contacts Railroads for the car or cars to be released.

Non-routine shipments of radioactive materials require job plans approved by the originating department, HP, and Railroads. There are special procedures for moving vessels, containers, and high loads.

In the case of derailments or other emergencies, the train crew must immediately notify the shipping supervisor, HP, and the Railroads area supervisor. If a cask car exposes or spills its contents as a result of a derailment, personnel are required to move away to a distance of 1000 feet, and arrange for flagging and stopping of all movements until clearance is given by HP.

4.2.2 Operating Experience

4.2.2.1 Releases from Normal Operations

Releases from normal operations are those releases that are small, routine, and have a negligible health and environment impact. They include releases of vapor while filling a tank truck or tank rail car or drips that might occur during unloading of these containers. They also include releases that occur because of usual and acceptable imperfections in containments, such as slight seepage of closure gaskets on tank trucks. Leakages resulting from improper assembly to quality defects, however, are considered to be accidents.

SRP training and operating procedures emphasize the care required by personnel in minimizing releases of HMs, both due to accidents and due to normal operations. Secondary spill containment is usually provided during loading, unloading, and storage of liquid HMs.

4.2.2.2 Accidents

For purposes of this report, an accident is defined as "an obvious failure of a containment, failure to adhere to established procedure, or other unplanned incident that results or could result in a release of hazardous material or results in an otherwise unanticipated health or environmental consequence". On the other hand, leakage from unshielded tank trailers due to leaking gaskets or valves during transport are recorded as incidents. Such leakage has occurred 10 times since 1958, each case leading to contamination of the roadways.

The SRP Fault Tree Data Bank was reviewed to determine the types of events/accidents that have occurred at SRP. This data base was originally developed for fault tree analysis and has limitations in other applications. With the limitations in mind, the review of the data base yielded the following tentative conclusions:

- It does not appear that any events posed a threat to personnel more than 100 feet away and probably none caused a threat to the offsite population.

- Most of the events (approximately 70%) refer to contamination found on vehicles or the ground and, from the point of view of release of HM, appear to be minor. Most of the remaining events/accidents involve minor vehicle collisions with negligible damage and accidents to non-employees driving on Highway 125.

- Very few accidents involved injuries to personnel. In some cases, radionuclides were detected on clothing and in rare cases, on skin. It appears that very few of these caused "injury" to personnel.

Table 4-5 provides semi-quantitative information on the type and frequency of accidents at SRP between 1957 and 1982. The majority of accidents are caused by vehicle operator errors (about 25/yr, including 8 accidents/yr while backing vehicles). The current frequency of rail crossing accidents/events is mainly from vehicle operators running the blinking red light or stopping and then "beating the locomotive" at the crossings of the onsite railroad.

The detailed history of transportation accidents/events at SRP, with emphasis on those involving radioactive materials, is included in Appendix G.

4.2.2.3 Overall Safety Record

Overall Plant Safety. SRP has had an excellent safety record since plant start-up and has consistently exceeded the national averages (3).

During construction, two world records for safety were attained by the Du Pont Construction Division, and a reduction of liability and insurance rates to one-thirteenth of the average of the construction industry was recorded.

In 1970, Du Pont Operations received the Atomic Energy Commission "Best Ever" Award in industrial safety for having accumulated the largest number of injury-free work-hours ever achieved by an AEC contractor. The accident-free record continued beyond winning the AEC award, and extended from June 1967 until May 1972, a period of four years and ten months. During that time the Du Pont operating group worked more than 39 million consecutive work-hours without a disabling injury. This was the best continuing safety performance by any industry during those years and is the second best safety record ever recorded in any industrial operation in the United States. No disability at the plant has resulted from a nuclear or radiation process (3).

Since inception of the project, there has been a continuing downward trend in accident experience and a parallel downward trend in the cost of workman's compensation. The direct costs of compensation for the overall plant, including SRL and the higher risk construction activities, has for several years been less than five percent of the national average for the chemical industry and less than ten percent of the national average for office workers.

TABLE 4-5. Summary of Transportation Accidents/Events at SRP 1957-1982

Category of Accident/Event	No. of Accidents/Events	Serious Consequences
Rail track switching	10	1 fatality, 1 operator broke both elbows
Derailments	19	none
Rail crossing accidents/events (mainly events - see test)	~6/yr	4 fatalities (including 3 prior to plant start-up)
Loss of load during rail transport	2	none
Loss of load during road transport	6	none
Fires - cargo during transport	none	
- cargo before or after transport	11	none
- carburetor fires	25	none
- other vehicle fires	32	none
- rail operation fires	8	none
Natural phenomena	none	
Aircraft interaction	1	none
Vehicle operator errors, including some of those mentioned in categories above.	~25/yr	none

Examples are:

- 1 gasoline truck overturned
- at least 3 accidents involving pulpwood trucks
- ~10 vehicles moving due to improperly set brake
- ~3 accidents/yr while backing vehicles

Transportation Safety. As can be seen from Table 4-5, the transportation safety record at SRP has been very good. As mentioned previously, there have been no accidents of vehicles carrying radioactive materials.

The reason for this excellent record is the emphasis placed on safety by Du Pont management. This includes precautions, such as not shipping radioactive materials during adverse weather conditions and forecasts of adverse conditions (e.g. tornado watches). Since 1982, HMs transported across or along Highway 125 are packaged in compliance with DOT regulations or, when such packaging is not feasible, transportation safety is augmented by administrative controls. In addition, the preventative maintenance program minimizes mechanical failures during operation of vehicles and, therefore, minimizes risks from this cause.

It is worth distinguishing between the different approaches to safety for offsite (shipments to destinations off the SRP) and onsite shipments. The offsite shipments are governed by DOT regulations which place emphasis on regulated containment systems, while onsite shipments balance reliance on the safety training and the safety consciousness of the involved personnel with reliance on containments. In addition, if there ever is a serious transportation accident on the site involving HMs the emergency response will be conducted by the SRP Spill Team. The response will be immediate, by trained personnel using locally available equipment, and under the direction of the SRP Technical Support Center (TSC).

4.3 PROCEDURES

4.3.1 Administrative Procedures and Control

A formal administrative control system ensures that the basic and important decisions affecting safety or operability are adequately reviewed (4). The system requires the review by a competent technical organization other than the one charged with direct responsibility for conducting and controlling the operation of the facility.

Transportation is a plant-wide activity that involves almost all departments as shippers and receivers. The actual transportation activities, however, are primarily the responsibility of Stores (in the Procurement and General Services Department), RR&FS (in the CSWE) and EM&GS (also in CSWE). Equipment is operated by qualified operators who have received rigorous training in operating procedures and safety systems, and who carry out transportation activities according to detailed written procedures.

The RHYTHM Committee provides independent inputs into program planning and implementation and a continual review of operations. The RHYTHM Committee also approves all operation procedures involving transportation and handling of HMs. Departments such as Health Protection and Long Range Planning provide advisory reviews. The Technical Division provides an independent review of transportation operations.

In addition to its independent review, the Technical Division provides basic technical information for process and equipment design and operation. The Technical Division prepares Technical Manuals, Systems Analyses, Technical Standards, and Safety Analysis Reports. This division also maintains liaison on technical matters with other interested parties such as DOE.

The Site Hazardous Material Coordinator (HMC) audits the performance of the plant departments that ship hazardous materials offsite. These audits include checks of selections of HM packagings, preparation of shipping papers, and documentation of compliance with procedural requirements. The HMC also independently reviews and approves all preparations for shipments of radioactive materials from the SRP. This last function was performed as a service to the local DOE field office which acted as the shipper for all radioactive material shipments from the SRP under the Du Pont contract.

4.3.1.1 Investigations and Reports

Notification and Reporting of Occurrences to DOE. A system for notification, investigation, and reporting of occurrences to DOE-SR is maintained. An occurrence is defined as any deviation from the planned or expected behavior or course of events if the deviation has safety, health, cost, or environmental significance. Occurrences are classified according to seriousness. Time limits and responsibility for notification or investigation are as follows:

- Type A: Immediate verbal notification; written follow-up within 72 hours; investigated by DOE-SR.
- Type B: Verbal notification within 24 hours; written follow-up within 72 hours investigated by DOE-SR, but may be delegated to Du Pont personnel.
- Type C: Verbal notification as soon as practicable, but no later than the workday following the end of the quarter; written information no later than the 8th calendar day following the end of the quarter; investigated by plant personnel.
- Unusual Occurrence: Occurrences that have significant adverse programmatic effect and involve information that can be used at other DOE sites to avoid similar occurrences are reported into this DOE-wide system. The coordination of the release of SRP Unusual Occurrence Reports to DOE-SR and the review of Unusual Occurrences Reports from other sites are made by the Manager of Operations or his delegate.

Special Incident Reports. Special Incident Reports are formal reports that are prepared when incidents are of major proportions or are likely to be of interest to outside groups. They are in addition to and entirely apart from the Notification and Reporting of Occurrences and the usual "Incident" report prepared by direct supervision. The decision to prepare a Special Incident Report is made by the Plant Manager or Wilmington management.

Process Incident Investigations and Reports. Various incident reports are usually initiated by a shipping or receiving group following a mishap involving transport of HMs. If the primary involvement is RR&FS equipment or an equipment operator, then RR&FS initiates the appropriate investigation and report.

Reports of process incidents are made using a system that provides a mechanism for prompt reporting of all incidents and assures that the thoroughness of the investigation, the follow-up, and the distribution given the report are commensurate with the seriousness of the incident. An incident is defined as any event that is a deviation from the accepted normal operation and appears to have significant implications relative to safety, equipment performance, or process operations. These reports are made as described below:

- Separations Incident Reports. Separation Incident Reports discussed here illustrate the scopes and effects of Incident Reports that are made by all Project Management Team organizations at the SRP. A Separations Incident Report is used to describe events that constitute deviations from the accepted normal operation of the process and associated equipment (note: process and equipment is broadly interpreted to include transportation and hazardous material transport containers where these are associated with a facility's operations). This report is intended to call the Separations Department's attention to incidents with significant potential and, through a study of compilations of these reports, to establish trends in the operation that might not be obvious over a short period of time. Separations Incident Reports are prepared by the Separations Technology Department and reviewed by the Separations Department.

- Operating Incident Reports. After an incident occurs that appears to have important significance to safety or operation of the facility (this could include an incident in a shipment made from the facility), the Separations Department Area Superintendent convenes a committee to investigate the incident and issue a report. (Note: As above, the Separations Department's practices are used here to illustrate the practices of all SRP Project Management Teams.) A Separations Department supervisor acts as chairman, and Separations Technology participates on the committee. Other groups that are involved in the incident, or that may be concerned with the findings, also participate. This committee attempts to determine the cause of the incident and to develop recommendations to prevent recurrence. The committee issues a report called an Operating Incident Report.

- Special Hazards Investigations. These investigations are made for unusual incidents involving actual or potential radiation exposure, radioactive material or if criticality control limits in Technical Standards, TAs, or OSRs have been exceeded. Jurisdiction over the investigations is assigned to the Plant Central Safety Committee.

- Unusual Incident Reports. Unusual Incident Reports (UIs) are prepared to describe situations involving high injury potential. The involved employee's department superintendent initiates the investigation. Where personnel are not directly involved, the superintendent of the department owning the equipment concerned initiates the investigation.

- Daily Reports. The Operations-Program Management Team (PMT) and Plant Facilities and Services organizations issue daily reports to Wilmington, with copies to SRL and DOE-SR. These reports include information about a significant incident shortly after it has happened.

- Monthly Reports. Activities of all Operations - PMT organizations and Plant Facilities and Services organizations are summarized in monthly reports. Individual program reports for Separations, Raw Materials and Tritium Facilities, and Waste Management describe technical studies of the nuclear safety and other technical aspects of facility operation, failure to meet a technical standard and/or an operations safety requirement, the status and efficiency of production, and design activities. Separate reports are issued to document the status of the Quality Assurance Program and Environmental Control.

  The Technical Division, Savannah River Laboratory, issues a monthly progress report of significant results from studies relating to nuclear safety, process improvements, and new processes and products.

- Annual Reports. An annual report of the results of the auditing and incident investigation system for the separations areas is made by the Separations Department and the Separations Technology Department. This report includes statistical information on the audit results and on the number and kinds of unusual incidents. It also includes short discussions of the investigation and action taken on incidents that appear to have the most safety significance.

4.3.1.2 Operational Control Documents

The following is a brief discussion of Du Pont Operational Control Documents. The sequence and level of control of each of these documents is shown in Figure 4-6.

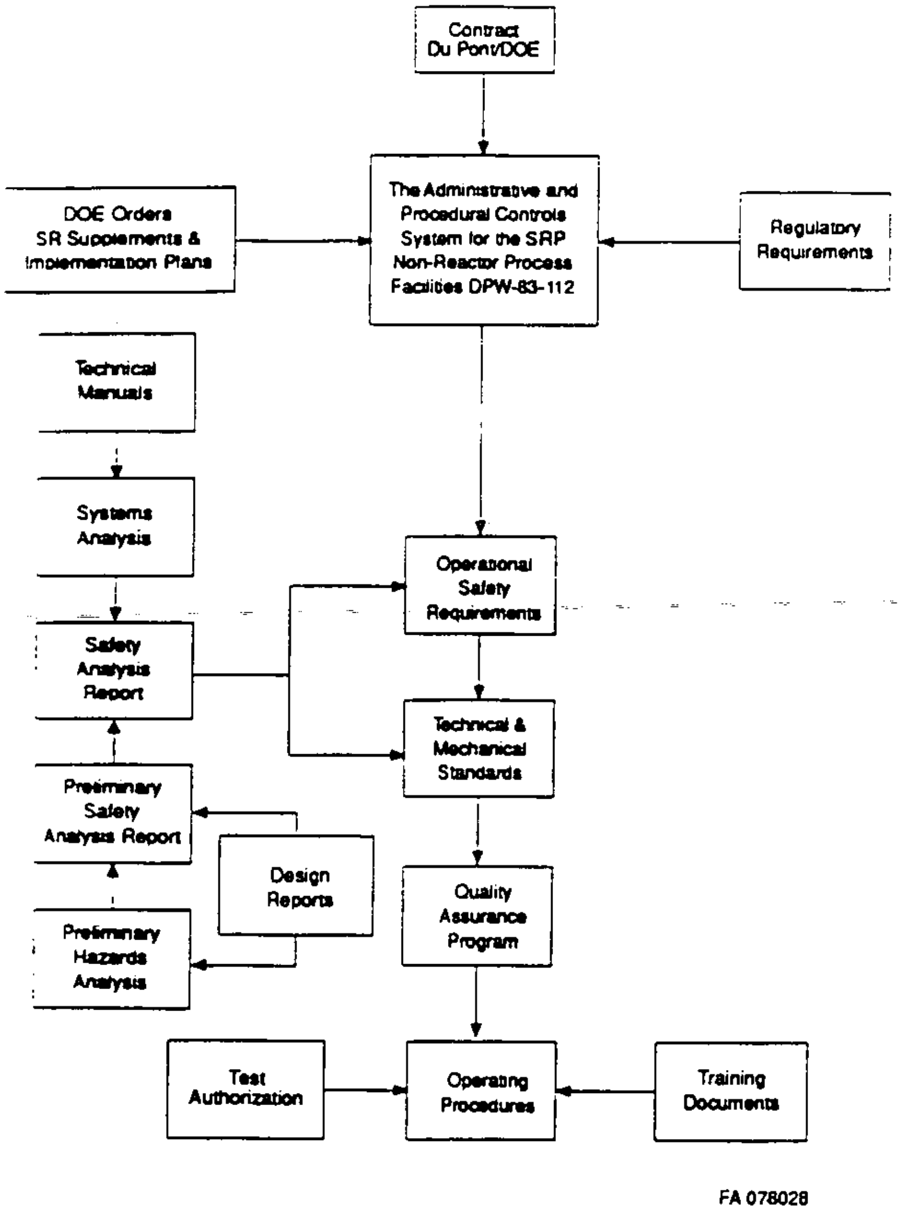


FIGURE 4-6. Document Requirements and Procedures Flow Chart

Nuclear Criticality Safety Control. Nuclear criticality safety controls are administratively achieved through:

- Systems Analysis Reports
- Safety Analysis Reports
- Operational Safety Requirements
- Technical Standards
- Nuclear Criticality Safety Supplements
- Operating Procedures

Systems Analyses. Systems Analyses (SA) are comprehensive reviews of the equipment, processes, and operations of functional systems. The objective of these reports is to determine the risk of operating each facility. The reports provide technical bases for determining the interaction of the various systems as presented in the Safety Analysis Report. Systems Analyses are prepared by the Technical Division, and the reports are reviewed and approved by both the Manufacturing Division and the Technical Division of AED.

Safety Analysis Reports. A Safety Analysis Report (SAR) is a document that describes the facilities, processes, equipment and operations analyzed, and evaluates the risk of accident sequences and consequences. Both onsite and offsite risks are included. The SAR is prepared by the Technical Division and is reviewed by the Technical and Manufacturing Division prior to significant facility modifications, and is updated within a five-yr period. New issues and revisions to SARs are approved by Du Pont AED and DOE-SR.

Operational Safety Requirements. Operational Safety Requirements (OSRs) define the envelope of authorized operations of the non-reactor nuclear facilities and formally document the requirements in the following categories:

- Safety Limits and Limiting Control Settings
- Limiting Conditions for Operation
- Surveillance Requirements
- Design Features
- Administrative Controls

OSRs and revision proposals are prepared by consultation of AED and DOE-SR staffs.

Technical Standards. Technical Standards define the process limits within which the facilities are operated ensuring the safety of personnel, permanently installed equipment, and the environment. The standards specify the requirements and bases for basic variables within which the process must be operated for reasons of safety, quality, and/or limitations of known technology. These requirements are within the boundaries of safe conditions reported in the OSRs, Safety Analysis Reports, and Technical Manuals. Technical Standards are authorized by the Director of the Technical Division after approval by the Manufacturing Division.

Mechanical Standards. Specifications for the physical installation of buildings, process and service lines, and equipment are termed Mechanical Standards. These standards are maintained in several forms as follows:

- Du Pont, Subcontractor, and Vendor Drawings. New issues or changes are approved by the cognizant SRP department and, as appropriate, the Departmental Engineer's Office in Wilmington.

- Du Pont Engineering Standards and Specifications and SRP Engineering Standards and Specifications. The Du Pont Engineering Department issues the Du Pont Engineering Standards and Specifications and keeps them current. The SRP Engineering Standards and Specifications are written for local use and provide uniform requirements for design and specifications. Additions and revisions are authorized by the cognizant department and approved by the program manager.

- SRP Project Specifications. These specifications for the purpose of material procurement may include requirements for vendors and for onsite installations. New specifications and supplements are authorized by the program manager and issued by the Du Pont Engineering Department.

Technical Manuals. Technical Manuals, issued by the Technical Division, may be prepared by either SRL or the cognizant SRP department. These manuals contain the basic technical information used for the design of facilities and for the preparation of Technical Standards. Technical Manuals are approved by both Technical and Manufacturing Divisions.

Design Reports. There are three different types of design reports: 1) Technical Data Summaries are prepared and issued by SRL for planning projects that evolve from results of research and process development activities; 2) Basic Data Reports are prepared and issued by SRP for planning projects for additions or modifications to plant processes or facilities; and 3) Design Data Reports are issued by the Engineering Department for final project design.

Test Authorizations. A Test Authorization (TA) authorizes temporary deviations from Technical Standards, Operating Procedures, or Mechanical Standards. The TA is used to conduct process study trials with plant equipment, or to authorize non-standard operations not covered by Technical Standards or Mechanical Standards. Limits defined by the TA will be at or within the boundaries of safe conditions specified in the OSRs. TAs are authorized by the Manufacturing Division Director after approval by the Technical Division; an exception is allowed when departures from Operating Procedures are within Mechanical Standards and Technical Standards. The TA may then be authorized by the Plant Manager after approval by the cognizant PMT (also by Nuclear Engineering and Materials Section of SRL when nuclear safety is involved).

Plant Interpretive Documents. These are interdepartmental memoranda which document such things as recommendations made by technology groups to operating groups regarding changes in processes or procedures, agreements on matters of departmental interactions, program planning and scheduling, transmittal of information developed during in-plant tests or studies, and actions necessary to implement any special programs. These memoranda usually are prepared by staff personnel and approved by the superintendent of the originating department, or his delegate.

Quality Assurance Assessment Reports. QA Procedures require that QA assessments be performed for existing facilities and processes, new designs, and modifications to existing designs to define the application of a formal QA program proportional to need. The SRP Quality Assurance Program is discussed in Section 7.0 of this report.

4.3.2 Operating and Maintenance Procedures

4.3.2.1 Overall Control System

Du Pont imposes an internally authorized system of control procedures to ensure that facilities are operated and maintained in conformance with management policies, as prescribed in the administrative control procedures for non-reactor nuclear facilities. The system incorporates the following operating objectives:

- Maintain safety of personnel, equipment, and facilities.
- Maintain continuity and increase efficiency of operations.
- Maintain compliance with applicable governmental regulatory requirements to ensure public health and safety and to protect the environment.

Inherent in the controls system is the precept that all process operations are to be performed according to approved written procedures that have been reviewed in an effort to preclude unsafe consequences, either directly or as a result of a possible chain of unfavorable events. Audits of procedures are performed and documented, and periodic reassessments of facilities and processes are conducted. The objective of the audits is to identify any previously unrecognized hazards that may have been created by changes in process conditions, operating practices and equipment, or knowledge of the condition and behavior of construction materials.

4.3.2.2 Operating Procedures

Applicable procedures that govern the preparation for transport, transport and receipt of hazardous materials at the SRP are as follows:

DPSOP-40	Savannah River Plant Radiation and Contamination Control
DPSOP-159	Shipment and Receipt of Nonradioactive Hazardous Materials
DPSOP-170	Interarea Shipments
DPSOP-176	Offplant Shipment and Receipt of Products, By products, and Other Radioactive Materials
DPSOP-176-2	Facility Procedures Packaging of Radioactive Materials for Offsite Shipment
DPSOP-301	Traffic and Transportation Department General Operating Procedures

All process operations and many allied activities, such as maintenance operations, are performed according to written procedures. A procedure supplies detailed how-to-do-it directions (usually in a stepwise manner) for a given process or operation. The intent is to ensure systematic control of safety, quality, and yield. It is a removable-page document, and routine practices are established for its continual revision so that directions can be kept up-to-date and obsolete copies are not available for inadvertent use. An explanation of these procedures is given below:

Du Pont Savannah Operating Procedure (DPSOP). A DPSOP is a book divided into chapters (I, II, etc.), then into divisions (A,B,etc.), and within these, into sections (1,2, etc.). A DPSOP may contain one or all three of the following types of unit-pages.

- A text page contains descriptive information and/or stepwise directions.
- A figure page consists of a chart, drawing, process diagram, or photograph.
- A DPSOL (Du Pont Savannah Operating Log) page is meant primarily for separate on-the-job use as a logsheet for recording data, time, and checkoff or initials to show job progress.

Du Pont Savannah Operating Log (DPSOL). There are two categories of DPSOLS: "Training and Reference" (T&R) and "Use Every Time" (UET). The T&R serves to standardize instructions and aid in instructing a person new to a job. DPSOLs are written or revised by department supervisors with technical assistance from SRL.

Manuals. Apart from DPSOPs, there are several unnumbered manuals that contain administrative procedures concerned primarily with plantwide policies applying to personnel. Three examples are: the SRP Procedures Manual, which contains procedures that involve intergroup rather than intragroup dealings, office letters issued by the Plant Manager, and announcements of long term interest; the Security and Safeguards Manual, which defines minimum security requirements for the plant based on DOE regulations; and the SRP Safety Manual, which defines basic plantwide safety policies and minimum requirements. These and other manuals are described in Reference 5.

4.3.3 Emergency Procedures and Plans

4.3.3.1 Emergencies in Transit

For nonfissile HM (radioactive and nonradioactive), in which the material is not involved, emergencies in transit are handled in the same way as for non-hazardous materials by RR&FS, i.e., the driver notifies the dispatcher, who notifies the drivers supervision and supervision takes appropriate action.

For intransit emergencies during any shipment of fissile materials and for intransit emergencies involving nonfissile radioactive materials in which the material is involved, all persons are required to move at least 200 ft upwind or crosswind from the scene. At least one person stays constantly at the scene but at the 200 ft distance. All traffic approaching the scene of the accident is stopped. The driver notifies the dispatcher by the most expedient means and the dispatcher notifies the shipper, who requests assistance from Wackenhut Services, HP, Medical, Fire Protection, and the Emergency Operating Center, the Energy and Environment Department and other SRP departments as appropriate. Any of the notified individuals or groups may in turn notify the SRP Spill Team if warranted. However, the Environment and Energy Department DHEC Coordinator will be notified in the case of any spill and will call the Spill Team if the team's capabilities and resources are needed.

4.3.3.2 Emergency Plans

The SRP staff has the organizational responsibility for determining emergency plans and courses of action for each plan. Periodically, the staff reviews the performance of the plant in emergency plan practice drills. The effectiveness of the plans is also reviewed periodically, and revisions are made as necessary. The policy of SRP is to limit the radiation dose to designated emergency workers to 25 rem (whole body) and 100 rem (hands) in an emergency which involves protection of personnel or property. In addition, the SRP policy is that radiation exposure to nonessential workers in an emergency situation should be limited to 30 mrem whole body equivalent. For life-saving acts, an exposure of 100 rem (whole body) plus 200 rem (hands) is considered as the guide value.

SRP has an Emergency Operating Center equipped with emergency materials such as radio equipment, maps, and plotting boards. Food and sleeping gear are also provided. In addition, each plant operating area has an emergency committee. In the case of the F- and H-Areas, there is a single committee which includes an F- and an H-Area Emergency Preparedness Representative.

The Area Safety Committees are responsible for implementing SRP emergency preparedness policies and procedures in their areas (6).

When this analysis was prepared, the Site Hazardous Materials Coordinator was responsible for developing and executing training programs and exercises for the nonradioactive transportation response team. He currently serves as point-of-contact for the EOC (now renamed Technical Support Center (TSC)) to screen incoming requests for transportation emergency assistance and, if appropriate, initiates the response procedure (such as securing approval, activation of team, notification, etc.). If the response team is activated, he advises and assists the emergency coordinator at the Emergency Operating Center.

There are four basic emergency plans (6, 7). They are:

- Shelter or Evacuation Plan
- Nuclear Incident Plan
- Offsite Warning Plan
- Spill Prevention, Control, and Countermeasures Plan

Shelter or Evacuation Plan. There are three types of emergencies considered which involve sheltering or evacuating personnel; all are practiced. They are:

- Facility Emergency (where an emergency may exist in only a single building).
- Area Emergency (where all buildings in an area are involved).
- Plant Emergency (where a local condition or a condition created offsite affects the plant site).

Each plant area has a designated emergency Facility Emergency Coordinator (FEC). Based upon his evaluation of any given situation, the Facility Emergency Coordinator determines whether evacuation or sheltering of personnel in the facility is or is not necessary. He announces that the facility emergency exists, provides instructions on the handling of personnel and facilities, and notifies the Area Emergency Coordinator. An Area Emergency is declared by the Area Emergency Coordinator, who notifies the plant EOC.

A plant emergency involving total plant evacuation or sheltering of facility personnel is initiated by the Plant Manager. Personnel, on the average, can be evacuated from or sheltered in a facility within 15 minutes from the time the evacuation is announced. An average area evacuation will take approximately 30 minutes up to the point of caravan formation.

Nuclear Incident. When the Nuclear Incident Monitor (NIM) bell alarms, all personnel evacuate immediately by predesignated, well-marked routes and gather at a predesignated rallying point. The alarms are connected to instruments in the control rooms of production facilities. Because of design and administrative controls, transportation vehicles and fissile material packages are not required to be equipped with NIMs or nuclear incident alarms.

Offsite Warning Plan. The Offsite Warning Plan sets forth the conditions for alerting offsite areas of a hazardous condition originating at SRP that may affect them. The radioactive or toxic gas source information, environmental monitoring data, and meteorological information available from eight towers and the Weather Center Analysis Laboratory received from the various locations onsite and offsite is plotted on appropriate maps by HP personnel at the EOC. The HP Senior Supervisor (HPSS) uses the Weather Information and Display (WIND) computer to calculate movement of the plume and arrival times at crucial location, such as the SRP site boundary, as well as predicted release consequences. Once the initial sequence is completed the mobile laboratory known as the Tracking Radioactive Atmospheric Contamination (TRAC) van is used provide near real-time monitoring and plume tracking of tritium and other contaminants. Using the assessment logic as found in DPSOP 286, a determination is then made regarding activation of the EOC or making notifications based on Action Guidelines. The HPSS is delegated authority to make offsite notification to state and local 24-hour emergency warning points if an SRP emergency has the potential to threaten public health and safety. The DPSOP 179 HPSS procedure is consistent with the South Carolina and Georgia SRP site-specific emergency plans and procedures. If a radiological release occurs to a stream the Area HP Coordinator (or EOC) determines the volume, concentration, type of release, location, and stream name.

Once the EOC is activated, data from the incident area is confirmed. WIND system calculations are verified regarding onsite downwind areas and population exposure points offsite. The TRAC van is used to verify downwind concentrations and determine offsite dose estimates. A determination is made regarding the classification level of the hazard. Offsite hazard classification guidance including maximum individual exposure thresholds for offsite warning and event declaration is given in DPSOL 179-104, Checklist for Health Protection Senior Supervisor (EOC) Supervisor).

The offsite area around the Savannah River Plant has been divided into sixteen 22-degree sectors extending from the center of the plant. the sectors are numbered 1 through 16, and one or more may be designated hazard sectors according to prevailing conditions. County maps showing more details are provided in the EOC and in map packets for emergency vehicles by monitoring teams (2).

Spill Prevention Control and Countermeasures Plan (SPCC) (8). The SPCC Plan is designed to be implemented to ensure protection of the environment through planned responses to oil and chemical spills onsite. In practice the spill response elements of the SPCC Plan are implemented whenever there is a spill of any environmentally damaging, or potentially damaging, substance (includes transportation of hazardous materials) at the SRP. The plan specifies actions required to ensure that spills of hazardous materials are 1) prevented to the extent practical, 2) controlled whenever a spill occurs to prevent dispersion into the environment, and 3) mitigated to ensure that releases to the environment remain within acceptable levels as specified by South Carolina Department of Health and Environmental Control (DHEC). The SPCC Plan is administered by the Energy and Environment Department of the Plant Facilities and Services Technical Department. SRP has contracted with the O.H. Materials Corporation of Ohio, an EPA-certified company, to assist in the development and implementation of the SPCC Plan.

4.4 TRAINING

4.4.1 General Training and Qualification

The type of equipment and the nature of the work performed at SRP are unusual and subject to requirements far beyond those of more conventional industries. Of primary importance are requirements regarding the qualifications and training of the individuals performing radiation work at SRP.

New employees attend an orientation series on the following safety or related subjects:

- Safety rules and requirements
- Security rules and requirements
- Automobile traffic rules and regulations on plant property

An individual becomes qualified when he or she can demonstrate adequate knowledge and skills in the areas to which he or she is assigned. Each Knowledge and Skills Area, as identified by job/task analyses, is a major subdivision of the knowledge and skills required by the employee to adequately perform a job assignment.

Within each job classification, a core curriculum has been identified consisting of the knowledge and skills associated with the initial duties to which a new trainee would most likely be assigned.

Trainees are given 120 days (17 weeks) to qualify in their assigned work area. The qualification period begins with the first day of the orientation program. Qualification procedures are discussed below:

- Orientation: Weeks 1-3. The orientation program is a two-week session which provides an overview of the various production groups and their functions and interactions. It includes Du Pont orientation, safety, lock, tag, and try procedures, defensive driving, CPR, use of protective equipment, basic radiological health, and security concerns. At the end of this two week period, trainees are sent to their respective departments and given a one-week, departmental orientation program. Following this, the trainees are divided into smaller groups by facility assignment. They are then given an additional three days of facility general training. Upon completion, the trainees begin facility specific training.

- Facility Specific Training: Weeks 4-17. Facility Specific Training takes place over a 14-week period which is divided into three 4-week sessions and a 2-week remedial period (if needed). Each of the three 4-week sessions cover a particular knowledge and skills area the trainee must understand and be able to perform. The first week of each 4-week session consists of classroom and laboratory training. The remaining three weeks consist of on-the-job training on the trainee's shift assignment. During the classroom/laboratory weeks and/or at the end of the on-the-job periods, each trainee receives a qualification evaluation of the particular Knowledge and Skills Area. These qualification evaluations identify strength and weaknesses of the trainee. The trainee becomes qualified after passing all evaluations. If the trainee fails to pass the qualification evaluations he/she remains in a trainee status during weeks 16-17. During weeks 16-17, the trainee works with his/her immediate supervisor and the facility training specialist to remedy areas of weakness. At the end of week 17 all trainees receive qualification evaluations on those areas not previously completed satisfactorily.

- Qualification Evaluation. All qualification evaluations are performance based. A qualification evaluation consists of a written evaluation and a job performance evaluation. Written evaluations are not always required as some knowledge and skills areas may be more appropriately measured by only a job performance evaluation. A job performance evaluation is conducted in all cases. Each evaluation is specifically designed for each knowledge and skills area to which the trainee is to be assigned.

Personnel receive training in the safety aspects of new jobs through periodic retraining in certain areas (e.g., chemical properties, self monitoring, etc.), and through scheduled safety meetings to implement plantwide programs. Personnel also receive training in emergency actions through scheduled drills and practices under simulated emergency conditions. Training records are kept for all employees.

4.4.2 Transportation Related Training

A person other than DOE personnel) operating a plant motor vehicle is required to have in his possession a valid state drivers license or learners permit issued by his resident state. The license or permit must be of the correct classification according to the type vehicle being driven as required by the driver's resident state. Persons with learner's permits must be accompanied by qualified licensed drivers while driving on any roadway at the SRP.

Each department responsible for operating assigned motor vehicles ensures that all their drivers are properly trained, licensed, and qualified to operate the vehicles. Those departments assigned motor vehicles rated 24,000 pounds GVWR or higher must have an established training program to train their drivers. In addition, the Plant Licensing Coordinator, a certified examiner in the State of South Carolina, roadtests and, if requirements are satisfied, issues class 3 (Heavy Truck) licenses to those drivers requiring the higher class licenses.

RR&FS has a Driver Training Program in which experienced drivers train new drivers and foremen instruct personnel involved in handling and transporting HMs. The training includes instructions about tiedowns, heavy load characteristics, and safety considerations.

Stores has its own training program for personnel that have completed all of the driver qualifications required by RR&FS. Stores personnel, however, are not specifically trained in packaging, tiedown, or the handling of HMs.

4.4.3 Hazardous Materials Training

4.4.3.1 RHYTHM Committee Training Programs

Each representative of the Committee is directly involved in the safe distribution of HM and represents a facility and/or activity where HM are known to be handled.

RHYTHM Representative Training. As soon as practicable after assignment, RHYTHM representatives and their alternates are given 8 hrs of familiarization training in RHYTHM application at the site. The basis of this instruction is site specific presentations developed at SRS with support of commercially available training materials.

Before being given authorization to sign shipping papers for offsite shipments of HMs (other than materials and movements specified in the following paragraph), RHYTHM representatives and alternates are given at least 32 hrs of additional training for compliance with title 49 Code of Federal Regulations.

Before being given authorization to sign shipping papers for radioactive materials, hazardous waste, or air shipments, the RHYTHM representative or alternate, in addition to a basic HM transportation course, is given additional intensive training in the relevant requirements of DOT and EPA regulations. This training is provided by the Site Hazardous Materials Coordinator, the Chairman of the RHYTHM Committee, or another specifically-qualified source.

RHYTHM representatives and alternates are required to maintain currency of knowledge by regular attendance at RHYTHM committee meetings and at such other special training sessions as may be called by the committee. Representatives are also expected to avail themselves of other professional training opportunities by attending appropriate conferences, seminars, and symposiums.

Shipping Personnel Training. All personnel involved with the offsite shipment of HMs, both supervisory and nonsupervisory, are given compliance familiarization training by the RHYTHM representative for their facility. This training includes the training videotapes developed by SRP. The RHYTHM representative ensures that written procedures contain the detailed instructions for regulatory compliance and that the associated activities are conducted in full compliance with the procedures.

First-line supervision has the responsibility to train all operating personnel in these procedures, to verify understanding, and to ensure compliance.

Line Organization Familiarization. Periodically, overview and sensitization seminars are conducted for upper supervision charged with the management of shipping operations. These short seminars emphasize general control and audit.

4.4.3.2 Other Training Activities/Programs

Continuing Occupational Health Training is given to each employee, as appropriate to the potential hazards of the employee's work place. The subjects covered in this training include the following:

- Ionizing Radiation
- Female - Radiation Pregnancy Policy
- Respiratory Protection
- Radiation Self-Monitoring
- Nonionizing Radiation
- Hearing Conservation
- Heat Stress
- Supervisory Education Program
- Nuclear Safety
- Personal Contamination Control
- Nonradioactive Toxic Materials (which includes individual procedures for handling approximately 40 different materials)

Employees receive this training on assignment to new work places and annually thereafter.

4.5 REVIEW AND SURVEILLANCE

Reviews to determine procedural adequacy are performed at several levels within WSRC operations.

Each RHYTHM representative of a facility/activity has surveillance responsibilities to observe distribution activities and inform appropriate supervision of the findings. He or she also maintains records of findings for follow-up.

The Site Hazardous Material Coordinator has audit responsibilities to assess the status of the safe distribution program by prearranged and random visits to involved facilities and activities. He or she informs line organization and management of observations and findings. The Site Hazardous Material Coordinator also reviews executed paperwork involved in RHYTHM activities to determine areas requiring specific attention and follow-up.

Onsite and offsite shipments of radioactive materials are audited as part of operating group process controls. In addition, fissile and accountable materials, including transfers between and among areas and site, are audited by the accountability organization. Criticality audit committees in the operating areas review the shipping of fissile materials quarterly.

Under the Du Pont contract, about once a year corporate management audited the effectiveness of SRP management activities in the areas of industrial safety, industrial hygiene, and RHYTHM Committee functions. Fire safety was audited on alternate years. These audits were an indication of the high level of importance placed on safety by Du Pont upper management. If there are an excessive number of findings in an audit, reaudits were scheduled for less than the usual one-year interval.

4.6 INSPECTION, TESTING AND MAINTENANCE

Routine, frequent inspection, surveillance, and maintenance activities are performed to ensure continued proper functioning of transportation equipment and related safety systems.

4.6.1 Packages and Containers

The shipper is responsible for the selection and assembly of proper packaging of HMs and inspection of the packages. The driver or train crew inspects the package and ensures that it is properly secured before moving. If the package is defective in any way it is not moved until the shipper is notified and corrective action has been taken.

RHYTHM Committee representatives check that the appropriate paperwork is correctly completed, but do not normally conduct an independent inspection of the package. However, each package for offsite shipment is inspected for compliance with DOT regulations by an inspector (Package Compliance Inspector (PCI)) who reports to the Site Hazardous Material Coordinator. If the PCI is not available the RHYTHM representative performs the compliance inspection.

4.6.2 Vehicles

Maintenance of wheel-mounted equipment and diesel engines is the responsibility of EM&GS. Surveys of all onsite transportation equipment are carried out monthly. These surveys are general in nature and are primarily to document the odometer readings of road vehicles. The odometer readings are used to track equipment for scheduled maintenance. Drivers of vehicles are responsible for noting vehicle operations defects on a "green tag" and notifying EM&GS. The Maintenance Information and Control System (MIAC) is used to control maintenance of vehicles that do not have odometers (e.g., forklifts), heavy equipment such as graders, and of pressure relief devices on vehicles.

Most repairs to transportation equipment are carried out in designated fixed maintenance facilities. Some repairs are made in the field and at other building locations. Highway vehicles are maintained in good operating condition by scheduled inspections and repairs, and by non-scheduled repairs as needed. Inspections are made every 6000 miles or 6 months, whichever occurs first. Road tests are carried out to test braking action, steering, and general performance.

Rail rolling stock which is assigned to Railroads is also maintained by EM&GS. Rolling stock not assigned to Railroads is the responsibility of the operating areas who use it. Some work is contracted with commercial railroad maintenance shops.

Incoming railroad cars carrying hazardous materials are inspected by EM&GS upon arrival at SRP per American Association of Railroads guides. These inspections are of safety appliances and other parts of the car except the tank and tank fittings. Maintenance of the tank and tank fittings is the responsibility of the operations department which unloads the car. Any defects affecting the tank, tank fittings, or safe movements of the car are reported to the Area Supervisor for Railroads. Special procedures are used for DOE-owned cask cars and regulated cars moved onsite. Cars not carrying hazardous materials do not require EM&GS inspections.

The maintenance of rail crossing signals is the responsibility of the CSWE; Railroads reports non-functioning signals for attention.

4.6.3 Roadways and Railways

RR&FS is responsible for the upkeep of all roads on the plant site. Most of the major road work is contracted out. A paving crew from RR&FS is responsible for patching and repairing asphalt surfaces (patching potholes and sealing cracks) and installing new asphalt paving of a minor nature. Another crew is responsible for installing and maintaining road signs, striping roadways and parking areas, and for the upkeep and repair of perimeter fences.

Railroad tracks are inspected weekly. After heavy rains or unusual weather conditions they are inspected before use; if track crews are not on duty the train dispatcher issues an appropriate order to reduce speed and to look out for hazardous conditions. Track is inspected visually. If there are any deviations from SRP standards, the inspector initiates the appropriate remedial action.

Fifty-eight miles of track have been improved to standards since the middle of 1984. Each year approximately 3000 crossties will be replaced, together with new ballasting, ditching, sloping, and brush cutting.

4.7 UNIQUE HAZARDS

During a previous analysis of the safety of the 200-Area facilities (9, 10), there was consideration of and a search for conditions uniquely different from normal industrial practice. Injury statistics for the past five years were examined based on data from the Data Bank and from the Safety Department computerized listing of first aid cases and OSHA reportable cases. All of the injuries were first aid or medical treatment cases; no lost workday cases were reported during the four-year analysis interval (November 1979 to October 1983). Most of the injuries were to the fingers or hands, and the most frequent type of injury was a laceration.

The most frequent difficulty experienced with protective clothing is failure to wear the prescribed pieces or failure to adequately don the clothing. About twice per year for the SRP this failure results in personnel contamination. Specific failures of protective clothing that occur include tears, penetration by sharp objects, saturation of clothing by liquids, disconnection of breathing air hoses, and tape being pulled loose from the clothing.

With regard to transportation hazards, the delivery of nonradioactive bulk materials from offsite points of origin are of primary concern. The more important shipments and their containment upon delivery are listed below:

Hazardous Material	Containment on Delivery
Chlorine	1-ton cylinders
Gasoline and diesel fuel	tank truck
Hydrogen fluoride	50 lb plastic bottles
Hypochlorite solution	tank truck and truck-load (vendor) lots of 15-gal drums
Nitric acid	tank truck
Phosphoric acid	55-gal drums
Sodium hydroxide	tank truck and rail tank car
Sulfuric acid	rail tank car and 55-gal plastic drums
1,1,1 - Trichloroethane	rail tank car (10,000 gal)

Since all the materials received onsite are transported over public roads and railroads to the site, they are subject to DOT packaging and transportation safety requirements. These materials do not present unique hazards not normally encountered in commerce and therefore do not pose any unique hazards during onsite transportation.

One example of concern is the possible interaction between hazardous material shipments on the site and onsite tanker trucks delivering flammable materials (particularly gasoline, No. 2 Fuel Oil, and diesel fuel). There is a low probability that these tankers can be involved in an accident and supply fuel for a fire that envelops a vehicle carrying another HM.

Many areas at SRP do not have loading docks. This can be a safety factor for operations involved in loading and unloading items from vehicles that have high beds. e.g., flatbed trucks.

4.8 CONTROL OF RELEASES AND MANAGEMENT OF SAFETY

As discussed previously, SRP releases are controlled and operations safety is managed through the use of operating guidelines and technical specifications. The guidelines are established in two broad areas, Occupational Safety Guidelines and Guidelines for Releases of Radioactivity to the Environment.

4.8.1 Control of Nonradioactive Releases

4.8.1.1 At Storage Locations

SRP has instituted the SPCC and the Best Management Practices (BMP) (11) plans. These plans have been implemented to achieve the objectives of: 1) improving facility and operating conditions aimed at improved spill prevention and control and 2) providing for effective responses to spills.

4.8.1.2 In Transit

Safety rules have been established to minimize the possibility of accidents and injuries to personnel in loading and unloading areas. These include keeping travel ways clear of cylinders and other objects, wearing the appropriate safety equipment for the job (e.g., gloves, glasses, toe protection), observing rules for chaining or tying-off cylinders to prevent them from falling, and for keeping safety chains in place at all times except during actual loading and unloading of materials. Vehicles must be chocked while personnel are working in the beds of the vehicles, and, for an uncoupled trailer. a stabilizing jack or fifth wheel support must be placed under the fifth wheel plate; personnel also attach tags to the vehicle to help prevent its premature departure. Any spills on the floor, including excess water, must be cleaned up immediately. Oil and grease on the floor or body of a delivery vehicle is also to be cleaned up immediately.

Safety rules in transit include:

- Requiring vehicles carrying compressed gas and nitrogen to stop at all railroad crossings and wait until the way is clear.
- Using a flagman to assist in backing all enclosed trailers and, as needed, to assist in backing all other vans and trucks.

All delivery trucks are equipped with face shields, acid gloves, goggles, rubber boots, and aprons, and the equipment is used when entering an area of a suspected spill. In the event of a spill, personnel are required to contact their immediate supervisors and the area RHYTHM coordinator, who will coordinate the necessary response from the appropriate departments. In the event that a spill warrants response by the SRP Spill Team, the team is called by the EOC, the area RHYTHM coordinator, the Energy and Environment Department's DHEC Coordinator, or any other cognizant individual.

4.8.2 Control of Radioactive Releases

SRP policy is that releases of radioactivity to the environment will be as low as reasonably achievable (ALARA).

Controls of radioactive releases from transportation operations are implemented through procedures which have been established for the safe handling of radioactive materials at SRP. These procedures have been discussed in Sections 4.2.1 "Transport Activities", 4.3.2 "Operating and Maintenance Procedures", and 4.3.3 "Emergency Procedures and Plans".

The role of the Health Protection Department in the control of radioactive releases is discussed in a later Section, 4.8.4.1 "Radiation and Contamination Control".

4.8.3 Effluent and Environmental Monitoring Program

The location and design of facilities on the site were planned from the beginning with public health, public safety, and environmental protection as major considerations. A continuous program of radiological and environmental monitoring, begun prior to plant start-up, provides a baseline against which subsequent environmental effects can be measured. This environmental baseline is an integral part of the planning process for new projects and changes to existing facilities and operations that can affect the environment. The baseline is also a means of assessing the impact of potential future accidents, including transportation accidents.

4.8.3.1 Radiological Monitoring

An extensive environmental surveillance program has been maintained continuously since 1951 (before SRP startup) to determine the concentrations of radionuclides in a 1200-square-mile area centered on the plant, and the radiation exposure of the population resulting from SRP operations. Samples representing most segments of the environment that may be affected by SRP radioactive emissions are monitored to ensure a safe environment. The current program includes the measurement of radioactive materials released at approximately 40 source locations and involves more than 500 sampling locations (3). The environmental monitoring program includes the following:

- Air and background surveys: air, rainwater, and fallout ambient gamma background levels
- Water: drinking water, river, stream effluent outfalls, and wells
- Soil: separation areas, plant perimeter, and 100-mile radius
- Vegetation: separation areas, plant perimeter, public zone, seepage basins, and solid waste storage facility
- Food: farm produce, milk, domestic livestock, wild animals, and aquatic specimens

Air and water are the major dispersal media. Therefore, the atmosphere, SRP streams, and the Savannah River represent a large part of the monitoring effort.

Samples collected and analyses performed are shown in Table 4-6. The results of this monitoring program are reported annually to the public. For example, the results of the radioactive airborne emission data accumulated during 1984 are shown in Table 4-7.

4.8.3.2 Nonradiological Monitoring

Savannah River. Since 1951, surveys of the aquatic environment and water quality of the Savannah River have been made by the Academy of Natural Sciences of Philadelphia (ANSP) upstream, adjacent to, and downstream from the SRP site. Quarterly surveys by ANSP include diatom flora, other algae, insects, invertebrates, and fish. Periodically, ANSP makes comprehensive surveys of the biota and chemical water quality of the Savannah River (3).

SRP Water Quality Monitoring. Water quality analysis for nonradioactive materials in the Savannah River became a part of the routine environmental monitoring program at SRP in 1959. Routine water quality analyses were begun on plant streams in 1972. Sampling locations are shown in Figure 4-7. Analyses and the sensitivities of each analysis are listed in Table 4-8. Details of the monitoring program from 1972 to the present are included in the SRP annual environmental monitoring reports.

Pesticide Monitoring. Water and sediment samples from two river locations above and below the plant were analyzed for pesticides, herbicides, and polychlorinated biphenyls during 1982. Similar samples have been analyzed

TABLE 4-6. Typical Analyses for Potential SRP Radionuclides in the Environment

Location Type	Sample Collected	Collection	Analysis	Sensitivity	Instrumentation
Air monitoring station	Particulates	Weekly	Alpha	0.0002 µCi/m^3	1
			Beta, Gamma	0.0088 µCi/m	2
	Rain water	Weekly	Alpha	0.0007 nCi/m^2	1
			Beta, Gamma	0.02 nCi/m^2	2
			^{90}Sr	0.004 nCi/m^2	3
			^3H	0.3 pCi/mL	4
			$^{238-239}Pu$	0.001 pCi/m^2	5
	Atmospheric moisture	Weekly	^3H	0.3 µCi/mL	4
	Iodine	Weekly	^{131}I	1.0 µCi/m^3	5
	Vegetation	Monthly	Alpha	0.12 µCi/g	1
			Beta, Gamma	3.5 µCi/g	2
	TLD dosimeter	Quarterly	dose	0.02 mR/day	6
Drinking water	Water	Semi-annually	Alpha	0.25 pCi/L	1
			Beta, Gamma	7.0 µCi/L	2
			^3H	300 pCi/L	4
Stream and river water	Water	Weekly	Alpha	0.25 µCi/L	1
			Beta, Gamma	7.0 µCi/L	2
			^3H	300 µCi/L	4
			^{90}Sr	0.02 µCi/L	3
			^{137}Cs	7 µCi/L	2

1. Zinc sulfide alpha counter.
2. Gas flow proportional beta counter.
3. Low background beta counter.
4. Liquid scintillation counter.
5. NaI (Tl) detector, 9 x 9 inches.
6. Photometric TLD reader.

TABLE 4-7. 1984 Atmospheric Releases and Concentrations

Nuclide	Curies Released at Emission Source	Calculated Average Concentration at Plant Perimeter, µCi/cu cm	Concentration Guide, µCi/cu cm	Percent of Concentration Guide
Gases and Vapors				
H-3	7.86E+05	2.8E-10	2.0E-07	0.14050
C-14	8.30E+01	3.0E-14	1.0E-07	0.00003
Ar-41	3.59E+04	5.5E-12	4.0E-08	0.01375
Kr-85m	1.18E+03	3.0E-13	1.0E-07	0.00030
Kr-85	8.40E+05	3.0E-10	3.0E-07	0.10033
Kr-87	5.99E+02	6.4E-14	2.0E-08	0.00032
Kr-88	9.23E+02	1.9E-13	4.0E-07	0.00005
Xe-131m	1.80E+01	6.4E-15	4.0E-07	<.00001
Xe-133	3.69E+03	1.3E-12	3.0E-07	0.00044
Xe-135	2.48E+03	7.5E-13	1.0E-07	0.00075
I-129	3.50E-02	1.1E-17	2.0E-11	0.00006
I-131	2.82E-01	9.1E-17	1.0E-10	0.00009
Particulates				
Co-60	5.40E-05	1.7E-20	1.0E-06	<.00001
Se-75	4.20E-05	1.4E-20	4.0E-09	<.00001
Sr-89,90	3.50E-03	1.1E-18	3.0E-11	<.00001
Zr-95	1.38E-02	4.5E-18	4.0E-09	<.00001
Nb-95	1.91E-02	6.2E-18	2.0E-08	<.00001
Ru-103	1.90E-02	6.1E-18	2.0E-08	<.00001
Ru-106	1.48E-01	4.8E-17	3.0E-09	<.00001
Cs-134	3.80E-05	1.2E-20	1.0E-09	<.00001
Cs-137	1.90E-03	6.1E-19	2.0E-09	<.00001
Ce-141	8.40E-04	2.7E-19	2.0E-08	<.00001
Ce-144	1.33E-02	4.3E-18	3.0E-10	<.00001
Os-185	4.00E-04	1.3E-19	2.0E-09	<.00001
U-235,238	2.20E-03	7.1E-19	2.0E-11	<.00001
Pu-238	1.20E-03	3.9E-19	7.0E-14	0.00055
Pu-239	4.72E-04	1.7E-20	6.0E-14	0.00026
Cm-242,244	2.60E-04	8.4E-20	3.0E-13	0.00003
Am-241,243	1.40E-04	4.5E-20	2.0E-13	0.00002

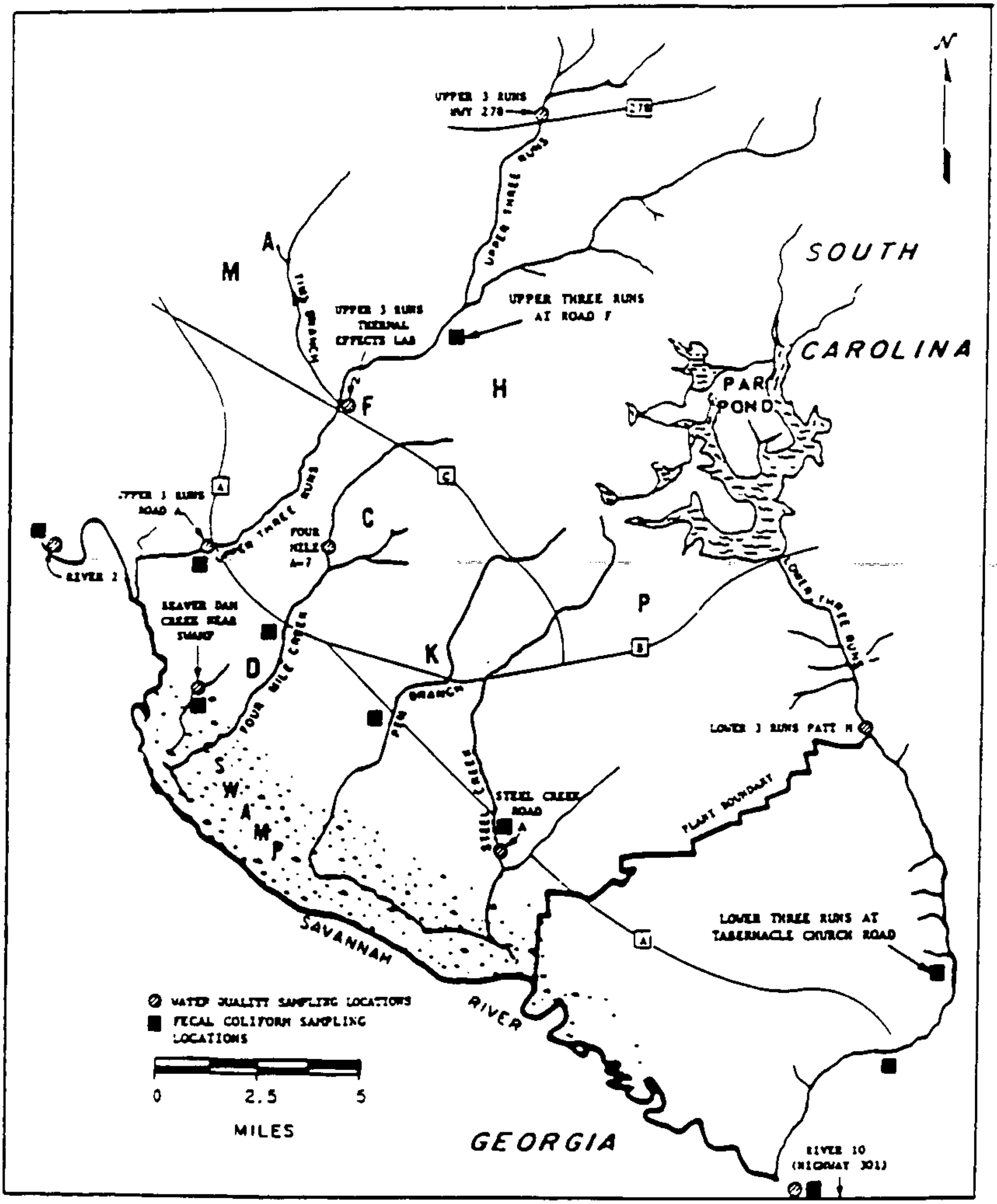


FIGURE 4-7. 1982 Water Quality and Fecal Coliform Sampling Locations

TABLE 4-8. Water Quality Analyses and Sensitivities

Parameter	Sensitivity, mg/L
pH* (tenth of a unit)	0.0
Alkalinity	1
Hardness	0.1
Conductivity (mho/cm)	1
Suspended solids	1
Volatile solids	1
Total dissolved solids	1
Fixed residue	1
Biochemical oxygen demand	1.0
Chemical oxygen demand	5
Lignin	1.0
Surfactant	0.02
Chloride	0.1
Nitrite	0.02
Nitrate	0.02
Sulfate	2
Sulfide	1.0
Ortho-phosphate	0.02
Total phosphate	0.02
Aluminum	0.5
Ammonia	0.1
Calcium	0.1
Sodium	0.1
Total iron	0.1
Lead	0.5
Fecal coliform (#/100 mL)	-

* Field analysis

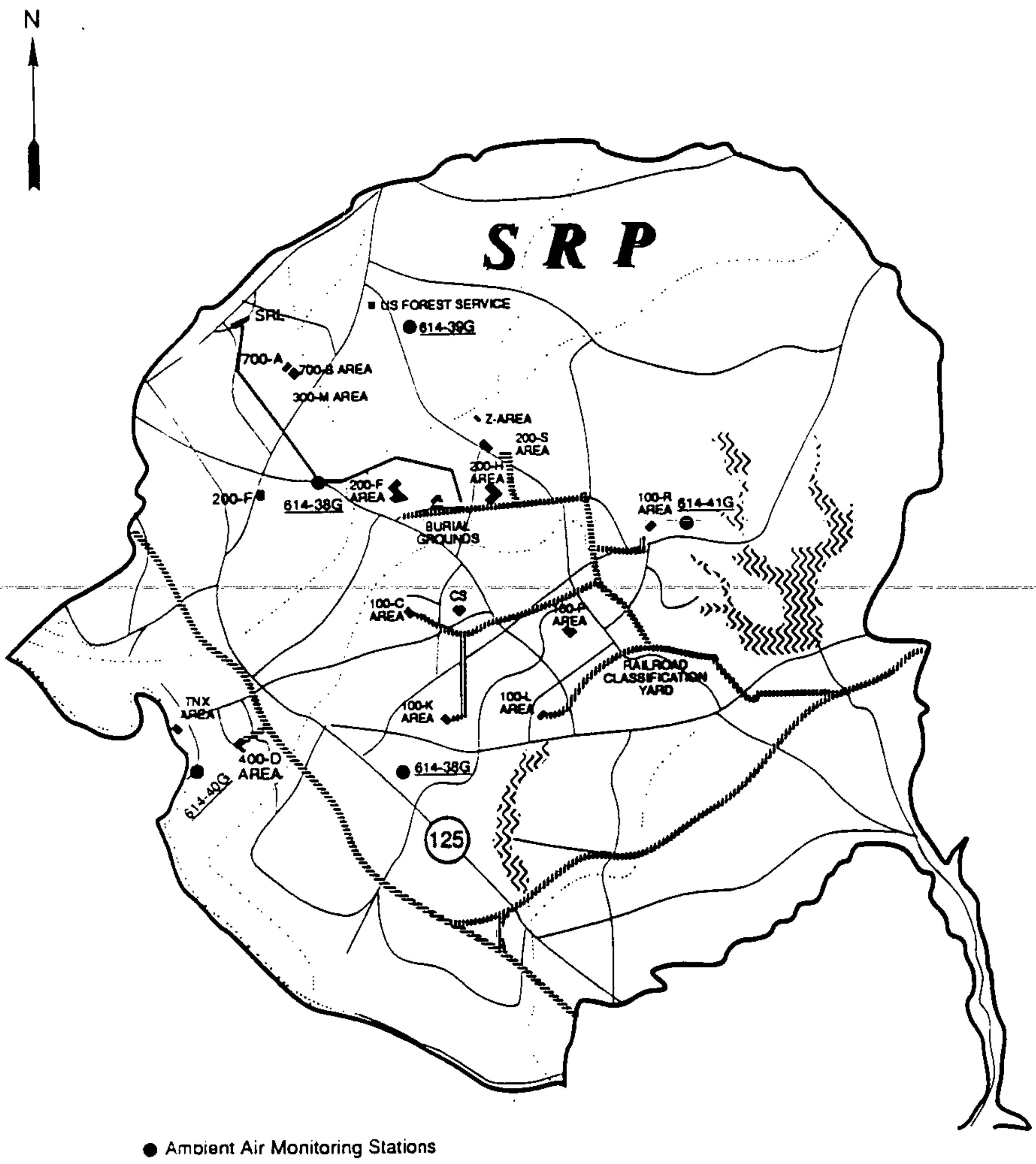


FIGURE 4-8. Locations of Ambient Air Monitoring Stations

since 1976 to determine if SRP is contributing significant quantities of these materials to the environment.

Atmospheric Monitoring. Section 110 of the Clean Air Act Amendments of 1970 requires each state to establish, as part of its State Implementation Plan, a network to monitor the ambient air quality within that state. South Carolina and Georgia have each implemented air-sampling networks.

The SRP monitoring network consists of five stations which monitor for total suspended particulates and nitrogen dioxide. In addition, three of the stations monitor for sulfur dioxide, and two monitor for ozone (Figure 4-8).

4.8.4 Safety Management Systems

It is the policy of SRP that safety and protection of employees comes first (12). There are two separate organizations dealing with safety. One concerns itself with the protection of man and his environment from the harmful effects of radiation, and the other deals with the industrial safety of the worker.

4.8.4.1 Radiation and Contamination Control

As discussed in Section 4.1, the Health Protection Department (or Occupational Health Protection personnel in SRL facilities) concerns itself with radiation and contamination control.

SRP's policy limits the radiation exposure of employees to as low as reasonably achievable (ALARA) (13). Radiation exposure guides are used to help control the exposure of operating personnel. In addition to ensuring that occupational exposures to ionizing radiation remain below the guide levels, the SRP management strives to reduce both individual and worker-group exposures to ALARA through administrative measures that involve periodic and special case (nonroutine) reviews of transportation activity. Section 4.8.4.1 addresses the safety function of the RHYTHM Committee which is responsible for conducting many of these reviews. Sections 4.4.3 addresses hazardous material training activities which also contribute to the effective implementation of the SRP ALARA policy and Section 4.5, Review and Audit, discusses the SRP management responsibilities concerned with the safe distribution of hazardous materials at the SRP. This audit function includes audits of the effectiveness of implementation of the SRP ALARA policy. Finally, Section 4.1 identifies the SRP Health Protection Department as the organization responsible for minimizing personnel exposures (ALARA).

The radiation exposure plant guide values are given in Table 4-9. The exposure of whole body (penetrating radiation) is estimated by combining the:

1. Radiation dose determined from thermoluminescent dosimeter (TLD) reading.

2. Neutron radiation dose as determined by thermoluminescent neutron dosimeters.

TABLE 4-9. Plant Radiation Dose Guide Values[a]

Type Exposure, Organ	Dose in Rems Per Qtr	Dose in Rems Per Yr
Occupational Exposure:		
Whole body, head and trunk, active blood forming organs, gonads, lens of eyes, red bone marrow	3	3
Skin, other organs, tissue, and organ systems (except bone)	5	15
Bone and forearms	10	30
Hands and feet	25	75
	Plant Emergency[b]	Life Saving
Emergency Exposure[c]:		
Whole Body	25	100
Hands	100[d]	200[e]

a Values at or less than those given in Department of Energy, Environment, Safety and Health Manual, Chapters XI, XII.

b Involving protection of property or personnel.

c Emergency exposure limits apply only to designated emergency workers.

d Includes whole body exposure.

e In addition to whole body exposure.

3. Dose received from tritium assimilation as determined by bioassay.

Internal deposition of radionuclides may be detected by routine programs for analysis of urine and by whole body or chest counting techniques.

Locations within SRP are classified into three categories that depend upon expected levels of radiation or contamination. A Clean Area is an area where no radioactive materials are handled and where the radiation or contamination levels are equivalent to natural background. A Regulated Area (RA) is where radioactive materials are handled or where radiation or contamination exceeds (whole body and skin) natural background, but where the radiation level does not exceed 300 mrad/hr or the dose rate does not exceed 50 mrem/hr (whole body) and contamination is low. A Radiation Zone (RZ) is where radiation or contamination levels exceed limits for a Regulated Area.

All work within an RA or RZ is performed according to procedures. These procedures are prepared and approved prior to entry into an RZ, or prior to starting nonroutine work in a regulated area.

All building areas occupied by personnel are surveyed routinely using portable or permanently installed instruments. Air samples are taken where the potential for airborne activity exists. When air activity exceeds the values shown in Table 4-10, respiratory protective equipment is required.

Protective clothing is prescribed in the procedures for work in RAs or RZs, when an actual or potential contamination hazard exists.

Operating procedures include instructions for radiological monitoring of packages and vehicles to verify that outside surfaces are contaminated to less than guide levels and to determine that radiation levels are acceptable for transportation. Monitoring programs include:

- HP radiological surveys during packaging and loading before shipping.
- HP routine monitoring of trucks and other vehicles upon request.
- HP surveys of vehicles returned to the garage, Building 716-A, or railcars to be serviced or repaired at Building 618-G.
- Operators of vehicles monitor their hands and feet before leaving Regulated Areas at different monitoring stations.
- HP annual surveys along site roadways and railroad beds.

4.8.4.2 Industrial Safety

The SRP safety policies are designed to help employees avoid injuries and to provide a safe environment in which to work. Management directs the program through the Plant and Area Central Safety Committees. The program includes planned educational activities on a daily, weekly, and monthly basis.

TABLE 4-10. **Airborne Radioactivity Concentrations Requiring Filter or Air-Supplied Respiratory Protective Equipment**

Element	Concentration, μCi	
	Filter	Air-Supplied
Unidentified		
Alpha	2.0E-12	1.0E-10
Beta-gamma	1.0E-9	5.0E-8
Uranium		
Natural	6.0E-11	3.0E-9
Enriched	3.0E-11	1.5E-9
Americium	6.0E-12	3.0E-10
Neptunium	4.0E-12	2.0E-10
Curium[b]	2.0E-12	1.0E-10
Californium	2.0E-12	1.0E-10
Plutonium	2.0E-12	1.0E-10
Thorium	2.0E-12	1.0E-10
Tritium	--	1.0E-10
Iodine	--	9.0E-9
Mixed fission product	1.0E-9	5.0E-8

[a] Based on 40-hr week.

[b] The radioactivity Concentration Guides for the various isotopes of curium produced during the transplutonium program at SRP ranged from 9.0E-12 for Cm-244 to 6.0E-13 for Cm-248. Because of the low yield of Cm-248 (0.05 wt %, mass abundance), the RCG for unidentified alpha isotopes was followed for all isotopes of curium produced by this method.

The Personal and Environmental Reporting System (PERS) is the SRP management information system that tracks HMs that are handled by SRP employees. SRP employees are given annual occupational health hazard training (see Section 4.4.3).

4.8.4.3 Safety Function of the RHYTHM Committee

As discussed in Section 4.1, the RHYTHM Committee assists line-organizations in the safe distribution of HMs by providing a means of centralized communication, coordination, training, and audit. Most of the RHYTHM Committee's activities address offsite shipments. Some onsite transportation activities have been given attention, but this has been mainly an adjunct to offsite shipments rather than as a result of focused actions.

In fulfilling its responsibilities, the RHYTHM Committee functions in the following areas:

- Arranging and providing training for facility/activity representatives.
- Providing reference material to facility/activity representatives.
- Coordinating the training of "hands on" personnel in facilities/activities.
- Disseminating information concerning legal/regulatory requirements and changes, company policies/practices regarding RHYTHM, local practices of plantwide applicability, problems of general concern, etc.
- Reviewing incidents and making recommendations where plantwide followup is indicated.
- Bringing problems requiring policy decisions to management's attention.
- Conducting annual audits of distribution activities.
- Reviewing and approving procedures (DPSOPs), forms (OSRs), and operating logsheets (DPSOLs).
- Assisting in the selection of shipping packages.
- Obtaining interpretations of legal/regulatory/policy requirements from appropriate regulatory and company sources.
- Reporting occurrences as specified in company procedures as follows:
  - The member of the committee for each facility/activity ensures that the appropriate persons in his

facility/activity are trained and periodically retrained in the reporting of occurrences.

- The member of the committee for the facility/activity involved reports each occurrence to the chairman of the RHYTHM Committee.

- The chairman reviews and may investigate the occurrence; if warranted, the chairman reports the occurrence to management and DOE-SR (DOE Order 5484.2).

- Keeping (through its written reports and through the oral reports of its chairman and the Site Hazardous Materials Coordinator) the Safe Distribution Subcommittee informed of its findings, recommendations, and concerns. The Safe Distribution Subcommittee is organized to provide appropriate level, line-organization management attention to and support of the RHYTHM Committee.

The Chairman of the RHYTHM Committee has the responsibility for the day-to-day administration of the Committee. The Site Hazardous Material Coordinator is currently the single point of contact to respond to questions on the transportation of HMs from offsite shippers and outside organizations. The Chairman of the RHYTHM Committee and the Site Hazardous Material Coordinator are responsible for defining the responsibilities of the RHYTHM Committee with regard to onsite shipments of HMs.

The Site Hazardous Materials Coordinator is appointed by management to a full-time assignment within the RHYTHM program. He or she advises, assists and coordinates with management and line-organizations in their implementation of the RHYTHM program for the safe distribution of HMs. He or she has no direct operational authority or responsibility but has stop work authority.

Because of the increasing scope of the Site Hazardous Materials Coordinator position at SRP, staff has been augmented by the assignment of 4 full-time professionals including 2 Package Compliance Examiners. The assistants act as field representatives/trainers in specialized activities. Package Compliance Examiners are responsible for ensuring that HM packages prepared for offsite shipments comply with all applicable requirements.

4.8.4.4 Industrial Hygiene

The purpose of the industrial hygiene program is to protect plant personnel and plant environs against hazards from nonradioactive materials. This includes hazard recognition, evaluation, and other environmental control factors.

The Health Protection Department (Figure 4-4) is responsible for the program, except ventilation surveys. Ventilation surveys are the responsibility of the Project Department.

The Industrial Hygiene Group is part of the Health Protection Studies Group (Figure 4-4). This group provides technical expertise, procedural guidance, and conducts special hygiene surveys.

Inspections are conducted in operating areas and all newly purchased materials used are reviewed for potential hazard. Special procedures are used when handling potentially carcinogenic materials.

4.8.4.5 Fire Protection

A Fire Prevention Subcommittee of the Plant Central Safety Committee (Figure 4-2) devotes itself to fire prevention and fire fighting activities. This subcommittee works closely with the Fire Protection Group within the Safety and Fire Protection Section. The Fire Protection Group maintains adequate mobile fire fighting equipment, trains personnel, and inspects protection equipment.

4.8.4.6 Occupational Exposure Experience

Whole body exposure to penetrating radiation during normal operations is monitored by HP and OHP as indicated above. Exposure includes both external radiation and exposure from inhalation or ingestion of radionuclides, principally tritium.

4.9 REFERENCES

1. Control of Processes in the Atomic Energy Division. Internal Report DPW-73-160, Polymer Intermediates Department, Atomic Energy Division, E. I. du Pont de Nemours & Co., Wilmington, DE (1973).

2. Internal memorandum entitled "Savannah River Plant - Organization Chart", dated as of October 31, 1985.

3. Dukes, E. K. The Savannah River Plant Environment. DP-1642. E. I. du Pont de Nemours & Co., Savannah River Laboratory, Aiken, S.C. (1984).

4. The Administrative and Procedural Controls System for the Savannah River Plant Nonreactor Facilities, Internal Report DPW-83-112, E. I. du Pont de Nemours & Co., Savannah River Plant, Aiken, SC, January 1985.

5. SRP Operating Procedure Systems. Internal Report DPSOP-1, E. I. du Pont de Nemours & Co., Savannah River Laboratory, Aiken, SC (1978).

6. SRP Emergency Management Plan. Internal Report DPSOP-286, E. I. du Pont de Nemours & Co., Savannah River Plant, Aiken, SC.

7. 200-Areas Emergency and Disaster Plans. Internal Report DPSOP-115-FH, E. I. du Pont de Nemours & Co., Savannah River Plant, Aiken, SC (1977).

8. Spill Prevention Control and Countermeasures Plan. Internal Report.

9. Safety Analysis - 200 Area Savannah River Plant F-Canyon Operations. DPSTSA-200-10, SUP-4, Prepared by Science Applications International Corporation for E. I. du Pont de Nemours & Co., Aiken, SC, February 1986

10. Safety Analysis - 200 Area Savannah River Plant H-Canyon Operations. DPSTSA-200-10, SUP-5, Prepared by Science Applications International Corporation for E. I. du Pont de Nemours & Co., Aiken, SC, February 1986

11. Savannah River Plant Best Management Practices (BMP) Plan. Internal Report. Rev. 1, July 1985.

12. Safety Manual. Internal Document, E. I. du Pont de Nemours & Co., Savannah River Plant, Aiken, SC (1984).

13. Savannah River Plant Radiation and Contamination Control. Special Hazards Bulletin 2: Reducing Radiation Exposure to as Low as Reasonably Achievable at the Savannah River Plant, Internal Report DPSOP-40, E. I. du Pont de Nemours & Co., Savannah River Laboratory, Aiken, SC (1975).

5.0 ACCIDENT ANALYSIS

This safety analysis addresses potential transportation accidents involving hazardous materials transported by truck and rail at the Savannah River Plant. Accidents involving both radioactive and nonradioactive hazardous materials identified in Chapter 3.0 are discussed.

The analysis of the potential transportation accidents presented in this section includes discussions of events that can initiate releases of and personnel exposures to hazardous materials (Section 5.1), analysis methods used (Section 5.2), estimates of accident frequencies (Section 5.3), estimates of source terms for releases of hazardous materials in accidents (Section 5.4), estimates of consequences and risks to the public and to SRP workers (Section 5.5), and a discussion of mitigation measures (Section 5.6). The analysis addresses accidents involving release to atmospheric and surface water pathways and subsequent dispersion of hazardous materials.

Risks to the public include those associated with inhalation and plume exposure for hazardous materials released to the atmosphere and ingestion for materials released to surface waters.

The analyses do not address potential non-SRP-related accidents involving through traffic on public transportation corridors that pass through the site. Except for occasional brief interruptions necessitated by SRP operations, the through traffic is not under SRP control and, therefore, not within the scope of this safety analysis. The corridors are South Carolina Highway Route 125 (northwest to south) and U.S. Route 278 (northwest to northeast), and CSX rails (northwest to south and east to south).

5.1 ACCIDENT INITIATING EVENTS AND ACCIDENT DESCRIPTIONS

Transportation accidents addressed in this safety analysis are those that have potential for causing unplanned and uncontrolled releases resulting in human exposures to hazardous materials. Source terms (quantities of hazardous materials released to the environment as a result of accidents) and accident frequencies were developed through analysis of historical accident data contained in a DOT database (1) and analyses of similar accident data performed by others, e.g., Sandia National Laboratory Albuquerque (SNLA) (2), Lawrence Livermore National Laboratory (LLNL) (3).

The historic database provides a broad coverage of significant accidents involving hazardous materials. The database is judged to be representative of transportation accidents that might occur at the SRP, including accidents initiated by severe weather conditions such as high winds, ice, or snow, adverse weather conditions, driver error, and vehicle malfunction.

For transportation of radioactive materials, there are studies performed by SNLA and others (2-11) in which the projected damage to packages for various accident or impact severities are estimated. Radionuclide releases for several package damage severity categories are developed from the database. It was judged that the packages used for onsite transportation at Savannah

River behave similarly to the corresponding generic package types analyzed in studies for accidents of like severity. For highly unlikely accidents with potentially high consequences, there are few if any direct data in the database. To accommodate this shortcoming in available data, SNLA (2) and others (4-8, 10, 11) have developed joint probability estimates for the frequencies of unlikely accidents.

These studies established accident severity categories (e.g., Minor, Moderate, Severe, Extra Severe, and Extreme) based on accident tests and analyses of radioactive material transportation packages. For each particular package type analyzed, the amounts of materials released are correlated to the accident severity categories. The frequencies of occurrence (accidents/vehicle-mile) of each severity category has been developed in these studies from national accident statistics (1).

In the SRP transportation analysis, the generic information was combined with the characteristics of SRP transportation operations to obtain SRP specific accident frequency/release distributions. Based on SRP operations data, the transportation package types used and the vehicle-mile/yr traveled for each type were assembled. The SRP accident frequencies (accidents/yr) for each package type were obtained from the miles/yr travelled and the generic accident frequencies (accidents/vehicle-miles) for each accident severity class. The SRP package types were correlated with the generic types to obtain the quantities of radioactive material released for each accident severity class.

For the transportation of nonradioactive HMs, data on accidents recorded in the Department of Transportation's HAZMAT Data Base (1) were used. These data, which include more than 150,000 accident reports, identify the types of materials involved in transport accidents and provide estimates of amounts of the materials released for each. The data also provide a basis for estimating the fraction of accidents that would result in releases. In some cases there are sufficient data to develop distribution for the amounts released.

For the nonradioactive HMs and transportation package types analyzed in this report (see Section 5.4), a large number of applicable accident reports were found in the data. Based on these data, frequency/quantity released distributions were developed for the package types and the specific materials (e.g., chlorine, gasoline) or physically similar material categories (e.g., liquefied gases, liquids). As with the radioactive materials analysis, SRP transportation operations data were analyzed to estimate the vehicle-miles travelled for each package type and high hazard potential material (see Section 5.4). This information was combined with the generic accident data to obtain SRP specific accident frequency/quantity released distributions.

5.1.1 Initiating Events Unique to the SRP

The national accident records include accidents caused by a wide variety of initiating events. Considered here are initiators classified as general, severe environmental events (high winds, tornadoes, earthquakes), unique transportation system initiators, and external events.

5.1.1.1 General Accident Initiators

Driver or operator error or incapacitation, equipment failure, inclement weather and many other factors contribute to accidents in the transportation of hazardous materials. The data used in this report to estimate the frequency of accidents and to estimate releases of hazardous materials in the accidents come from U.S. Government reports and databases. The data are judged to be representative of accidents caused by credible initiators. If transportation at the SRP is similar to transportation in domestic commerce, it can be expected that initiators for accidents at the SRP will also be similar both in kind and likelihood. In general, the transportation environment at the SRP was found to be compatible with or more benign than that in general commerce. Thus, using national aggregate accident statistics can be expected to lead to comparable or conservative results when applied to SRP onsite transportation operations for hazardous materials.

5.1.1.2 Severe Environmental Events

High winds, tornadoes, or earthquakes, if occurring at significantly greater frequency at the SRP than in general commerce, would require separate consideration for analyses of transportation risks on the site. High winds and tornadoes lead to several accident scenarios including blowing a vehicle off the roadway or into the path of oncoming traffic. Earthquakes of sufficient severity can cause vehicles to run off roadways or can cause roadways to be damaged. As will be discussed in Section 5.3.1 severe environmental events at the SRP are not expected to be significantly different in intensity or frequency from those occurring during transportation on the nations highways and railroads.

5.1.1.3 Unique Transportation System Initiators

If they occurred at the SRP, unusually high numbers of highway miles over steep terrain, unusually dense traffic conditions, unusual vehicle configurations, or unique (in kind or degree) hazardous material packaging and package preparation requirements could call into question the use of aggregate national transportation safety statistics. Under such conditions a site-specific analysis is needed. For example, a higher likelihood of falls from high bridges leads to more frequent occurrences of extra severe damage conditions for packages. Dense traffic conditions might lead to more frequent accidents. Unusual vehicle configurations can have higher accident exposure rates than those for vehicles in commerce. Packages that are unusually complex or whose designs depart in some significant way from conventional packages can have different accident responses from those for which the accident data are relevant. Conversely, effective administrative controls are expected to reduce accident rates because such controls are designed to eliminate or reduce the likelihood of targeted initiators.

For the SRP, the onsite transportation environment (operational and physical) and the extensive administrative controls are expected to result in a lower than average frequency of initiating events and causes for accidents involving the transportation system.

5.1.1.4 External Events

An airplane crash with resulting fire, if significantly more likely on SRP highways or railroads than on highways and railroads elsewhere, would require separate consideration in this safety analysis. If the airplane were to crash onto a vehicle transporting HM and a large fire were to result, large amounts of the HM payload would be distributed into the atmosphere. As will be discussed in Section 5.3.2, the likelihood of such an occurrence is extremely low and there is no reason to expect the rate for the SRP transportation corridors to be higher than for elsewhere on highways and railroads.

5.2 ANALYSIS METHODS

This section presents the methods used to develop the estimates of risk presented in Section 5.5. Included are discussions of methods used to estimate the probabilities of accidents and releases of HMs during or following accidents. Also discussed is the approach used to select from the extensive list of HMs transported a limited list of materials that present the greatest hazard potential. Finally, methods used to estimate consequences, given releases, are discussed. Because of differences in the available data, historic analysis approaches, and accepted practices for reporting results, the methods for estimating risk for accidents involving radioactive HMs are discussed separately from those for nonradioactive HMs.

5.2.1 Analysis Approach

The methods used in this evaluation are consistent with the overall approach used in safety analysis reports for Savannah River facilities (12, 13). For radioactive materials, studies of transportation accidents that have been performed by Sandia and others (2-7) were used to assess the likelihood and severity of accidents in rail and truck transportation at the SRP. For nonradioactive HMs, the analyses were based on data from the DOT HAZMAT Data Base (1) and other sources (14-36, 3). Figure 5-1 summarizes the steps in the analysis and lists the methods employed at each step.

The information collected from the various sources cited above was used to estimate the likelihoods of transport accidents and the amounts of materials released. The data were used in conjunction with quantities and associated distances transported to assess the relative likelihood of accidents during material movement at SRP. A list of materials to be considered in the detailed analysis was developed by screening a detailed list of HMs transported at the SRP (see Appendix B). The materials selected were ones with the greatest consequence potential based on total quantities transported, and toxicity. Consequences of accidents involving these materials were estimated using the methods used in other SRP safety analysis reports. Risks were calculated as the product of expected frequency and consequences.

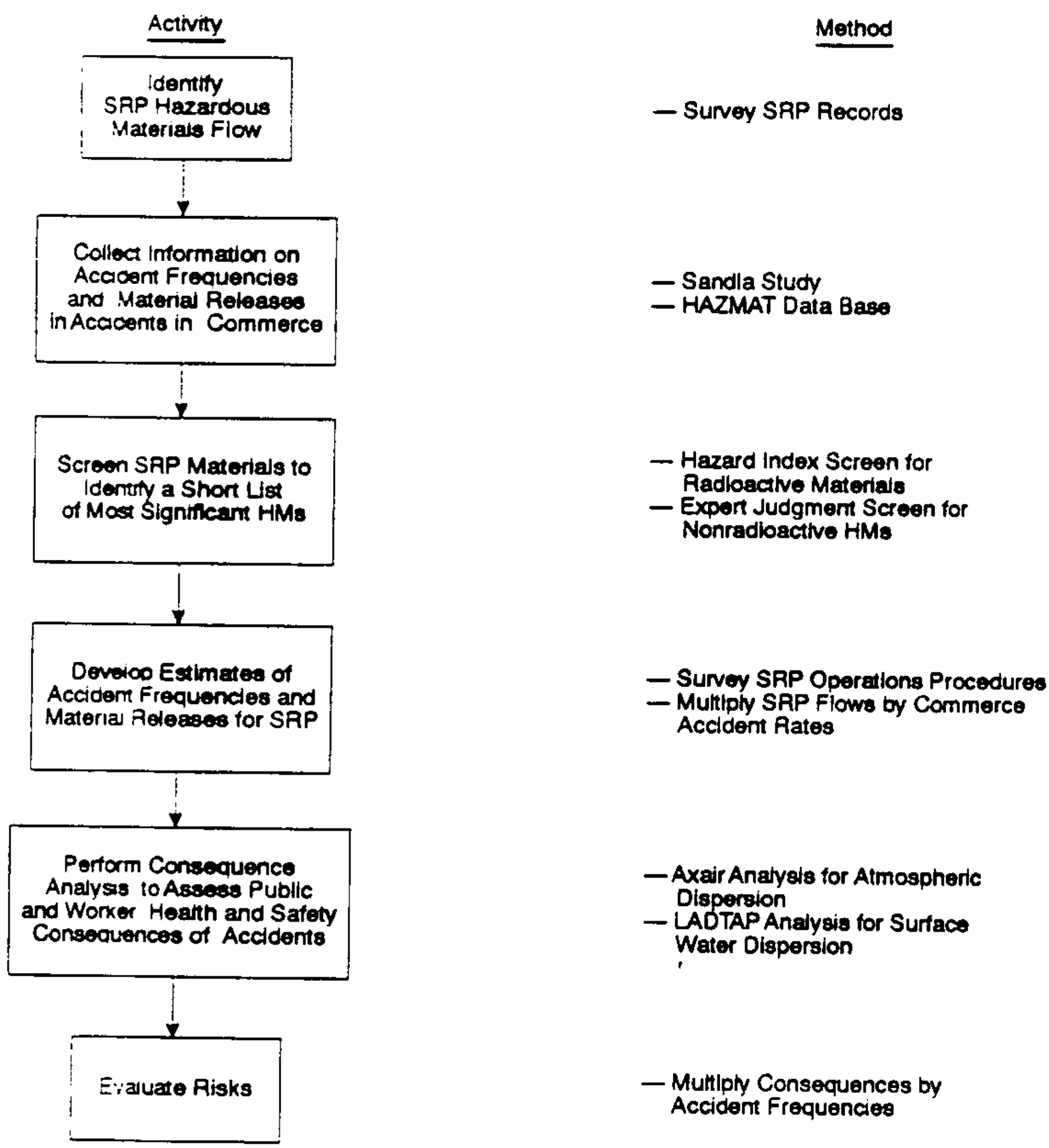


FIGURE 5-1. SRP Hazardous Materials Transportation Safety Analysis Flow

5.2.2 Site Data for Quantities of Hazardous Material Transported and for Accidents

Each organization at the SRP maintains records for shipments of materials for which it has responsibility. The records are maintained in log books, computer data bases, procurement records, Transportation Work Requests, Cask Car Move Orders. Material Receiving Reports, shipment records, and other SRP documents. To obtain a comprehensive list of HMs received from offsite vendors it was necessary to review procurement records. As part of this review, onsite destinations for the materials were identified.

Operating area log books provided information on the frequencies of material shipments and receipts, quantities shipped or received, and the packagings used both for shipments arriving from offsite locations and for those between onsite areas. Central Trucking, Railroads, and EM&GS records were reviewed to develop supporting information on quantities of materials flowing between areas on the site. Procedures and other SRP operations documents were reviewed to identify administrative methods employed in controlling HM transportation operations. Interviews were conducted to determine the detailed routings for HM shipments. Finally, the onsite incident database and log book records were searched for reports of accidents or incidents relevant to hazardous material transportation safety at the SRP.

The review of transportation accident experience at the SRP did not find records of collisions involving trucks hauling radioactive materials. Hence, it was necessary to utilize other data sources to obtain estimates of accident frequencies for movement of hazardous materials.

5.2.3 Methods and Data Bases for Estimating Accident Frequencies

Lawrence Livermore National Laboratory, in a study completed in 1987 (3), reports that highway accident rates depend on many elements including road type, vehicle type, regulations and driving practices. The study reports that accident rates for California highways range from $1x10^{-6}$ to $5x10^{-6}$ accidents/vehicle-mile Highway accident rates derived from Bureau of Motor Carrier Safety (BMCS) for all roadways, based on 1960 through 1972 data, is reported in the Lawrence Livermore report to be $2.5x10^{-6}$ accidents/vehicle-mile. Also reported are American Petroleum Institute (API) data for the period 1968 through 1987 for all roadways. The reported API data suggests an average accident rate of $6.4x10^{-6}$ accidents/vehicle-mile. The authors of the Lawrence Livermore report judged that the API data are more reliable than the BMCS data. The API truck accident rate ($6.4x10^{-6}$/vehicle-mile) will be used in this report.

The LLNL study also reports railroad accident rate data. The data reported were compiled by the Federal Railway Administration (FRA). These data indicate that the accident rate for trains is $1.2x10^{-5}$ accidents/train-mile. The rate is an average for the years 1975 through 1982; it reflects only accidents involving on-track railroad equipment that resulted in damages to railroad on-track equipment, signals, track or track structure, and roadbed at or exceeding a damage threshold value. The damage threshold was adjusted for inflation from $1,750 in 1975 to $4,100 in 1982.

The LLNL report further notes that the average rail accident likely to cause a release of material (derailment or collision) results in damage to about 10% of the cars in the train. For normal commercial train operations this implies an accident probability of 1.2×10^{-6}/railcar-mile. This value does not apply to rail shipments of hazardous materials at SRP however, because of the special conditions that exist during these shipments. Rail shipments of hazardous materials at SRP typically involve a locomotive and one or two rail cars. So, any railcars damaged in a train accident will necessarily be those carrying hazardous materials. At the SRP, the probability of a railcar being involved in an accident is assumed to be equal to the probability of a rail accident, or 1.2×10^{-5}/mile.

It can be argued that the plant trains used on-site, coupled with strict operating procedures such as the 25 mph speed limit, result in accident rates lower than the national average for commercial traffic but the data do not exist to support this argument. As a result, the train accident rate used in this report will be 1.2×10^{-5} accidents/train-mile.

Sandia National Laboratory Albuquerque has analyzed transportation accidents to develop estimates of the values for the conditional probabilities of accidents severe enough to cause releases from radioactive material packages (2). However, the studies did not include evaluation of accidents involving large casks or protective packagings. Notwithstanding this shortcoming, the probability estimates for the various accident severity classifications are considered appropriate for use in this safety analysis.

SRP transportation data were analyzed to develop site specific conditional probability estimates, for example for packaging errors, to augment the aggregate data reported in the open literature. SRP data and values derived from it for use in this study are presented in Appendix E.

5.2.4 Methods For Screening Hazardous Materials

It is both impractical and unnecessary to evaluate risks associated with all of possibly HMs transported at the SRP since a relatively small number can be expected to dominate the total risk. Therefore, for this safety analysis only those materials assessed to have significant hazard potential were selected from the list of more than 200 HMs. The selections were made using screening methods prior to the analysis of accident consequences and risks. Because of the differing nature of risks for radioactive and nonradioactive HMs, these materials were screened separately; their transportation risks were also analyzed separately.

5.2.4.1 Screening of Radioactive Materials

For radioactive materials a hazard index (HI) was used as the screening parameter. This index was computed for each shipment type. The HI is the product of the assumed or estimated releases of radionuclides in an accident and the probability the accident will occur in any given year, divided by a measure of the hazard to human health for the radioactive materials that would be released. The measure used to quantify the health hazards was the maximum permissible intake (MPI)* for adult humans in a single exposure (37).

5.2.4.2 Screening of Nonradioactive Materials

Generally, the selection of indicator compounds for nonradioactive materials is based upon such factors as: 1) the quantity of the compound present, 2) the extent of environmental contamination by the compound, 3) the toxicity of the compound, 4) mobility of the compound, and 5) the persistence of the compound in the environment. In a 1985 review of the literature to identify existing selection methods (38) two sources were identified that presented actual detailed methods for selecting indicator contaminants. These are the Superfund Risk Evaluation Manual (39) and a publication by J. V. Rodricks entitled Risk Assessment at Hazardous Waste Disposal Sites (40). The methods presented in those sources are essentially the same. The ranking and selection method used in this safety analysis is similar to those outlined in the references.

Using data collected from SRP operations records, a listing of nonradioactive materials handled in bulk at SRP was developed (see Appendix B). This list was then reviewed to select the chemicals of greatest concern. By this process, the large listing of bulk chemicals was narrowed to a list of nonradioactive chemicals of primary concern. For these compounds, available literature was reviewed and relevant computer databases were searched to obtain toxic effects information (see Appendix H and Reference 41). That final list of compounds was established based upon additional factors, namely: 1) the inherent toxicity of the compound through inhalation and ingestion exposure routes; 2) the adequacy of the available toxicity data; 3) the DOT designation of the chemical (i.e., hazardous or non-hazardous as transported) (42). To develop the list, the factors were combined qualitatively using professional judgment.

The materials selected were ones frequently transported at the SRP in large quantities (see Appendix B); ones which would be expected to be mobile in at least one of the two environmental pathways of concern (atmosphere and surface waters); and ones having relatively low threshold concentration values for the onset of toxic effects (see Section 5.2.6.5). Table 5-1 lists the compounds which were selected.

5.2.5 Methods for Estimating Material Releases in Accidents

This safety analysis employs two approaches in developing estimates of releases of HMs in transportation accidents. The first is that developed in

*Maximum permissible intake (MPI) is defined as that amount of a radionuclide which, if inhaled in a single exposure, will result in a dose of 0.3 rem/wk, 15.7 rem/yr, or 150 rem/70 yr to the critical organ.

TABLE 5-1. Nonradioactive Hazardous Material Selected for Analysis of Risks in Transportation at the SRP

Selected Materials (14)
• Chlorine
• Gasoline
• Hydrogen fluoride
• Nitric acid
• Phosphoric acid
• Sodium hydroxide
• Sodium hypochlorite
• Sulfuric acid
• 1,1,1-Trichloroethane

previous studies by SNLA, the AEC, and others (2-7, 10, 11) to estimate releases for radioactive materials shipments. The second, employed for nonradioactive hazardous materials, synthesizes release amount or source terms from generic release data available in HAZMAT accident reports (1).

5.2.5.1 Methods for Estimating Radioactive Material Releases

Sandia conducted studies in the early 1970's (2) in which transportation accidents were characterized by severity classes and by mode of transportation. Impacts range from minor damage to extensive damage leading to release of a major fraction of a package's contents. The severity classes were developed with a view toward categorizing accidents according to impacts on the integrity of radioactive materials packagings. For example, minor and moderate accidents involving Type B packages would not be expected to cause a release of material whereas severe, extra severe, and extreme accidents could lead to a release of contents. The effect of accidents on less robust packages, ranging from Type A to "strong, tight" is expected to be more dramatic, and could lead to complete loss of containment. The accident severity categories, and the expected impact on package types, are summarized in Table 5-1.

Studies by Holmes and Narver (7), those reported in WASH-1238 (4), Leimkuhler (6), Gibson (7), and others have developed responses of Type B packages to accident conditions. More recent studies have focuses on Type A and LSA (55) package accident response.

In addition, other studies, such as one by Holmes and Narver (7) (which developed fault tree analyses for plutonium oxide and irradiated fuel transportation) and those reported in WASH-1238 (4), Leimkuhler (5), Gibson (6), and technical journal articles have developed responses of Type B packages to accident conditions.

Estimates for releases of radioactive materials for accidents during material transport at the SRP were synthesized by using: 1) the data presented in the referenced studies, 2) information from the HAZMAT Data Base (1), 3) design information for SRP packages, 4) the characteristics of the radioactive materials being transported, 5) reported experience in industry for packages similar to, or the same as, SRP packages, 6) scenarios for postulated SRP accidents involving the radioactive materials and their packagings, and 7) engineering judgment.

5.2.5.2 Methods for Estimating Releases of Nonradioactive Hazardous Materials

A key feature of the accident analysis methodology for nonradioactive HMs is that releases from accidents were predicted using aggregate statistics obtained from the HAZMAT data base. The HAZMAT data base (1) is the hazardous materials accident data base maintained by the U.S. Department of Transportation. It contains over 150,000 records. Each record corresponds to an incident report filed by a carrier following an accident involving any material classified by DOT as a HM (see Appendix D for an example of a

TABLE 5-2. Estimated Damage to Packages and Consequences for Accident Severity Categories

Accident Severity Category	Damage to Type B Package	Consequences for Type B Packages	Consequences for Other Packages
Minor	Minor damage to outside of package; transport may continue.	None.	No loss of general containment. Some minor venting may occur.
Moderate	Outer container badly damaged; some repairs required before transport may continue.	No loss of containment or shielding features of the package.	No significant loss of contents, but some material may be released.
Severe	Slight damage to containment features and some loss of shielding or fissile materials spacing.	No significant loss of contents but radiation intensities may increase. For spent fuel shipments, small release of gases or coolant may result.	Some or most of the available contents are released. The percentage released is a function of the accident environment package location, and accident characteristics. Since the amount of radioactive material contained in other than Type B packages is limited, the total consequences are low even if the accident results in a completed release of package contents.
Extra Severe	Damage may include partial loss of containment, a significant loss of shielding, or spacing and damage to heat transfer media.	A small faction of the available contents may be released. For irradiated fuel shipments, loss of most of the free gases and coolant may result.	Same as severe.
Extreme	Damage may include loss of containment, loss of most of the shielding or spacing and loss of heat transfer media.	Some of the available contents, the percentage being a function of the accident environment and characteristics of the contents, may be released; high radiation intensities locally.	Same as severe.

Hazardous Material Incident Report). The incident reports are required for unintentional releases of HMs during transportation meeting the criteria set forth in 49CFR171.16. In addition to the incident report data, there are several auxiliary databases that contain additional information on shipping containers, damages, and the HMs themselves. The databases were searched for specific details regarding accidents involving HMs. These data were used to develop frequency distributions for the amounts of material released in accidents for each of the materials of interest (those which were selected in the screening process) (see Section 5.4.4).

5.2.6 Methods for Analyzing Transport, Dispersion, and Consequences for Released Hazardous Materials

The transport, dispersion, and consequence of released HMs were evaluated using computer codes employed in the safety analysis reports for other operations at the SRP (12). Methods (computer programs used at the SRP) for both air pathways and surface liquid pathways transport were used. Although the SRP codes were designed for calculating consequences for releases of radioactive materials, for analyses concerned with nonradioactive hazardous materials it was possible to use the AXAIR code to determine contaminant concentrations. In addition, supplemental analyses were performed to evaluate the persistence of dense gas effects that occur locally following release of a denser-than-air vapor.

Also, since accidents in transportation of HMs at the SRP can occur anywhere along onsite transport routes, it was necessary to develop approaches to permit application of consequence analysis results developed for a limited number of release points to the overall site. Finally, toxic thresholds for nonradiological HMs were established. The thresholds are necessary for estimating public health impacts resulting from the release of the nonradioactive HMs.

5.2.6.1 Atmospheric Dispersion Calculational Methods

The AXAIR code was used to calculate the dispersion and radiological consequence for radioactive materials. AXAIR was also used for nonradioactive materials to calculate the downwind concentrations resulting from releases and subsequent atmospheric transport of the materials.

The environmental transport models used in AXAIR are based on Gaussian plume dispersion correlations (USNRC Regulatory Guide 1.145 (43)) using the joint frequency distribution of weather conditions at the SRP site. The calculations are based on a non-uniform Gaussian plume model rather than a semi-infinite plume model. The meteorological conditions considered are screened in the calculational scheme of AXAIR such that the worst combination of wind speed and weather stability class are selected up to the frequency limit of 0.5% for each of 16 compass sectors. The worst sector is further selected, which then forms the basis for the contaminant concentration and, for radioactive contaminants, radiation exposure of the affected population. External gamma shine from the passing plume depends on the spatial distribution of the airborne radionuclides, and the energy of the emitted radiation.

No shielding from cloud shine was considered. Hence, external cloud exposure was maximized. Ground deposition of airborne radionuclides was not modeled. Hence, consistent with previous SARs performed for the site, gamma shine from contaminated ground is not considered.

Consequences for radioactive material releases are expressed as cumulative person-rems for the worst sector for both the onsite and offsite population groups. Dose commitments for a maximum exposed individual are also calculated and reported. The distance used for the maximum individual doses varied with the postulated release point. In general, these were calculated to be the distance to the nearest site boundary. 1980 Census data were used to determine population groups within 50 miles.

The radiation exposure pathways considered in AXAIR include inhalation of radionuclides and gamma radiation from the plume. The dosimetry for the inhalation exposure pathway considers the nature of the radionuclide, in particular, the physical and chemical properties which can affect the transport, assimilation and biological removal rates within the body. The calculated dose to an individual depends on the concentration of the airborne radionuclides, the exposure period, and, for inhalation doses, the breathing rates of different age groups of the population.

For nonradioactive HMs, concentrations of the contaminant at the plume centerline to which affected offsite and onsite population groups and the maximally exposed individual at the site boundary are exposed, are calculated to determine impacts. Each chemical contaminant is evaluated individually in terms of a comparison between exposure concentration and toxic effects limits. Consequences are expressed in terms of the number of persons exposed to concentrations above the toxic effects limit. Toxic effects limits used in this evaluation are discussed in Section 5.2.6.5.

Scoping calculations were performed to determine the need for a separate evaluation of denser-than-air gases. These calculations (documented in more detail in Appendix G) show that dense gas effects persist for only a few minutes of transport and, therefore, are not significant for the chemicals and release scenarios considered. Hence, airborne concentrations derived from AXAIR were used.

Release for materials, transported by truck or rail as liquids, which would vaporize under ambient conditions are treated for separate time phases. The first phase is associated with flashing of the pressurized discharge of the material. The second phase considers the continuing release which might result from evaporation from a liquid pool. In this later phase, only the non-flashed fraction of liquid material released is included. Both phases of this release are included in the consequence calculation.

With the typical storage conditions for pressurized low boiling point materials such as chlorine, 15% of the liquid could be immediately flashed and the rest entrained and vaporized. A more detailed assessment is presented in Appendix G.

The second phase of the release involves evaporation of the spilled material and is more complicated than the first release phase. This phase of the release occurs if a liquid pool is formed. Release rates for the second phase normally are smaller than for the first phase. The significant factors determining the rate for the second phase included: boiling point of the liquid relative to the temperature of the substrate surface on which the spill pool forms and area of the spill (especially if not confined). If the effective release rate for the second phase is near that for the first phase, the release can be modeled as occurring uniformly over a finite release period.

5.2.6.2 Surface Water Dispersion Calculation Methods

The consequences of hazardous materials releases to liquid pathways (surface waters) are evaluated for a variety of pathways: drinking water, aquatic food consumption, recreational uses of bodies of water, and irrigation of food crops.

A review of water utilization from the Savannah River downstream of the SRP site reveals that there is no known use of river water for irrigation; therefore, the irrigation of food crops is not considered as a pathway. The relative importance of other pathways generally depends on the materials of concern. For SRP liquid releases to the Savannah River drainage system, the exposure pathways of most concern are ingestion of drinking water and aquatic foods. Models were not available for this safety analysis that characterize the uptake and retention of contaminants by aquatic foods (fish, invertebrates, etc.) under transient conditions or over short periods as would be experienced in the case of releases caused by transportation accidents. Rather than omit the aquatic foods pathway, exposures are calculated assuming that the short term release levels may be represented by steady-state continuous releases. This methodology leads to overestimates of consequences.

The method of calculating dose-to-man from liquid effluent pathways is that recommended in the U.S. Nuclear Regulatory Commission (NRC) Regulatory Guide 1.109 (44). The LADTAP II Code, developed by the NRC and Oak Ridge National Laboratory (ORNL), is a computer code which performs dose calculations using the dose models specified in the Regulatory Guide. The 50-yr age-specific dose commitment factors are specified in the Regulatory Guide 0172 and are consistent with the ICRP2 model (45, 46) for ingestion pathways. The water user populations downstream assessed were Port Wentworth, population 20,000, and Beaufort-Jasper, population 51,000. The assumed riverflow was 10,400 cfs.

The consequences of nonradioactive HMs accidentally released to surface waterways onsite are evaluated using the dilution factors calculated for the SRP site with site-specific data also using the LADTAP II code. In this study onsite population effects are not calculated for liquid releases because the streams are not used as a source of supply for domestic or process water systems.

5.2.6.3 Atmospheric Dispersions for High Straight Winds and Tornadoes and Ground Water Transport

Because SRP operating procedures dictate that HMs will not be transported at the SRP during violent weather conditions, no analyses were performed for dispersions of HMs released under such conditions. High straight wind and tornado conditions result in much greater dilution of contaminants than do the normal atmospheric transport conditions. Furthermore, to help ensure conservatism, accident rates are not reduced to eliminate accidents attributable to severe environmental conditions (see Section 5.1).

Groundwater transport is of concern if there are chronic releases of hazardous contaminants resulting from onsite transportation activities. Except for minor leakage, such chronic releases are not evident. In addition, groundwater contamination resulting from spills in accidents would be minimized by the mitigation measures that would be applied immediately following an accident; therefore, dispersion of transported HMs by groundwater is not evaluated.

5.2.6.4 Treatment of Accident Location for Consequence Analyses

As discussed in Chapter 2.0, there are 200 miles of highways and 63 miles of railroads at the SRP. It is impractical to perform consequence analyses for all possible accident locations. Accordingly, for analysis purposes, accident locations were selected following one of three strategies discussed below.

Releases to Surface Waters. For accidents having the potential to release materials to surface waters, accident locations were selected where roads or railroads cross onsite streams or marsh areas (see Chapter 2.0, Figures 2-30 through 2-34). It was conservatively assumed that an accident in the one mile interval centered on the stream or marsh crossing would result in a release to surface waters. Thus, for highway transportation where there are 39 locations at the SRP where roads cross streams or marshes, a conditional probability of an accident where liquids could be carried into surface waters was estimated to be 0.2 (39 miles of road near streams or marshes divided by 200 miles of SRP highways). For railroad accidents, the conditional probability for release to surface waters was estimated to be 0.14 using the same approach.

The onsite point of release for contaminants is assumed not to significantly affect down river consequence results. Therefore, differentiation by potential release point was not made either for radioactive or nonradioactive contaminants.

Releases to Air Pathways. Accidents leading to the releases of HMs to air pathways can occur anywhere along the 200 miles of highways and 63 miles of railroads at SRP. An approximation method employing a few discrete release points (typically the locations of a shipment's origin and destination) was used to develop the expected radiological consequence values. This method yields conservative results since: radioactive materials are transported by the most direct route from origination points to destinations; one of these two points is nearest to offsite populations and to a potential maximally exposed individual; and both the shipping and receiving locations are generally in populated onsite areas. Exposure consequences via air pathways are then given weights of 0.5 each for shipping and receiving location. The weighted values are summed to estimate consequences. This approach results in reasonable estimates for population dose indices.

For radioactive HM, releases were postulated for A, D, F, H, C, K, and P areas. A different strategy was used to select representative locations for accidents involving nonradioactive HM. This strategy makes use of the observation that toxic effects from exposures to a nonradioactive HM occurs when concentrations of the material in the environmental pathway exceeds a threshold unique to the material. Centers of onsite population, and site gates where transportation vehicles (e.g., trucks or railroad trains) generally enter the site, were selected as the release points for AXAIR calculations. From these calculations, the extent of areas where toxic limits would be exceeded for transportation accidents are estimated.

Once the sizes of these areas are estimated, the number of miles of transportation route in each area is multiplied by the accident rate. This product is then multiplied by the number of individuals in the exposed population group. The resultant products are summed for each material to develop a measure of risk for transport of the material at the SRP. In effect, this strategy assumes an equal likelihood for accidents to occur along each mile of highway or railroad that lies within a critical radius from a population center. The critical radius is that calculated radius within which the level of exposure to a contaminant would exceed the toxic effects threshold. Another assumption (which is conservative) is that consequences to the population group located in the population center would be the same for an accident occurring any where within the circumscribed area.

Since detailed meteorological data are available for a number of SRP site locations, meteorological parameters from the meteorological (met) tower closest to the release points were used in the analyses. The locations of the met towers are identified in Table 5-3. Sensitivity analyses were performed to ascertain the importance of local meteorologic conditions in computing consequences. Variations in the sensitivity study results were not significant.

5.2.6.5 Determinations of Toxic Effects and Effects Thresholds

For the nine nonradioactive hazardous compounds selected (Section 5.2.4.2) the literature was reviewed and computer databases were searched to identify appropriate endpoints for use in risk characterization (see Appendix H and Reference 41). The focus of the search was on endpoints that were appropriate for use in evaluating acute exposure. Since transportation accidents are assumed not to cause chronic releases, only short-term exposure scenarios are considered in the safety evaluations for the nonradiological HMs. An SAIC report (47) discusses the current status of knowledge regarding risk assessments for nonradioactive compounds. Addressed

TABLE 5-3. **Generic Meteorological Sites for Transportation Accident Analysis**

General Facility Bldg. No.	Coordinates of Northeast Corner	Transportation/Accident Generic Area
# 614-20	N107586, E50948	A
614-21	N67167, E21331	D
614-22	N70413, E64256	H
614-23	N77687, E51345	F
614-24	N66164, E47906	C
614-25	N51812, E41296	K
614-26	N41458, E66332	P

are long term effects resulting from simple event exposures to nonradioactive toxic materials. The endpoints considered include the following:

- TLV-STEL is a 15-minute time-weighted average concentration not to be exceeded at any time during a work day. ACGIH indicates that exposures to this average 15-minute level should not occur more than four times per day, and with less than 60 minutes between exposure episodes.

- Ceiling Limit - Concentration that should not be exceeded even instantaneously (48).

- TD_{LO} - Lowest concentration at which adverse effect occurs (48).

- IDLH - (Immediately Dangerous to Life and Health). This level represents the maximum level to which a healthy worker can be exposed for 30 minutes and escape without suffering irreversible health effects or impairing symptoms (49).

The exposure concentrations associated with toxic effects endpoints for the nine selected chemicals are presented in Table 5-4. Each chemical has been assigned an inhalation toxicological limit. For four of the nine chemicals, an ingestion limit is also listed. The remaining five compounds are acids or bases. A chemical-specific toxicological limit for water is not established for these compounds since the principal effects are those associated with altering the pH of the water to which the substance is released.

The degree to which the limits may be exceeded for short periods without health effects depends upon a number of factors including the nature of the material, whether very high concentrations for short periods produce acute effects, whether or not the effects are cumulative, and the duration of exposure. Given these factors, levels above the STEL were chosen for several contaminants. There is evidence that these higher concentrations produce only mild transitory effects following exposures of greater than 15 minutes. For example, for 1,1,1-trichloromethane, the level chosen is the IDLH value. Though this level is more than twice the STEL, a person can be exposed for 30 minutes without suffering irreversible effects. The effects, in this case, consist of light-headedness, uncoordination, slight loss of equilibrium, and transient eye and nose irritation.

Specific effects associated with exposure to the materials at various concentrations are listed along with a rationale for selecting a particular impact value. Summaries of toxic effects for each compound are presented in Appendix H.

The concentrations chosen for each compound are trigger levels of concern. They do not represent levels at which irreversible effects will occur, or concentrations at which effects will occur in 100% of the exposed population. Instead, in most cases the concentrations represent those levels at which it can be expected that mild, reversible effects such as eye, nose, and throat irritation, or slight dizziness will occur if the duration of exposure exceeds specified time periods.

TABLE 5-4. Recommended Air and Water Exposure Concentrations to be Used as Toxicological End-Points for Selected Nonradiological Compounds

Compound	Air Concentration Limits	Water Concentration Limits	Effect	Rationale for Selection
Chlorine	3 ppm; 9 mg/m^3	10.5 mg/l	Irritation of eyes and upper respiratory tract.	The air concentration chosen is based on the STEL which is the concentration to which workers can be continuously exposed for short periods of time without suffering from irritation, chronic or irreversible effects, or significant narcosis. The STEL is a 15-minute time-weighted average exposure which should not be exceeded at any time during a work day. Exposures should not be longer than 15 minutes and should not be repeated more than 4 times per day. Exposure to chlorine in water is based on the tentative acceptable daily intake of chlorine.[a] While it is recognized that this value is not entirely acceptable for use in the evaluation of acute exposures, no other data are available.
Gasoline	990 ppm 2,700 mg/m^3	N/A	Slight dizziness, irritation of eyes, nose, and throat within 1 hour.	The air concentration chosen is based on a threshold for toxic effects. While the STEL is 500 ppm (1,500 mg/m^3), 900 ppm (2,700 mg/m^3) represents the upper limit of toxic effects that may be experienced within one hour. Above 900 ppm, irritation, dizziness, and intoxication is manifested within minutes. There was insufficient information to determine an acceptable concentration in water.

TABLE 5-4. Recommended Air and Water Exposure Concentrations to be Used as Toxicological End-Points for Selected Nonradiological Compounds (Continued)

Compound	Air Concentration Limits	Water Concentration Limits	Effect	Rationale for Selection
Hydrogen fluoride	5 mg/m^3	4 mg/l	Irritation of eye, skin, respiratory tract after 15-minute exposure to 5 mg/m^3.	The air concentration chosen is based on a ceiling level recommended by NIOSH. At 5 mg/m^3, little or no eye, skin, or respiratory tract irritation should occur within 15 minutes. The water concentration is based on the proposed MCL.[c] This level is protective against crippling skeletal fluorosis with an adequate margin of safety. The lethal dose for fluoride is approximately 2.5 gm
Nitric acid	4 ppm 10 mg/m^3	N/A[b]	Dryness of throat and nose, coughing and difficulty breathing.	The value chosen for exposure to nitric acid in air is based on the STEL, which is a 15-minute time-weighted average that should not be exceeded at any time during a work day. Exposures should not be longer than 15 minutes and should not be repeated more than 4 times per day.
Phosphoric acid	11 mg/m^3	N/A[b]	Coughing, irritation of upper respiratory tract.	Exposure to 11 mg/m^3 of phosphoric acid in air may produce discomfort and irritation in unacclimated workers. It is not expected that this level will produce serious health effects.
Sodium hydroxide	2 mg/m^3	N/A[b]	Upper respiratory tract irritation, possible damage to upper respiratory tract and lung tissue at higher levels.	The value chosen for exposure to sodium hydroxide is based on the ceiling value, which should not be exceeded, even instantaneously.

TABLE 5-4. Recommended Air and Water Exposure Concentrations to be Used as Toxicological End-Points for Selected Nonradiological Compounds (Continued)

Compound	Air Concentration Limits	Water Concentration Limits	Effect	Rationale for Selection
Sodium hypochlorite	3 ppm (as free chlorine) 9 mg/m^3 (as free chlorine)	10.5 mg/l	Irritation of eyes and upper respiratory tract.	The inhalation hazard results from the release of free chlorine, thus the air concentration chosen is based on the STEL for chlorine. In water, toxicity would also be related to the presence of free chlorine. The value chosen for water is based on the tentative acceptable daily intake of chlorine.[a] While it is recognized that this value is not entirely appropriate for use in the evaluation of acute exposure, no other data are available.
Sulfuric acid	5 mg/m^3	N/A[b]	Eye and throat irritation, coughing, increased respiratory rate, and impaired ventilatory capacity.	At 5 mg/m^3, exposure to sulfuric acid may be objectionable, though it may be tolerated for brief periods without serious irreversible effects.

TABLE 5-4. Recommended Air and Water Exposure Concentrations to be Used as Toxicological End Points for Selected Nonradiological Compounds (Continued)

Compound	Air Concentration Limits	Water Concentration Limits	Effect	Rationale for Selection
1,1,1 Trichloro-ethane	1,000 ppm 5,400 mg/m^3	200 ug/l	Below 1,000 mg/m^3, eye irritation and central nervous system effects can occur.	The value chosen for 1,1,1-trichloroethane is based on the IDLH.[d] Though this value is above the STEL, there is evidence that inhalation of 500 ppm (2,700 mg/m^3) has no significant effects other than transient mild eye and nose irritation, light headedness, slight incoordination, and loss of equilibrium. This level can be tolerated for brief periods. The value chosen for water is based on the proposed MCL.[c] MCLs are enforceable standards that are set at levels to prevent the occurrence of any known or anticipated adverse effect.

[a]Personal communication with Michael Dourson, U.S. Environmental Protection Agency, Office of Drinking Water, Cincinnati, Ohio.

[b]There are no Federal criteria, standards, or guidelines for acids and bases in water. Toxicty of these compounds in drinking water is evaluated by examining change in the pH of the water. Criterion for pH in drinking water is 5-9.

[c]MCL = maximum contaminant level.

[d]IDLH - Immediately Dangerous to Life and Health.

N/A - Not Available.

5.2.7 Methods for Assessing Risks

For this safety analysis, risk is calculated as the product of the evaluated consequences and the release frequency. The accident frequency is calculated as the product of the accident probability per mile multiplied by the miles traveled in transporting the material on the SRP site.

Consequence indices calculated for accidental releases of radioactive materials are in person-rem for onsite and offsite populations and rem exposure for maximum exposed individuals. The risks associated with transport of radioactive materials are therefore reported as person-rem/yr for onsite and offsite populations and rem/yr for maximum exposed individuals.

For transportation of nonradioactive HMs risks are only reported for the onsite and offsite population groups and not for a hypothetical maximally exposed individual. The threshold effects assumption for responses to toxic materials and the assumption that there are no residual effects for exposures below the threshold makes the maximum exposed individual measure of consequences meaningless for this analysis. For nonradioactive materials, consequences are reported as the number of individuals exposed to toxic agents above thresholds. Therefore, risks are the multiples of the numbers of individuals who will be exposed above thresholds in a single occurrence and the number of exposure occurrences in a year. Appropriate endpoints for evaluating acute single event exposures needed for human health effects risk characterization of the nine radioactive hazardous materials analyzed were not available in current literature (see References 41, 47, and 49, and Appendix H).

5.3 ESTIMATES OF ACCIDENT PROBABILITIES

This section presents estimates of the probabilities of in-transit, loading/unloading and personal injury accidents for the transportation of hazardous materials at the SRP. The frequencies are used in Section 5.5 in estimating risks. Frequencies for accidents initiated by severe environmental events or other external events are either below values for credible accidents or are considered part of the accident statistics as discussed below. The accident probabilities reported were developed using the approaches discussed in Section 5.2.3.

5.3.1 Severe Environmental Phenomena and Other External Events

5.3.1.1 Winds

The occurrence of high straight winds and tornadoes at the SRP is not believed to be significantly more or less frequent or severe than those which affect transportation in other areas of the United States. Section 2.1.5 discusses the meteorology of the SRP.

During very severe wind conditions and weather conditions which lead to tornadoes, hazardous material transportation activities are not conducted on the SRP site. Accidents induced by winds are part of the overall database used to estimate accident frequencies and severities for hazardous material incidents, and are not considered separately here.

5.3.1.2 Earthquake

Earthquake frequencies for SRP are shown in Figure 5-2 (50). The expected frequency of a MM VIII earthquake is $2x10^{-4}$/yr. An earthquake of this magnitude can result in damage to roadways and railways causing transportation on the site to cease. Accidents during an actual earthquake resulting from roadbed damage or loss of control due to surface motion are not expected to be any more severe than accidents from other causes; the frequency for such effects is substantially lower. Earthquake effects are considered to be included within the envelope of risk values for accidents during normal hazardous material transport.

5.3.1.3 Other Natural Phenomena Related Events

Extremes in temperature, snow, rain, lightning and flood may adversely affect transportation operations. The impacts are manifested principally as initiators for, or contributors to, an accident during hazardous material movement. Such effects are considered to be included in the database for accidents during material movement (see Section 5.2.3).

5.3.2 Externally Induced Failures

The only identified significant source for externally induced transportation accidents is an aircraft crash. Studies related to power reactors, based on U.S. Civil Aviation accident data, indicate that the expected frequency of aircraft overflights becomes essentially constant at distances greater than five miles from an airport runway as is the case for Savannah River operations.

The expected accident frequency is about $3x10^{-9}$/(flight)(mi^2) for commercial aviation and about $7x10^{-9}$/(flight)(mi^2) for general aviation (51).

For a bounding estimate for the site, it is conservatively assumed that on the average ten vehicles containing hazardous materials each of 1000 ft^2 cross section can exist at any one time onsite. The exposed area of 10,000 ft^2 is about $4x10^{-4}$ mi^2. Based on 4000 overflights of SRP/yr and an accident frequency of $7x10^{-9}$/flight mi^2, the frequency for crash of an aircraft into a transportation vehicle which is of the order of 10^{-8}/yr which is less than the cutoff frequency of 10^{-6}/yr for a credible accident (52).

5.3.3 Accident Probabilities for Hazardous Material Movements

Accident probabilities for transportation accidents were derived from national databases, as discussed in Section 5.2.3. The value is $6.4x10^{-6}$ accidents/mi for truck transport and $1.2x10^{-5}$ accidents/train mi for movement via railroads.

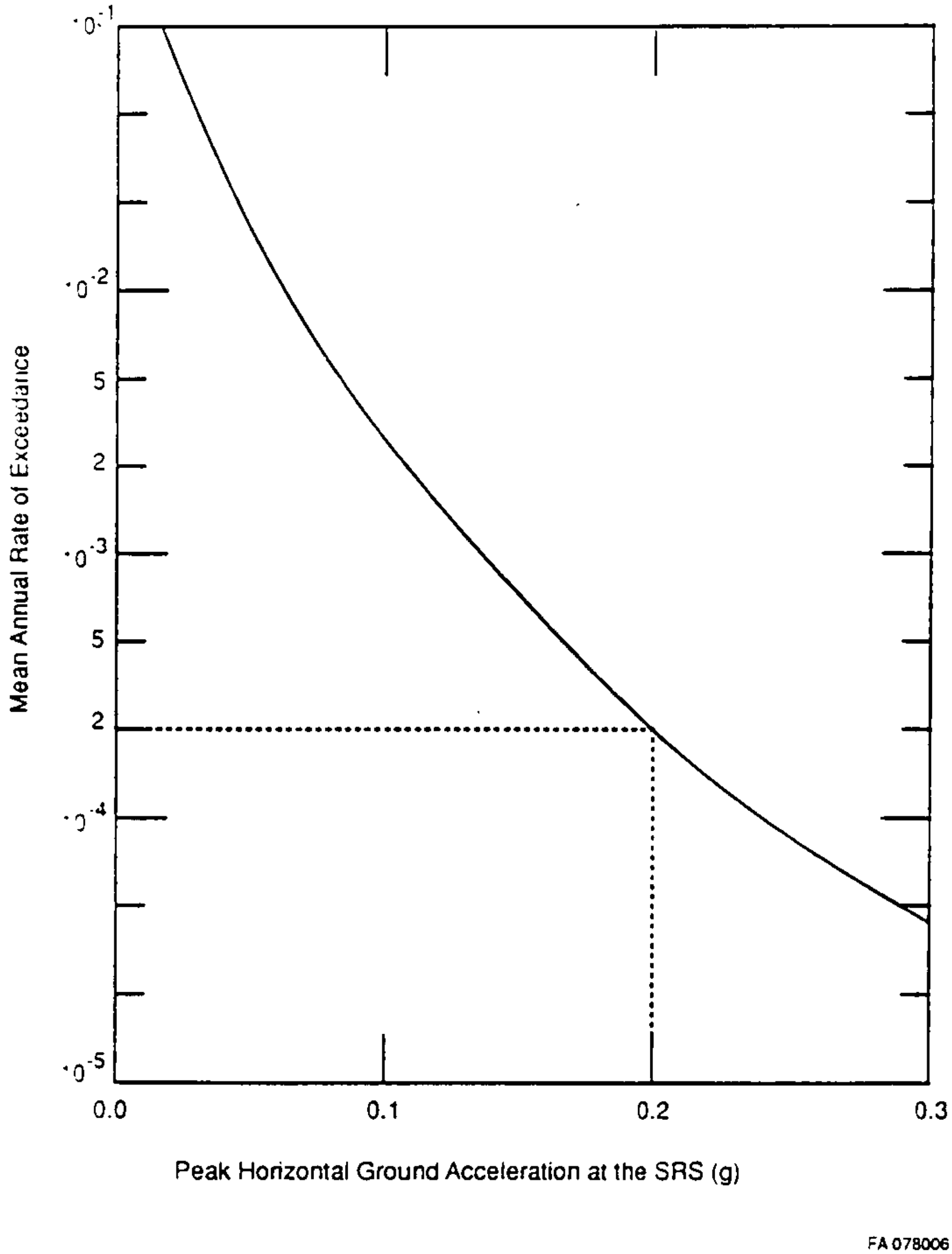


FIGURE 5-2. Earthquake Frequency at the SRP

Accidents during transport for truck and railroad shipments have been segregated into severity categories with associated probabilities. The data were taken from Reference 2 and reflect data for transport of radioactive materials.

Table 5-2 presents the accident severity categories and was derived from Reference 2, 10, 11. Table 5-5 lists conditional probabilities of an accident in a particular severity category for each accident as well as the joint probabilities for truck transport of radioactive and nonradioactive materials. Table 5-6 is a similar table for railroad transport and is based on accident frequency/car mile.

Table 5-5 is used with Table 5-2 to establish the total probability/mi for an accident that would result in a release of radioactive material from a package. In general, this is done by summing the probability/mi for each accident category that could cause a release from a package. Typically, this includes the Severe, Extra Severe, and Extreme categories for Type B packages, and those categories plus the Moderate category for Other Package types.

5.4 SOURCE TERMS FOR CONSEQUENCE AND RISK ANALYSIS

This section presents the results of analyses to estimate quantities released in transportation accidents (Ci of radioactive materials or pounds or gallons of nonradiological hazardous materials). The estimates were developed by applying the methods discussed in Section 5.2 above. The quantities released to air or water pathways are the source terms used for the consequence analyses and risk assessment. As with other sections of this report, there are separate discussions for radioactive and nonradioactive hazardous materials.

Source terms have been developed for a limited set of accident cases. For both accidents involving radioactive material release and those involving release of nonradioactive materials, a screening process was performed to identify the materials contributing to risk. Source terms were developed for accident cases for these materials.

5.4.1 Screening of Materials for Accident Analysis

Since only a few HMs dominate risk estimates, it is both impractical and unnecessary to evaluate risk associated with every one of the large numbers of HMs transported at the SRP. The materials and their release estimates were screened to select from the list of more than 200 HMs those having the greatest hazard potential. Methods described in Section 5.2.4 were used.

5.4.1.1 Screening for Radioactive Materials

A Hazard Index (HI) was used to identify the most important materials. This index is the product of an estimated release for the accident (see Section 5.4.3), and the estimated accident frequency, divided by a value for the

TABLE 5-5. **Probabilities of Truck Accidents by Severity Categories***

Accident Severity Category	Probability of Category Given an Accident	Joint Probability (accidents/vehicle-mile)
Minor	0.977	6.3×10^{-6}
Moderate	0.018	1.2×10^{-7}
Severe	0.0029	1.9×10^{-8}
Extra Severe	0.0014	9.0×10^{-9}
Extreme	0.0005	3.2×10^{-9}

Probability of truck accident = 6.4×10^{-6}/vehicle-mile.

*Reference 2.

TABLE 5-6. Probabilities of Rail Accidents by Severity Categories*

Accident Severity Category	Probability of Category Given an Accident	Joint Probability (accidents/ train mile)
Minor	0.8	9.6×10^{-6}
Moderate	0.09	1.1×10^{-6}
Severe	0.08	9.6×10^{-7}
Extra Severe	0.02	2.4×10^{-7}
Extreme	0.01	1.2×10^{-7}

Probability of train accident = 1.2×10^{-5}/train-mile

*Reference 2.

maximum permissible intake (MPI) for the radionuclide (37). Table 5-7 lists the radioactive materials transported at SRP in descending order of their HI. Also listed are accident frequencies associated with movement of the material. MPI values for radionuclides transported at the SRP are presented in Appendix F. Although the HI does not consider material form, dispersion mechanisms and related exposure or uptake pathways, it is considered to be an appropriate method for screening to identify the most important materials in terms of risk.

Eight materials having HIs of 20 or greater were selected for consequence and risk analysis. The cumulative HIs for these materials comprises more than 99.9% of the total sum of HIs for radioactive materials transported at the SRP.

5.4.1.2 Screening for Nonradioactive Hazardous Materials

For nonradioactive materials, the selection of those contributing most to risk was based on the following information: the quantity of the compound transported annually at the SRP; the toxicity of the compound; and the material form of the compound and its mobility in the environment.

As is discussed in Section 5.2.4.2 a final list of 9 compounds was established. This list is presented in Table 5-1.

5.4.2 Partition Factors

Partition factors were applied to estimate the fraction of a dissolved material that released from the solution to the air pathway as the liquid from the solution evaporates. The partition factors used for radionuclides are consistent with those used in other Savannah River SARs. The values and their bases are contained in Reference 53. The values utilized are regarded as conservative (that is, a larger fraction of the material is assumed to be released as vapor than would be expected).

Partition factor values are as follows:

Radionuclide Class	Partition Factor
Noble gases	1.0
Tritium	1.0
Iodine and other halogens	1.0
Ruthenium	10^{-2}
Other radionuclides	10^{-4}

For those nonradioactive nonvolatile solutes dissolved in water that are of interest in this evaluation, a partition factor value of 10^{-4} was also used. The principal material to which the value was applied is sodium hydroxide. Releases of liquids which rapidly vaporize when spilled is discussed in Appendix G. Releases of respirable materials to the atmosphere pathway during fires is assumed to be 1% of the total amount released (54).

TABLE 5-7. Summary - Hazard Indices for Release of Radionuclides During Transport by Truck or Railcar (in Descending Order of Risk)

Description of Shipment	Hazard Index (see Appendix I)	Release Event Shipment Accident Frequency (see Appendix I)
TRU solid wastes to Burial Ground	128	$3x10^{-5}$
100-Areas basin sludge to Building 241-F in a bottom discharge trailer	3.6×10^3	$1x10^{-1}$
Low-level wastes, Building 776-A to Building 221-F	300	$3.9x10^{-5}$
Small casks on stake body truck	100	$2x10^{-5}$
UNH trailer traveling onsite	187	$1.3x10^{-4}$*
Low-level waste, 100-C to Building 241-F	67	$1x10^{-1}$
Routine H-Area samples on H-Area sample truck to Building 772-F	143	$4.5x10^{-5}$
Other samples on H-Area sample truck	37	$6x10^{-7}$
High-level waste trailer, Building 776-A to Building 221-F	20	$3x10^{-9}$
D_2O in drums between 100 and 400 Areas	100	$6.2x10^{-5}$
Wastes and obsolete equipment by rail	63	$2x10^{-1}$
100 Area Deionizer Casks	20	$2x10^{-1}$
Contaminated equipment (for repairs or Burial Ground) moved by truck	8	$5x10^{-2}$
Waste load lugger pans***	19	$1.8x10^{-3}$
Pu-238 oxide HB to building 773-A	13	$1.3x10^{-8}$
Radioactive items on nonradioactive vehicles and noneffective controls	5	$1x10^{-4}$
Waste boxes on truck***	7	$1.5x10^{-3}$
Small packages of neptunium and plutonium oxides on H-Area sample truck	9	$9x10^{-8}$
100 Areas routine samples	11	$3.4x10^{-4}$
Radioactivity into Upper Three Runs Creek from low- and high-level waste trailers & H-Area sample truck to and from 3/700 Area	19	$4x10^{-6}$
Offsite shipment - alpha-emitting products	2	$5x10^{-9}$*
Offsite shipments - packages containing tritium	1	*
Neptunium oxide, HB Line to Building 235-F	4	$6.2x10^{-7}$
Irradiated fuel element casks - rail	10	$1.5x 10^{-3}$
Neptunium-aluminum, plutonium-aluminum, uranium-aluminum billets	160	$4.7x10^{-5}$
Irradiated element sections to Building 773-A	0.4	$3.6x10^{-7}$
Neptunium solution, 200-F Area to 200-H Area	0.9	$3x10^{-6}$
Pu-238 to Buildings 235-F and 773-A	0.2	$4x10^{-9}$
Solvent trailer	0.07	$2x10^{-9}$
Spent melts, Building 232-H to Burial Ground	0.02	*

TABLE 5-7. **Summary - Hazard Indices for Release of Radionuclides During Transport by Truck or Railcar (in Descending Order of Risk) (Continued)**

Description of Shipment	Hazard Index (see Appendix I)	Release Event Shipment Accident Frequency (see Appendix I)
Target casks, 100 Areas to H Area	0.0003	-
Pu-238 from Building 221-F to offsite	ES**	-
Unirradiated fuel elements (including criticality potential during vehicle accidents)	-	-
Rail-outgoing or incoming shipments	ES**	$3x10^{-8}$
Scrap metal from 100 Areas and RBOF to Burial Ground		
A-Line depeleted uranium product to storage	-	-

* Representative Value - actual value is security sensitive information.

** ES means extremely small.

*** Low level waste handling and transportation at the SRP is conservatively represented in this report through analyses of consequences and risks associated with practices and equipment for which historic data is available. The practices and equipment have since been improved. For example, use of waste load lugger pans and general waste boxes was discontinued in 1985. Engineered metal burial boxes or DOT specification 17-C waste drums are now used as containers for all low level waste transportation at the SRP.

5.4.3 Source Terms for Radioactive Materials

Postulated accident releases for radioactive material shipments at the SRP are listed in Table 5-8. These releases are for the those accidents involving materials most important to risk as identified by the screening process (see Section 5.4.1). The screening process followed an extensive analysis of potential accidents and incidents in radioactive materials transportation at the SRP. Appendix I contains the detailed information that was used to develop the table.

Two of the source terms (for the accidents involving uranyl nitrate and high-level waste trailers) are used for analysis of consequences for releases into surface water streams. For the other source terms, only releases into the atmosphere are evaluated.

Assumed radionuclide releases during accidents involving the packages or vessels transported were identified through review of the SRP transportation operations. These assumed releases are listed in Appendix I and are the basis for the releases listed in Table 5-8. In some cases, radionuclides were identified only as curies of alpha activity. Pu-239 was the isotope selected to conservatively represent alpha emitting radionuclides. Where the listed radionuclides were indicated to be mixed beta-gamma radioactivity, a fission product distribution typical of H-Area high-level waste was used for analyzing the consequences of release (13).

5.4.4 Source Terms for Nonradioactive Hazardous Materials

The nonradioactive materials for which source terms were developed were those identified in the screening process and are listed in Table 5-1 (see Section 5.4.1). For each of these materials, a distribution of released quantity versus accident severity was developed from data in the HAZMAT data base (1). From the data, probability values were compiled for various fractional releases. Probability distributions for releases of each material resulting from postulated accidents at the SRP are listed in Table 5-9. The total probability of release for a particular material is the probability of an accident/vehicle-mile (Section 5.3), the probability of a release in an accident (Table 5-9), and the miles/year for shipment of the materials (Table 3-1).

As a specific example, the calculation of a frequency distribution for chlorine releases for a transportation accident is summarized below.

Chlorine is shipped in 1-ton cylinders by truck to a number of sites at SRP. There are approximately 57 shipments per year, with an average of 8 cylinders per shipment. The average annual number of loaded chlorine truck-miles onsite is about 570. Using the rate of truck accidents for nonradioactive materials of $1.3x10^{-6}$/mi, the frequency of chlorine truck accidents is:

$$P(\text{chlorine truck accident}) = (1.3x10^{-6}/\text{mi})\ (570\ \text{mi/yr})$$

$$= 7.4x10^{-4}/\text{yr}$$

TABLE 5-8. **Radiological Hazard Source Terms For Transportation Accidents**

Accident Description	Amount Released	Total Isotopic Inventory of Release		Partition Fraction*	Inventory Released to Environmental Transport Pathways
Break or puncture of TRU drum & fire	0.84 Ci TRU	0.84 Ci	Pu-239	10^{-2}**	$8.4x10^{-3}$ Ci
Basin sludge leakage from trailer	10 gals	$4x10^{-4}$ Ci	Pu-239	10^{-4}***	$4x10^{-6}$ Ci
		$2.1x10^{-3}$ Ci	Zr-95		
		$4.2x10^{-4}$ Ci	Nb-95		
		$4.6x10^{-3}$ Ci	Ru-103		
		$3.1x10^{-2}$ Ci	Ru-106		
		$6.0x10^{-5}$ Ci	Cs-134		
		$5.3x10^{-4}$ Ci	Cs-137		
		$4.4x10^{-5}$ Ci	Ce-141		
		$3.3x10^{-3}$ Ci	Ce-144		
Product wastes cask falls off truck - sludge leakage	1 gal	0.1 Ci	Pu-239	10^{-4}***	$1x10^{-5}$ Ci
Spill Contents of UNH trailer (liquid release)	1000 gals	.1 Ci	U-238	1.0	10.1 Ci
		10 Ci	β-γ		
Low level waste trailer leak (atmospheric release)	10 gals	$1x10^{-5}$ Ci	Pu-239	10^{-4}***	$5.1x10^{-8}$ Ci
		$3.8x10^{-7}$ Ci	Zr-95		
		$2.9x10^{-6}$ Ci	Nb-95		
		$1.5x10^{-6}$ Ci	Ru-103		
		$8.0x10^{-5}$ Ci	Ru-106		
		$1.7x10^{-4}$ Ci	I-129		
		$1.7x10^{-4}$ Ci	I-131		
		$5.1x10^{-7}$ Ci	Cs-134		
		$2.1x10^{-5}$ Ci	Cs-137		
Low level waste trailer accident (liquid release)	1% of load	4 times the above		1.0	$2.0x10^{-3}$ Ci
H-area sample truck accident	50 ml sample (0.06 Ci Pu-238)	.06 Ci	Pu-238	10^{-4}***	$6.6x10^{-5}$ Ci
		$6x10^{-4}$ Ci	Zr-95		
	60 ml sample (0.6 Ci)	$2.5x10^{-4}$ Ci	Nb-95		
		$1.3x10^{-2}$ Ci	Ru-103		
		.58 Ci	Ru-106		

TABLE 5-8. Radiological Hazard Source Terms For Transportation Accidents (Continued)

Accident Description	Amount Released	Total Isotopic Inventory of Release	Partition Fraction*	Inventory Released to Environmental Transport Pathways
High level waste trailer accident (atmospheric release)	3000 gals	100. Ci Pu-239 10.5 Ci Zr-95 2.1 Ci Nb-95 22.9 Ci Ru-103 144. Ci Ru-106 .3 Ci Cs-134 2.66 Ci Cs-137 2.2 Ci Ce-141 16.6 Ci Ce-144	10^{-4}***	$3x10^{-2}$ Ci
High level waste trailer overturns into Upper Three Runs Creek (liquid release)	3000 gals	Same as above	1.0	300 Ci
Rupture of D_2O drum	1000 Ci Tritium	1000. Ci H-3	1.0	1000 Ci

* Partition Fraction: the amount dispersed and transported downwind. Is estimated to be 10^{-4} for dry and wet sludge materials released and 1.0 for gases and liquid pathways release scenarios.

** Scientific notation.

*** The partition factors used for radioactive isotopes of iodine and ruthenium in nonvolatile solutes dissolve in aqueous solution are the same as those for other radionuclides dissolved in the solutions.

TABLE 5-9. Probability Distribution for Nonradioactive Material Accident Releases at SRP
(Table entries under each release quantity are frequency, i.e., probabilities/yr)

Material	Quantity Unit	Shipment Miles/Yr	Quantities Releases (Pounds or Gallons)					Total Frequencies
			0	1-10	11-100	101-1000	1001 & up	
Chlorine (truck)	Pounds	570	1.824E-3	8.025E-4	5.839E-4	4.742E-4	0	3.648E-3
Gasoline (truck)	Gallons	25,000	6.080E-2	5.278E-2	3.360E-2	9.60E-3	3.20E-3	1.60E-1
Aqueous Hydrogen Fluoride (truck)	Pounds	70	2.24E-4	9.85E-5	7.168E-5	5.824E-5	0	4.48E-4
Nitric Acid (truck)	Gallons	2,410	4.781E-3	6.016E-3	1.696E-5	1.542E-3	1.542E-3	1.542E-2
Phosphoric Acid (truck)	Gallons	40	1.126E-4	1.28E-4	1.54E-5	1.02E-6	0	2.6E-4
Sodium Hydroxide (rail)	Gallons	1,272	4.885E-3	6.258E-3	3.969E-3	1.526E-4	1.526E-4	1.526E-2
Sodium Hydroxide (truck)	Gallons	590	1.435E-3	1.246E-3	7.931E-4	2.266E-4	7.552E-5	3.78E-3
Sodium Hypochlorite (truck)	Gallons	880	2.47E-3	2.591E-3	2.82E-4	2.253E-4	5.632E-5	5.632E-3
Sulfuric Acid (rail)	Gallons	120	4.61E-4	5.90E-4	3.74E-4	1.44E-5	1.44E-5	1.44E-3

TABLE 5-9. **Probability Distribution for Nonradioactive Material Accident Releases at SRP** (Continued)
(Table entries under each release quantity are frequency, i.e., probabilities/yr)

Material	Quantity Unit	Shipment Miles/Yr	Quantities Releases (Pounds or Gallons)					Total Frequencies
			0	1-10	11-100	101-1000	1001 & up	
Sulfuric Acid (truck)	Gallons	280	5.553E-4	6.99E-4	2.0E-4	1.79E-4	1.79E-4	1.79E-3
Trichloro-ethane (rail)	Gallons	72	3.89E-4	3.28E-4	9.504E-5	3.46E-5	2.59E-5	8.72E-4

To obtain the frequency distribution of chlorine releases, the conditional probability (conditional on an accident occurrence) that a given volume of chlorine will be released was developed. First, 152 records involving chlorine accidents were found in the HAZMAT data base. About 12 different containers were found to be involved, including steel cylinders. For simplicity, these were divided into two groups, those containing under 2000 lb (small containers) and those containing over 2000 lb (large containers). It should be noted that none of the small container accidents involved rail shipment, whereas over half of the large container accidents involved rail shipment. Based on these data, the following release distributions were calculated:

Release Amount, lb	Number of Accidents Involving Small Containers (fraction of accidents in parenthesis)	Number of Accidents Involving Large Containers (fraction of accidents in parenthesis)
0	16 (.5)	54 (.45)
0-10	7 (.22)	45 (.38)
10-100	5 (.16)	13 (.11)
100-1,000	4 (.13)	5 (.04)
1,000-10,000	0	3 (.03)

These distributions are smooth and of similar shapes. This was judged to be a valid representation of release distributions for chlorine accidents.

Each number in parentheses represents the conditional probability of a release in its corresponding range, given an accident. Using the small container distribution, and multiplying the conditional probability of release times the truck accident frequency results in the following set of chlorine release frequencies:

Accident Release	Frequency	Release x Frequency
Zero:	3.7×10^{-4}/yr	0
0-10 lb:	1.6×10^{-4}/yr	1.6×10^{-3}
10-100 lb:	1.2×10^{-4}/yr	1.2×10^{-2}
100-1000 lb:	9.6×10^{-5}/yr	9.6×10^{-2}

Noteworthy for accidents involving releases of chlorine is that the multiple of the release quantity (upper limit value) and the frequency of occurrence is greatest for the largest releases. This indicates that risks are dominated by the larger releases.

5.5 CONSEQUENCES AND RISKS FOR SRP HAZARDOUS MATERIALS TRANSPORTATION

In this section consequences and risks from potential accidents in the transportation of hazardous materials at the SRP are estimated. Estimates are of health impacts to the public (i.e., individuals living or working beyond the boundaries of the SRP) and to SRP workers. Consequences or risks associated with actions taken to recover from accidents or those associated with normal transportation operations are not included in these evaluations.

Risks to the public result from inhalation, ingestion, or exposure to hazardous materials that may be released. Because SRP drinking water sources are from deep wells on the site, risks to workers are only those due to inhalation or exposure. Consequences and risks are reported only for those materials assessed in the screening analyses (see Section 5.4.1) to have the greatest hazard potential. Although possible, it is unlikely that the materials and associated shipments that were not selected would contribute significantly to overall SRP hazardous materials transportation risks. Results are reported separately for radioactive and nonradioactive materials.

5.5.1 Consequences and Risks for Radioactive Materials Transportation at the SRP

Table 5-10 includes consequences and risks to the offsite public and SRP workers resulting from the transportation of radioactive materials at the SRP. As noted in Section 5.2, each accident is postulated to occur with equal likelihood at the shipment origin and destination points for the purpose of calculating consequences (0.5 probability/location). The table contains summary descriptions of the accidents; the frequencies for the accidents(see Section 5.3); the amounts of materials estimated to be released to the environment (see Section 5.4); conditional probabilities for the various release quantities (see Section 5.4); the assumed accident locations (see Section 5.2); and the calculated offsite population dose, maximum individual dose, and onsite population dose. The table also shows the calculated values of risks to the offsite population, the onsite population and the hypothetical maximally exposed individual. The total risk for radioactive materials transportation is the sum of the individual accident risks.

5.5.2 Consequences and Risks for Nonradioactive Hazardous Material Transportation at the SRP

Table 5-11 summarizes the consequences and risks resulting from nonradioactive hazardous materials transportation at the SRP. As for the radioactive materials, results are for the offsite public and for SRP workers. A major difference in the data presented for the nonradioactive hazardous materials is in the postulated locations of accidents. For the nonradioactive materials, accidents are assumed to have an equal likelihood of occurrence at all locations on the transportation routes. Accident consequences are reported for accidents that occur near to major population centers onsite and offsite. The radii of areas where exposure exceeds toxic limits are established for this analysis and fractions of SRP route miles encompassed in the areas are also

TABLE 5-10. Consequences and Risks to Onsite and Offsite Populations - Radioactive Materials

							Consequences[f]			Risk[g]		
Accident	F(A)/yr[a]	Amt Rel[b]	P(R/A)[c]	Location	P(E/R,A)[d]	Released[e] to Pathway	Max Ind rem	Offsite pers-rem	Onsite* pers-rem	Max Ind rem/yr	Offsite pers-rem/yr	Onsite* pers-rem/yr
Breach or Puncture of TRU Drum	3.0E-5	8.4E-1 Ci TRU	1.0	Bur Gnd	0.5	8.4E-3 Ci	1.9E-2	1.3E+2	2.7E+1	2.85E-7	1.95E-3	4.05E-4
				A-Area	0.5	Same	5.5E-1	1.2E+2	3.3E+1	8.25E-6	1.8E-3	4.95E-4
Basin Sludge Trailer Leak	1E-1	4E-2 Ci BG 4E-4 Ci Al	1.0	F-Area	0.5	4E-6 Ci	1.3E-7	4.4E-5	7.8E-5	6.6E-9	2.2E-6	4.0E-6
				100-Areas	0.5	Same	1.2E-7	3.0E-4	7.2E-5	6.2E-9	1.5E-5	3.6E-6
Product Waste Cask Accident	2.0E-5	1E-1 Ci Al	1.0	200-Area	0.5	1E-5 Ci	2.3E-5	1.4E-1	3.4E-2	2.3E-10	1.4E-6	3.4E-7
				A-Area	0.5	Same	6.8E-4	1.2E-1	4.2E-2	6.8E-9	1.2E-6	4.2E-7
UNH Trailer Leak (liquid)	1.3E-4	1E-1 Ci U 1E+1 Ci BG	0.07	UTRC**	0.1	1.0E+1 Ci	3.6E-4	1.4E+1	_***	3.2E-10	1.2E-5	_***
Low Level Waste Trailer (atm rel)	1E-1	1E+1 gal 1E-5 Ci Al 5E-4 Ci BG	1.0	200-Area	0.5	5.1E-8 Ci	8.8E-8	3.0E-4	5.1E-5	4.5E-9	1.5E-5	2.6E-6
				100-Area	0.5	Same	8.1E-8	2.0E-4	4.7E-5	4.1E-9	1.0E-5	2.4E-6
Low Level Waste Trailer Leak (liq rel)	3.9E-6	1E-3 Ci Al 1E-3 Ci BG	0.2	UTRC**	0.1	2E-3 Ci	8.0E-8	1.7E-4	_***	6.3E-15	1.3E-11	_***

TABLE 5-10 Consequences and Risks to Onsite and Offsite Populations - Radioactive Materials (Continued)

							Consequences[f]			Risk[g]		
Accident	P(A)/yr[a]	Amt. Rel.[b]	P(R/A)[c]	Location	P(L/R,A)[d]	Released[e] to Pathway	Max Ind rem	Offsite pers-rem	Onsite* pers-rem	Max Ind rem/yr	Offsite pers-rem/yr	Onsite* pers-rem/yr
H-Area Sample Truck Accident	4.5E-5	5.0E+1 ml 6.0E-2 Ci Pu or 6.0E+1 ml 6.0E-1 Ci BG	1.0	200-Area	1	6.6E-5 Ci	1.7E-5	7.5E-2	1.8E-2	7.7E-10	3.4E-6	8.1E-7
High Level Waste Trailer Accident (atm rel)	3.0E-9	3.0E+3 1.0E+2 Ci Al 2.0E+2 Ci BG	1.0	A-Area	0.5	3.0E-2 Ci	6.9E-1	1.2E+2	4.2E+1	1.0E-9	1.8E-7	6.4E-8
				200-Area	0.5	Same	3.1E-2	1.0E+2	1.8E+2	4.7E-11	1.5E-7	2.7E-7
High Level Waste Trailer Accident (liq rel)	3.0E-9	3.0E+3 gal 1.0E+2 Ci Al 2.0E+2 Ci BG	0.05	UTRC**	0.1	3.0E+2 Ci	5.6E-2	2.1E+3	_***	8.5E-13	3.2E-8	_***

TABLE 5-10. Consequences and Risks to Onsite and Offsite Populations - Radioactive Materials (Continued)

							Consequences[f]			Risk[g]		
Accident	P(A)/yr[a]	Amt. Rel.[b]	P(R/A)[c]	Location	P(L/R,A)[d]	Released[e] to Pathway	Max Ind rem	Offsite pers rem	Onsite* pers rem	Max Ind rem/yr	Offsite pers-rem/yr	Onsite* pers rem/yr
Rupture of D20 Drum	6.2E-5	1.0E+3 Ci Tritium	1.0	D-Area	0.5	1.0E+3 Ci	2.1E-3	3.0E+0	1.5E-1	6.8E-8	9.3E-5	4.7E-6
				100-Area	0.5	Same	5.4E-4	1.3E+0	3.2E-1	1.7E-8	4.0E-5	9.9E-6
Totals										7.5E-6	2.7E-3	7.8E-4

[a] P(A)/yr - frequency of an accident - annual rate (see Appendix I)

[b] Amt. Rel. - assumed amount of containment released in the accident (see Appendix I)

[c] P(R/A) - assumed probability of release in an accident (see Appendix I)

[d] P(L/R,A) - assumed probability of a release accident occurring at the designated location

[e] Released to Pathway - Product of the amount released and the partition factor (see Table 5-8)

[f] Calculated onsite, offsite, and maximum individual dose based on a single event

[g] Product of P(A)/yr, P(R/A), P(L,R,A), and the consequent dose

* Does not include occupational dose and risk associated with recovery of radioactive materials released in an accident. Also, does not include occupational dose and risks resulting from normal operations.

** Upper Three Runs Creek

*** No onsite consumption of water from downstream areas

TABLE 5-11. Consequences and Risks to Onsite and Offsite Populations - Nonradioactive Hazardous Materials

Released Material	P(A)/yr[a]	Amt Rel from container	P(R/A)[b]	Location	Iso. Line[c] R(mi)	P(L/R,A)[d]	Amount Distributed to Pathway	Peak Conc at Site Boundary (mg/m^3)[e]	Offsite[f] Pop Exp > Limit (# pop)	Onsite[f] Pop Exp > Limit (# pop)	Offsite Pop Risk (pop/yr)	Onsite Pop Risk (pop/yr)
								Consequence			Risk[g]	
Liquid Chlorine	3.65E-3	2.0E+3 lb	0.29	D-Area	1.4	4/200*	1.0E+3 lb (App. G)	7.4	0	300	0	6.4E-3
				100-Areas	2.1	37/200	1.0E+3 lb (App. G)	3.4	0	155	0	3.1E-2
				A-Area	0.9	5/200	1.0E+3 lb (App. G)	45.0	4	1470	1.1E-4	3.9E-2
				200-Area	1.4	15/200	1.0E+3 lb (App. G)	2.0	0	635	0	5.0E-2
				Gate 7	1.0 est	2/200	1.0E+3 lb (App. G)	--	400	2	4.2E-3	2.1E-5
Gasoline and 1-1-1 Trichloroethane	1.60E-1	5.0E+3 gal	0.29	All Areas	NE**	--	1.7E+2 gal (App. G)	32.0	0	0	0	0
				Gates	NE	--	1.7E+2 gal (Append G)	--	0	0	0	0
Sodium Hydroxide	1.53E-2	5.0E+3 gal	0.28	All Areas	NE	--	5.0E-1 gal	0.2	0	0	0	0
				Gates	NE	--	5.0E-1 gal	--	0	0	0	0
Hydrogen Fluoride (aqueous)	4.5E-4	1.0E+2 lb	0.51	A-Area	NE	--	2.1E+1 lb (App. G)	0.94	0	0	0	0
				200-Area	NE	--	2.1E+1 lb (App. G)	0.04	0	0	0	0
				Gates	NE	--	2.1E+1 lb (App. G)	--	0	0	0	0

TABLE 5-11. Consequences and Risks to Onsite and Offs... ulations - Nonradioactive Hazardous Materials (Continued)

Released Material	P(A)/yr[a]	Amt. Rel. from container	P(R/A)[b]	Location	Tox. Lim.[c] R(mi)	P(L/R,A)[d]	Amount Distri- buted to Pathway	Consequence: Peak Conc at Site Boundary (mg/m³)[e]	Consequence: Offsite[f] Pop Exp > Limit (# pop)	Consequence: Onsite[f] Pop Exp > Limit (# pop)	Risk[g]: Offsite Pop Risk (pop/yr)	Risk[g]: Onsite Pop Risk (pop/yr)
Nitric Acid	1.54E-2	1.0E+3 gal	0.29	A-Area	1.4	5/200	1.3E+2 gal (App. G)	69	0	1470	0	1.6E-1
Sulfuric Acid, and				200-Area	1.8	15/200	1.3E+2 (App. G)	3.1	0	635	0	2.1E-1
Phosphoric Acid				D-Area	1.8	4/200	1.3E+2 (App. G)	50 est	0	300	0	2.7E-2
				Gate 7	1.0 est	2/200	1.3E+2 (App. G)	--	0	2	0	8.9E-5
Sodium Hypochlorite	5.63E-3	1.0E+3 gal	0.10	All Areas	Sodium hydrochlorite contains 12% chlorine by weight. Therefore, data for liquid chlorine are conservatively used here.						5.9E-5	6.7E-2
				Gates							2.2E-3	1.1E-5
Totals											8.6E-3	5.9E-1

* 4/200 is the ratio of miles of SRP roads inside the radius where toxic limits are exceeded to the total miles of SRP roads.

** NE - the toxic threshold limit is not exceeded even near to the release point.

[a] P(A)/yr - Probability of an accident, see Table 5-8.

[b] P(R/A) - Probability for a release greater than 10 (lb/gal) given an accidents.

[c] Radius which the level of exposure would exceed the toxic effect threshold.

[d] P(L/R,A) - Probability of the location given a release and an accident (number of miles of transportation route within the area where toxic limits are exceeded/total SRP mileage).

[e] Calculated peak concentration of material at site boundary (mg/m³), number of offsite and onsite population exposed above the toxic effect threshold.

[f] Calculated onsite and offsite population exposed above threshold.

[g] The product of P(A)/yr, P(R/A), P(L/R,A), and number of population.

reported (see Section 5.2.6.4 for a discussion of risk evaluation methods for nonradioactive materials).

Consequences and risks are reported for offsite and onsite populations. Consequences are measured in terms of numbers of individuals exposed above thresholds for toxic effects. Included are the conditional probability that the accident locations are near the population center, amounts released to the environment,* the amount released to the air pathway, and the frequency for the accident. The total for nonradioactive material transportation risks is reported as the sum of risks for individuals exposed above thresholds for toxic effects from each accident and location. As discussed in Sections 5.2.6.5 and 5.2.7, sufficient information is not available in current literature to characterize human health effects risks from single event exposures during/after transportation accidents in terms of injuries/fatalities.

5.5.3 Effects on the Environment

The focus of the transportation SAR is the evaluation of risks to public health and safety. As such, no formal assessment of potential impacts on terrestrial or aquatic biota has been included. Of the nonradioactive bulk chemicals selected for evaluation in the transportation SAR, Federal environmental guidelines are available for only one compound: 1,1,1-trichloroethane. The available data for freshwater fish indicate that acute toxicity occurs at concentrations as low as 1.8 mg/L (55). However, no formal ambient water quality criterion for the compound has been proposed for the protection of aquatic life.

5.6 ACCIDENT MITIGATION

Wherever and whenever possible, consequences of accidents that may occur in the transportation of hazardous materials are mitigated by actions taken by SRP emergency response teams. These teams are maintained in a state of readiness at the site. They are promptly notified by the vehicle operator using an onboard radio or SRP employees who witness or arrive at the scene of the accident. Because of constant vehicle traffic on the site the likelihood of an accident being witnessed or quickly discovered is high. An emergency response team (established by SRP procedures) arrives at the hazardous material accident scene soon after being notified. Actions taken are directed at assessing the nature of the accident and identifying any needs for assistance, notifying responsible SRP and DOE managers (who would in turn take appropriate actions to notify public officials in nearby communities), treating and removing injured persons from the accident scene, establishing a safe perimeter, taking feasible actions to confine or limit distribution of the HM, and implementing measures to neutralize and/or recover any HM that may be released and distributed. To maximize effectiveness, emergency response teams have at their command all necessary physical and employee resources of

---

*For this analysis it was conservatively assumed that all accidents resulting in releases would release maximum amounts.

the SRP. These include radio communications, security forces, fire-fighting personnel and equipment, highly trained experts on radiological and chemical hazards, heavy equipment, and many other kinds of support personnel and equipment. These personnel and equipment can be mobilized rapidly and quickly deployed to any onsite accident scene and to any onsite or offsite area which may be impacted by an onsite transportation accident.

These administrative means for mitigating transportation accident consequences (when considered with limitations on releases of HMs in transportation accidents set by container capacities) provide a basis for assuming that HMs that are not dispersed while materials are being released during the accident will likely remain near the accident site and be recovered. This is the basis for not including long term (chronic) effects following accidents in the risk analysis presented in Section 5.5.

5.7 REFERENCES

1. U.S. Department of Transportation. The Hazardous Materials Information System, U.S. DOT Research and Special Programs Administration, Office of Hazardous Materials; Washington, D.C.

2. Clarke, R. K., Foley, J. T., Hartman, W. F., and Larson, D. W. Severities of Transportation Accidents, Volume I - Summary. Sandia Laboratories Report SLA-74-0001. Albuquerque, NM (1976).

3. Fischer, L. E., et. al. Shipping Container Response to Severe Highway and Railway Accident Conditions Main Report. NUREG/CR-4829-VI. Prepared for the Nuclear Regulatory Commission by Lawrence Livermore National Laboratory, February 1987.

4. U.S. Atomic Energy Commission, Directorate of Regulatory Standards. Environmental Survey of Transportation of Radioactive Materials to and from Nuclear Power Plants, Supplement No. 1. WASH-1238, Washington, DC (1972).

5. Leimbuhler, F. F. Trucking of Radioactive Materials: Safety vs. Economy in Highway Transport. The Johns Hopkins Press, Baltimore, MD (1973).

6. Gibson, R., Ed. The Safe Transport of Radioactive Materials. Perganon Press, New York, NY (1966).

7. Hodge, C. V. and Harrett, A. A. Transportation Accident Risks in the Nuclear Power Industry 1975-2020. Report NSS 8191.1, Nuclear and Systems Sciences Group, Anaheim, CA (November 1974). (Prepared for Office of Radiation Programs, EPA.)

8. Brobst, W. A. The Probability of Transportation Accidents. Department of Defense Explosives Safety Board 14th Annual Explosives Safety Seminar in New Orleans, LA, November 10, 1972, United States Atomic Energy Commission, Washington, DC (1972).

9. Garrick, B. J., Gekler, W. C., Baldonaldo, O. C., Elder, H. K., and Shapley, J. E. A Risk Model for the Transport of Hazardous Materials. Accession Number AD860120 (1969). (No Foreign Distribution.)

10. Finley, N. C., McClure, J. D., Reardon, P. C. An Analysis of the Risk and Consequences of Accidents Involving Shipments of Multiple Type A Radioactive Material Packages, SAND88-1915, August 1988.

11. Ostmeyer, R. M., Finley, N. C., Cashwell, J. W., McClure, J. D. The Potential Consequences and Risks of Highway Accidents Involving Gamma-Emitting Low Specific Activity (LSA) Waste, SAND88-2808, August 1988.

12. Beary, M. M., et. al. Safety Analysis - 200 Area Savannah River Plant F-Canyon Operations, Science Applications International Corporation for E. I. du Pont de Nemours & Co., Savannah River Laboratory, DPSTSA-200-10, SUP-4, (1986).

13. Beary, M. M., et. al. Safety Analysis - 200 Area Savannah River Plant H-Canyon Operations, Science Applications International Corporation for E. I. du Pont de Nemours & Co., Savannah River Laboratory, DPSTSA-200-10, SUP-5, (1986).

14. National Safety Council. Accident Facts, National Safety Council Pub., Chicago, IL (1984).

15. U.S. Department of Transportation. Accidents of Motor Carriers of Property 1979. Federal Highway Administration, Bureau of Motor Carrier Safety.

16. U.S. Department of Transportation. Accidents of Motor Carriers of Property 1980. Federal Highway Administration, Bureau of Motor Carrier Safety.

17. U.S. Department of Transportation. Accidents of Motor Carriers of Property 1981. Federal Highway Administration, Bureau of Motor Carrier Safety.

18. U.S. Department of Transportation. Accidents of Motor Carriers of Property 1982. Federal Highway Administration, Bureau of Motor Carrier Safety.

19. U.S. Department of Transportation. Accidents of Motor Carriers of Property 1983. Federal Highway Administration, Bureau of Motor Carrier Safety.

20. Association of American Railroads. Trends May 2, 1985. Office of Information and Public Affairs.

21. Association of American Railroads. Trends May 9, 1985. Office of Information and Public Affairs.

22. Association of American Railroads. Trends May 16, 1985. Office of Information and Public Affairs.

23. Association of American Railroads. Trends May 23, 1985. Office of Information and Public Affairs.

24. Association of American Railroads. Trends May 30, 1985. Office of Information and Public Affairs.

25. Association of American Railroads. Trends June 6, 1985. Office of information and Public Affairs.

26. Association of American Railroads. Trends June 13, 1985. Office of Information and Public Affairs.

27. Association of American Railroads. Trends June 20, 1985. Office of Information and Public Affairs.

28. Association of American Railroads. Trends June 27, 1985. Office of Information and Public Affairs.

29. Association of American Railroads. Trends July 3, 1985. Office of Information and Public Affairs.

30. Association of American Railroads. Trends July 11, 1985. Office of Information and Public Affairs.

31. Association of American Railroads. Trends July 18, 1985. Office of Information and Public Affairs.

32. Association of American Railroads. Trends July 25, 1985. Office of Information and Public Affairs.

33. U.S. Department of Transportation. The President's 1981 Annual Report to the Congress on the Administration of the Federal Railroad Safety Act of 1970. Federal Railroad Administration.

34. U.S. Department of Transportation. The President's 1979 Annual Report to the Congress on the Administration of the Federal Railroad Safety Act of 1970. Federal Railroad Administration.

35. U.S. Department of Transportation. 1978 Annual Report by the President to the Congress on the Administration of the Federal Railroad Safety Act of 1970. Federal Railroad Administration.

36. U.S. Department of Labor. Annual Construction Industry Report. Labor-Management Service Administration, Office of Construction Industry Service. Source: BLS, Occupational Injuries and Illnesses in 1978: Summary. March 1980, Table 9, P. 24, (April 1980).

37. E. I. du Pont de Nemours & Co. Hazard from Short-Time Inhalation of Radionuclides. Savannah River Laboratory, Aiken, SC, DPST-66-579.

38. Science Applications International Corporation. Methodology for Ranking Nonradiological Compounds for Selecting Indicator Contaminants at Savannah River Plant Waste Sites, SAIC-85/1863, Du Pont Contract AX681812, McLean, VA (1985).

39. U.S. Environmental Protection Agency. Superfund Risk Evaluation Manual. Part I. Draft. Office of Emergency and Remedial Response, U.S. Environmental Protection Agency, Washington, DC (1983).

40. Rodricks, J. V. Risk Assessment at Hazardous Waste Disposal Sites. Hazardous Waste 1(3):333-362, (1984).

41. Dialog Information Services. DIALOG Data Base, Palo Alto, CA.

42. U.S. Department of Transportation. Code of Federal Regulations, Title 49, Transportation.

43. U.S. Nuclear Regulatory Commission. Atmospheric Dispersion Models for Potential Accident Consequences Assessment at Nuclear Power Plants. Regulatory Guide 1.145. Washington, DC (1979).

44. U.S. Nuclear Regulatory Commission. U.S. NRC Regulatory Guide 1.109, Washington, DC.

45. Hoenes, G. R. and Soldat, J. K. Age-Specific Radiation Dose Commitment Factors for a One-Year Chronic Intake. NUREG-0172, November 1977.

46. International Commission on Radiation Protection. ICRP Publication No. 2, Pergamon Press, Maxwell House, Fairview Park, Elmsford, NY 10523.

47. Zafran, F. A. Risk Assessment for Nonradioactive Compounds: A Briefing Paper Prepared for E. I. du Pont de Nemours & Co., SAIC-89/1107, Science Applications International Corporation, McLean, VA, February 14, 1989.

48. American Conference of Governmental Industrial Hygienists. Threshold Limit Values for Chemical Substances and Physical Agents in the Work Environment With Intended Changes for 1984-85. Cincinnati, OH. ISBN: 0-936712-54-6, (1984).

49. U.S. Environmental Protection Agency. Chemical Emergency Preparedness Program, Interim Guidance. Washington, DC, (1985).

50. Blume, J. A. Update of Seismic Criteria for the Savannah River Plant. DPE-3699, Prepared for E. I. du Pont de Nemours & Co. by John A. Blume and Associates, Engineers, San Francisco, CA (September 1982).

51. E. I. du Pont de Nemours & Co. Preliminary Safety Analysis, Defense Waste Processing Facility, Staged Case. Internal Report DPST-81-241. Savannah River Laboratory, Aiken, SC (1981).

52. Elder, J. C., et. al. A Guide to Radiological Accident Considerations for Siting and Design of DOE Non Reactor Nuclear Facilities. LA-10294-MS, Los Alamos National Labs, Los Alamos, NM (1986).

53. Durant, W. S., and Perkins, W. C. Systems Analysis - 200-Area, Savannah River Plant - H-Canyon Operations, Appendix A, DPSYST-100-1H, Volume 2, (October 1983).

54. Bradley, R. F. The Potential Off-Site Consequences of Postulated Upperlimit Accidents in the SRP Burial Ground, DPST-72-462, E. I. du Pont de Nemours & Co., Savannah River Plant, Aiken, SC, February 25, 1985.

55. U.S. Environmental Protection Agency. Ambient Water Quality Criteria for Chlorinated Ethanes. U. S. Environmental Protection Agency, Office of Water Regulations and Standard, Washington, DC (1980).

6.0 SAFETY RELATED ITEMS

Safety related items include those whose proper operation, by intentional design, may prevent, mitigate, or monitor conditions during an accident, or whose failure to operate properly may initiate an accident. These items include but are not restricted to those identified as "Q" under the Quality Assurance (QA) program. Failure of safety related items may not lead to an accident, but are of safety concern.

6.1 HAZARDOUS MATERIALS TRANSPORTATION SYSTEM ITEMS IMPORTANT TO SAFETY

The following groups of equipment and facilities are considered important to safety for the transportation of hazardous materials at the SRP:

- Vehicles - SRP vehicles, vendor vehicles, and common and private carrier vehicles provide means of safe conveyance. Safety features include brakes; steering mechanisms; wheels, axles and tires; lights and signaling devices; instruments for monitoring vehicle status and safety system functions; drive train components; and vehicle structures.

- Packagings - Hazardous material packagings provide containment and health protection (e.g., radiation shielding) under normal transport and handling conditions and under prescribed accident conditions. Safety features include containment vessels including closures and valves; impact and puncture resistant devices or components; mechanisms and materials for precluding nuclear criticality; radiation shielding; insulation and/or heat transfer features; package structures including structures for tiedown and handling; absorbent materials; pressure relief and pressure sensing devices; and ancillary tiedown and handling equipment. (Note: some packagings are integral with their transport vehicles, e.g., DOT Specification MC312 Tank Trailer used for shipments of uranyl nitrate solution).

- Roadways and Railways - Roadways and railways are the improved surfaces over which vehicles transport hazardous materials. Safety features include hard, smooth rolling surfaces or rails that are clear of obstacles, large surface breaks or failures, and large heaves or depressions; that are well marked and clearly designated; that are routed and engineered to avoid steep grades and embankments; that incorporate engineered structures (e.g., bridges) adequate for the traffic and load service; that include ancillary safety features such as guardrails; and for rails, include switches.

- Loading and Unloading Areas - Loading and unloading areas provide loading/unloading equipment, spill collection and recovery features and monitoring services. Safety features include monitoring instruments, filling and emptying devices and equipment, lifting devices and equipment, spill collection and recovery systems. Specific items of equipment important to safety in these facilities are listed in the appropriate sections in the facility safety analysis reports.

6.2 SURVEILLANCE REQUIREMENTS FOR SAFETY-RELATED ITEMS

Surveillance programs for safety related transportation equipment are discussed under Inspection and Maintenance (Section 4.6).

TABLE 6-1. Onsite Transportation System Inspection, Testing and Maintenance

Safety Related Item	Inspection, Test and Maintenance Requirements or Practices at SRP
1. Packages, Packagings, and Containers for Hazardous Materials	a. Shippers inspect packagings or containers prior to each use. b. Shippers inspect packages prior to release for shipments. c. Train crews or truck drivers visually inspect packages for any abnormal or suspect conditions prior to transport. d. Receivers inspect packages for any abnormal conditions after receipt. e. DOE or NRC certified packagings are inspected in conformance with provisions of the Certificate of Compliance.
2. Vehicles	a. Drivers inspect highway vehicles prior to each use. Green tags are attached to vehicles by the drivers when defective components are found. b. Railroad crews inspect rolling stock daily or prior to each use. c. Highway vehicles are surveyed once each month to identify those needing special or routine maintenance. d. Railroad crews inspect incoming rail cars prior to delivery to SRP onsite destinations. e. SRP trailers' king pins and tank vehicle pressure relief valves are inspected at scheduled intervals to insure continued safe operations.
3. Roadways and Railways	a. Railroad tracks are inspected weekly and before use after heavy rains or unusual weather. b. Roads and rails are maintained on a continuing basis. Items maintained include signs, signals, guard rails, road surfaces, crossties and rails, roadway striping, shoulders and clear areas. c. Highway bridges are inspected by a professional engineering firm under contract to Du Pont every five years.

7.0 QUALITY ASSURANCE

7.1 QUALITY ASSURANCE PLAN AND MANUAL

A Quality Assurance Plan (1) and Manual (2) provide general procedures for implementing the QA policy principles. The manual establishes methods, practices, and requirements for the Savannah River Quality Assurance Program. Although the QA requirements in the manuals are specific, additional instructions and procedures in lower level documents are normally required in order to perform the QA functions. The particular organization performing the quality assurance function provides for compliance with its organization procedures and instructions.

7.2 QUALITY ASSURANCE IMPLEMENTATION

The transportation of HMs on the Savannah River Plant is controlled to provide adequate confidence that the involved systems, structures, and components perform satisfactorily in service and to provide adequate confidence that the activities associated with safe and environmentally acceptable transportation are conducted in accordance with prescribed requirements. The controls are achieved through the implementation of the Savannah River Quality Assurance Manual (QA Plan) (1). The QA Plan is implemented by the procedures presented in the Savannah River Quality Assurance Manual (QA Manual) (2). The requirements outlined in the QA Plan and the QA Manual are further implemented through a system of procedures encompassing both operations and administrative practices and through operating requirements. These procedures and requirements embrace all elements of QA.

As an example of implementation of the QA Plan, hazards associated with SRP transportation facilities, processes, projects, and equipment and their associated operations are reviewed in accordance with the requirements presented in Reference 3. Hazards reviews are used to determine the adequacy of designs, operations procedures, administrative controls and QA requirements in so far as these measures are implemented to assure the safety of the SRP workers and the public and in so far as the measures provide for the protection of the environment. For new projects, hazards reviews are elements of Design Control which is an component of the SRP QA Plan.

For ongoing transportation activities, existing facilities and equipment at the SRP, hazards reviews are conducted whenever SRP Management determines a need based on considerations such as changes in requirements, new information, changes in environmental or other conditions, or requirements for audit. For these ongoing activities and for the existing transportation equipment and facilities, hazards reviews are elements of the Audit component of the QA Plan.

7.3 RHYTHM COMMITTEE

In addition to procedural controls, the Du Pont RHYTHM Committee monitors the performance of the SRP Areas in preparing hazardous materials for shipment offsite. The RHYTHM Committee (see Chapter 4.0) meets regularly to review compliance findings, discuss problems, identify information needs, identify and designate training needs, and assign actions. The RHYTHM Committee conducts periodic audits to help assess performance of the SRP operations areas in complying with HM transportation requirements. These are QA activities primarily directed toward assuring quality in offsite shipments. However, they also have impact on the quality of onsite interarea transportation activities.

7.4 REFERENCES

1. Savannah River Quality Assurance Plan. Internal Report DPSPM-SITE-1, E. I. du Pont de Nemours & Co., Aiken, SC, March 4, 1987.

2. Savannah River Quality Assurance Manual. Internal Report DPF-83-111-3, E. I. du Pont de Nemours & Co., Aiken, SC, April 1984.

3. SRP Process Hazards Review Manual. Internal Report DPSPM-GEN-13, E. I. du Pont de Nemours & Co., Aiken, SC, June 1987.

8.0 GLOSSARY OF TERMS

Absorbed Dose	Amount of energy absorbed per unit of mass of irradiated material. Measured in rads.
Activity	Number of spontaneous nuclear disintegrations occurring in a given quantity of material during a suitably small interval of time, divided by that interval of time.
Actinides	Radioactive chemical elements with atomic numbers greater than that of actinium (i.e., >88).
Airborne Activity	Radioactive materials which are present-in-air.
Alpha Decay	Radioactive decay in which an alpha particle is emitted. (This lowers the atomic number of the nucleus by two and its mass number by four.)
Alpha Radiation	Emission of particles (helium nuclei) from a material undergoing nuclear transformation.
Attenuation	Reduction of a radiation quantity upon passage of radiation through matter resulting from all types of interaction with that matter.
AXAIR	SRP computer code which calculates transport and resultant dose from airborne radioactive materials over a wide region.
Background (Radiation)	Ionizing radiation present in the region of interest and coming from sources other than that of primary concern.
Beta Decay	Radioactive decay in which a beta particle is emitted or in which orbital electron capture occurs.
Beta Particle	An electron, of either positive or negative charge, which has been emitted by an atomic nucleus or neutron in a nuclear transformation.

Beta Radiation	Electrons and positrons emitted from the nucleus of an atom undergoing nuclear transformation.
Body Burden	The total quantity of radionuclide present in the body.
Body Burden, maximum permissible (MPBB)	That body burden of a radionuclide that, if maintained at a constant level, would produce the maximum permissible dose equivalent in the critical organ.
Bone Seeker	Substance which migrates, <u>in vivo</u>, preferentially into bone.
X/Q	Chi/Q is the calculated air concentration from a specific air release. Units are (Ci/m^3/Ci/sec), or (sec/m^3).
Carrier	Any person engaged in the transportation of passengers or property, as common, contract, or private carrier, or freight forwarder.
Containment Vessel	Receptacle on which principal reliance is placed to retain radioactive material during transport.
Contamination	Radioactive materials located where it is undesirable (outside its normal location).
Controlled Area	Specified area in which exposure of personnel is controlled.
Cooling (Radioactive)	Reduction of radioactivity of a material by radioactive decay.
Critical Mass	Mass of fissionable material that can be made critical with a specified geometrical arrangement and material composition.
Critical Organ	That organ (or tissue) in which the dose equivalent would be most significant due to a combination of the organic radiosensitivity and a particular dose pattern through the body.

Curie	Unit of radioactivity equal to $3.7x10^{10}$ disintegrations per second.
Decay, Radioactive	Disintegration of the nucleus of an unstable nuclide by the spontaneous emission of charged particles and/or photons.
Decontamination	Removal of radioactive material from a contaminated surface or from within.
Decontamination Factor (DF)	The ratio of the amount of undesired radioactive material initially present to the amount remaining after a process step.
Decommissioning	The measures taken at the end of the facilities operating lifetime to decontaminate the facility and restore the site.
Dose, Absorbed	The energy imparted to matter in a volume element by ionizing radiation, divided by the mass of irradiated material in that volume element.
Dose Commitment Factor	Radiological dose to man (rem) due to exposure to radiation (Ci).
Dose equivalent.	A term used to express the amount of effective radiation when modifying factors have been considered. The product of absorbed dose multiplied by a quality factor, multiplied by a distributrion factor. It is expressed numerically in rem.
Fissile	A nuclide capable of undergoing fission by interaction with slow neutrons.
Fissile Material	Uranium-233, uranium-235, plutonium-238, plutonium-239, and plutonium-241.
Fission Products	Nuclides produced either by fission or by the subsequent radioactive decay of the nuclides thus formed.

Fissionable	A nuclide capable of undergoing fission by any process.
Fuel Assemblies	Fissionable material placed in a specific form for use as the source of power in a nuclear reactor.
Half-life, Biological	Time required for a particular substance in a biological system to be reduced to one-half of its original amount by biological processes when the rate of removal is approximately exponential.
Individual Dose	Dose to a hypothetical individual located at the point of interest.
Ion Exchange	Process for selective removal of a constituent from a particular solution. The process reversibly transfers ions between an insoluble solid and the fluid stream.
Ionization	Any process by which an atom, molecule, or ion gains or loses electrons.
Maximum Exposed Individual	Hypothetical individual located offsite that could potentially receive the maximum dose.
Neutron	Elementary particle having no electric charge, a rest mass of 1.67 x 10^{-27} kg, and a mean life of 1000 seconds.
Neutron Radiation	Emission of a neutron from a material during a nuclear transition.
Nuclear Materials	Materials produced as a result of a nuclear reaction such as those produced in a nuclear reactor.
Nuclear Reactor	Equipment in which a chain reaction of fissionable material is initiated and controlled.
Nuclide	Species of atom having a specific mass, atomic number, and nuclear energy state.

Offsite	Area outside the boundary line marking the limits of the plant property.
Onsite	Area within the boundary line marking the limits of the plant property.
Package	Packaging and its radioactive contents.
Packaging	One or more receptacles and wrappers and their contents excluding fissile material and other radioactive material, but including absorbent.
Person-rem Dose (formerly Man-rem Dose)	Measure of population dose equivalent. It is calculated by summing the dose equivalent received by each person in the population discussed.
Quality Assurance	Systematic actions to provide adequate confidence that a material, component system, process, or facility performs satisfactorily or as planned in service.
R (Roentgen)	Unit of radiation dosage equal to the quantity of ionizing radiation (gamma or x-ray) that produces one electrostatic unit of electricity in one cubic centimneter of dry air at 0°C and standard atmospheric pressure.
Rad	Energy imparted to matter by ionizing radiation. One rad is the absorption of 100 ergs/gram of absorbing material.
rem	Roentgen equivalent man - A unit of ionizing radiation that produces damage to human tissue equivalent to 1 roentgen of x-rays or gamma rays. See dose equivalent.
Radioactive	Of, or exhibiting radioactivity.
Radioactivity	Property of certain elements to spontaneously emit radiation including alpha particles, neutrons, electrons, and gamma rays from disintegration of atomic nuclei.

Radionuclide	A radioactive nuclide.
RHYTHM	(Remember How You Treat Hazardous Materials) is Du Pont's registered service mark for its safe distribution program.
Safety Related Item	An item providing information that may prevent or mitigate the frequency or consequence of accidents.
Source Material	Uranium or thorium or any combination thereof. Source material does not include special nuclear material.
Special Nuclear Material	Plutonium, uranium-233, uranium enriched in the isotope 233 or in the isotope 235, and any other material which DOE determines to be special nuclear material, but does not include source material.
Transplutonics	Nuclides having an atomic number greater than plutonium (i.e., >94).
Transuranics	Nuclides having an atomic number greater than uranium (i.e., >92).
Type A Quantity	A quantity of radioactive material, the aggregate radioactivity of which does not exceed DOE specifications for Type A in DOE Order 5480.3.
Type B Quantity	A quantity of radioactive material, the aggregate radioactivity of which does not exceed DOE specifications for Type B in DOE Order 5480.3.

SYMBOLS AND ABBREVIATIONS

AEC	Atomic Energy Commission
AED	Atomic Energy Division
ALARA	As Low As Reasonably Achievable
ANSP	Academy of Natural Sciences of Philadelphia
API	American Petroleum Institute
BMCS	Bureau of Motor Carrier Safety
cfs	Cubic feet per second
Ci	Curie
CSWE	Central Services Works Engineering
DBE	Design Basis Earthquake
DBT	Design Basis Tornado
DF	Decontamination Factor
DHEC	Department of Health and Environmental Control
d/m	Disintegrations per minute
d/m/ml	Disintegrations per minute per milliliter
DOE	Department of Energy
DOT	Department of Transportation
DPSOL	Du Pont Savannah River Operating Log
DPSOP	Du Pont Savannah River Operating Procedure
E&I	Electrical and Instrumentation Maintenance
EM&GS	Equipment Maintenance and General Services
EOC	Emergency Operating Coordinator
FC	Facility Coordinator
FRA	Federal Railway Administration
GVW	Gross vehicle weight

HAN	Hydroxylamine nitrate
HAW	High activity waste
HEPA filter	High efficiency particulate air filter
HI	Hazardous Index
HM	Hazardous materials
HMC	Hazardous Materials Coordinator
HP	Health Protection
HPSS	Health Protection Senior Supervisor
IDLH	Immediately dangerous to life and health
LAW	Low activity waste
LLNL	Lawrence Livermore National Laboratory
LLW	Low level waste
MCC	Motor Control Center
MCL	Maximum contamination level
MIAC	Maintenance Information and Control
mph	Miles per hour
MPI	Maximum permissible intake
MTF	Materials Test Facility
NIM	Nuclear Incident Monitor
NPH	Normal paraffin hydrocarbons
NRC	Nuclear Regulatory Commission
NSRC	Nuclear Safety Review Committee
OHP	Occupational Health Protection
ORNL	Oak Ridge National Laboratory
OSR	Operational Safety Requirement
PA	Public address
PCC	Process Control Center

PCI	Package Compliance Inspector
PERS	Personal and Environmental Reporting System
PMT	Program Management Team
QA	Quality assurance
R	Roentgen
RA	Regulated Area
rad	Radiation absorbed dose
RBOF	Receiving Basin for Offsite Fuels
RCG	Radiation Control Guide
rem	Roentgen equivalent man
RFSA	Rocky Flats Scrub Alloy
R/hr	Roentgen per hour
RHYTHM	Remember How You Treat Hazardous Materials
RR&FS	Railroad, Roads and Ground, and Field Services
RTD	Resistance temperature device
RZ	Radiation zone
SAR	Safety Analysis Report
SARP	Safety Analysis Report for Packaging
SCDHEC	South Carolina Department of Health and Environmental Control
SCL	Seaboard Coast Lines
SG	Silica gel
SNM	Special nuclear material
SNLA	Sandia National Laboratory Albuquerque
SPCC	Spill Prevention Control and Countermeasures Plan
SREL	Savannah River Ecology Laboratory
SRL	Savannah River Laboratory

SRP	Savannah River Plant
SRS	Savannah River Site
TA	Test authorization
T&R	Training and reference
TI	Transport index
TLD	Thermoluminescent dosimeter
TLND	Thermoluminescent neutron dosimeter
TLV	Threshold limit value
TRAC	Tracking Radioactive Atmospheric Contamination
TRU	Transuranic
UET	Use Every Time
UI	Unusual incident
UNH	Uranyl nitrate hexahydrate
USFS	United States Forestry Service
WIND	Weather Information and Display
WSRC	Westinghouse Savannah River Company

together then grouped with through-bolts to simplify handling (Figure A-2). A strap handle has been added to the top gang of insulation to provide easier removal. The insulation disks are fitted to the drum so that the radial clearance between the "Celotex", the primary containment vessel, and the drum does not exceed 1/4 in. The radial, top, and bottom thicknesses of the insulation are nominally 6 in.; this exceeds the Spec 6M minimum of 3.75 in. prescribed by 49 CFR 178.104-3.

Two 1/2-in.-thick aluminum bearing plates are added to the packaging to provide additional load bearing surface against the insulation-centering medium. The bottom bearing plate is equipped with a square key to prevent rotation of the primary containment vessel when its closure nut is being attached or removed. The through-bolts which group the insulation also pass through the bearing plates to prevent their rotation.

The primary containment vessel (PCV) consists of a stainless steel pressure vessel that is designed in accordance with Section VIII of the ASME Boiler and Pressure Vessel Code, 1980 edition, with design conditions of 1000 psig at 500°F. By definition, the design conditions shall be higher than the pressure and temperatures that can be generated during normal or accident conditions of transport. The PCV is fabricated from 5-in. schedule 40 seamless type 304 SS pipe (0.258-in. wall) with standard weight pipe cap (0.258-in. wall) at the blind end.

A 4-in. schedule 40 pipe of the same material is welded to the convex side of the cap to form a skirt to support the PCV vertically. The skirt has two slots on its bottom surface (180° apart) to engage with the bearing plate in the packaging to prevent rotation.

The PCV closure consists of a male-female cone joint; the surfaces have been machined to identical angles so that they mate with zero clearance. Two grooves for O-rings have been machined onto the face of the male cone. A leakage test port is provided between the two O-ring gloves. Two "Viton" (trademark of Du Pont) GLT fluoroelastomer O-rings are placed in the grooves to form a leak tight seal (less than 10^{-7} atm cc/sec air) at 1000 psig and 500°F. Zero clearance behind the two O-rings prevents extrusion and loss of sealing ability at these pressures and temperatures. The leakage test port, when opened after loading of the radioactive materials, allows for simple leakage tests (pressure drop method). When the leakage test port is plugged (as in normal shipment), a redundant O-ring seal is formed. A snap-ring fits onto the male cone for use in unseating the cone during disassembly. The seal nut, which forces the male cone against the female cone, is threaded into the containment vessel body. Dissimilar materials were selected for the seal nut ("Nitronic" 60) and containment vessel body (Type 304 SS) to minimize galling. When assembled, the primary containment vessel has a gross internal volume of 213.35 cubic in. (3.5 liters), weighs 27.5 lb, and is 13-5/8 in. long.

An aluminum honeycomb spacer (Figure A-2) is inserted into the concave cavity of the primary containment vessel to provide a horizontal flat surface for the product cans. The aluminum spacer increases heat transmission from the radioactive material to the containment vessel. However, the thermal tests

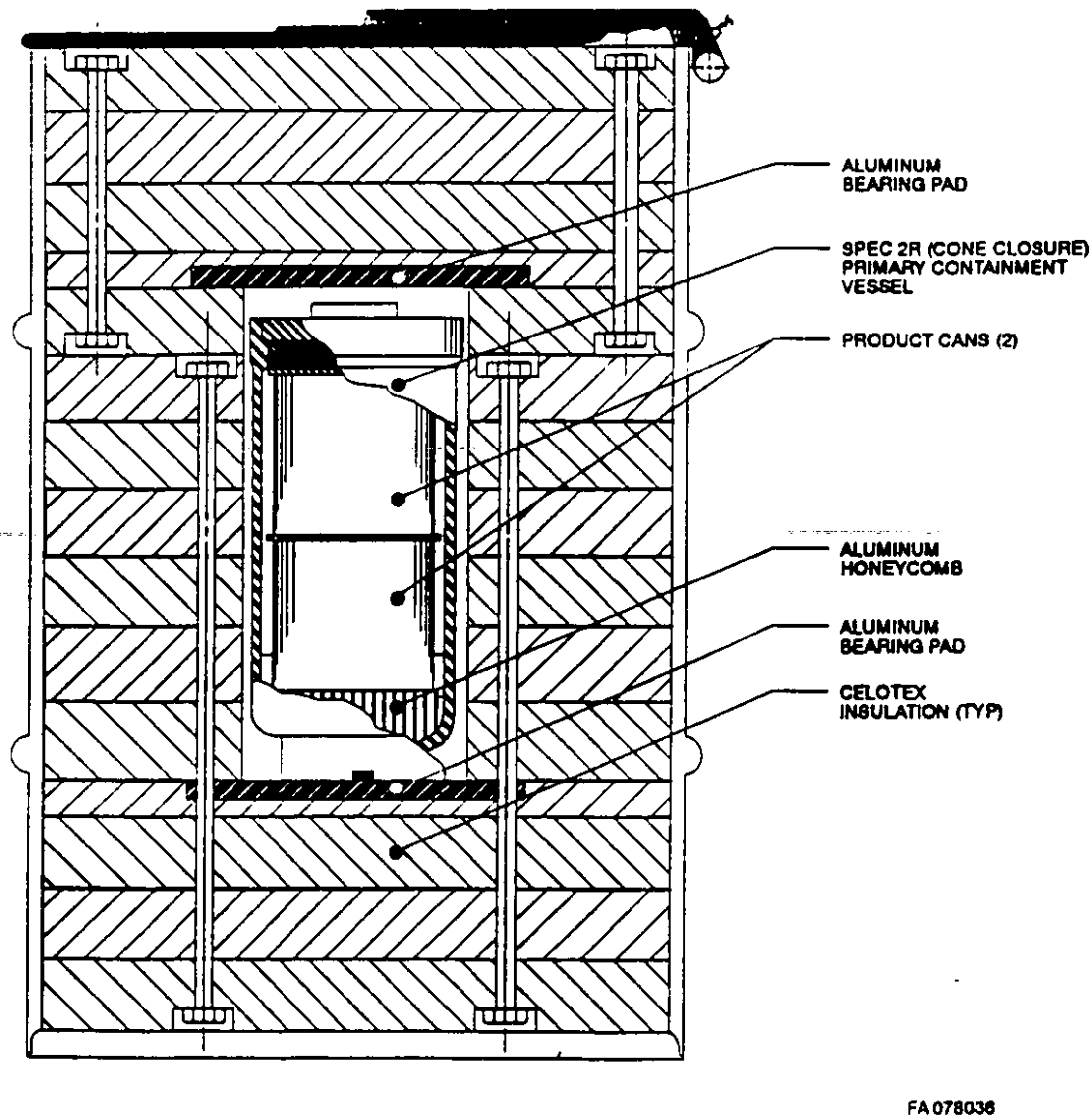


FIGURE A-2. SP9965 Assembly

reported in Chapter 3 were performed without the aluminum spacer to provide conservative test results.

APPENDIX B

RADIOACTIVE AND NONRADIOACTIVE MATERIALS TRANSPORTED AT THE SRP

(Appendix to Chapter 3.0)

APPENDIX B. Radioactive and Nonradioactive Materials Transported at the Savannah River Plant

Tables B-1, B-2, and B-3 present comprehensive lists of hazardous materials that are transported at the SRP. Table B-1 identifies radioactive materials, their typical shipment origins and destinations, the types of containers and packagings used in their transport, the modes of shipment, annual numbers of shipments, and the modes of transport. Table B-2 identifies the bulk nonradioactive materials transported at the SRP, their transport modes, container types, annual receipts at SRP for 1985, the onsite destinations, and on and offsite origins. Table B-3 is a comprehensive listing of essentially all of the nonradioactive hazardous materials that are transported at the SRP. The materials listed in Table B-3 that are not listed in Table B-2 are received in small lots and/or infrequently.

TABLE B-1. Radioactive Materials Shipped and Received at the SRP

Material	To	From	Containers	Transport Mode	Annual Shipments	Administrative Controls
Irradiated Fuel	200-Area	100-Area	70-ton casks. CD-4,5,6 for fuel tubes in bundles; Harp in 55-ton Failed Element Cask for failed fuel; Certified Type-B casks for offsite.	Rail shipments from 100-Areas to 200-Areas; Highway and rail (infreq) for shipments offsite.	350	SRP Procedures
	200-Area	Offsite			100	DOT Regulations
	Offsite	200-Area			20	DOT Regulations
Irradiated Targets (Depleted or slightly enriched uranium slugs, Np-Al tubes, Li-Al targets)	200-Area	100-Area	70-ton casks: CD-1,2, and 3 for slugs in buckets; Harp in 55-ton Failed Element Cask for failed targets; 45-ton Target Cask.	70 and 55-ton casks by rail; 45-ton cask by truck.	Sensitive information*	SRP Procedures
Irradiated Fuel Specimens	773-A (SRL)	200-Area (RBOF)	8-ton Cask	Truck	2	SRP Procedures
TRU Wastes	643-7G (Burial Ground)	200-Area	DOT Specification 17C poly lined 55-gal drums (avg. 15 drums per shipment).	Truck	1575 drums/yr	SRP Procedures
Inoperative or Obsolete Equipment and Jumpers	643-7G	200-Area 100-Areas 3/700 Area	Miscellaneous containers including concrete and fiberglass boxes, steel boxes, and canvas covers.	Rail flatcar flatbed truck	20-30	SRP Procedures

TABLE B-1. Radioactive Materials Shipped and Received at the SRP (Continued)

Material	To	From	Containers	Transport Mode	Annual Shipments	Administrative Controls
Beta-Gamma Wastes 10 nCi/gm and moderate radiation levels (e.g., sandfilter sand, reactor containment filters, contaminated soil, job control)	643-7G	Various Areas	Small cardboard boxes, plastic bags or cardboard cartons in load-lugger pans, sand in metal cans, tritium wastes in wood boxes after bagging, job control wastes in DOT 17C drums and engineered burial boxes, higher activity wastes in 6 ft x 6 ft concrete culverts.	Load-lugger truck, vans and other highway vehicles.	2400-3600	SRP Procedures
Reactor Scrap Metal	643-7G	100-Areas RBOF	15-Ton Scrap Cask CD No. 8 70-ton cask, and other special casks.	Tractor-trailer Lowboy trailer for 70-ton cask.	200-300	SRP Procedures
Large Process Equipment	643-7G 200-Area	200-Area 643-7G	Packaged to control particulates and spillage during transport.	Rail and highway; highway moves on 100 ton lowboy.	100	Equipment is decontaminated to reduce doses to workers.
Contaminated Liquid Wastes except Oil and Solvent	643-7G	Various Areas	Absorbed on solid in container or protected in equal manner.	Highway	N/A** (infreq)	SRP Procedures
Scrap from other DOE Facilities, principally U-236 and DOE Classified Wastes	643-7G	Offsite	Packaging complies with USDOT regulations. DOT approved or DOE certified packagings.	Highway and Rail	N/A (infreq)	SRP Procedures

TABLE B-1. Radioactive Materials Shipped and Received at the SRP (Continued)

Material	To	From	Containers	Transport Mode	Annual Shipments	Administrative Controls
Obsolete Naval Reactor Components and Other Naval Wastes	643-7G	Offsite	Packaging complies with USDOT regulations. DOT approved or DOE certified packagings.	Highway and Rail	N/A (infreq)	SRP Procedures
Process Analytical and other Samples (e.g., Met Lab samples)	772-F 772-D SRL 773-A	677-G 200-H 235-F HB-Line 772-F	Waste sludge collector cask (1575 lb). Generally package depends on shielding requirements - cardboard containers to shielded containers (e.g., Doorstops) - several containers per shipment 200-mL samples in vials and sst bottles; 10 gal sample container in 8-ton cask for wastes.	Highway, e.g., enclosed sample trucks with safe-secure transport (sst) bodies	Up to 6 trips/shift 50/yr to SRL 15-30/yr from waste tanks and canyons	SRP Procedures
Spent Solvent	643-7G	F- and H-Areas	Retired liquid HLW shielded tank trailer	Highway	2-3*** (1900 gal/ shipment)	SRP Procedures
High Level Liquid Radioactive Waste	211-F	776-A	High Level Waste Trailer - 5000 gal with 2 in. Pb shield in 1 in. thick steel containment box - 85-tons when fully loaded.	Highway	30	Escort, 20 mph speed restriction, 2 people in truck cab - one to chock trailer wheels in case of brake failure
Regenerable Deionizer Resin in Steel Vessels	245-H 643-7G	100-Areas	Casks (4 shielded designs, 9 casks), heaviest is 75-tons with 6 in. Pb shielding	Casks on flatbed trailers for highway shipment.	120-240	SRP Procedures

TABLE B-1. Radioactive Materials Shipped and Received at the SRP (Continued)

Material	To	From	Containers	Transport Mode	Annual Shipments	Administrative Controls
Low Level Liquid Radioactive Waste and Sludge	211-F	100-C 678-G	5000 gal unshielded tanks on semitrailers - one type is bottom loading, the other type is top loading through a dip tube	Highway	30 45	SRP Procedures
	100-C 211-F	100-P&K 235-F	Drums 500 gal tank			
Uranyl Nitrate Solution	716-A 232-H Offsite	211-H 716-A 232-H	DOT MC-312 insulated cargo tanker	Highway	Sensitive* information	Shipments are escorted onsite. Shipments offsite use safe, secure transports.
Tritium and Reactor Effluent Gas Samples and D2O Liquid Samples	772-D 772-F 234-H 421-2D 100-P 300 Area Occasionally 735-A infreq.	100-Areas 772-D	Sampling devices, usually of set in 55-gal drums containing up to 1000 Ci tritium. D2O samples (500 mL) in DT-7 drum fastened to truck bed. 250 mL samples to 300 Area	H-Area sample truck, pickup trucks and other vehicles as needed.	Samples are shipped each shift.	SRP Procedures. Radioactive materials crossing SC Highway 125 require packaging to DOT requirements.
Product Gasses Tritium and Gas Standards	Offsite 232,234-H	232,234-H Offsite (empties)	DOE-approved packaging - LP-50, LP-12 overpacks for shipments from 232-H, JP-100, JP-157, JP-157 Special, JP-179 for shipments from 234-H. Also, T-10, T-50, T500 packages, M-102 overpacks, 16 gal AN cans or	Highway	N/A (infreq)	DOE couriers, some by air from Bush Field

TABLE B-1. Radioactive Materials Shipped and Received at the SRP (Continued)

Material	To	From	Containers	Transport Mode	Annual Shipments	Administrative Controls
Product [illegible] Tritium and Gas Standards (Cont.)			other approved packages, e.g., UC-609 package from other DOE sites.			
Neptunium Nitrate**** Solution (150 gm Np)	HB-Line 773-A	F-Area HB-Line	Steel tank with protective steel packaging for shipments to HB-Line. To 773-A in Doorstop casks.	Highway on stake-body trucks to HB-Line, H-Area sample trucks to 773-A.	24	SRP Procedures
D2O Contaminated with Tritium and Fission Products	421-2D 100-Areas	100-Areas Offsite 421-2D	Aluminum or sst 55-gal drums DOT Spec. 5-B, 42-B, 42-C. Also, infrequently kegs from offsite (LSA material).	Highway by Regulated van or (papered) stake body truck. Exclusive use vehicles from offsite.	1000 drums/yr	SRP Procedures
Np-237 Oxide Powder**** up to 1 kg Np	773-A 235-F	HB-Line	Plastic bottles or steel vials in small steel clad Pb cask (1 in. Pb).	H-Area sample truck	N/A	SRP Procedures
Contaminated Nitric Acid	Onsite Facility	F- and H-Areas	55-gal drums	Highway	N/A (infreq)	SRP Procedures
Pu-239 Oxide Powder 2 kg PuO2 per Batch	235-F 773-A	221-F JB-Line	Bagged, sealed in Al can sealed in plastic then placed in DOT-approved (6-M, SP 9965, M-102) containers.	Highway	15-20 per campaign. Infrequent to 773-A	Offsite shipments are made in sst by by DOE only in DOT-approved packagings.

TABLE B-1. Radioactive Materials S and Received at the SRP (Continued)

Material	To	From	Containers	Transport Mode	Annual Shipments	Administrative Controls
Pu-238 Oxide Powder up to 430 g. Also, PuFF Recoverable Scrap	773-A 235-F Offsite	HB Line	Quantities <5 g in small Spec. 2-R containers in plastic bag in 1-gal bucket. Quantities >5 g in COC 5320-3 offsite shipping cask. To Mound Labs in PISA (COC-5320-4) cask.	Highway H Area sample truck to 773-A	150	Couriers for offsite shipments. Q-cleared security escort onsite
Pu and Np Oxides in Al Matrix-Billets and GPHS Fuel Forms	321-M 235-F	235-F Rejects	In 5-gal buckets with billets positioned by wood blocking	Highway - modified truck with shielding behind driver	36 5 billets/trip	Offsite shipments to Mound of GPHS fuel forms by sst
Reactor Fuel Assembly Tubes, Pu-Al and Np-Al and Target Assembly Tubes	100-Areas 321-M 773-A	321-M Rejects 321-M	Fabricated tubular assemblies in steel boxes in criticality safe configurations - 4 assemblies per box.	Highway - flatbed trailer with 8 boxes. To 773-A on trailer towed by pickup - 1 or 2 assemblies	Sensitive* Information	SRP Procedures
U (enriched) Metal (Oraloy) and Oxide Powder	300-Area Offsite	Offsite Scrap	DOT-approved or DOE-certified package (USA/9852/BF(DOE-OR)) from offsite. Scrap in 6-M, DT-14, and DT-7 packages - HEPA filters in DOT 12-B cardboard boxes.	Highway - sst	Varies	Safeguarded shipments. Scrap to offsite in available space on sst.

TABLE B-1. Radioactive Materials Shipped and Received at the SRP (Continued)

Material	To	From	Containers	Transport Mode	Annual Shipments	Administrative Controls
Interlaboratory Comparison Samples and Solid Specimens	Offsite 772-F	772-F Offsite	DOT approved packages, e.g., LP-12-1 tritium package, DOT 6-M (USA/5908/BLF)	Highway	2-4 for intercomparison samples. 35-40 to Idaho	
Offsite, DOE-Owned Spent Fuel	244-H	Offsite	Certified Type B casks	Highway	100	—
Reactor Process Water Deionizers, Filters, Evaporators	643-7G 100-K	100-K 100-P and L	Equipment cask (40 ton)	Highway - flatbed trailer (lowboy)	20	SRP Procedures
Pu-239 Metal Buttons	Offsite 773-A Offsite	JB-Line 221-F	Canned, sealed in plastic bags, canned again, and packaged in DOE-approved LLD-1 containers or 6-M (modified) USA/9965/BF (DOE-OR)	Highway - sst	Sensitive* information	Safeguarded shipments
Pu-239 Scrap	JB-Line	Offsite	DOT 6-M	Highway	30	—
Cf-252 (35-50 mg batches)	773-A	Offsite	DOE-approved casks	Highway	5-10	SRP Procedures

TABLE B-1. Radioactive Materials Shipp... nd Received at the SRP (Continued)

Material	To	From	Containers	Transport Mode	Annual Shipments	Administrative Controls
Cf-252 Encapsulated Sources	SRP General Offsite	773-A	Spec. 7-A or DOE-approved Type B packages for offsite (5 gal buckets filled with n-shield material to 12-ton casks)	Highway	Several onsite 25-30 offsite	SRP procedures
Small Quantity Radioactive Materials for sources or tracers	773-A 735-A 713-A	Offsite	Canned and packaged in DOT-approved fiberboard containers.	Highway	Routine	SRP Procedures
Sealed Radio-active Sources	736-A SRP General	SRP General 736-A	Shielded containers on specially modified pickup to provide tie-down of source during transport	Small van or pickup	N/A (infreq)	SRP Subcontractor and Savannah River Ecology Laboratory (SREL) procedures
Slightly Contaminated Equipment	Central Shops 716-A 722-A	SRP General	—	Highway	Occasional to storage	SRP Procedures
Spent Li-Al Melts	643-7G	232-H	Crucible cask	Highway	Sensitive* Information	SRP Procedures
Depleted Uranium Oxide	F-Area Central Shops 105-R	A-Line	Plastic lined 55-gal drums	Highway	N/A (infreq)	SRP Procedures

TABLE B-1. Radioactive Materials Shipped and Received at the SRP (Continued)

Material	To	From	Containers	Transport Mode	Annual Shipments	Administrative Controls
Depleted Uranium or Slightly Enriched Slugs	313-M 100-Areas	Offsite 313-M	Wooden shipping boxes from offsite. Canned and placed in cardboard or metal boxes for shipment to 100-Areas.	Highway - onsite shipments use side-loading trailer. Avg. load 27,000 lb.	Sensitive* Information	SRP Procedures
Slightly Enriched Uranium Sludge	Offsite	313-M	55-gal drums and DOT Spec. 7-A, Type A TRU waste drum	Highway	1-2	Nuclear safety controls
300-Area Sample Solutions	Offsite	320-M	13-gal polyethylene bottle inside 25-gal steel drum - DOT Spec. 7-A, Type A	Highway	N/A	SRP Procedures
Pu Gaseous and Solid Compounds from Offsite	773-A	Offsite	DOE-certified offsite shipping packages or M-102 containers	Highway	N/A (infreq)	Safeguarded shipments

* Sensitive information is not presented. However, the analyses presented in Chapter 5.0 of this Safety Analysis Report were prepared using all relevant information.

** Historic value - currently, one or fewer solvent shipments are made per year.

*** N/A - not available.

**** Production of this material has been discontinued. Data presented here is historical for use in bounding transportation risks.

TABLE B-2. Nonradioactive Hazardous Materials and Other Bulk Chemicals Received at SRP Facilities*

Material	Mode of Transport	Type of Container	Amount of Material	Where Received	Transfer From	Number of Shipments (per yr)
Aluminum Fluoride	Box Van	100-lb Bag	N/A	300 Area	Origin Atlanta, GA	N/A
Lithium Fluoride	Box Van	100-lb Bag	N/A	300 Area	N/A	N/A
Hydrogen Peroxide	Box Van	Returnable 250-lb Polyethylene Drum	8,630 lb	300 Area	Origin Columbia, SC	2
Draw Bench Oil	Box Van	55-gal Drum	1,308 gal	300 Area	Origin Greenville, SC	2
Butyl Stearate	Box Van	55-gal Drum	N/A	300 Area	N/A	N/A
Argon (Liquid)	Tank Truck	—	9,891,035 Cu ft	300 Area	N/A	40
Isopropyl Alcohol	Box Van	N/A	N/A	300 Area	N/A	N/A
Hyflo Supercell	Box Van	50-lb Bag	31,800 lb	300 Area	Origin Atlanta, GA	4
Lithium	Box Van	Small Aluminum Can	N/A	300 Area	Origin Bessemer City, NC	N/A
Hydraulic Oil (A532)	Box Van	55-gal Drum	1,320 gal	300 Area	Origin Augusta, GA	2
Nitric Acid 51%	Tank Truck	—	728,120 lb	300 Area	Origin Augusta, GA	16
Phosphoric Acid	Box Van	55-gal Drum (Plastic)	70,000 lb	300 Area	Origin Charlotte, NC	
Sodium Nitrate	Box Van	100-lb Bag	91,100 lb	300 Area	200-F Area	12
Trichlorethane	10,000-gal Rail Car	—	50,129 gal	300 Area	N/A	6
Filterbestos	N/A	50-lb Bag	N/A	300 Area	N/A	N/A

TABLE B-2. Nonradioactive Hazardous Materials and Other Bulk Chemicals Received at SRP Facilities* (Continued)

Material	Mode of Transport	Type of Container	Amount of Material	Where Received	Transfer From	Number of Shipments (per yr)
Nickel Carbonate	Box Van	50-lb Bag	N/A	300 Area	Origin Augusta, GA	N/A
Sodium Bicarbonate	Box Van	100-lb Bag	5,000 lb	300 Area	Origin Augusta, GA	1
Aluminux	Box Van	50-lb Fiber Drum	40,598 lb	300 Area	N/A	1
Nickel Sulfate 22.50%	Box Van	50-100-lb Bag	10,000 lb	300 Area	Origin Atlanta, GA	1
Nickel Chloride 24.50%	Box Van	50-lb Plastic Bag	6,000 lb	300 Area	Origin Augusta, GA	1
Boric Acid (Granular)	Box Van	Paper Bag	2,000 lb	300 Area	Origin Augusta, GA	1
Activated Charcoal	Box Van	Bag	N/A	300 Area	N/A	1
Lead Powder 201 Pb	Box Van	200-lb Steel Pail	9,000 lb	300 Area	N/A	1
Aquadag	Box Van	1-gal Metal Container (6-9 lb)	36 lb	300 Area	Origin Brookfield, OH	1
Sulfuric Acid	Box Van	55-gal Plastic Drum	12,000 lb	300 Area	Origin Columbia, SC	2
Sodium Hydroxide	Tank Truck	—	147,492 lb	300 Area	Origin Augusta, GA	5
Aluminum Sulfate	Box Van	55-gal Drum	7,076 lb (11 Drums)	300 Area	Origin Atlanta, GA	1
Monolec-4701 Industrial Lubricant	Box Van	55-gal Drum	660 gal	300 Area	Origin Ft. Worth, TX	1
Fiske	Box Van	55-gal Drum	4,800 lb	300 Area	Origin Toledo, OH	1

TABLE B-2. Nonradioactive Hazardous Materials and Other Bulk Chemicals Received at SRP Facilities* (Continued)

Material	Mode of Transport	Type of Container	Amount of Material	Where Received	Transfer From	Number of Shipments (per yr)
Liquid Alum	Tank Truck	—	351,180 lb	D-Area	Origin Atlanta, GA	7
Dry Alum	Box Van	50-lb Bag	10,500 lb	Receiving Department then D-Area	Origin Augusta, GA	2
Butane	Vendor Truck	—	1,300 gal	D-Area	Origin Aiken, SC	2
Chlorine	Vendor Truck	1-ton Cylinder	340,000 lb	683-D	Origin Savannah, GA	15
			54,000 lb	100-C	683-D	5
			100,000 lb	100-K	683-D	8
			40,000 lb	100-P	683-D	5
			12,000 lb	200-F	683-D	6
			24,000 lb	400-D	683-D	9
			98,000 lb	681-1-3	683-D	5
			14,000 lb	681-5	683-D	2
			12,000 lb	681-6	683-D	2
Propane			550 gal	400-D		1
Freon No. 114		2,200-lb Cylinder	37,400 lb	700-A		4

TABLE B-2. Nonradioactive Hazardous Materials and Other Bulk Chemicals Received at SRP Facilities* (Continued)

Material	Mode of Transport	Type of Container	Amount of Material	Where Received	Transfer From	Number of Shipments (per yr)
Sodium Hypochlorite	Bulk shipments Tank Truck Vendor Truck 15-gal Drum	Tank Truck 15-gal Drum	3,945 gal	100-C	Bulk shipments direct to area. Small amounts to receiving.	9
			5,880 gal	100-K		10
			23,650 gal	100-L		11
			5,445 gal	100-P		10
			1,860 gal	200-F		10
			7,605 gal	200-H		12
			735 gal	400-D		6
			2,550 gal	Central Shops		9
			4,800 gal	700-A		11
Lime	Box Van	50-lb Bag	8,400 lb	700-A	Origin Augusta, GA	8
Calgon (Polyphosphate)	Box Van	100-lb Bag	4,100 lb	Receiving Department then 100-L	Origin Augusta, GA	3
Caustic Soda	Rail Tank Car		1,989,239 lb	400-D	Origin Savannah, GA	16
	Tank Truck		30,080 lb	282-H	Origin Savannah, GA	1
			30,200 lb	282-F	Origin Savannah, GA	1
			58,066 lb	100-C	400-D	5
			171,729 lb	100-K	400-D	9

TABLE B-2. Nonradioactive Hazardous Materials and Other Bulk Chemicals Received at SRP Facilities* (Continued)

Material	Mode of Transport	Type of Container	Amount of Material	Where Received	Transfer From	Number of Shipments (per yr)
Caustic Soda (Cont.)			14,069 lb	100-L	400-D	2
			70,910 lb	100-P	400-D	6
			194,390 lb	200-F	400-D	8
			143,386 lb	200-H	400-D	10
			578,710 lb	Trailer and Central Storage	400-D	11
Sodium Sulphite	Box Van	100-lb Bag	1,500 lb	100-K	Receiving Department	2
			1,000 lb	100-P	Receiving Department	1
			500 lb	200-H	Receiving Department	1
			7,000 lb	400-D	Receiving Department	2
			500 lb	700-A	Receiving Department	1
Sulphuric Acid	Rail Tank Car		1,163,514 lb	400 Area	Origin Copper Head, TN	10
	Tank Truck		42,487 lb	100-C	400 Area	4
			98,184 lb	100-K	400 Area	8
			48,785 lb	100-P	400 Area	5
			26,099 lb	200-F	400-Area	2
			74,259 lb	200-H	400-Area	7

TABLE B-2. Nonradioactive Hazardous Materials and Other Bulk Chemicals Received at SRP Facilities* (Continued)

Material	Mode of Transport	Type of Container	Amount of Material	Where Received	Transfer From	Number of Shipments (per yr)
Trisodium Phosphate	Box Van	50-lb Bag	1,100 lb	100-K	Receiving Department	1
			1,200 lb	200-H	Receiving Department	2
			2,300 lb	700-A	Receiving Department	4
			2,000 lb	100-P	Receiving Department	2
Fuel Oil (#2)	Tank Truck		328,509 gal	D-Area	Origin Sweatwater, SC	41
Diesel Fuel Oil	Tank Truck		159,969 gal	100-C	Origin Sweatwater, SC	20
			262,865 gal	100-K		31
			135,549 gal	100-L		17
			264,290 gal	100-P		33
			182,176 gal	200-F		23
			239,811 gal	200-H		28
Gasoline	Tank Truck		736,673 gal	715-A	Origin Sweatwater, SC	95
			86,733 gal	Central Shops		10
			13,335 gal	200-F		2
Diesel Fuel	Tank Truck		339,596 gal	715-A		44
			56,086 gal	Central Shops		7
			24,167 gal	618-G		3

TABLE B-2. Nonradioactive Hazardous Materials and Other Bulk Chemicals Received at SRP Facilities* (Continued)

Material	Mode of Transport	Type of Container	Amount of Material	Where Received	Transfer From	Number of Shipments (per yr)
Kerosene	Tank Truck		5,020 gal	715-A		3
			6,038 gal	618-G		1
Aluminum Nitrate	Rail Tank Car		183,720 lb	F-Area	Classification Yard	2
Mercurous Nitrate	Box Van	110-lb Fiber Drum	2,530 lb	F-Area	Receiving Department	5
Hydrazine Mononitrate	Box Van	55-gal Drums	N/A	F-Area	Receiving Department	N/A
Sodium Dichromate	Box Van	100-lb Bag	5,000 lb	H-Area	Receiving Department	3
Nitrogen	Tank Truck		6,130,150 ft^3	F-Area		81
Gelatin	Box Van	25-lb Carton	1,000 lb	F-Area	Receiving Department	1
Celite	Box Van	50-lb Bag	4,250 lb	H-Area	Receiving Department	6
Anion Resin (Donex 21-K)	N/A	N/A	N/A	F-Area	N/A	N/A
Cation Resin (Donex 50Wx12)	Box Van	1 ft^3-Drum	10 lb	F-Area	Receiving Department	1
Calcium	Box Van	Drums	N/A	F-Area	Receiving Department	N/A
Calcium Fluoride	Box Van	5-lb Bottle	500 lb	F-Area	Receiving Department	1
Ascorbic Acid	Box Van	50-kg Fiber Drum	2,000 kg	F-Area	Receiving Department	1
Liquid Hydrogen Fluoride	Box Van	50-lb Plastic Bottle	20,000 lb	F-Area	Receiving Department	7

TABLE B-2. Nonradioactive Hazardous Materials and Other Bulk Chemicals Received at SRP Facilities* (Continued)

Material	Mode of Transport	Type of Container	Amount of Material	Where Received	Transfer From	Number of Shipments (per yr)
Resin (Dowex MSA 1)	Box Van	1 ft^3-Fiber Drum	N/A	F-Area	Receiving Department	N/A
Ferrous Sulfamate (50%)	Tank Truck		516,450 lb	F-Area		12
			110,060 lb	H-Area	F-Area	10
Ceric Ammonium Nitrate	N/A	N/A	N/A	N/A	N/A	N/A
Formic Acid	N/A	N/A	N/A	N/A	N/A	N/A
Hydroxylamine Sulfate	N/A	N/A	N/A	N/A	N/A	N/A
Argon	Tank Truck		3,777,950 ft^3	F-Area		12
Hydroxylamine Nitrate	Tank Truck		402,930 ft^3	F-Area		16
n-Paraffin	Rail Tank Car		127,780 gal	Classification Yard		1
			63,820 gal	F-Area	Classification Yard	1
			63,940 gal	H-Area	Classification Yard	1
Manganous Nitrate	Box Van	55-lb Drum	25,300 lb	H-Area	N/A	2
Torch Welding Gas	N/A	N/A	N/A	N/A	N/A	N/A
Nitric Acid (64%)	Tank Truck	—	5,706,260 lb	F-Area	N/A	117
Nitric Acid (51%)	Tank Truck	—	7,927,920 lb	200-Area	N/A	108

TABLE B-2. Nonradioactive Hazardous Materials and Other Bulk Chemicals Received at SRP Facilities* (Continued)

Material	Mode of Transport	Type of Container	Amount of Material	Where Received	Transfer From	Number of Shipments (per yr)
Aluminum Powder	N/A	N/A	N/A	N/A	N/A	N/A
Dodecanol	N/A	N/A	N/A	N/A	N/A	N/A
Oxalic Acid	Box Van	50-lb Bag	40,020 lb	F-Area	N/A	4
			14,795 lb	H-Area	N/A	6
Potassium Fluoride	N/A	N/A	150 lb	H-Area	N/A	N/A
Propane Gas	Tank Truck	—	121,744 ft^3	F-Area	N/A	13
Phosphoric Acid	Box Van	55-gal Drum	28,000 lb	H-Area	N/A	2
Potassium Permangenate	Box Van	110-lb Drum	7,920 lb	H-Area	N/A	4
			1,3025 lb	F-Area	N/A	2
Sodium Carbonate	Box Van	100-lb Bag	180,000 lb	F-Area	N/A	11
			31,400 lb	H-Area	N/A	4
Linde Ion Siv Resin	Box Van	50-lb Drum	5,000 lb	F-Area	N/A	1
			17,400 lb	H-Area	N/A	2
Sodium Hydroxide	Rail Tank Cars	—	7,915,130 lb	F-Area	N/A	62
			3,448,760 lb	H-Area	N/A	28
Sodium Nitrate	Rail Box Cars	N/A	600,000 lb	F-Area	N/A	6
	Box Van	N/A	58,800 lb	714-5G	F-Area	6

TABLE B-2. Nonradioactive Hazardous Materials and Other Bulk Chemicals Received at SRP Facilities* (Continued)

Material	Mode of Transport	Type of Container	Amount of Material	Where Received	Transfer From	Number of Shipments (per yr)
Sodium Nitrite	Box Van	100-lb Bag	97,500 lb	F-Area	N/A	8
			33,600 lb	H-Area	F-Area	5
Calcium Oxide	N/A	N/A	N/A	N/A	N/A	N/A
Mercury (Single Distilled)	N/A	N/A	N/A	N/A	N/A	N/A
Sulfamic Acid	N/A	50-lb Bag	23,200 lb	F-Area	N/A	5
Boric Acid	Box Van	100-lb Bag	8,000 lb	F-Area	N/A	2
			600 lb	H-Area	N/A	1
Tributyl Phosphate	Tank Car	—	***	***	N/A	***
Pulverizer Coal	Rail Car	—	181,121.86 tons	D-Area	N/A	2441
Stoker Coal	Rail Car	—	37,781.53 tons	K-Area	N/A	504
			12,669.30 tons	P-Area	N/A	169

* 1985 data

** N/A - not available

*** TBP not received in 1985. Normal annual receipts is 2 Tank Cars.

TABLE B-3. Detailed List of Nonradioactive Hazardous Materials Received and Transported at the SRP*

Hazardous Material

Acetone

Acetylene

Adhesive

Air, Compressed

Alcohol, n.o.s.

Aluminum Nitrate

Aluminum Sulfate Solution (RQ-5000/2270)

Ammonia, Anhydrous (RQ-100/45.4)

Ammonium Hydroxide (containing not less than 12% but not more than 44% ammonia) (RQ-1000/454)

Ammonium Hydroxide (containing less than 12% ammonia) (RQ-1000/454)

Ammonium Nitrate (no organic coating)?

Ammonium Nitrate, Solution (containing not less than 15% water)

Argon or Argon, Compressed

Asbestos

Asphalt, Cut Back (Flammable Liquid)

Asphalt, Cut Back (Combustible Liquid)

Battery, electric storage, wet, filled with acid, with automobile

Bleaching Powder, containing 39% or less available chlorine

Boric Acid

Calcium Fluoride

Calcium, Metal

Calcium Oxide

Carbon Dioxide

Carbon Dioxide, Solid or Dry Ice, or Carbonice

Cement

Cement, Roofing, Liquid

Cement, Rubber

Charcoal Briquettes

Chlorine (RQ-10/4.54)

Coal, Ground Bituminous, Sea Coal, Coal Facings, Etc.

Coating Solution

Compressed Gas, n.o.s. (Flammable)

Compressed Gas, n.o.s., (Nonflammable)

Cyclohexane (RQ-1000/454)

Dichlorabenzene, Ortho, Liquid (RQ-100/45.4)

Dihydrazine Sulphate

Etching Acid, Liquid, n.o.s. (RQ-1000/454)

Ethyl Alcohol

Ferric Sulfate (RQ-1000/454)

Ferrous Sulfamate

Film (Nitrocellulose)

Fuel Oil

Fuel Oil, No. 1, 2, 4, 5, or 6

Gasoline (including Casing-head and natural)

TABLE B-3. Detailed List of Nonradioactive Hazardous Materials Received and Transported at the SRP* (Continued)

Hazardous Material
Helium or Helium, Compressed
Helium, Refrigerated Liquid (Cryogenic Liquid)
Hexane
High Explosive
Hydrazine Mononitrate
Hydrochloric Acid (RQ-5000/2270)
Hydrofluoric Acid Solution (RQ-5000/2270)
Hydrogen or Hydrogen, Compressed
Hydrogen, Refrigerated Liquid (Cryogenic Liquid)
Hydrogen Chloride (RQ-500/2270) or Hydrogen Chloride, Anhydrous (RQ-5000/2270)
Hydrogen Fluoride (Hydrofluoric Acid) (RQ-5000/2270)
Hydrogen Peroxide Solution (8 to 40% Peroxide)
Hydroxylamine Nitrate
Hydroxylamine Sulphate
Hypochlorite Solution containing not more than 7% available chlorine by weight (RQ-100/45.4
Ink, Combustible Liquid
Ink, Flammable Liquid
Isopropanol (Isopropy Alcohol)
Kerosene
Lacquer Base or Lacquer Chips, Plastic (wet with alcohol or solvent)
Lead, Metal Powder
Liquified Petroleum Gas (e.g. Propane)
Lithium Metal, in cartridges?
Manganese Nitrate
Mercuric Nitrate (RQ-10/4.54)
Mercury, Metallic
Methane or Methane, Compressed
Methyl Ethyl Ketone
Methyl Methacrylate Monomer, Inhibited (RQ-5000/2270)
Methyl Methacrylate
Nickel Chloride (RQ-5000/2270)
Nickel Sulfate (RQ-5000/2270)
Nitric Acid (over 40%) (RQ-1000/454)
Nitric Acid, 40% or less (RQ-1000/454)
Nitrobenzene, Liquid or Nitrobenzol, Liquid (oil of mirbane) (RQ-1000/454)
Nitrogen or Nitrogen, Compressed
Nitrogen Dioxide, Liquid (RQ-1000/454)
Oil, Described as Oil, Oil, n.o.s., Petroleum Oil or Petroleum Oil, n.o.s. (Combustible Liquid)
Oil, Described as Oil, Oil, n.o.s., Petroleum Oil or Petroleum Oil, n.o.s. (Flammable Liquid)
Oxalic Acid
Oxygen or Oxygen, Compressed
Paint (Combustible Liquid)

TABLE B-3. **Detailed List of Nonradioactive Hazardous Materials Received and Transported at the SRP*** (Continued)

Hazardous Material

Hypochlorite Solution containing more than 7% available chlorine by weight (RQ-100/45/4)

Phosphoric Acid (RQ-500/2270)

Polychlorinated Biphenyls (RQ-10/4.54) (RQ-10/4.54)

Potassium Hydroxide Liquid or Solution (RQ-1000/454)

Potassium Permanganate (RQ-100/45.4)

Potassium Fluoride

Refrigerant Gas, n.o.s. or Dispersant Gas, n.o.s.

Resin Solution (Resin Compound, Liquid

Monomer, Uninhibited (high-purity, if acceptable under 173.21)

Silver Nitrate (RQ-1000/454)

Sodium Carbonate

Sodium Chromate (RQ-1000/454)

Sodium Dichromate (RQ-1000/454)

Sodium Hydroxide, Liq/Sol (RQ-1000/454)

Sodium Nitrate (RQ-100/45.4)

Sodium Phosphate, Tribasic (RQ-5000/2270)

Sodium, Metal Liquid Alloy (RQ-1000/454)

Sulfamic Acid

Paint (Flamable Liquid)

Paint Related Material (Combustible Liquid)

Paint Related Material (Flammable Liquid)

Sulfur Dioxide

Sulfuric Acid (RQ-1000/454)

Tetrachlorethylene or Perchloroethylene

Tributyl Phosphate

1,1,1-Trichloroethane

Trichloroethylene (RQ-1000/454)

Uranium Trioxide

Vinyl Chloride

Xylene (Xylol) (RQ-1000/454)

Zinc Chloride, Solid (RQ-5000/2270)

Zinc Chloride, Solution (RQ-5000/2270)

Zinc Chromate

* Includes all materials listed in SRP Caption Items: 3-Paint and Related Materials, 6-Laboratory Chemicals, 7-Cylinder Gasses, 17-Janitorial Supplies, and Bulk Chemicals. Some specialty chemicals used in small quantities may not be listed.

APPENDIX C

REGULATORY REQUIREMENTS FOR PACKAGES USED FOR TRANSPORTING RADIOACTIVE MATERIALS TO DESTINATIONS OFF THE SRP SITE

(Appendix to Chapter 3.0)

APPENDIX C. REGULATORY REQUIREMENTS FOR PACKAGES USED TRANSPORTING RADIOACTIVE MATERIALS TO DESTINATIONS OFF THE SRP SITE

Packages containing quantities of radioactive materials greater than the A_1 or A_2 value for the radionuclide(s) to be shipped must withstand tests shown in Tables C-1 and C-2 before they can be certified for offsite shipments. A Safety Analysis Report of Packaging (SARP) must be submitted to DOE before a Certificate of Compliance can be issued for a specific package. DOE issues Certificates of Compliance for its contractors as specified in a Memorandum of Understanding with DOT and NRC and reflected in DOT regulations at 49 CFR 173.7. NRC issues Certificates of Compliance for licenses and overseas shipments as requested by the DOT acting as the United States' competent authority.

For Type B packages containing large quantities of radionuclides, design may include pressure relief devices to control release of gases generated during fires in an accident environment. Pre-operative and preuse testing of such devices is required. Transmission of heat from the contents through the cask wall is a major design consideration for high specific alpha emitters and for other concentrated radionuclides. Conversion of radionuclides to solids is preferred for offsite shipments because regulations require the design to guarantee no leakage if the package is involved in a hypothetical accident. Effective June 1978, Federal regulations require that quantities of plutonium over 20 curies must be converted to solid form before shipping.

Packages containing lesser quantities of radionuclides (called Type A quantities) must comply with the tests (Table C-1) which evaluate package environments during normal transportation. In addition, a documented safety analysis is required for each such package, effective January 1, 1976.

For additional information on cask design, testing, and criteria for packages, see DOE Order 5480.3 "Safety Requirements for the Packaging of Fissile and Other Radioactive Materials" and Code of Federal Regulations 10 CFR 71.31 through 10 CFR 71.73.

TABLE C-1. Tests - Normal Conditions of Transport* (Effective 9/7/83)

Heat	Direct sunlight at an ambient temperature of 100°F in still air.
Cold	Ambient temperature at -40°F in still air and shade.
Pressure	Reduced external pressure, 3.5 psi; increased external pressure, 20 psi.
Vibration	Vibration normally incident to transport.
Water Spray	Water spray sufficiently heavy to keep the entire exposed surface of the package except the bottom continuously wet during a period of thirty minutes.
Free Drop	Between 1-1/2 and 2-1/2 hours after conclusion of the water spray, a free drop through the distance specified below onto a flat essentially unyielding horizontal surface, striking the surface in a position for which the maximum damage is expected.

Free Fall Distance

Package Weight	Distance, ft
Less than 11,000	4
11,000 to 22,000	3
22,000 to 30,000	2
More than 33,000	1

Corner Drop	Free drop onto each corner of the package in succession or in case of a cylindrical package onto each quarter of each rim, from a height of one foot. This test applies to packages which are constructed primarily of wood or fiberboard boxes and cylinders.
Penetration	Impact of the hemispherical circular end of a vertical steel cylinder one and one-quarter inches in diameter and weighing 13 pounds, dropped from a height of four feet, normally onto the exposed surface of the package, which is expected to be most vulnerable to puncture.
Compression	Packages not exceeding 11,000 pounds in weight, a compressive load equal to either five times the weight of the package or 265 pounds per square foot, whichever is greater. The load shall be applied during a period of 24 hours, uniformly against the top and bottom of the package in the position in which the package would normally be transported.

*49 CFR 173.465.

TABLE C-2. Tests - Hypothetical Accident Conditions*

Free Drop	Free drop for a distance of thirty feet onto a flat essentially unyielding horizontal surface, striking the surface in a position for which maximum damage is expected.
Puncture	Free drop through a distance of forty inches striking, in a position maximum damage is expected, the top end of a vertical cylindrical mild steel bar mounted on an essentially unyielding horizontal surface. The bar shall be six inches in diameter, with the top horizontal and its edge rounded to a radius of not more than one-quarter inch, and of such a length as to cause maximum damage to the package, but not less than eight inches long. The long axis of the bar shall be normal to the package surface.
Thermal	Exposure for thirty minutes within a source of radiant heat having a temperature of 1,475°F and an emissivity coefficient of 0.9, or equivalent. For calculational purposes, it shall be assumed that the package has an absorption coefficient of 0.8. The package shall not be cooled artificially until after the thirty-minute test period has expired and the temperature at the center of the package has begun to fall.
Water-Immer sion	Immersion in water for not less than eight hours under a head of water at least 15 meters (or 50 feet). - effective 9/7/83.

*49 CFR 173.467 and 10 CFR 71.73.

APPENDIX D

EXAMPLE OF A HAZARDOUS MATERIAL INCIDENT REPORT

(Appendix to Chapter 5.0)

DEPARTMENT OF TRANSPORTATION — Form Approved OMB No. 04-S613

HAZARDOUS MATERIALS INCIDENT REPORT

INSTRUCTIONS: Submit this report in duplicate to the Secretary, Hazardous Materials Regulations Board, Department of Transportation, Washington, D.C. 20590, (ATTN: Op. Div.). If space provided for any item is inadequate, complete that item under Section H, "Remarks", keying to the entry number being completed. Copies of this form, in limited quantities, may be obtained from the Secretary, Hazardous Materials Regulations Board. Additional copies in this prescribed format may be reproduced and used, if on the same size and kind of paper.

A INCIDENT

1. TYPE OF OPERATION: 1 ☐ AIR 2 ☒ HIGHWAY 3 ☐ RAIL 4 ☐ WATER 5 ☐ FREIGHT FORWARDER 6 ☐ OTHER (Identify) ____

2. DATE AND TIME OF INCIDENT (Month - Day - Year): March 7, 1972 — 11:30 a.m. / p.m.

3. LOCATION OF INCIDENT: Exit 3 on I-495 near Alexandria, Va.

B REPORTING CARRIER, COMPANY OR INDIVIDUAL

4. FULL NAME: ABC Trucking Company, Inc.

5. ADDRESS (Number, Street, City, State and Zip Code): 204 Post Avenue, Fayetteville, North Carolina 28301

6. TYPE OF VEHICLE OR FACILITY: Tractor - Van Trailer

C SHIPMENT INFORMATION

7. NAME AND ADDRESS OF SHIPPER (Origin address):
XYZ Chemical Company
1101 South Peachtree Street
Atlanta, Ga. 30303

8. NAME AND ADDRESS OF CONSIGNEE (Destination address):
J & J Chemicals
1506 Wayne Street
Alexandria, Va. 22301

9. SHIPPING PAPER IDENTIFICATION NO.:
Shipper's B/L: FNC 12345
Carrier's Pro: 98765

10. SHIPPING PAPERS ISSUED BY: ☒ CARRIER ☐ SHIPPER ☐ OTHER (Identify) ____

D DEATHS, INJURIES, LOSS AND DAMAGE

DUE TO HAZARDOUS MATERIALS INVOLVED

11. NUMBER PERSONS INJURED: -1-

12. NUMBER PERSONS KILLED: -0-

13. ESTIMATED AMOUNT OF LOSS AND/OR PROPERTY DAMAGE INCLUDING COST OF DECONTAMINATION (Round off in dollars): $ 1,000.00

14. ESTIMATED TOTAL QUANTITY OF HAZARDOUS MATERIALS RELEASED: 45 gals.

E HAZARDOUS MATERIALS INVOLVED

15. CLASSIFICATION (Sec. 172.4)	16. SHIPPING NAME (Sec. 172.5)	17. TRADE NAME
Corrosive Liquid	Formic Acid	None

F NATURE OF PACKAGING FAILURE

18. (Check all applicable boxes)

	(1) DROPPED IN HANDLING	X	(2) EXTERNAL PUNCTURE	X	(3) DAMAGE BY OTHER FREIGHT
	(4) WATER DAMAGE		(5) DAMAGE FROM OTHER LIQUID		(6) FREEZING
	(7) EXTERNAL HEAT		(8) INTERNAL PRESSURE		(9) CORROSION OR RUST
	(10) DEFECTIVE FITTINGS, VALVES, OR CLOSURES		(11) LOOSE FITTINGS, VALVES OR CLOSURES		(12) FAILURE OF INNER RECEPTACLES
	(13) BOTTOM FAILURE		(14) BODY OR SIDE FAILURE		(15) WELD FAILURE
	(16) CHIME FAILURE	X	(17) OTHER CONDITIONS (Identify) Traffic Collision		

19. SPACE FOR DOT USE ONLY

Form DOT F 5800.1 (10-70)

G	PACKAGING INFORMATION - If more than one size or type packaging is involved in loss of material show packaging information separately for each. If more space is needed, use Section H "Remarks" below keying to the item number.			
	ITEM	#1	#2	#3
20	TYPE OF PACKAGING INCLUDING INNER RECEPTACLES (Steel drums, wooden box, cylinder, etc.)	(Inner) Plastic Liner	(Outer) Steel Drum	
21	CAPACITY OR WEIGHT PER UNIT (55 gallons, 65 lbs., etc.)	55 gals.	55 gals.	
22	NUMBER OF PACKAGES FROM WHICH MATERIAL ESCAPED	1	1	
23	NUMBER OF PACKAGES OF SAME TYPE IN SHIPMENT	72	72	
24	DOT SPECIFICATION NUMBER(S) ON PACKAGES (21P, 17E, 3AA, etc., or none)	DOT 2SL	DOT 17H	
25	SHOW ALL OTHER DOT PACKAGING MARKINGS (Part 178)	55-12-71	STC 18/16-55-70	
26	NAME, SYMBOL, OR REGISTRATION NUMBER OF PACKAGING MANUFACTURER	AAA	FUBAR	
27	SHOW SERIAL NUMBER OF CYLINDERS, CARGO TANKS, TANK CARS, PORTABLE TANKS	N/A	N/A	
28	TYPE DOT LABEL(S) APPLIED	N/A	Corrosive Liquid	
29	IF RECONDITIONED OR REQUALIFIED, SHOW — A. REGISTRATION NO. OR SYMBOL	N/A	DOT R1000	
29	IF RECONDITIONED OR REQUALIFIED, SHOW — B. DATE OF LAST TEST OR INSPECTION	N/A	Tested 2/72	
30	IF SHIPMENT IS UNDER DOT OR USCG SPECIAL PERMIT, ENTER PERMIT NO.	None	None	

H REMARKS - Describe essential facts of incident including but not limited to defects, damage, probable cause, stowage, action taken at the time discovered, and action taken to prevent future incidents. Include any recommendations to improve packaging, handling, or transportation of hazardous materials. Photographs and diagrams should be submitted when necessary for clarification.

Our vehicle was involved in a minor traffic accident which caused the load to shift and puncture one of the drums. The leaking drum was removed by the consignee to their disposal area and buried. The vehicle was taken to our Alexandria terminal and cleaned (washed down and steamed). A Highway Patrolman on the scene had some of the spilled liquid splash on his hand. He was taken to a local hospital where he was treated and released.

31. NAME OF PERSON PREPARING REPORT (Type or print)	32. SIGNATURE
Ira Jeopard	
33. TELEPHONE NO. (Include Area Code)	34. DATE REPORT PREPARED
(202) 143-0510	March 15, 1972

Reverse of Form DOT F 5800.1 (10-70)

APPENDIX E

RADIOACTIVE MATERIAL TRANSPORTATION

INCIDENTS AT THE SRP

(Appendix to Chapter 5.0)

APPENDIX E. Radioactive Material Transportation Incidents at SRP

Appendix E provides the history of reported transportation incidents at the SRP. Truck and railroad accidents, leaks and spills of liquids, roadway contamination, high radiation intensities during shipment, fires, natural phenomena, and human error which have occurred in, or incident to, transportation during 34 years of operation are described below.

Accidents Involving Trucks and Truck Trailers

Table E-1 is a listing of trucking accidents. Except for the minor backing accidents, there have been 89 reported accidents at the SRP in which trucks were involved; this is an accident rate of about 3/yr for all onsite truck transportation. Estimating that 10% of onsite truck operations are for HM shipments (which amount to about 100,000 mi/yr) and that 10% of the recorded accidents are serious enough to be reported if occurring in public commerce, the relevant SRP truck accident rate is believed to be approximately $3x10^{-7}$/vehicle mile. This is about one-tenth the rate for truck commerce on public highways.

Rail Car Accidents

Table E-2 lists accident occurrences involving rail operations. Minor damage was experienced except:

- While an agitator on a flatcar was pushed into Building 211-H it struck overhead air and steam lines. The tiedown chains were broken and the agitator fell to the ground and sustained damage.
- When a canyon jumper box on a flat car struck a light and wire, ripping the overhead 2300-volt lines. The electrical lines draped over the load, but fortunately the circuit breaker opened.
- When a fatality occurred during a routine switching operation in 1970. No one witnessed the accident.

Damage to rail cars has occurred four times, all in the 200-Area railroad tunnels where cars are moved by a battery operated locomotive (dinky). The dinky brakes failed, damaging CD-4 and CD-5 70-ton cask cars by hitting the end stops at excessive speeds. The third damaged car involved air brake lines being incorrectly operated and the car decoupled. After decoupling, tiedown chains to the cask broke when the car abruptly stopped, the cask moved and damaged a retaining rib on the end of the car. Also, a fire curtain fell 2-3 feet onto a flat car, damaging the car. DPSTSY-200-1,(1), Section 2.4.4.1 evaluates operations in the railroad tunnel.

TABLE E-1. Truck Accidents

Incident	Number of Occurrences
Minor backing accidents for trucks, including pickups from 1963 to 1982	Average 8/yr
Tractor trailer struck parked vehicle	4
Van truck ran into another truck	3
Truck struck by crane headacheball	1
Tractor trailer jack-knifed (skid on ice and snow or front wheels locked)	3
Passing truck hit vehicle	3
Truck pulled into intersection and hit vehicle	7
Driver lost control and ran off road	3
Truck lost load (one was a pulpwood truck)	2
Truck struck tractor (farm type) on road	1
Tractor trailer released brakes and rolled back into pole (one commercial vehicle)	2
Truck ran stop sign and hit car	2
Tractor trailer hit entrance gate	15
Driver blacked out and hit pole	1
Driver veered to left of road over guard rail	1
Truck turned left into pickup which was passing	1
Parked commercial trailer rolled backward and hit building	2
Commercial vehicle - left rear dual wheels rolled off axle and truck overturned	1
Load struck overhead lines	4
Truck struck other vehicle during poor visibility (smoke, rain, snow) (one was pulpwood truck)	3

TABLE E-1. Truck Accidents (Continued)

Incident	Number of Occurrences
Light weight trucks - blowout and hit guard rail	2
Foot slipped onto accelerator and vehicle hit object	2
Cranes being moved damaged gatehouse	3
Crane being moved hit vehicle with boom	1
Crane carrier struck overpass	1
Hydrocrane pulled down section of wall onto a parked truck	1
Trailer came loose from tractor and overturned	1
Concrete truck overturned - unbalanced load in mixer	1
Dump truck overturned	3
Truck hit gatehouse	1
Truck hit fixed object	14

TABLE E-2. Rail Accidents

Incident	Number of Occurrences
Locomotives and cars struck doors	4
Locomotives and cars struck gates	3
Equipment beside the tracks was hit	2
Overhead piping was struck	2
Electrical line was hit	1
Rail track switch accidents	10
Failed brakes (Rubber gasket had spread into application port of automatic brake valve)	1
Employees fell from deck of flatcar	2
During coupling of 70-ton cask car, a steel chock flew about 30 feet from track and nearly hit employee	1
Air hose fell to track, was severed and blew a valve out of the backup hose and almost hit employee	1
The subgrade and track bed were eroded near Building 105-C by water being discharged from a fire hose. The track was immediately closed for repairs.	1
Several sticks of dynamite and fuses were found in a carload of rock, but the fuses were detached.	1
Contamination of up to 15,00 c/m beta-gamma was detected in a traction blower motor, brake system, and wheels of a locomotive during a required Health Physics survey before routine maintenance.	1
A chain chock not removed from a car slid along the track and lodged in a switch point - potentially causing a derailment.	1
Road bed embankments were partially washed out during a very heavy rain in 1976	1
A loaded courier car awaiting pickup on a rail siding began rolling and finally stopped on the mainline tracks	1

TABLE E-2. Rail Accidents (Continued)

Incident	Number of Occurrences
The subgrade was eroded and damaged by beaver activity near Building 105-C at the intersection with Road 5	1
Tiedown problems with an Elk River reactor cask received at 244-H. The flatcar bowed under the load, the tiedowns flexed and broke cable strands. For the return trip, the cask was bolted onto a skid which was bolted to the car.	1
1971 - two cars used for $ThNO_3$ solution storage exhibited localized weld metal corrosion up to 1/16 inch deep. The solution is no longer stored in these cars.	1

Rail Crossing Accidents

There was one rail crossing accident recorded in December 1957 after production startup. This accident involved a fatality caused by an employee driving into the side of a train. Following this accident, SRP railroad procedures were revised to require the engineer to slow the train to 4 mph when approaching highway crossings. Furthermore, a high intensity revolving yellow light was installed on the locomotive cab roof. The light is illuminated while the locomotive engine is operating. These changes in procedure have averted at least four crossing accidents involving logging trucks, a private vehicle which slid into the crossing when its brakes locked, and a shuttle bus which ignored the signal lights, the locomotive bell, horn and revolving light. With these changes in procedure, it is estimated that the probability of a vehicle hitting a cask car or flat car carrying radioactive waste or equipment is approximately $<1x10^{-2}$/yr. The current frequency of operators of vehicles running the red light at railroad crossings is six or more per year. Most of these latter incidents are probably the result of vehicle operator impatience with slow moving trains.

Near the 400-Area, onsite highways cross the mainline of the Seaboard Railroad System where trains travel at full speed. Highway vehicle operators can see the trains at a good distance from each of these crossings. However, during construction of the 400-Area, three construction workers were killed at one of these crossings in a train-car collision.

Derailments

In the period 1961 through 1982, 19 derailments were reported - a frequency of 1.1/yr or $1.2x10^{-4}$/hr. Three of these derailments involved 70-ton fuel element cask cars. No significant consequences occurred. Two cases of cask car derailment occurred outside of the railroad tunnel but within the exclusion area (fenced area with security-controlled access) of 200-H Area. The cars remained upright and no contaminated water was lost to the environment. Three similar derailments occurred offsite during the shipment of Canadian fuel in 55-ton casks. The speed at the time of derailment (2) was approximately 30 mph, and the cask cars remained upright with no loss of contaminated water to the environment.

Sandia data (3) show that the probability per car mile of derailment is $6.6x10^{-6}$ at speeds of 30 mph or less. Data from a fault tree analysis by Holmes and Narver, Inc. (4) indicate a probability per mile of about $6x10^{-8}$ for derailment of a cask car with subsequent over- turn, loss of coolant, or puncture of the cooling water expansion tank.

Contaminated equipment is moved by rail from the canyons at a frequency of less than 11 trips per year. The distance traveled is 1 to 1-1/2 miles. The estimated frequency of derailment is $<2x10^{-4}$/yr during these infrequent, short hauls (3).

Table E-3 reveals that in most incidents reported derailments were caused by operator errors. Six of the 19 derailments involved faulty or misoperated

TABLE E-3. Derailments 1961 through 1982

Derailment Causes	Number of Occurences
Ramming rear of railroad tunnel at excessive speed	2
Misaligned derailer (a derailer is a device that causes car(s) to derail before striking a building, other car, or running off the end of a dead-end track)	1
Pushed over derailer	1
Hit derailer at excessive speed	1
Rolled off track onto dirt road	1
Car pulled over chock or foreign object on track	3
Cars uncoupled, rolled, and struck other cars	1
Coupling pin not engaged, side pressure on curve	2
Faulty or misoperated switch	6
Worn flange on car wheel	1
TOTAL DERAILMENTS	19

switches and occurrences were caused by a car pulled over the chock or a foreign object on the track.

Leaks and Spills of Liquids onto Vehicles

From 1959 to 1976, two small volume leaks and spills of liquids occurred onto railcars and 19 small volume leaks onto trucks and trailers. Table E-4 describes these spills of liquids onto vehicles. From 1977 to 1983, thirteen small volume leaks occurred onto trucks or trailers but none were reported for rail cars. The frequency of these spills with the liquid contaminating only the carrier vehicle is approximately one per year. Liquid leaked ten times onto the trailer and twice onto a rail car from equipment being transported and nine times from a cask onto its trailer during onsite operations. The probability of leakage per shipment of equipment is about 0.05.

The frequency of leakage of waste liquids into a load-lugger pan is about 0.1/yr and is a function of operator performance. However, the pans are sealed by continuous welding and the probability of leakage onto the vehicle and road during transit is very small.

Drums containing D_2O have leaked, but transportation equipment has not been contaminated. However, the 2800 drums stored outside were inspected and 56 drums were pitted. Pitting corrosion was caused by flyash and rainwater. Drum inspections prior to filling operations are necessary safety precautions.

Casks and packages received from offsite occasionally arrive at SRP with the outer surfaces contaminated, possibly from minor leakage. Containers in at least six shipments to the Burial Grounds have been contaminated but have presented little hazard during onsite transportation.

Approximately 1% of the casks containing irradiated materials received at Building 244-H (RBOF) were contaminated above limits prescribed by Federal regulations. Contamination of the trailer beds occurred only near the casks.

Potential causes of leaks and spills of liquids are listed in Table E-5. Table E-6 presents evaluated truck accident statistics for SRP for radioactive materials including the experienced frequency of leakage during shipment.

Railroad Bed Contamination

The primary cause of contamination of the railroad beds and tracks has been the transport of equipment from 200-H or 200-F Canyons to the Burial Ground. From 1959 to 1960 the railroad beds and tracks in the 200-H and 200-F exclusion areas were contaminated four times. In this period, the roadbed between these exclusion areas and the Burial Ground were contaminated three times. Table E-7 lists the occurrences of railroad bed contamination..

TABLE E-4. Leaks and Spills of Liquids onto Vehicles from 1959 to 1976

Spills onto Vehicles	Number of Occurrences	Consequences
Uranyl nitrate leaked from hatches of HM trailers after trailers were filled.	3	Hatches were sealed and decontaminated before transport.
HM trailer leaked about 1/2 gal from a dip tube flange when pressure was not relieved after the preshipment pressure test.	1	Trailer was decontaminated before shipment.
Liquid from a Building 776-A load lugger pan spilled when it was dumped in the Burial Ground but did not leak enroute.	1	Residual radioactivity in the pan was 60.000 d/m alpha.
A leak into a pan involved a leak from a 5-gal carton inside a 772-F pan.	1	Severity unknown.
In 1982 a leak of two gallons from packaged waste into a 772-F pan.	1	Radiation intensity of 35 R/hr at 3 in. from the pan revealed a punctured waste carton
In 1973, 304 stainless steel moderator drums were found leaking during an inspection.	6	The cause was defective seal welds and shrinkage cracks.
Leaks from D_2O drums were reported in 1976, (Works Technical Monthly Reports.)	8	Drum inspections prior to filling operations.
Since 1976 only one D_2O drum was reported as leaking from a small hole in the side.	1	Severity unknown.
Small leaks occurred in transit and contaminated gondola cars as much as 1.2 rad/hr at 3 in.	2	Paper towel swipes (from about 1 sq ft surface area) radiated 4 rad/hr at 3 in.
In 1976 uranyl nitrate trailers returned from Y-12 were contaminated at a front unloading hatch.	10	The trailers were contaminated to 80,000 d/m alpha.

TABLE E-4. Leaks and Spills of Liquids onto Vehicles from 1959 to 1976 (Continued)

Spills onto Vehicles	Number of Occurrences	Consequences
From 1977 through 1982, uranyl nitrate trailers returned from Y-12 contaminated.	5	Contamination to a maximum of 50,000 d/m/100 cm^2 alpha smearable.

TABLE E-5. Potential Causes of Leaks and Spills of Liquids

- Incomplete drainage of liquid or decontamination solution from equipment.
- Misoperation of valves, particularly those on deionizer casks, the bottom emptying low-level trailer, and other vessels where a valve is the only barrier between the vessel contents and the environment.
- Puncture by a forklift truck during loading or unloading operations.
- Incorrect assembly of gasketed closures such as manholes, hatches, flanges, and lids.
- Inadequate connection of hoses.
- Inadequate packaging of liquids and powders containing radionuclides. Transport operations can cause leakage within the package resulting in liquid leakage or sifting of powders from the package.

TABLE E-6. Evaluated Truck Accident Statistics for SRP

Trailer or Container Type	Used to Transport	Frequency of Leakage	Average Mi/Yr	Probability of Accident
Mounted tanks with No Shielding	Low-level waste	0.2/yr	1200-1500	$<3x10^{-5}$/yr
High-level waste trailer	High-level waste	$3x10^{-9}$/yr	<300	$<10^{-10}$/vm at ≤20 mi/hr
Solvent trailer	Spent solvent	$5x10^{-2}$/yr	≤2	10^{-9} to 10^{-10}/vm
Deionizer casks	Deionizer resin	10^{-8}/vm**	800	$<10^{-4}$/trip
Heavy casks: 100 Area scrap metal irradiated melt RBOF scrap 100-Area deionizer & large offsite shipment	Tritium irradiated fuel	Disassemby Basin Water*	N/A	10^{-9}/vm
Trailer hauling cask up to 8 tons	Sheilded concrete waste boxes, fuel element casks, and contaminated equip.	N/A***	<100/load	10^{-8}/vm
Load lugger pans	Solid waste	N/A	500-3000 mi/month	10^{-7}/vm
Van - 55-gal drums w/punctures	TRU waste	$<3x10^{-4}$/yr	<500	$4.5x10^{-8}$/vm
Stake Body & Van Trucks: 100-P Area	D_2O in drums	$<1x10^{-5}$/yr	1500	$7x10^{-9}$/vm

TABLE E-6. Evaluated Truck Accident Statistics for SRP (Continued)

Trailer or Container Type	Used to Transport	Frequency of Leakage	Average Mi/Yr	Probability of Accident
Onsite Areas	^{238}Pu oxide ^{235}U scrap	$1x10^{-7}$/yr	500-600	$2x10^{-10}$/vm
	Casks ≤8 tons	<$4x10^{-4}$/yr	100-200	Between $2x10^{-6}$ and $1x10^{-7}$/vm
100-Area sample pickup trucks	D_2O samples to 772-D & 772-F	<$3x10^{-9}$	75/mi/day: Onsite: (2)Offsite:	 $2.7x10^{-2}$/yr $7.2x10^{-9}$/vm
200-Area sample Van Trucks	5 to 6 process Samples/Load	<10^{-9}/vm	per day: (M-F) 18 trips (S&S) 3/shift 25-50/yr to SRL	$5x10^{-8}$/vm
300-Area pickup trucks	Plutonium Aluminum Neptunium Aluminum ^{235}U-Al billets & reject fuel elements	N/A	1500	<$7x10^{-9}$/vm
Pickup truck to Pittsburgh Testing Laboratory	Cask containing sealed radiography source	<$1-^{-11}$/vm	N/A	N/A
Motor freight carriers	Californium	10^{-11}	25-30 shipments	10^{-9}/yr

* The activity of basin water is normally controlled below 0.4 uCi T/mL, 10^{-3} uCi nonvolatile beta-gamma mL and 5 dis/(min-mL) alpha.

** vm - vehicle mile

*** N/A - Not Avaliable

TABLE E-7. Railroad Bed Contamination

Accident	Consequences
From 1959 to 1960, railroad beds and tracks in the 200-H and 200-F Areas.	Contaminated three times.
In December, 1959, radioactive particles were shaken loose from a box containing obsolete jumpers.	Decontamination costs were $5,200, (TID-5360, Suppl. 3). Rail bed contaminated 80,000 c/m to 5 R/hr at 2 in. between the railroad tunnel and the Burial Ground. Maximum radiation intensity of 120 particles found outside the H-Area was 500 mrad/hr.
From 1961 to 1976 during two jumper shipments, between the 200 Areas and the Burial Ground.	Rails and roadbed were contaminated.
Since 1959, railroad beds outside 200-F and 200-H Areas on three occasions when water in 70-ton casks leaked.	Railroad beds were slightly contaminated.
An improperly loaded cask shifted into position.	Slight railroad bed contamination as cooling water splashed from the car.
Two instances involved 70-ton cask cars in the 200-F Area and one in the 100-K Area.	Rail contamination occurred.
Rain washed contamination of 30,000 c/m onto the rails from a cask.	Contaminated 20 mrad/hr.

The historical frequency for slight contamination of the railroad bed is approximately 0.3/yr for 70-ton cask operations. In the early 1960s, packaging techniques were modified including covering the load with canvas sheeting. This change in packaging reduced the frequency to approximately 0.2/yr and greatly lessened the severity of contamination along the railroad bed. Also, water leak surveillance during transport of 70-ton cask cars minimizes the magnitude of spills onto the roadbed.

Railroad equipment, including the tracks, has been contaminated in the railroad tunnel of F-Area and H-Area Canyons on numerous occasions. The causes were air reversals from the canyon, contamination dropped from items being loaded or unloaded, and splashing water from 70-ton casks on cars.

Roadway Contamination

The historical frequency of reported transportation incidents contaminating onsite roadways within 200-F and 200-H Areas is 0.39/yr and outside the areas is 0.26/yr. All incidents except two were caused by trailers used to transport waste solutions. Table E-8 shows the roadway contamination occurrences involving high-level waste, unshielded trailers containing degraded solvent, and 100-Area low-level trailers.

Roadways in the Burial Ground were contaminated (80,000 c/m beta-gamma) when steam cleaned yokes were returned to 200-F Area canyon.

Transportation of uranyl nitrate trailers on the site roads has not caused road contamination. However, in one instance solution leaked from an inspection manhole gasket onto the 300-Area shipping scales during weighing. Twelve spots on the scales ranged from 6000 to 80,000 d/m alpha.

High Radiation Intensities During Shipment

High radiation intensities during transport of radioactive materials are generally associated with canyon equipment going to the Burial Ground. Table E-9 summarizes the radiation exposure rates during these shipments in the period 1960 through 1982.

After 1968 the frequency of high radiation intensities associated with canyon equipment shipments decreased. Changes in techniques such as permitting re-gasketing of jumpers in canyon facilities and partial decontamination of large equipment prior to sending to the Burial Ground have contributed to this reduction. Using a shielded high-level waste trailer for hauling spent solvent from F- and H-Areas reduced exposure rates by a factor of 100 or greater to < 1.5 R/hr. However, during 1969 exposure rates of 8 to 12 R/hr were reported for 3 series of solvent shipments. From 1974 to 1982, the maximum radiation exposure rate reported was 10 R/hr at 15 ft. This shipment was from Building 242-3F and included a tank from the concentrate transfer system that was not decontaminated before shipping.

TABLE E-8. Roadway Contamination

Incident	Consequences	Comments
__High-Level Waste Trailer:__		
In 1970, contamination was transferred outside the exclusion area around Building 776-A to the adjacent roadway (40,000 d/m alpha). A check valve was held open by a piece of debris.	Tires were contaminated in the Building 776-A loading dock. High level waste backed up out of a floor drain after the trailer was loaded, decontaminated, and surveyed. The road within the exclusion area was contaminated $2x10^8$ d/m alpha.	This waste trailer has a history of small amounts of contamination on its catch pan around the fill, discharge, and vent lines after transport between Building 776-A and 211-F. No highway contamination resulted.
Liquid spills or line ruptures.	Tires were contaminated four times during the filling or unfilling operations.	Highway contamination was prevented by decontaminating the trailer and its tires before transport.
__Unshielded Trailer Containing Degraded Solvent:__		
In April, 1959, a degraded solvent leaked during transport from H-Area to the Burial Ground (the sixth load in a series of transfers). The driver suddenly braked at the crossing near H-Area.	1-1/2 miles (spots of up to 8000 c/m) of roadway contaminated from the railroad crossing to the Burial Ground. About 1 gal of solvent leaked from a front hatch.	The hatch was not leak-tight due to the wrong type of nuts and lack of inspection. Roadway replacement cost was $8700. (TID 5360, Supl. 3).
Loading & unloading operations.	Enough solvent spilled to contaminate the roadway around the trailer five times.	The trailer and tires were partially decontaminated to permit transport to the Burial Ground without contaminating roadway beyond loading area.

TABLE E-8. Roadway Contamination (Continued)

Incident	Consequences	Comments
100-Area Low-Level Trailer:		
In October, 1964, trans- from Building 211-F to Building 105-C, a drain hose came loose in transit to Building 105-C.	Maximum roadway contamination was 10,000 d/m alpha and 80,000 c/m beta-gamma.	The drain hose was not secured and leaked at the gatehouse and along the route taken within the exclusion area.
In October, 1975, within the 100-C Area the trailer leaked while being driven to mix caustic potash added to the trailer contents.	About 2,000 ft. of roadway was contaminated 500 to 40,000 c/m beta-gamma and 200-100 d/m alpha. (3)	During the intentional mixing of contents, solution leaked from a cracked weld and a crimped gasket.
In October, 1981, contaminated water spilled when the truck stopped at three Area security gates.	30 gallons of low-level waste leaked onto the roadway. The roadway was contaminated 4000 c/m beta-gamma.	Contaminated water came through drain holes of an empty scrap cask to the roadway.

Six spills on other occasions during the loading of this trailer contaminated the roadway around the trailer.

TABLE E-9. Radiation Exposure Rates During Shipment Of Canyon Equipment (1960-1982)

Type of Equipment	Exposure Rate Category by Shipments*		
	0.5 to 5R/hr	6 to 25R/hr	≥ 25R/hr
Pipe sections (jumpers)	16	8	5
Centrifuges & evaporators	3	1	1
Pumps	12	1	0
Other equipment	2	1	1
Casks, obsolete canyon equipment & jumper shipments	8	5	2

* Dose rate set by the Health Protection Department for personnel handling the shipment.

Except for 100-Area sand filter back flush sludge, shipments in low-level trailers usually do not have associated radiation problems. In July 1970, aload containing an estimated 375 Ci radiated 3R/hr at 1 ft from the trailer.

There were three incidents involving evaporators with unusually high radiation intensities moved by rail with spacer cars between the carrier car and the locomotove:

Date	Radiation Level at 50 Feet from the Evaporator	Intensity in the Locomotive
June 1967	33 R/hr	120 mR/hr
July 1969	3 R/hr	N/A
March 1975	10 R/hr	10 mR/hr

Burial of the March 1975 evaporator (contained 59,700 Ci after extensive decontamination) was authorized by Test Authorization 2-875. A special loadout procedure and a practice run were used to minimize exposures during transport.

Between 1975 and 1976 the maximum radiation exposure rates were 10 rem/hr at 18 in from drums containing californium wastes. The maximum californium content in the four largest shipments was 735 micrograms.

Frequency of future radiation intensities are unpredictable since the conditions for each incident varies. There has been a decrease in incidents since 1969, due to improvements in processes, programs, decontamination efforts, procedures, technology, and design.

Aerial Dispersal

There are no recorded incidents of aerial dispersal of hazardous materials during transportation onsite at the SRP.

Natural Phenomena

T&T dispatchers and the Emergency Control Center work together to assure against transport of radioactive materials during adverse weather conditions.

An earthquake above Intensity VII on the Modified Mercalli Scale (MM) is not expected at the SRP based on 30 yrs of earthquake data (5). An Intensity of VIII or more must occur before steering of vehicles are affected and damage to buildings begins.

There are six recorded transportation incidents that have occurred at the SRP which can be attributed to adverse weather conditions. There are no recorded incidents of transportation accidents at the SRP which can be attributed to earthquake.

Aircraft Interactions

In 33 years of operation of the SRP site, one single-engine plane landed on an onsite highway during a period of low traffic density. The pilot avoided highway vehicles. A security patrol helicopter crashed on the site in September 1985.

The frequency of unauthorized flights over the restricted airspace was about 100/yr until 1976 when air space restriction over the site was lifted. Based on data from Bush Field Airport, Augusta, Georgia, the frequency of flights over the site is estimated to have increased to 4000/yr. Current considerations are in progress by DOE to reimpose the air space restrictions.

The probability of an aircraft crash is assumed to be $5x10^{-9}$/flight mile (6). With 4000 overflights, the probabiltiy of an aircraft crash anywhere within the SRP site boundaries is $2x10^{-5}$/yr (2). Trucks carrying enough radioactive materials to be of concern, travel on plant highways and railroads for a total of 1000 hr/yr. The target area of the largest highway vehicle is $2.3x10^{-4}$ miles. Therefore, the calculated frequency of a plane crashing onto a cask car or truck is around $5x10^{-10}$/yr.

Fire

No fires have been reported in cargo space on SRP trucks or rail flatcars during the transport of radioactive materials. Therefore, calculations of risks are estimated using non-SRP data (7,3).

Eleven fires have occurred in radioactive waste packages before and after transport. These incidents occurred at a frequency of 0.58/yr and are listed in Table E-10, along with 57 other fires involving trucks. The probability per vehicle mile of all vehicle fires is approximately $5x10^{-7}$. The eight fires involving SRP rail operations are described in Table E-11.

Human Error

The physical and mental condition of the vehicle operator may be responsible for creating an accident situation. Conditions which fall into this category are:

- Inattention or human error,
- Major physical impairment (heart attack or stroke),
- Drug induced drowsiness, or
- Loss of consciousness.

Most vehicular accidents which have been reported have been caused by operator inattention, such as running stop signs, driving off the highway, or misjudging distances.

TABLE E-10. Fires Involving Trucks

Description of Incident	Number of Incidents
<u>Fires Involving Radioactive Waste Packages Before and After Transport</u>	
Waste (swipes) in a box ignited.	1
Spontaneous ignition of load lugger pan.	5
Waste burst into flame when dumped from truck onto the Burial Ground.	1
Wastes ignited by spontaneous ignition in trench after being dumped.	2
Uranium, abrasive wheel wastes ignited before transfer to a load lugger pan.	1
Zinc powder ignited when placed in a can before transfer to a load lugger pan.	1
Other nonradioactive fires	
Carburetor fires in 25 years (a frequency of one per year).	25
In cab of vehicle - carelessness with smoking materials.	10
Electrical short.	8
Brakes (includes an ORNL Truck making a delivery to the site).	4
Oil on engine.	3
Grass fire caused by fuel pump fire.	1
Flammables onto exhaust system.	5
Wooden truck bed ignited by hot exhaust.	1

TABLE E-11. Fires Involving SRP Rail Operations

Incident	Number of Incidents
Fires in cross ties.	4
Fire in grass adjacent to the roadbed.	1
Fire in a car of sodium nitrate where paper on the floor spontaneously ignited.	1
Journal box on a coal car caught fire delivering to the 400-Area.	1
An electrical fire occurred in the No. 2 traction motor of a locomotive.	1

Accident reports from 1973 to 1982 indicate that there are an estimated 17 truck accidents (including pick up trucks) per year which occur during backing and are caused by operator inattention. The two railroad crossing accidents described earlier were caused by inattention of the vehicle operators. Also, operator inattention contributed to at least three pulpwood truck accidents. These incidents have not involved or threatened a vehicle carrying radioactive or other hazardous materials. Most of the truck and rail accidents involve the operator's lack of attention.

Six to eight cases of vehicles moving when driverless were reported. The most frequent cause was from not setting the brake. The probability is extremely small that this type of occurrence would involve a truck carrying hazardous materials.

Barricades were installed in 1983 on SRP Roads 2, 3, 6 and other roads at Highway 125 intersections to prevent through-traffic vehicles from straying from Highway 125 onto site highways. Prior to these barricades, about 15 vehicles strayed from Highway 125 onto site roads annually. The probability for vehicles carrying 400-Area and TNX shipments to become involved in a collision with through traffic is small while travelling on Highway 125.

Vendor and other commercial trucks are also subject to the same operator problems while onsite. Vendor vehicles are operated during low traffic density periods onsite beyond 713-A or directly to Construction Central Shops. There was one incident reported involving an overturned gasoline tanker when the driver turned onto Road 1 near Jackson, South Carolina. Packaging errors are often the major causes of spills, leaks, contamination during onsite transport, and fires. The SRP system is estimated to detect greater than 90% of packaging errors. For undetected errors the probability of having reportable consequences is estimated to be 20 to 30%.

The number of packaging errors for onsite shipments has decreased primarily due to the use of checkoff sheets, improved procedures, supervisory audits, and equipment improvements. A study (8) of plutonium shipments evaluated the use of checkoff sheets. The checkoff sheets improved safety conditions during packaging. Furthermore, detailed SRP-SRL procedures, associated data sheet improvements, and equipment upgrades (e.g., catch pans, collection pots under valves, and secondary containments around the vessels), have decreased the potential consequences of operator error.

Incorrectly installed gaskets permit leakage of contents particularly in transporting liquids or powders. Such problems have occurred on the UNH trailers, low-level waste trailers, spent solvent trailers, and casks.

Incomplete packaging can defeat protective barriers and lead to potential problems such as leakage from boxed waste, combinations of chemicals and waste that may cause spontaneous ignition, and contamination. Casks with damaged lids cannot be sealed with a gasket. In the mid-1970s the target cask was used for more than two years without repair of a damaged closure. Damaged lids are now repaired by the 100-Area maintenance before the next use. The more significant packaging problems such as faulty gaskets and damaged lids are described in Table E-12.

TABLE E-12. Improper Packaging Occurrences

Container	Incident	Number of Occurrences	Comments
232-H Spent Melt Cask	Tritium Leak	1	Gasket was omitted.
Target Cask	Leakage	4	Faulty Gaskets.
Target Cask	Damaged Lids	N/A	Now repaired before use.
Cask 70-Ton Fuel Element Cask	Leakage of Cooling Water	N/A	Improper sealing of Lid Gasket.
70-Ton Fuel Element Cask	Buckets of Slugs Left in Cask when returned to 200-Areas from 100 Areas	N/A	Loose Lids.
Shipping Container	Valving Errors with Significant Consequence	4	Frequency for valving errors = 0.05/yr.
Doorstops	Contamination	1	4×10^6 d/m alpha.
Doorstops	Decontaminated Container with Vial that Radiated	1	500 rad/hr at 3 in.
Boxed Plutonium Wastes	Contamination in the Cargo Space, 703-A, REA Truck, Air Freight Facilities	1	4×10^6 d/m alpha.
Inadequate Package	Personnel and Truck Contaminated	1	Package was placed on truck with forklift.

Shipping errors have occurred from 100-Areas to the 200-Area Canyons, but have not influenced the hazard potential during normal transport. The following shipping errors have posed processing hazards:

- Wrong blend, 2 cases involving 4 carloads,
- Zirconium-clad material, incompatible with process,
- Short cooled slugs, 78 days cooled rather than the required 140 or more days cooling,
- Mark VI-J elements shipped in a Mark VI bundle,
- 1959, a 70-ton cask returned to the 100-L Area with the fuel still in the cask, causing a gamma alarm to sound in the disassembly area (the cask lid was latched),
- Through 1959, six cases involving loose slugs in casks without latched lids, after unloading in the railroad tunnel returned to the 100-Areas have occurred, but since then no additional cases have been reported, and
- The presumed shipping of more or less than was actually shipped such as when 13 g of Pu-238 was presumably shipped to Mound Laboratory but was later found in a B-Line tank.

Shipping errors involving discrepancies of contents occur at a frequency of $1.3x10^{-4}$/hr according to the Systems Analysis of RBOF Operations (9). Information concerning the processing consequences can be found in DPSTSY-200-1, (1) and shipping errors associated with RBOF are described in DPSTSY-200-4, (9) Section 2.4.1.2.

Loss of Load

The frequency of reported loss of load from trucks is 0.39/yr. In all cases, no radioactivity has leaked or spilled from the package.

No package containing radioactive materials has been lost during rail operations. There were two incidents where loss of load occurred during rail operations:

- A large piece of canyon equipment fell from the flatcar during transit when a 2300-V power line was struck.
- An agitator on a flatcar hit overhead lines, the tiedown chains broke, and the agitator fell from the car.

Loss of load almost occurred when a Fermi cask was transported without tiedowns from H-Area to Central Shops on a vendor's trailer. However, the T&T Department installed tiedowns before the cask was shipped offsite. At least three irradiated fuel casks have been received from offsite with inadequate tiedown arrangements. Table E-13 reports the seven incidents involving losses of loads from trucks.

Equipment Failure

Table E-14 lists recorded SRP incidents in which transportation equipment essential to safe operations has malfunctioned or failed during use at the SRP.

In addition, three reports suggest that truck trailers arriving at the SRP were operated at reduced speed because of structural deficiencies.

TABLE E-13. Reported Losses of Loads from Trucks*

- Drum filled with D_2O fell from a truck. No observable damage.
- Empty Slug Cask was thrown from a trailer between the 100 and 200 Areas.
- 2 cans of resin on pallets bound together by masking tape fell off during a turn.
- The target cask slid off its trailer near Building 232-H. The trailer was moved after tiedowns were removed and the wheels ran off the pavement.
- A cart containing filled sample casks fell out of an H-Area Sample Aisle truck at Building 221-H. No sample vials were broken.
- A cart containing casks with empty vials fell out of the back of an H-Area Sample Aisle truck at an area gate. The cart and the back door were improperly latched.
- A box marked "Radioactive" slid off a turning truck. The roadway was not contaminated.

*. Information presented here was current in 1984.

TABLE E-14. **Truck Maintenance for SRP Vehicles Assigned to Onsite Transportation of Radioactive Materials**

Incident	Vehicle Type	Comments
Cracked welds	Trailers used to haul large casks or shielded tanks	Frequency - 0.7/yr
Fifth wheels	Tractors	Repairs common
King pins	HM trailers & byproduct trailers. In 1976 a king pin on a Uranyl Nitrate trailer failed after 20 years of service	Inspected now ultrasonically every 5 years or whenever there is "due cause"
Wheel lugs	Several types of trucks and trailers	Frequently replaced
Steering wheel came off	T&T gasoline truck on Road C	Ran off road, did not overturn
Brake failures*	DOE owned trucks	4 incidents
	Logging trucks on SRP roads	5 failures, 2 overturns, damage to 2 barricades
	Commercial vehicle	Hit barricade #5
Sticking or locking brakes	Tractor-Trailer	Jack-knifed - 2 other incidents caused brakes to burn

* All new trailers, large trucks and many older vehicles (by back-fitting) are equipped now with a braking system which requires adequate air pressure to release the brakes - A "Fail-Safe" system.

References

1. Durant, W.S., and Prout, W.E. Systems Analysis 200 Area, Savannah River Plant, Chemical Separations Facilities Canyon Operations. Internal Report DPSTSA-200-1, E. I. du Pont de Nemours & Co., Savannah River Laboratory, Aiken, SC (1977).

2. Yadigaroglu, G., Reinking, A.G., and Schrocks, V.E. "Spent Fuel Transportation Risks", Nuclear News 15(11), November, 1972.

3. Clarke, R.K., Foley, J.T., Hartman, W.F., and Larson, D.W. Severities of Transportation Accidents, Volume I - Summary. Sandia Laboratories Report SLA-74-0001, Albuquerque, NM (1976).

4. Hodge, C.V., and Harrett, A.A. Transportation Accident Risks in the Nuclear Power Industry 1975-2020. Report NSS 8191.1, Nuclear and System Sciences Group, Anaheim, CA, November, 1974. (Prepared for Office of Radiation Programs, EPA.)

5. Dukes, E.K. The Savannah River Plant Environment. E. I. du Pont de Nemours & Co., Savannah River Laboratory, Aiken, SC (1984).

6. Nomm, E. Probability of Aircraft Crash at SRP. Internal Report DPST-73- 402, E. I. du Pont de Nemours & Co., Savannah River Laboratory, Aiken, SC (1973).

7. Environmental Survey of Transportation of Radioactive Materials to and from Nuclear Power Plants and Supplement No. 1. USAEC Directorate of Regulatory Standards, WASH-1238, Washington, DC (1972).

8. McSweeney, T.I., and Hall, R.J. Assessment of the Risk of Transporting Plutonium Oxide and Liquid Plutonium Nitrate by Truck. USAEC Report BNWL-1846, Battelle Pacific Northwest Laboratories, Richland, WA, August 1975.

9. Kelley, H.M. Safety Analysis - 200 Area RBOF Operations. Internal Report DPSTSY-200-4, E. I. du Pont de Nemours & Co., Savannah River Laboratory, Aiken, SC, February 1977.

APPENDIX F

MAXIMUM PERMISSIBLE INTAKE VALUES (MPI)

FOR RADIONUCLIDES TRANSPORTED AT THE SRP

(Appendix to Chapter 5.0)

TABLE F-1. Radiological Data for Radioactive Materials Shipped at SRP

Isotope	MPI, μCi*	MPI of Nuclide per curie
^{237}Np	0.033	3.0×10^7
^{239}Pu	0.017	5.9×10^7
^{243}Am	0.053	1.9×10^7
^{241}Am	0.054	1.9×10^7
^{238}Pu	0.020	5.0×10^7
^{244}Cm	0.011	9.1×10^7
^{252}Cf	0.027	3.7×10^7
^{90}Sr	3.58	2.8×10^5
^{137}Cs	144	6.9×10^3
^{106}Ru	8.78	1.1×10^5
Mixed Fission Products	<10 (Est)	$<1 \times 10^5$
^{3}H	620	1.6×10^3
^{234}U	0.88	1.1×10^6
^{235}U	0.23	4.4×10^6
^{236}U	0.92	1.1×10^6

*DPST-66-579, Hazard from Short-Time Inhalation of Radionuclides.

MPI - Maximum Permissible Intake

TABLE F-1. Radiological Data for Radioactive Materials Shipped at SRP (Continued)

Isotope	Activity Ci/g	MPI, μCi*	MPI, gm	MPI of Nuclide per curie
^{237}Np	0.00063	0.033	1.9×10^4	3.0×10^7
^{239}Pu	0.061	0.017	3.6×10^6	5.9×10^7
^{243}Am	0.18	0.053	3.4×10^6	1.9×10^7
^{241}Am	0.28	0.054	5.3×10^6	1.9×10^7
^{238}Pu	16.8	0.020	8.4×10^8	5.0×10^7
^{244}Cm	81	0.011	7.4×10^9	9.1×10^7
^{252}Cf	537	0.027	2.0×10^{10}	3.7×10^7
^{90}Sr	141	3.58	3.9×10^7	2.8×10^5
^{137}Cs	98	144	6.8×10^5	6.9×10^3
^{106}Ru	3.360	8.78	3.7×10^8	1.1×10^5
Mixed Fission Products	>180 day cooled	<10 (Est)	--	$<1 \times 10^5$
^{3}H	--	620	--	1.6×10^3
^{234}U	6.1×10^{-3}	0.88	6.9×10^3	1.1×10^3
^{235}U	2.1×10^{-6}	0.23	9.1	4.4×10^6
^{236}U	6.4×10^{-5}	0.92	7.0×10^2	1.1×10^6
^{238}U	3.4×10^{-7}	0.24	0.14	4.2×10^6

*DPST-66-579. Hazard from Short-Time Inhalation of Radionuclides.

APPENDIX G

EVALUATION OF IMPACT OF RELEASE OF HEAVIER-THAN-AIR VAPORS IN ATMOSPHERIC DISPERSION

(Appendix to Chapter 5.0)

APPENDIX G. EVALUATION OF IMPACT OF RELEASE OF HEAVIER-THAN-AIR VAPORS IN ATMOSPHERIC DISPERSION

Some of the hazardous materials considered in this evaluation are transported as liquids under pressure in tanks, usually cylinders. At normal atmospheric pressure and ambient temperatures, some of the materials are gases denser than air. The specific material of most concern is chlorine.

If a chlorine tank is punctured, penetrated, or opened to the atmosphere by an accident, escaping liquid chlorine partially flashes as a cold, denser-than-air gas and the remainder drains as a liquid. The liquid then boils releasing gas as heat is drawn from the surroundings. The denser-than-air vapor can persist for some distance as a stratified cloud which remains near the surface as it is transported by wind forces. The cloud eventually mixes sufficiently with the surrounding atmosphere such that the released vapor can be considered a contaminant transported by normal atmospheric processes. Once such concentrations of a dense contaminant are sufficiently reduced, dispersion and dilution estimates can be made with the normal methodology employed for such calculations (in this case, Pasquill atmospheric dispersion categories and parameters).

This appendix discusses background and sources of information concerning the impact of dense vapors on dispersion (Section G-1), an evaluation to estimate the magnitude of the release of the dense vapor of most concern (chlorine) in the event of a transportation accident involving a chlorine cylinder (Section G-2), and an evaluation of the significance of dense-vapor effects relative to normal dispersion/mixing estimates in terms of time/distance of persistence of effects (Section G-3).

G-1 BACKGROUND

The following discussion on the impact of denser-than-air gases on dispersion of released vapor was taken primarily from two references on the subject (1,2). In Reference 2, Munger provides an integrated theory for evaluating dense gas dispersion culminating in a criteria for judging when a Gaussian model can be used, i.e., when dense gas effects are no longer significant. Blackmore, in Reference 1, provides experimental evidence for determining when dense gas effects are no longer significant. Since both references present their results in terms of similar dimensionless parameters, the Richardson number or the square root of the Richardson number, their criteria can be compared. Blackmore's criteria were found to be more restrictive and were based on experiments performed at a variety of locations under a variety of conditions. Because of the supporting experimental evidence available in Blackmore (1), its criteria are used for estimating the point at which the transition to use of a standard Gaussian plume model is appropriate. Blackmore's criteria were integrated into Munger's method for the scoping calculations reported here.

It should be noted that entrained liquid was not considered to be part of the vapor mass. Estimates of the fraction of liquid entrained as droplets can be made. The entrained liquid acts as an aerosol. Conditions involving entrainment of liquid also involve significant entrainment of air. As the entrained liquid evaporates, it is mixed and diluted with the entrained air and dense-gas effects are not expected to result.

G-2 VAPOR RELEASE

If a vessel containing a liquid which flashes to vapor at ambient condition fails catastrophically, it is reasonable to assume that any vapor release will be instantaneous. The magnitude of the release is determined by the material form and chemical properties as well as by the storage characteristics. The more difficult assessment is for liquids for which both flashing to a gas phase and/or entrainment of the liquid must be considered.

The amount of material which flashes to a gaseous state upon container failure will depend on the storage pressure and temperature, the ambient temperature, and the boiling point of the liquid. Stored liquids which flash upon container failure are either pressurized and/or refrigerated. The amount flashed can be estimated by thermodynamic calculations. A calculation for chlorine under typical storage conditions indicates about 20% flashes initially.

Pressurized liquids are also subject to entrainment into the surrounding air upon container failure. Munger conservatively recommends that pressurized liquids be considered as completely entrained, while pressurized and refrigerated liquids be considered as about 50% entrained (2). For the purpose of estimating the impact and persistence of dense-gas effects, it is assumed that 50% of a one-ton chlorine cylinder (or 1000 lbs) is released as a vapor cloud over a relatively short time. It is further assumed that the rest of the chlorine inventory remains in the cylinder as liquid and is subjected to slow evaporation or drainage over a longer period of time. To determine the persistence of dense-gas effects the calculations here are focused on the initial release phase.

The second phase of release involving evaporation of the released liquid is more complicated than the first. The two significant factors determining the nature of the second release phase are: the boiling point of the liquid in relation to the temperature of the substrate (whose temperature may be higher than ambient for a blacktop road on a day with bright sunlight), and the area of the spill, especially if it is not confined. Conceivably, if the boiling point of the liquid is much lower than the temperature of the substrate and if the pool area is unconfined, the release can be relatively rapid. The rate of release increases for rapid spreading of the pool (assuming the liquid is not very viscous). The mass released can be significant in comparison to the first phase of release. However, the release period is likely to be significantly longer.

Calculations have been made to estimate the release rate or source term for the second evaporative phase of release. Calculations are scoping in nature because of the lack of definitive information such as initial material temperature, ambient temperatures of the ground or the air, and data on spill rates and pool sizes. The example presented is for chlorine evaporation. Estimates for other materials are listed in Table G-1.

TABLE G-1. Summary of Estimated Release Rates for Hazardous Materials

	Puff Release	Release First Hr	Total Release First Hr	Total Release Time	Spill Volume	Pool Size
Chlorine	200 lb mass	550 lb mass	750 lb mass	<2 hrs	1000 lb	110 ft^2
Gasoline	0	785 lb mass	785 lb mass	30 hrs	1000 gal	8000 ft^2
Nitric Acid	0	1520 lb mass	1520 lb mass	<8 hrs	1000 gal	8000 ft^2
Hydrogen Fluoride	0	21 lb mass	21 lb mass	<5 hrs	100 lb	small
Sodium Hydroxide	0	0	0	0	5000 gal	8000 ft^2
Sodium Hypochlorite	0	0	0	0	1000 gal	8000 ft^2

For purposes of estimating evaporation rates from a volatile spill, a simplified one-dimensional model for the simultaneous heat and mass transfer problem was developed. Assuming that the spill is configured in the form of a thin layer, that the underlying earth is impermeable, and that entrainment of liquid droplets is negligible, an energy balance at the spill free surface give

$$\dot{m}''h_{fg} = q_{rad} + q_{conv} - q_{cond} \tag{2-1}$$

where, as illustrated in Figure 2.1, $\dot{m}''$ is the evaporation flux, h_{fg} is the heat of vaporization, and q_{rad}, q_{conv}, and q_{cond} are radiation, convection, and conduction heat fluxes, respectively.

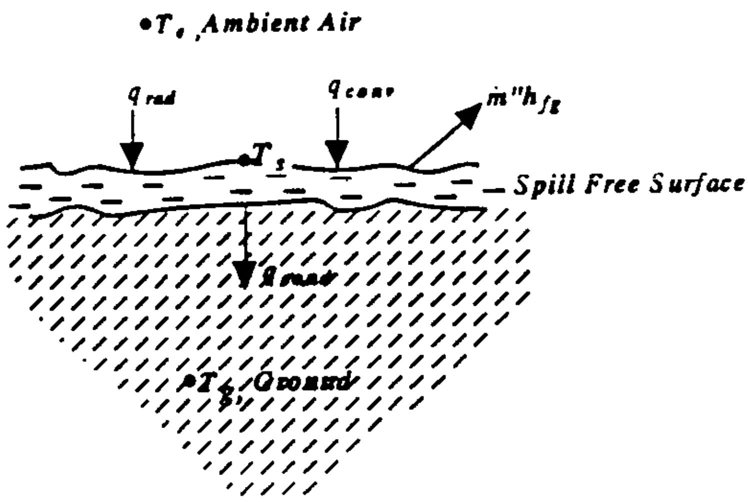


FIGURE 2.1. Energy Balance at the Spill Free Surface

Considering radiation exchange between environs at temperature T_e and the spill surface at (a priori unknown) temperature T_s, the radiative flux is taken as

$$q_{rad} = \sigma(T_e^4 - T_s^4) \tag{2-2}$$

where σ is the Stefan-Boltzman constant and, further, it is assumed that all surfaces are black. For convection,

$$q_{conv} = h(T_e - T_s) \tag{2-3}$$

where h is the convective heat transfer coefficient, a function of local meteorological conditions and, possibly, the blowing rate.

Assuming that the thermal resistance of the evaporating layer is negligible, q_{cond} is simply [1]

$$q_{cond} = \frac{k_g}{\sqrt{\pi \alpha_g t}} (T_s - T_g) \qquad (2\text{-}4)$$

where k_g is thermal conductivity, α_g is thermal diffusivity, t is time, and T_g is the (undisturbed) temperature of the ground.

Substituting Eqs. (2-2) through (2-4) into Eq. (2-1) gives

$$\dot{m}'' h_{fg} = \sigma(T_e^4 - T_s^4) + h(T_e - T_s) + \frac{k_g}{\sqrt{\pi \alpha_g t}} (T_g - T_s) \qquad (2\text{-}5)$$

where the evaporation flux is eliminated [1] by means of

$$\dot{m}'' h_{fg} = K_G \beta_m = K_G \frac{m_e - m_s}{m_s - 1} \qquad (2\text{-}6)$$

In Eq. (2-6), K_G is the mass transfer coefficient (a complex function of the local velocity field), β_m is the mass-transfer driving force, and m_e/m_s are mass fractions of evaporating species in the bulk flow and at the vapor/liquid interface, respectively. An internally consistent approximation to the mass transfer coefficient is

$$K_G = K_G^0 \frac{\ln(1 + \beta_m)}{\beta_m} \qquad (2\text{-}7)$$

where K_G^0 is the mass transfer coefficient in the limit $\dot{m}'' \to 0$. Substituting Eq. (2-7) into Eq. (2-6) yields

$$\dot{m}'' = K_G^0 \ln(1 + \beta_m) = K_G^0 \ln\left(1 + \frac{m_s}{1 - m_s}\right) \qquad (2\text{-}8)$$

where m_e is taken to be negligibly small. Values of K_G^0 are obtained from the Chilton-Colburn analogy [2] where

$$j_h = \frac{Nu_h}{Re(Pr)^{1/3}} = \frac{c_f}{2} \qquad (2\text{-}9)$$

for heat transfer, and

$$j_D = \frac{Nu_m}{Re(Sc)^{1/3}} = \frac{c_f}{2} \qquad (2\text{-}10)$$

for mass transfer. In Eqs. (2-9) and (2-10), $Nu_{h/m}$ are Nusselt numbers for heat and mass transfer, respectively, while Pr is the Prandtl number, Sc is the Schmidt number, Re is the Reynolds number, and c_f is the skin friction coefficient.

Combining Eqs. (2-9) and (2-10) gives

$$Nu_h = Nu_m(Pr/Sc)^{1/3} = Nu_m Le^{1/3} \qquad (2\text{-}11)$$

where

$$Le = Pr/Sc = \rho D c_\rho / k \qquad (2\text{-}12)$$

is the Lewis number, a function of the gas density, ρ, the binary diffusion coefficent, D, the mixture specific heat, c_ρ, and thermal conductivity, k.

Assuming $Le^{1/3}$ is of order unity,

$$Nu_h = Nu_m \qquad (2\text{-}13)$$

that is,

$$\frac{hL}{k} = \frac{K_G^0 L}{\rho D} \qquad (2\text{-}14)$$

(For evaporation of chlorine into air, Pr/Sc = 0.5 [1], giving $Le^{1/3} = 0.8$).

In Eq. (2-14), L is the characteristic length of the spill; rearranging the expression

$$K_G^0 = \frac{h\rho D}{k} = \frac{h}{c_\rho} \cdot \frac{Pr}{Sc} = \frac{h}{c_\rho} Le \qquad (2\text{-}15)$$

which, with somewhat larger error, can be simplified further to give

$$K_G^o \cong \frac{h}{c\rho} \tag{2-16}$$

Substituting Eq. (2-16) into Eq. (2-8) gives the final expression for the evaporative flux, i.e.,

$$\dot{m}'' = \frac{h}{c\rho} \ln\left(1 + \frac{m_s}{1 - m_s}\right) \tag{2-17}$$

where m_s is related to T_s in terms of vapor pressure. Substituting Eq. (2-17) into Eq. (2-5) gives

$$\frac{h}{c\rho} h_{fg} \ln\left(1 - \frac{m_s}{1 - m_s}\right) = \sigma(T_e^4 - T_s^4) + h(T_e - T_s) + \frac{k_g}{\sqrt{\pi\alpha_g t}} (T_g - T_s) \tag{2-18}$$

which provides, for given functional dependence of m_s, time-dependent values of interfacial temperature, T_s and, hence, $\dot{m}''$.

For a binary mixture,

$$m_s = \frac{\chi_s M}{\chi_s M + (1 - \chi_s)M_{air}} \tag{2-19}$$

where M/M_{air} are molecular weights of evaporating species and air, respectively, whereas,

$$\chi_s = P_s(T_s)/P_e \tag{2-20}$$

is the mole fraction of evaporating species. In Eq. (2-20), P_s is the vapor pressure of the evaporating species and P_e is the ambient air pressure.

For chlorine, the temperature of the surface of the pool was found to be about -53° F. This value for T_s yielded an evaporation mass fraction after one hour of about 0.77 and an evaporation rate of 5.0 lb mass/hr ft^2. This rate corresponds to a value of 5.5 lb mass/hr ft^2 reported in Reference 5. Using a spill area of 110 ft^2, the total release rate is 550 lb mass/hr. Given that roughly 20% of the chlorine flashes during the initial storage tank failure and 550 lb evaporates in the first hour, nearly all of the 1000 lb assumed to be released is predicted to evaporate in the first hour.

For gasoline, the temperature of the surface of the pool was assumed to be about 150° F. This value for T_s yielded a mass fraction of about 0.12 in the first hour and an evaporation rate of 0.098 lb mass/hr ft^2. Using a spill area of roughly 8000 sq ft, the total release rate is roughly 800 lbm/hr.

G-3 PERSISTENCE OF DENSE GAS EFFECTS

The calculations of consequences resulting from atmospheric release of HMs involve calculation of concentrations versus distances so that a toxicity measure can be employed for determining the furthest distance at which a health threat exists. The calculation can be subdivided into three steps.

The first step is to calculate the release magnitude as a function of time (Section G-2 and Table G-1). The second step is to determine the distance to which dense-gas effects are important and, thereby at what point a transition to standard Gaussian plume calculations can be made. The third step is to use AXAIR results for the SRP, possibly modified, to determine the concentration versus distance to evaluate hazards.

A dense gas like chlorine will eventually be mixed with enough air such that the plume dispersion can be modeled with a standard Gaussian approach. The objective of this section is to determine how long dense-gas considerations are important.

The other materials listed in Table G-1 are either solids or were liquids whose boiling temperatures are greater than ambient conditions except for liquid hydrogen floride. Liquid hydrogen fluoride evaporates or flashes into a gas which is lighter than air. For the other materials, gasoline produces vapors heavier than air. However, these are produced at a slower, evaporative rate. Hence, the source strength is very unlikely to cause significant dense gas effects. Note also that a dense gas in small quantities quickly mixes with air and becomes dilute due to atmospheric turbulence.

Both Blackmore (1) and Munger, et al. (2) include criteria for determining the transition point. Munger, et al. uses the following approach. The velocity of the dense cloud edge is chosen based on a formula for one-dimensional density infusion,

$$\frac{\alpha R}{\alpha t} = c \sqrt{g(\rho - \rho\alpha)h/\rho} \qquad (3\text{-}1)$$

where:

- R = radius of cloud
- t = velocity of the radius of the cloud
- c = a constant roughly equal to 1.0
- g = gravitational acceleration
- ρ = density of the cloud
- $\rho\alpha$ = density of air
- H = effective height of cloud

The criteria for the determination of the dominance of atmospheric turbulence are:

$$\frac{\alpha R}{\alpha t} \leq c\ u \tag{3-2}$$

where:

u is the mean wind speed.

Combining Equations 3-1 and 3-2, the criterion can be restated as:

$$u \geq \sqrt{g(\rho - \rho\alpha)h/\rho} \tag{3-3}$$

Blackmore in Reference 1 also provides a criterion and complimentary experimental evidence. This criterion is established in terms of a dimensionless variable, the Richardson number (Ri), and also another dimensionless value, the ratio of the initial spreading velocity to the mean wind speed, called N_L. Experiments show that lateral plume spread is not significant for $N_L^2<0.02$ and that vertical mixing was not important for Ri<8. These parameters are defined as follows:

$$N_L = \sqrt{g(\rho - \rho\alpha)h/\rho}\ /u \tag{3-4}$$

$$Ri = (g(\rho - \rho\alpha)h/\rho)/u^{*2} \tag{3-5}$$

where u* is the friction velocity and the other terms are defined earlier. Dividing Equation 3-5 by Equation 3-4 squared, one obtains:

$$\frac{Ri}{N_L 2} = \frac{u^2}{u^{*2}} \tag{3-6}$$

The friction velocity can be related to the flow velocity by the equation:

$$u^{*2} = .5\ C_D u2 \tag{3-7}$$

where C_D is the drag coefficient.

Equation 3-6 can be rewritten as:

$$\frac{Ri}{N_L^2} = \frac{2}{C_D} \tag{3-8}$$

Using C_D = .0043 which is the flat plate value C_D at the transition Reynolds number,

$$\frac{Ri}{N_L^2} = -65 \qquad (3\text{-}9)$$

Blackmore (1) indicates that Ri/N_L^2 = 400. Two conclusions can be drawn. First, the data indicate that considering the pool as a flat plate is appropriate. Second, and much more important, with Ri and N_L replaced by a constant, lateral plume spread and vertical mixing effects can both be measured with one parameter.

With this conclusion in mind, using the criteria of N_L^2 <.02 and rearranging Equation 3-4, one obtains:

$$u \geq \sqrt{g(\rho - \rho a)h/\rho} \qquad (3\text{-}10)$$

This equation is similar in form but different in scale from that in Reference 2 (Munger, et al.) Because the scale values are consistent with experimental evidence and representative of lateral and vertical mixing, Blackmore's criteria, Equation 3-10 was used in the scoping study for chlorine.

A scoping calculation was performed to determine the time and distance for which dense gas effects would persist. The calculation starts with a 1000 lb chlorine vapor release. The initial conditions are established by an assumption based on Munger, et al., that a violent container failure results in mixing of 20 times as much air as the released vapor. The density of chlorine is 3.22 g/L and the density of air is 1.29 g/L. Combining them at a 20 to 1 ratio yields an effective density of the cloud of 1.39 g/L.

Given the above described input conditions, one can solve Equation 3-10 to determine the height of the cloud for which density effects would no longer be important. Since the volume of the cloud is known also, the radius of the cloud can be determined. Equation 3-9 also can yield the velocity of the cloud edge. By using the velocity obtained when the criteria are satisfied, a lower bound velocity of the cloud edge is found. That lower bound velocity can be used to determine an upper bound estimate of the time that dense gas effects would persist.

For the above situation, the cloud height at the time dense-gas effects no longer persist is 0.21 m. The corresponding cloud radius is 20.7 m and the corresponding cloud edge velocity is 0.4 m/s. Therefore dividing 20.7 m by 0.4 m/s yields less than one minute. That is dense-gas effects persist for only a short period of time and for a much smaller distance than the distance measures in AXAIR, i.e., 1 mile. Therefore, dense-gas effects need not be considered explicitly for the cases considered in this analysis.

G-4 REFERENCES

1. Blackmore, D. R. "Dense Gas Dispersion Observations and Theory," Atmospheric Dispersion of Hazardous/Toxic Materials from Transport Accidents, W. F. Dabbart (Editor), Elocuier Science Publications, B.U, Amsterdam (1984).

2. Munger, Brenner, et al., "Integrated Modeling of Release and Dispersion of Hazardous Gases in the Atmosphere," Transportation Research Record 902 - Atmospheric Energy Existing Capabilities and Future Needs, Transportation Board, National Academy of Sciences (1983).

3. Edwards, Dennly and Mills, Transfer Processes - An Introduction to Diffusion, Convection and Radiation, 2nd Ed. John Wylie & Sons Inc., Los Angeles, CA (1980).

4. Lunde, P. J., Solar Thermal Engineering. Hemisphere Publishing Corp., Hartford, Conn. (1979).

5. Zajic, J. E., et al., Highly Hazardous Materials Spills and Emergency Planning. Marcel Decker, Inc., New York (1981).

6. D. K. Edwards, V. E. Denny, and A. F. Mills, Transfer Processes, 2nd Edition, Hemisphere Publishing Corp., Washington, D.C., 1979.

7. R. W. Fahien, Fundamentals of Transport Phenomena, McGraw-Hill Book Company, New York, N.Y., 1983.

APPENDIX H

TOXIC EFFECTS SUMMARIES FOR NONRADIOACTIVE HAZARDOUS MATERIALS TRANSPORTED AT THE SRP

(Appendix to Chapter 5.0)

CHLORINE

Summary Of Toxic Effects

Exposure can cause pulmonary effects (bronchitis, pneumonia, emphysema), cardiac effects, gastrointestinal symptoms, and neuroses. Acute exposure can result in pulmonary edema and death. Chlorine is a primary irritant of the eye, nose, throat, and the entire lining of the respiratory tract. Liquid chlorine is corrosive to the skin and eyes. Death from exposure results from irritation of the respiratory tract. There may be a delay of several hours between exposure and onset of pulmonary effects.

Effects In Animals

Underhill (as cited in NIOSH 1976) exposed 4 dogs to varying concentrations of chlorine gas for 30 minutes. The results were as follows:

Concentration (ppm)	Result (# dead/total exposed)
50	1/9 (11%)
400-500	5/17 (29%)
500-600	4/10 (40%)
600-700	14/21 (67%)
800	11/18 (61%)
900	not given (91%)

Barbour (as cited in NIOSH 1976) exposed four dogs to varying concentrations of chlorine gas for 30 minutes. The results were as follows:

Concentration (ppm)	Effect
14-30	Irritation, lacrimation, salivation, vomiting
100-200	Dyspena, depressed muscle activity
800-900	Death

Effects In Humans

Several studies have been conducted in which humans have been exposed to various concentrations of chlorine gas. The results are summarized in the following table. In addition, Patty (1981) lists the lowest toxic concentration (TC_{lo}) producing respiratory distress in man at 15 ppm. The lowest concentration reported to cause death in humans is 430 ppm after a 30 minute exposure.

Study	Concentration (ppm)	Length of Exposure (minutes)	Effect
Matt	1.3	7	Unpleasant burning of eyes and nose.
	2.5	5	Severe burning of eyes, mouth and throat.
	3.5-4	16	Nasal congestion and coughing.
Rupp and Henschler	0.03	--	Tickling of nose.
	0.06	--	Tickling of throat.
	0.45	--	Burning of conjunctivae.
	1.0	--	Headache, shortness of breath.
	>1.0	--	Uncomfortable to all subjects.
Beck	0.05	--	No effect.
	0.09	--	Tickling and stinging of nose, weak cough, dry throat.
	0.2	--	Slight sensation in conjuctivae, itching nose within 4-20 minutes.
	1.0	--	7/10 subjects had symptoms including headache, burning and stinging eyes, and cough. 1/10 had labored breathing. This concentration became unbearable after 20 minutes.
	0.3	--	Stinging in throat.
	0.36	--	Choking in 1 subject.
	1.4	--	Irritation of conjuctivae, slight headache.

Current Standards for Chlorine

ACGIH TLV and OSHA PEL - 1.0 ppm (3 mg/m^3)

ACGIH STEL - 3 ppm (9 mg/m^3)

NIOSH recommended standard - 0.5 ppm (0.7 mg/m^3)

Development of an Emergency Exposure Limit In Air

AL*	MAL**	LC_{Lo}***
1 ppm	3 ppm	430 ppm

* Allowable limit; this is the TLV.

** Maximum allowable limit. This is the STEL. This concentration is recommended as the maximum upper exposure limit since exposure to 3 ppm may irritate the eyes and respiratory tract.

*** Lowest lethal concentration.

Conclusions and Rationale

Although subjects in experimental studies experienced unpleasant effects of chlorine exposure at levels of 1 ppm and higher, 3 ppm (the STEL), should be tolerable for a short period of time.

Development of an Emergency Exposure Level in Water

There are no Federal guidelines, criteria, or standards for chlorine in water. Therefore, the emergency exposure limit is based on the average acceptable daily intake for chlorine. A tentative ADI (acceptable daily intake) for chlorine is reported to be 0.3 mg/kg/day (Dourson 1985). Assuming that a 70-kg person drinks 2 liters of water per day, the intake of chlorine from drinking water would be 10.5 mg/L. Although it is recognized that this value is not entirely appropriate for use in the evaluation of acute exposure, no other data are available.

References

ACGIH. 1984. TLVs. Threshold Limit Values for Chemical Substances and Physical Agents in the Work Environment with Intended Changes for 1984-85. American Conference of Governmental Industrial Hygienists. Cincinnati, OH. ISBM: 0-936712-54-6.

NIOSH. 1976. Criteria for a Recommended Standard: Occupational Exposure to Chlorine. National Institute for Occupational Safety and Health. Washington D.C. DHEW (NIOSH) Publication No. 76-141.

Patty's Industrial Hygiene and Toxology. 1981. 3rd revised ed. Vol. 2B. Clayton GD, Clayton, FE (eds.). John Wiley and Sons.

Personal communication. 1985. SAIC staff with Michael Dourson, Office of Drinking Water, U.S. Environmental Protection Agency, Cincinnati, Ohio, (513) 569-7544.

GASOLINE

Summary of Toxic Effects

Gasoline vapors irritate the eyes, nose, and throat and cause headache, blurred vision, dizziness, nausea, and anesthesia. Ingestion of gasoline causes central nervous system depression with symptoms of depression, drowsiness, tremors and convulsions. Aspiration of vomitus containing gasoline can cause chemical pneumonitis and pulmonary edema (a buildup of fluid in the lungs) which can be fatal.

Airborne Levels	Effects
160-270 ppm (ACGIH 1984).	Eye and throat irritation in several hours
550 ppm	No effect (Patty 1981).
500-900 ppm (ACGIH 1984).	Eye, nose and throat irritation in one hour
900-1000 ppm	Threshold for toxic effects (ACGIH 1984).
900 ppm	TC_{lo} -- Slight dizziness, irritation of eyes, nose and throat in one hour (Yaglin and Warren as cited in Patty 1981).
10,000 ppm	Nose and throat irritation in 2 minutes, dizziness in 4 minutes, intoxication in 4 to 10 minutes (Patty 1981).
30,000 ppm	LC_{lo} -- Lethal dose for the mouse (RTECS 1981-1982).

Current Standards for Exposure to Gasoline

- ACGIH -- TLV, 300 ppm (900 mg/m^3), safe exposure limit.
- ACGIH -- STEL, 500 ppm (1500 mg/m^3), safe for short-term exposure. Exposure is based on a 15 minute time-weighted average not to be exceeded any time during a work day.
- 400 ppm -- This level should cause only minimal irritation over a 30 minute exposure period.
- 10,000 ppm -- Immediately dangerous to life and health.

Development of Emergency Exposure Limit for Air

AL*	MAL**	AUL***	IDLH****
500 ppm	900 ppm	1,300 ppm	10,000

* Allowable limit; this is the STEL

** Maximum allowable limit. Exposure to this limit should not exceed 30 minutes.

*** Absolute upper exposure limit based on physical effects. This level is one tenth the lower explosion limit.

**** Immediately dangerous to life and health.

References

ACGIH. 1984. TLV's. Threshold Limit Values for Chemical Substances in the Work Environment Adopted by ACGIH for 1984-85. American Conference of Government Industrial Hygienists. Cincinnati, OH. ISBN: 0-936712-54-6

Patty's Industrial Hygiene and Toxicology. 1981. 3rd revised edition. Vol. IIB. Clayton GD, Clayton FE (eds.). John Wiley and Sons, Inc.

RTECS. 1981-82. Registry of Toxic Effects of Chemical Substances. Vol. 1-3. DHHS (NIOSH) Publication No. 83-107.

HYDROGEN FLUORIDE

Summary of Toxic Effects

Hydrogen fluoride (HF) is highly corrosive and a severe irritant to the eyes, nose, and respiratory tract. Exposure to doses as low as 50 ppm for 30 minutes can be lethal to man (RTECS 1981-82). Although bone disease (osteosclerosis) can develop after chronic exposure to low levels, only the irritating effects are considered in the development of exposure limits for short-term exposures to atmospheric HF.

Effects In Animals

Machle (as cited in NIOSH 1976) exposed rabbits and guinea pigs to 24-8,000 mg/m^3 of hydrogen fluoride for 5 minutes to 41 hours. Eye and respiratory tract irritation was observed at all levels; however, these effects were mild and not immediate in animals exposed to 24 and 50 mg/m^3 for 5-15 minutes. Weakness and the "appearance of illness" was apparent in all animals exposed to more than 500 mg/m^3 for 15 minutes. No deaths were observed at 1000 mg/m^3 for up to 30 minutes of exposure or at 100 mg/m^3 for 5 hours or 24 mg/m^3 for 41 hours. Death occured in 1-3 hours in rabbits and guinea pigs exposed to 250 ppm. At 50 ppm, guinea pigs died after one day exposure and rabbits were moribund after 3 days. At 10 ppm (8 mg/m^3) no mortality occured after 5 days though labored breathing and eye irritations were noted in guinea pigs. Ronzani (as cited in NIOSH 1976) indicated that 3 ppm (2.5 mg/m^3) is a no-effect level (NOEL) following experiments with HF at 7.5, 5, and 3 ppm (6, 4, 2.4 mg/m^3). No pathology was observed in pigeons, rabbits and guinea pigs exposed to 3 ppm for 30 days.

Rosenholtz (as cited in NIOSH 1976) exposed rats to single exposures of HF. The results are listed below.

LC_{50} (mg/m^3)	Length of Exposure (minutes)
4060	5
2200	15
1670	30
1070	60

Higgins et al. (as cited in NIOSH 1976) reported an LC_{50} for rats at 18,200 and for mice at 6247 ppm following 5 minutes of exposure.

Summary of Toxic Effects In Animals

In all of the above studies primary effects were on the respiratory tract with pathologic tissue change also found in kidneys and liver. Exposures of up to 3 hours at concentrations between 200-20,000 mg/m^3 resulted in severe irritation of the respiratory tract and eyes and death in most of the animals. Kidney damage was noted following exposure of 309 animals to 15 mg/m^3.

Effects In Humans

Machle (as cited in NIOSH 1976) exposed humans to various concentrations of HF. The results are summarized below.

Concentration (mg/m^3)	Effect
26	Mild eye, throat and nose irritation. This level could be tolerated for several minutes.
50	Tickling and discomfort in respiratory tract.
100	Highest tolerable concentration. Skin smarted within one minute. Marked eye and respiratory tract irritation.

Largent (as cited in NIOSH 1976) exposed 5 people for 6 hours/day for 10-50 days. The results are summarized below.

Concentration (mg/m^3)	Effect
1.6	No adverse effect.
2.1-3.9	Mild eye irritation, slight irritation of nose. Exposure to this level for 10 days caused cutaneous erythema in one person.

RTECS (1982-82) listed the following values for exposure to hydrogen fluoride:

Species	Route	Dose	End Point
Human	Inhalation	110 ppm/1 minute	TC_{lo}
Human	Inhalation	50 ppm/30 minutes	LC_{lo}
Rat	Inhalation	1276 ppm/1 hour	LC_{50}
Rat	Intraperitoneal	25 mg/kg	LC_{50}
Mouse	Inhalation	456 ppm/1 hour	LC_{50}
Monkey	Inhalation	177 ppm/1 hour	LC_{50}

Rabbit	Inhalation	260 mg/m^3/7 hour	LC_{lo}
Guinea Pig	Inhalation	4327 ppm/15 minutes	LC_{50}

Current Standards for Exposure to Hydrogen Fluoride

- ANSI-upper limit -- 10 ppm (ceiling) this is the basis for the maximum upper limit.
- ACGIH-TLV TWA -- 3 ppm (2.5 mg/m^3) as fluoride; established to avoid irritation on skin, eyes and respiratory tract and to prevent deleterious effects of skeletal fluorosis (increased bone density or osteosclerosis).
- ACGIH-STEL -- 6 ppm (5.0 mg/m^3) as fluoride.
- NIOSH - recommended ceiling - 5 mg/m^3 for 15 minutes - to prevent acute irritation.

Development of an Emergency Exposure Limit for Air

- Allowable Limit = 2.5 mg (F)/m^3 or 3 ppm.

  This is the TLV. Experience indicates that adults can be exposed to this level with no adverse effects.

- Allowable Upper Limit = 5 mg/m^3 or 6 ppm for 15 minutes.

  This is the STEL. There should be little or no irritation resulting from short exposures to this level. Exposures greater than 15 minutes may irritate the eye and respiratory tract.

- Maximum Upper Limit = 8 mg/m^3.

  Exposure to 8 mg/m^3 is advisable only in extreme emergency situations. Mild eye, skin, and respiratory tract irritation can be expected to occur after a few minutes exposure. The effects will become more severe with time or with increasing concentrations. Exposure should not exceed 5 minutes.

Development of an Emergency Exposure Limit for Water

Development of standards for HF in the water supply is based on the following assumptions:

1) The average adult drinks two liters of water daily.

2) The average adult male weighs 70 kg.

3) Single doses causing acute effects would have the same effects if spread out over 16-hour day in the drinking water. Although this is not quite accurate, it introduces a safety factor which may counteract, to some degree, the greater sensitivity of the young, aged, and infirm to toxic chemicals.

A level of 1 ppm fluoride in the water supply is generally considered to be safe. As reported in the NIOSH Criteria Document (1976), several studies have been performed on persons exposed for years to water levels of 8 ppm. No acute effects were reported to be present in these persons, but findings of osteosclerosis after years of exposure were common in persons exposed to this level. Thus, it would appear that 8 ppm would be an acceptable level (should elicit no acute toxic effects) in an emergency situation, but exposure to this level should not be allowed for an extended period of time.

The level at which minimal symptoms (nausea, vomiting, stomach cramps) begin to appear has been reported to be 1/50 the lethal dose or 100 mg. Considering the assumptions listed above, the level at which these symptoms are expected to occur in the average adult male would be 50 ppm.

- Allowable Limit - 1 ppm (1 mg F/L drinking water). This level is considered absolutely safe and is standardly added to public drinking water.

- Allowable Upper Limit - 8 ppm (8 mg F/L drinking water). This level should be safe in an emergency situation. Consumption of this level should not exceed 24 hours.

- Unsafe Level - 50 ppm. Toxic effects (nausea, vomiting, stomach cramps) can be expected from consumption of water containing 50 ppm.

References

ACGIH. 1984. TLVs. Threshold Limit Values for Chemical Substances in the Work Environment Adopted by ACGIH for 1984-85. American Conference of Government Industrial Hygienists. Cincinnati, OH. ISBN: 0-936712-54-6.

NIOSH. 1976. Criteria for a Recommended Standard: Occupational Exposure to Hydrogen Fluoride. National Institute for Occupational Safety and Health. Washington, D.C. DHEW (NIOSH) Publication Number 76-143.

Patty's Industrial Hygiene and Toxicology. 1981. 3rd revised edition. Vol. IIB. George D. and Florence E. Clayton (eds.). John Wiley and Sons, Inc.

Proctor NH, Hughes JP. 1978. Chemical Hazards of the Workplace. J.P. Lippencott Co.

RTECS. 1981-82. Registry of Toxic Effects of Chemical Substances. Vol. 1-3. DHHS (NIOSH) Pub. No. 83-108.

NITRIC ACID

Summary of Toxic Effects

Splashes of liquid nitric acid in the eyes may cause permanent damage. Inhalation causes dryness of the throat and nose, cough, chest pain, difficulty breathing, and pulmonary edema (buildup of fluid in lungs). Nitric acid also causes severe skin burns and corrosion of the mucous membrane.

Effects of Nitric Acid Exposure in Animals

Gray et al. (as cited in NIOSH 1976) conducted several studies of nitric acid exposure in rats. After exposing animals by inhalation to 40, 56, and 96 hr, Gray concluded that exposure to more than 8 ppm may be injurious. In a second study, Gray et al. determined the LC_{50} of red fuming and white fuming nitric acid to be 310 and 334 ppm respectively. Chronic exposure to 4 ppm nitric acid for 4 hours/day, 5 days/week for 6 months had no effect. On this basis a maximum acceptable concentration (MAC) of 5 ppm was suggested. Diggle and Gage (as cited in NIOSH 1976) exposed rats to 25 ppm for an unknown length of time. No toxic effects were reported.

Current Standards for Exposure to Nitric Acid

TLV - 2 ppm (5 mg/m^3)

STEL - 4 ppm (10 mg/m^3)

ACGIH - 2 ppm (5 mg/m^3) Chosen to prevent pulmonary irritation and corrosive effect on teeth.

Conclusion and Rationale

There are no data on the acute effects in humans of exposure to low concentrations of nitric acid. Therefore, animal experiments must be used for the formulation of emergency standards. NOELs (No Observable Effect Levels) in the rat were reported to be 8 ppm and 25 ppm in two different studies. Taking the worst possible case (which includes safety factors for extrapolation of animal data to man), 8 ppm is recommended as the maximum exposure level to be permitted in emergency situations.

Development of an Emergency Exposure Limit in Water

Currently there are no Federal guidelines, criteria or standards for acids in water. The toxicity of these compounds in drinking water is thus evaluated by examining the change in pH of the water. Criteria for pH in drinking water for the protection of human health are 5-9.

References

ACGIH. 1984. TLVs. Threshold Limit Values for Chemical Substances and Physical Agents in the Work Environment with Intended Changes for 1984-85. American Conference of Governmental Industrial Hygienists. Cincinnati, OH. ISBN: 0-936712-54-6.

Gosselin, Hodge, Smith and Gleason. 1976. Clinical Toxicology of Commercial Products. Fourth edition. Williams and Wilkins Co., Baltimore, MD.

NIOSH. 1976. Criteria for a Recommended Standard: Occupational Exposure to Nitric Acid. National Institute for Occupatinoal Safety and Health, Washington D.C. DHEW (NIOSH) Publication No. 76-141.

PHOSPHORIC ACID

Summary of Toxic Effects

Exposure to phosphoric acid mists and dusts causes irritation to the eyes, upper respiratory tract, and skin. The risk of pulmonary edema resulting from the inhalation of mist or spray is remote. Skin and eye burns may result from splashes of concentrated solution. Prolonged or repeated exposures may cause dermatitis.

Effects of Phosphoric Acid Exposure in Man

Unacclimatized workers could not tolerate exposure to fumes of phosphoric acid at a concentration of 100 mg/m^3 though "hardened" workers could endure this level. Unacclimated workers could easily tolerate 1 mg/m^3. Exposure to 3.6 and 11.3 mg/m^3 produced coughing. Concentrations of 0.8-5.4 mg/m^3 were noticeable but not uncomfortable (NIOSH 1981).

Current Standards for Exposure to Phosphoric Acid

TLV - 1 mg/m^3

STEL - 3 mg/m^3

Development of an Emergency Exposure Level for Water

Currently there are no Federal guidelines, criteria or standards for acid in water. The toxicity of these compounds in drinking water is thus evaluated by examining the change in pH of the water. Criteria for pH in drinking water for the protection of human health are 5-9.

References

ACGIH. 1984. TLVs. Threshold Limit Values for Chemical Substances and Physical Agents in the Work Environment with Intended Changes for 1984-85. American Conference of Governmental Industrial Hygienists. Cincinnati, OH ISBN: 0-936712-54-6.

Gosselin, Hodge, Smith and Gleason. 1976. Clinical Toxology of Commercial Products. Fourth edition. Williams and Wilkins Co., Baltimore, MD.

NIOSH. 1981. Occupational Health Guidelines for Chemical Hazards. DHHS (NIOSH) Pub. No. 81-123.

Proctor NH. Hughes, JP. 1978. Chemical Hazards of the Workplace, J.P. Lippencott Co.

RTECS. 1981-82. Registry of Toxic Effects of Chemical Substances. Vol. 1-3. DHHS (NIOSH) Pub. No. 83-107.

Sittig, M. 1981. Handbook of Toxic and Hazardous Chemicals. Noyes Publications. Park Ridge, NJ.

SODIUM HYDROXIDE

Summary of Toxic Effects

Sodium hydroxide is highly corrosive to the eyes, skin, and mucous membranes. Low levels can cause skin irritation in a short period of time. Exposure to 0.03 N (0.12%) can cause erythema in one hour. Ingestion of sodium hydroxide can cause violent pain of the esophagus and stomach and severe corrosion of the lips, mouth, pharynx, and tongue. Contact with 1 N sodium hydroxide (2%) for one minute can cause eye injury. It can cause blindness within a few seconds of contact.

Sodium hydroxide is an upper respiratory tract irritant. Inhalation of dust or concentrated mist may damage the upper resiratory tract and lungs. Effects of inhalation may vary from mild irritation of the nose and throat to severe pneumonia depending on the concentration and duration of exposure.

Current Standards for Exposure to Sodium Hydroxide

Ceiling Limit = 2 mg/m^3

NIOSH recommended standard = 0.2 mg/m^3

Development of an Emergency Exposure Limit for Air

Exposure to airborne concentrations as low as 0.2 mg/m^3 causes eye irritation in some individuals. Because of this NIOSH established a recommended standard of 0.2 mg/m^3. A ceiling of 2 mg/m^3 was established by the ACGIH. Since even this level can cause some irritation, it is recommended that the ACGIH ceiling of 2 mg/m^3 not be exceeded and that it be adopted as the emergency standard.

Development of an Emergency Exposure Limit for Water

Currently, there are no Federal guidelines, criteria, or standards for acids (or bases) in water. The toxicity of these compunds in drinking water is thus evaluated by examining the change in pH of the water. Criteria for pH in drinking water for the protection of human health are 5-9.

References

ACGIH. 1984. TLV's. Threshold Limit Values for Chemical Substances and Physical Agents in the Work Environment with Intended Changes for 1984-85. American Conference of Governmental Industrial Hygienists. Cincinnati, OH. ISBN: 0-936712-54-6.

Gosselin, Hodge, Smith and Gleason. 1976. Clinical Toxicology of Commercial Products. Fourth Edition. Williams and Wilkens Co. Baltimore, MD.

NIOSH. 1975. Criteria for a Recommended Standard: Occupational Exposure to Sodium Hydroxide. National institute for Occupational Safety and Health. Washington. D.C. DHEW (NIOSH) Publication No. 46-105.

SODIUM HYPOCHLORITE

Summary of Toxic Effects

Sodium hypochlorite is a corrosive agent. It is irritating to mucous membranes, eyes, and skin.

Although sodium hypochlorite may become an inhalation hazard if misted, the release of free chlorine from sodium hypochlorite solutions is likely to be the most significant problem in emergency situations. The concentration of available chlorine in solution increases as the pH is reduced, and heating the solution releases free chlorine. Standards developed for chlorine gas apply to chlorine released from sodium hypochlorite solutions. There are no OSHA standards or NIOSH or ACGIH recommended standards for sodium hypochlorite.

Development of an Emergency Exposure Limit in Air

AL*	MAL**	AUL***
1 ppm	3 ppm	5 ppm (5 minutes)

* Allowable limit; this is the TLV for Chlorine.

** Maximum allowable limit. This is the STEL for chlorine.

*** Absolute upper limit. This level may cause extreme discomfort within very short exposure periods. Persons not wearing respirators should not remain in areas where the concentration is 5 ppm or higher for more than 5 minutes without full face masks.

Development of an Emergency Exposure Limit in Water

If ingested, sodium hypochlorite is irritating and causes pain and inflammation to the pharynx, larynx, esophogus and stomach. It is moderately poisonous by ingestion. The toxicity is related to the amount of free chlorine in solution. Usually only rather large doses of 5% sodium hypochlorite (i.e., 1 quart) are lethal. 0.5% sodium hypochlorite should cause at most only mild injury. Sodium hypochlorite is sometimes used to purify drinking water. 0.1% sodium hypochlorite does not cause adverse effects. If sodium hypochlorite enters a waterway it becomes rapidly diluted to harmless levels.

There are no Federal guidelines, criteria, or standards for sodium hypochlorite in water; therefore, the emergency exposure limit is based on the presence of free chlorine. A tentative ADI (acceptable daily intake) for chlorine is reported to be 0.3 mg/kg/day (Dourson 1985). Assuming that a 70 kg person drinks two liters of water per day, the intake of chlorine from drinking water would be 10.5 mg/L. Although it is recognized that this value is not entirely appropriate for use in the evaluation of acute exposure, no other data are available.

References

Arena JM. 1979. Poisoning. Charles C. Thomas, Publisher.

Gosselin, Hodge, Smith and Gleason. 1976. Clinical Toxicology of Commercial Products. Fourth edition. Williams and Wilkins Co. Baltimore, MD.

Patty's Industrial Hygiene and Toxology. 1981. Vol. IIB, 3rd revised edition. George D. and Florence E. Clayton (eds.). John Wiley and Sons, Inc.

Personal communication. 1985. SAIC staff with Michael Dourson, Office of Drinking Water, U.S. Environmental Protection Agency, Cincinnati, Ohio. (513) 569-7544

NIOSH. 1976. Criteria for a Recommended Standard: Occupational Exposure to Chlorine. National Institute for Occupational Safety and Health, Washington, D.C. DHEW (NIOSH) Pub. No. 76-141.

SULFURIC ACID

Summary of Toxic Effects

Sulfuric acid is a strong irritant of the eyes, respiratory tract, and skin. Concentrated sulfuric acid causes burns of the skin and mucous membranes; dilute sulfuric acid sprays and mists irritate the skin, respiratory tract, and mucous membranes and cause dermatitis. Contact with sulfuric acid can result in irreparable damage to the eyes. Chronic exposure can cause erosion of dental enamel. Some tolerance develops after repeated exposure to low levels of sulfuric acid, and acclimated persons can tolerate levels three to four times higher than that tolerated by persons not previously exposed.

Effects in Humans

Several inhalation studies have been conducted in humans. Exposure to airborne concentrations of sulfuric acid were generally for 10-20 minutes. The results are summarized below.

Study	Concentration (mg/m^3)	Effect
Dorsch (as cited in NIOSH 1974)	0.5	Hardly noticable annoyance, slight change in pulmonary function.
	>1.0	No significant respiratory changes.
	2.0	Changes in pulmonary function.
Dorsch (as cited in NIOSH)	0.5-2.0	Slight annoyance in terms of taste, odor, and irritation.
Amdur (as cited in NIOSH)	1.0	Detected by 2/15 individuals.
	3.0	Detected by 15/15 individuals.
	5.0	Objectionable to some persons; deep breath usually caused cough; alterations in respiratory patterns.
Bushtueva as cited NIOSH)	0.7	Tickling and scratching of in throat.
	1-2	Irritation of base of esophagus; eye irritation in 40% of exposed persons

2-6	Acute irritation of mucous membranes; pronounced cough; eye irritation in 100% of exposed persons.

Current Standards for Exposure to Sulfuric Acid

5 mg/m^3 NYS Department of Labor

2 mg/m^3 Utah Department of Health

1 mg/m^3 ACGIH TLV (8-hour TWA)

1 mg/m^3 NIOSH

Development of an Emergency Exposure Limit in Air

AL*	MAL**	AUL***	IDLH****
1 mg/m^3	2 mg/m^3	5 mg/m^3	80 mg/m^3

* Allowable limit; this is the TLV.

** Maximum allowable limit. Exposure to this level should not exceed 30 minutes.

*** Absolute upper exposure limit. This level will cause discomfort but should not cause serious effects.

**** Immediately dangerous to life and health.

Conclusion and Rationale

One mg/m^3 can be tolerated well (TLV). Two mg/m^3 may cause mild irritation but is readily tolerated for a short time. At five mg/m^3, eye and throat irritation may be objectionable; coughing is to be expected. This concentration results in an increased respiratory rate and an impaired ventilatory capacity. This level can be tolerated for a very brief period of time in emergency situation.

Development of an Emergency Exposure Limit in Water

Currently, there are no Federal guidelines, criteria, or standards for acids in water. The toxicity of these compounds in drinking water is thus evaluated by examining the change in pH of the water. Criteria for pH in drinking water for the protection of human health are 5-9.

References

ACGIH. 1984. TLVs. Threshold Limit Values for Chemical Substances and Physical Agents in the Work Environment with Intended Changes for 1984-85. American Conference of Governmental Industrial Hygienists, Cincinnati, OH. ISBN: 0-936712-54-6.

Gosselin, Hodge, Smith and Gleason. 1976. Clinical Toxicology of Commercial Products. Fourth edition. Williams and Wilkins Co., Baltimore, MD.

NIOSH. 1974. Criteria for a Recommended Standard: Occupational Exposure to Sulfuric Acid. National Institute for Occupational Safety and Health. Washington, D.C. DHEW (NIOSH) Pub. No. 74-128.

Proctor NH, Hughes JP. 1978. Chemical Hazards of the Workplace. J.B. Lippencott Co.

RTECS. 1981-82. Registry of Toxic Effects of Chemical Substances. Vol. 1-3. DHHS (NIOSH) Pub. No. 83-107.

Sittig, M. 1981. Handbook of Toxic and Hazardous Chemicals. Noyes Publications, Park Ridge, NJ.

1,1,1-TRICHLOROETHANE

Summary of Toxic Effects

1,1,1-Trichloroethane (TCE) causes central nervous system depression, with symptoms such as dizziness, drowsiness, incoordination, decreased reaction time, unconcsciousness, and death. It is an eye and skin irritant and can be absorbed through the skin to a moderate degree. The odor threshold is 16 to 400 ppm.

Effects in Humans

The following table summarizes the effects of 1,1,1-trichloroethane experienced at various concentrations.

Study	Concentration (mg/m^3)	Effect
Salvini et al. (as cited in NIOSH 1976)	350	None.
Stewart et al. (as cited in NIOSH 1976)	500	Some beginning anesthetic response in a few persons. No disturbances of reflexes or central nervous system response.
	800-1,000	Some persons show minor central nervous system impairment.
Torkelson et al. (as cited in NIOSH 1976)	900-1,000 for 20 min.	Some persons experienced light-headedness, incoordination and slight loss of equilibrium; transient mild eye and nose irritation.
	2,000 for 5 min.	Disturbance of equilibrium.
	10,000 for 30 min.	Marked incoordination.
Proctor and Hughes 1981	20,000 for 60 min.	Coma and possibly death.

Current Standards for Exposure to 1,1,1-Trichloroethane

TLV = 300 ppm (1900 mg/m^3)

STEL = 450 ppm (2450 mg/m^3)

NIOSH recommended standard = 200 ppm; STEL, 350 ppm

IDHL - 1000 ppm (5400 mg/m^3)

Development of an Emergency Exposure Limit in Air

AL*	IDLH**
500 ppm	1000 ppm

* Allowable limit; levels higher than this may produce central nervous system depression.

** Immediatley dangerous to life and health; some effects are experienced at this level, though they are reversible. This level can be tolerated for 30 minutes.

Development of an Emergency Exposure Limit in Water

The proposed maximum contaminant level (MCL) for 1,1,1-trichloroethane in drinking water is 200 ug/L (Federal Register 1985). At this level, there are no known or anticipated adverse effects on human health.

References

ACGIH. 1984. TLVs. Threshold Limit Values for Chemical Substances and Physical Agents in the Work Environment with Intended Changes for 1984-85. American Conference of Governmental Industrial Hygienists. Cincinnati, OH. ISBN: 0-936712-54-6.

NIOSH. 1976. Criteria for a Recommended Standard: Occupational Exposure to 1,1,1-trichloroethane (Methyl Chloroform). National Institute for Occupational Safety and Health. DHEW (NIOSH) Pub. No. 76-184.

NRC. 1980. Drinking Water and Health. Vol. 3. National Research Council, National Academy Press. Washington, D.C.

Patty's Industrial Hygiene and Toxicology. 1981. Vol. IIB. 3rd revised edition. George D. and Florence E. Clayton (eds.). John Wiley and Sons, Inc.

Proctor NH, Hughes JP. 1978. Chemical Hazards of the Workplace. J.B. Lippencott Co.

Sittig, M. 1981. Handbook of Toxic and Hazardous Chemicals. Noyes Publications, Park Ridge, NJ.

APPENDIX I

BASIC DATA FOR ANALYSES OF RADIOACTIVE MATERIAL RELEASES IN TRANSPORTATION ACCIDENTS AND INCIDENTS AT THE SRP

(Appendix to Chapter 5.0)

APPENDIX I. BASIC DATA FOR ANALYSES OF RADIOACTIVE MATERIAL RELEASES IN TRANSPORTATION ACCIDENTS AND INCIDENTS AT THE SAVANNAH RIVER PLANT

This appendix presents tables of basic data used to develop hazard indices for the transportation of radioactive materials at the SRP. Included are the following:

1) Summary descriptions of the types of shipments of radioactive materials.

2) Estimates of total annual shipment miles for each type of shipment.

3) Estimated accident probabilities (rate/mile) for each type of shipment. These probabilities take into consideration the shipment mode, SRP historical accident/incident data, national accident data, and SRP administrative controls.

4) Estimated frequencies for incidents/accidents that would result in releases of radioactive materials. These are reported, as appropriate, both for normal transport during which there may be releases due to package preparation errors or packaging defects, and for transport accidents. These values are the multiple of the accident or incident rate (in events/vehicle mile) and the annual transport miles at the SRP for each shipment type.

5) Estimates of releases, in curies, for the accidents or incidents. These estimates are reported for alpha emitting isotopes, beta-gamma emitting isotopes, and tritium.

6) Expected values of annual releases in curies/year (Ci/yr). This value is the product of the accident/incident frequency and the amount of curies released.

7) Expected values for the hazard index in maximum permissible intake/year (MPI/yr). These values are the product of the conversion factors (curies to MPI) for each isotope whose release is postulated and the expected values of annual releases.

The tables include footnotes, as appropriate, to explain assumptions or observations germain to the development of data entries.

There are fifteen tables (Tables I-1 through I-15) each containing data for a particular grouping of shipments. The shipment groupings are:

- I-1 Cask Containing Irradiated Assemblies
- I-2 Solid Wastes - TRU Wastes in Drums
- I-3 Solid Wastes - Non-TRU Wastes
- I-4 Analytical Samples up to 200 ml Each

Table I-16 summarizes the release data presented in Table I-1 through I-15. Presented for each shipment type are the expected values of annual releases by radiation type and the expected values for MPI/yr. The shipments which have the highest hazard indices are identified. Consequences and risk from accidents involving these shipments are analyzed in the transportation safety analysis.

Table I-17 presents approximate mileage distances between areas. These distances were used to develop total transport miles presented in Tables I-1 through I-15.

REFERENCES

1. C. V. Hodge and A. A. Harrett. Transportation Accident Risks in the Nuclear Power Industry 1975-2020. Report NSS 8191.1, Nuclear and Systems Sciences Group, Anaheim, CA, November 1974. (Prepared for Office of Radiation Programs, EPA.)

2. W. A. Brobst. "The Probability of Transportation Accidents." Department of Defense Explosives Safety Board 14th Annual Explosives Safety Seminar in New Orleans, LA, November 10, 1972, United States Atomic Energy Commission, Washington, DC (1972).

3. R. K. Clarke, J. T. Foley, W. F. Hartman, and D. W. Larson. Severities of Transportation Accidents, Volumes I - Summary, p. 28. Sandia Laboratories Report SLA-74-001, Albuquerque, NM (1976).

4. R. E. Rhoads, J. L. Buelt, G. W. Dawson, T. W. Horst, P. L. Peterson, and B. A. Ross. An Assessment of the Risk of Transporting Gasoline by TRUCK. PNL-2133. Pacific Northwest Laboratory, Richland, WA (1978).

TABLE I-1. Cask Containing Irradiated Assemblies

Shipment Description	Annual[a] Distance, mi	Assumed Probability/mi for an Accident with Release	Estimated Frequency of Release/yr for the SRP: Incidents During Normal Operations[b]	Estimated Frequency of Release/yr for the SRP: Accidents	Assumed[c] Release, Ci	Expected Value Release x Frequency: Ci/yr	Expected Value Release x Frequency: MPI/Ci[d]	Shipment Hazard Index
Irradiated fuel from 100-Area 200-Areas	4200	3.6×10^{-7}*		1.5×10^{-3}	2×10^{-5} α**	3×10^{-8}	5×10^{7}	1.5
					7×10^{-3} β-γ	1.1×10^{-5}	1×10^{5}	1.1
					3 Tritium	4.5×10^{-3}	1.6×10^{3}	7.2
Sections of irradiated fuel elements RBOF to Building 773-A in 8-ton cask	<30	1.2×10^{-8}***		3.6×10^{-7}	<10*** β-γ	3.6×10^{-6}	1×10^{-5}	0.4

* Estimated probability per car mile of derailment severe enough to dislodge the load.

** Estimated contamination in water released from cask cavity. Failed fuel is doubly contained in the HARP to provide containment equivalent to fuel cladding.

*** Lid closure system is not expected to survive a severe accident.

NOTE: Footnotes a-d are located on page I-22.

TABLE I-2. **Solid Wastes - TRU Wastes in Drums (Based on 1976 Experience) (See Note)**

Shipment Description	Annual[a] Distance, mi	Assumed Probability/mi for an Accident with Release	Estimated Frequency of Release/yr for the SRP: Incidents During Normal Operations[b]	Estimated Frequency of Release/yr for the SRP: Accidents	Assumed[c] Release, Ci	Expected Value Release x Frequency: Ci/yr	Expected Value Release x Frequency: MPI/Ci[d]	Shipment Hazard Index
Building 773-A (17 trips/yr)*		$3.0x10^{-8}$	Small	$1.2x10^{-6}$	0.01α** Small	$1.2x10^{-8}$ Small	$5x10^7$	0.6
Building 772-F		$3.0x10^{-8}$		$1.2x10^{-6}$	0.5α**	$6x10^{-7}$	$5x10^7$	0.30
Building 221-F		$3.0x10^{-8}$		$1.2x10^{-6}$	0.03**	$3.6x10^{-8}$	$5x10^7$	1.8
Building 221-H (HB-Line)		$3.0x10^{-8}$		$1.2x10^{-6}$	0.8α**	$9.6x10^{-7}$	$5x10^7$	48
Building 235-F (including PuFF projections)		$3.0x10^{-8}$		$1.2x10^{-6}$	0.8α**	$9.6x10^{-7}$	$5x10^7$	48
Total	200			$6.0x10^{-6}$		$2.6x10^{-6}$		128
Wastes from offsite - in Type B packaging						ES****		ES****

* Concrete waste boxes are conservatively assumed to provide no more protection than 55-gal drums.
** If fire is involved in the accident 10% of average load may be released.
*** Accident rate for accidents in classes exceeding minor severity - crush assumed with a probability of 0.2.

NOTE: Consequences and risks from the breach or puncture of a waste drum are analyzed in the transportation safety analysis. Footnotes a-d are located on page I-22.

TABLE I-3. **Solid Wastes - Non-TRU Wastes**

Shipment Description	Annual[a] Distance, mi	Assumed Probability/mi for an Accident with Release	Estimated Frequency of Release/yr for the SRP: Incidents During Normal Operations[b]	Estimated Frequency of Release/yr for the SRP: Accidents	Assumed[c] Release, Ci	Expected Value Release x Frequency: Ci/yr	Expected Value Release x Frequency: MPI/Ci[d]	Shipment Hazard Index
Load Lugger pans	12,000	1.5×10^{-7}***	Small	1.8×10^{-3}	$<0.1\beta$-γ* $<10^{-5}\alpha$	$1.8\times10^{-4}\beta$-γ $1.8\times10^{-8}\alpha$ ES	1×10^{5} 5.9×10^{7}	18β-γ 1.1α ES
Boxes waste	~10,000	1.5×10^{-7}***	Small	1.5×10^{-3}	$3\times10^{-2}\beta$-γ** $3\times10^{-5}\alpha$**	$4.5\times10^{-5}\beta$-γ $4.5\times10^{-8}\alpha$ ES	1×10^{5} 5×10^{7}	4.5β-γ 2.3 ES
Contaminated equipment†	<200	10^{-8}††	~5×10^{-2}	2×10^{-6}	$<1\beta$-γ $<10^{-3}\alpha$ $10^{-3}\beta$-γ¶ $10^{-8}\alpha$¶	$2\times10^{-6}\beta$-γ $2\times10^{-9}\alpha$ $5\times10^{-5}\beta$-γ $5\times10^{-8}\alpha$	1×10^{5} 5×10^{7} 1×10^{5} 5.9×10^{7}	0.2β-γ 0.1 5β-γ 3
100-Area scrap metal	<3000	$2\times6\times10^{-11}$†††		$<3\times10^{-8}$	Small	ES		ES

* Average shipment is assumed.
** Shipment is 50 boxes at average of about 1 mCi mixed fission products and 1 uCi alpha emitter in each box is assumed. Furthermore, one-half of the load is assumed to be involved in a fire. Risk was reduced in 1985 with change to 55 gal drums and metal waste burial boxes.
*** Probability of an accident more severe than minor.
† For convenience this includes equipment moved intra-area for repairs.
†† Probability of a moderate accident at 30-50 mph including a large, lengthy fire.
††† Probability of ≥ severe accident at 30-50 mph.
¶ Leakage of small quantity of decontamination solution from the equipment.
NOTE: Footnotes a-d are located on page I-22.

TABLE I-4. Analytical Samples Up to 200 mL Each

Shipment Description	Annual[a] Distance, mi	Assumed Probability/mi for an Accident with Release	Estimated Frequency of Release/yr for the SRP: Incidents During Normal Operations[b]	Estimated Frequency of Release/yr for the SRP: Accidents	Assumed[c] Release, Ci	Expected Value Release x Frequency: Ci/yr	Expected Value Release x Frequency: MPI/Ci[d]	Shipment Hazard Index
Reactor Samples moderator on 100 Area pickup in carrier	27,400	1.2×10^{-8}***	Small	3.4×10^{-4}	20 Tritium	6.8×10^{-3} Very small	1.6×10^{3}	11
200-N Area <u>Sample Truck</u>								
To Building 772-F	15,000	3×10^{-9}†††	Small	4.5×10^{-5}	0.06α* 0.6 β-γ**	2.7×10^{-8}α† 2.7×10^{-5}β-γ††	5×10^{7} 1×10^{5}	140 2.7
To Building 773-A dissolver solution HAW or Pu-238 solution - 200 mL/cask	200	3×10^{-9}†††		6×10^{-7}	1.2α¶ 12 β-γ¶	7.2×10^{-7}α 7.2×10^{-6}β-γ††	5×10^{7} 1×10^{5}	36 0.7
Other samples to Building 773-A (waste tank supernate, moderator NpO_2, etc., in sample truck) - fraction of a percent of the risk shown above						Very small		Very Small

TABLE I-4. Analytical Samples Up to 200 mL Each (Continued)

Shipment Description	Annual[d] Distance, mi	Assumed Probability/mi for an Accident with Release	Estimated Frequency of Release/yr for the SRP		Assumed[c] Release, Ci	Expected Value Release x Frequency		
			Incidents During Normal Operations[b]	Accidents		Ci/yr	MPI/Ci[d]	Shipment Hazard Index
Trips to Building 773-A over Upper Three Runs Creek	20 (on bridge and approaches)	$3x10^{-9}$†††		$6x10^{-8}$	1.2α 12β-γ	$7.2x10^{-8}$α¶¶ $7.2x10^{-7}$β-γ¶¶	$5x10^7$ $1x10^5$	3.6 0.07

* Normal load is 5 to 6 samples. About 1/4 of the loads include a sample of Pu-238 product stream. A load usually a IAF feed sample or two HM dissolver solution samples. Assumed release:

α - one IAF sample plus 1/4 Pu-238 product sample and 10% leaks from truck - (10 mL x $5x10^{10}$) + 1/4 (10 mL x $3.5x10^{11}$).

γ - two RM dissolver solution samples on truck and 10% leaks from truck - (10 mL x $6x10^{11}$//L) x 10%.

** β to γ ratio of 1:1 is assumed.

*** Probability of a severe onsite truck accident, $3.1x10^{-8}$ with a 60% reduction due to lower onsite speeds and traffic density.

† α of Pu-238 or $5x10^7$ MPI/Ci is assumed.

†† $1x10^5$ MPI/Ci is assumed.

††† Probability of a moderate accident $1.5x10^{-7}$, with 0.1 probability of dislodging package and 0.2 probability of overturn.

¶ The sample volume at risk is assumed to be 20 times routine sample loads.

¶¶ Risk to put radioactivity into Upper Three Runs Creek.

NOTE: Consequences and risks from H-Area sample truck accident (No. 1) are analyzed for the transportation safety analysis.

Footnotes a-d are located on page I-22.

TABLE I-5. Unshielded Trailers - 100 Areas

Shipment Description	Annual[a] Distance, mi	Assumed Probability/mi for an Accident with Release	Estimated Frequency of Release/yr for the SRP: Incidents During Normal Operations[b]	Estimated Frequency of Release/yr for the SRP: Accidents	Assumed[c] Release, Ci	Expected Value Release x Frequency: Ci/yr	Expected Value Release x Frequency: MPI/Ci[d]	Shipment Hazard Index
Low level wastes from tanks by Building 100-C stack to Building 221-F (10-13 loads/yr)	~200	$3x10^{-8}$+		$6x10^{-6}$	$5x10^{-3}\alpha$*	$3x10^{-8}\alpha$	$5x10^{7}$	1.5α
			0.1**		0.25β-γ*	$1.5x10^{-8}\beta$-γ	$1x10^{5}$	0.2β-γ
					$1x10^{-5}\alpha$†	$1x10^{-6}\alpha$	$5.9x10^{7}$	60α
					$5x10^{-4}\beta$-γ†	$5x10^{-5}\beta$-γ	$1x10^{5}$	5β-γ
100-Area basin sludge to Building 241-F tanks - about 20 trips/yr	~200	$3x10^{-8}$+		$6x10^{-6}$	20β-γ††	$1.2x10^{-4}\beta$-γ	$1x10^{5}$	12
			0.1**		0.2α	$1.2x10^{-8}\alpha$	$5.9x10^{7}$	71
					$4x10^{-2}\beta$-γ¶	$4x10^{-3}\beta$-γ	$1x10^{5}$	$4x10^{2}$
					$4x10^{-4}\alpha$	$4x10^{-5}\alpha$	$5.9x10^{7}$	$2.4x10^{3}$
			$5x10^{-5}$¶¶		20β-γ††	$1x10^{-3}\beta$-γ	$1x10^{5}$	$1x10^{2}$
					0.2α	$1x10^{-5}\alpha$	$5.9x10^{7}$	$6x10^{2}$
							Total	$3.6x10^{3}$

TABLE I-5. Unshielded Trailers - 100 Areas

* Whole tank may drain (5 mCi α and 250 mCi β-γ assumed as average load).

** Historical frequency of all low-level waste trailers leaking is about 0.2/yr; 0.1/yr assigned to this operation.

† Leakage of less than 10 gal assumed at about 1 μCi α and 50 μCi β-γ/gal.

†† Average contents of the load. The infrequent maximum is 5 to 10 times greater.

¶ A leak of 10 gal is assumed.

¶¶ A mechanical failure rate of the value 5×10^{-6} hr x 10 hr/yr in transit is derived from estimated failure rates.

\+ Probability of an accident more severe than minor, 1.5×10^{-7}, with a tank puncture is assumed to be 0.2.

NOTE: Leakage of 10 gal of low-level waste from a trailer are analyzed in the transportation safety analysis.

Footnotes a-d are located on page I-22.

TABLE I-6. Unshielded Waste Trailers - Building 776-A (See Note)

Shipment Description	Annual[a] Distance, mi	Assumed Probability/mi for an Accident with Release	Estimated Frequency of Release/Yr for the SRP: Incidents During Normal Operations[b]	Estimated Frequency of Release/Yr for the SRP: Accidents	Assumed[c] Release, Ci	Expected Value Release x Frequency: Ci/yr	Expected Value Release x Frequency: MPI/Ci[d]	Shipment Hazard Index
776-A low-level waste trailer to Building 211-F (about 125 loads/yr)	1300	$3x10^{-8}$†	<0.1	$3.9x10^{-5}$ $3.9x10^{-5}$	$2.5x10^{-4}$* $2.5x10^{-4}$* $6x10^{-5}$** $6x10^{-5}$**	$9.8x10^{-9}\alpha$ $9.8x10^{-9}\beta$-γ $6x10^{-6}\alpha$ $6x10^{-6}\beta$-γ	$5x10^7$ $1x10^5$ $5x10^7$ $1x10^5$	0.5α $9.8x10^{-4}\beta$-γ 300α $0.6\ \beta$-γ
Trips over Upper Three Runs Creek (on bridge)	130	$3x10^{8}$†		$3.9x10^{-6}$	$1x10^{-3}\alpha$ $1x10^{-3}\beta$-γ	$4x10^{-9}\alpha$ $4x10^{-9}\beta$-γ	$5x10^7$ $1x10^5$	0.2α $4x10^{-4}\beta$-γ

* Since use of the SRL seepage basins was discontinued in October 1982, the contents of the average load was 5 mCi α/load and 8 mCi β-γ/load. Future programs may increase these values so an "average" load was assumed to contain 25 mCi α and 25 mCi/β-γ. Maximums may be as much as a factor of 5 higher. Assumed released for an accident was 1% of "average" load contents.

** Ten-gal leakage as maximum and 4200 gal load are assumed.

† Probability of an accident more severe than minor, $1.5x10^{-7}$, with a tank puncture to be 0.2.

NOTE: Consequences and risks resulting from accidental leakage from a low-level waste trailer are analyzed in the transportation safety analysis.

Footnotes a-d are located on page I-22.

TABLE I-7. Shielded Tanks on High-Level Trailers (See Note)

Shipment Description	Annual[a] Distance, mi	Assumed Probability/mi for an Accident with Release	Estimated Frequency of Release/yr for the SRP: Incidents During Normal Operations[b]	Estimated Frequency of Release/yr for the SRP: Accidents	Assumed[c] Release, Ci	Expected Value Release x Frequency: Ci/yr	Expected Value Release x Frequency: MPI/Ci[d]	Shipment Hazard Index
High-level waste trailer, Building 776-A to Building 221-F (~30 trips/yr)	~300	10^{-11}***	$3x10^{-7}$*	$3x10^{-9}$	<100α <200β-γ 0.3α** 0.6β-γ	$3x10^{-7}$α $6x10^{7}$β-γ $9x10^{-8}$α $2x10^{-7}$β-γ	$5x10^{7}$ $1x10^{5}$ $5x10^{7}$ $1x10^{5}$	15 $6x10^{-2}$ 5 $2x10^{-2}$
High-level waste trailer near creek (on bridge)	30	10^{-10}†		$3x10^{-9}$	<100α <200β-γ	$3x10^{-7}$α $6x10^{-7}$β-γ	$5x10^{7}$ $1x10^{5}$	15 $6x10^{-2}$

* Thirty trips/yr with two consecutive errors of consequence each with a probability of 10^{-4} ($30x10^{-4} \times 10^{-4}$ = $3x10^{-7}$) is assumed.

** Leakage of 1 gal of contents with 30 mCi α/gal 60 β-γ/gal is assumed.

*** Probability of a severe accident for a truck travelling 20 mph or less[2], <10^{-10}, with 0.1 probability of overturn.

† Tractor failure during travel uphill at Upper Three Runs Creek and the probability that it will go out of control (and "fail safe" brakes not hold the heavy load) is assumed to be 0.1. The probability of landing inverted in the creek is assumed to be 0.5. Furthermore, it is assumed that somehow the whole tank leaks into the creek. The SRP brake failure rate with reported accident consequences for all onsite trucks is $2x10^{-9}$/mi.

NOTE: Consequences and risks resulting from high-level waste trailer accidents are analyzed in the transportation safety analysis.

Footnotes a-d are located on page I-22.

TABLE I-8. Shielded Tanks on Other Trailers

Shipment Description	Annual[a] Distance, mi	Assumed Probability/mi for an Accident with Release	Estimated Frequency of Release/yr for the SRP: Incidents During Normal Operations[b]	Estimated Frequency of Release/yr for the SRP: Accidents	Assumed[c] Release, Ci	Expected Value Release x Frequency: Ci/yr	Expected Value Release x Frequency: MPI/Ci[d]	Shipment Hazard Index
Solvent Trailer	2	10^{-8}***		2×10^{-8}	0.5α*	$1\times10^{-8}\alpha$	5×10^{7}	0.5
					$50\ \beta\text{-}\gamma$*	$1\times10^{-6}\beta\text{-}\gamma$	1×10^{5}	0.1
			1×10^{-6}**		$<10^{-4}\alpha$	$1\times10^{-10}\alpha$	5×10^{7}	5×10^{-3}
					$<10^{-2}\beta\text{-}\gamma$	$1\times10^{-8}\beta\text{-}\gamma$	1×10^{5}	1×10^{-3}
<u>Deionizers</u>†								
Disassembly basins to Building 245-H (110 trips/yr)	800	$<10^{-8}$***		8×10^{-6}	$10^{4}\beta\text{-}\gamma$††	8×10^{-10}	1×10^{5}	8×10^{-5}
			0.2¶		$10^{-3}\beta\text{-}\gamma$	2×10^{-4}	1×10^{5}	20
Spent purification deionizer (in cask No. 4) (10/yr)	150	$<10^{-8}$***		$<2\times10^{-6}$	$10^{-4}\beta\text{-}\gamma$	ES	—	ES

* Total loss of a 5000-gal load at present limits is assumed. This may be conservative--perhaps as much as a factor of 10.

** One trip/yr with two consecutive errors of consequence each with a probability of 10^{-3} each is assumed.

*** Probability of a moderate truck accident[2] at speeds of 30-50 mph.

† Free liquid in deionizer contains <10 μCi/gal; radionuclides are bound on the resin.

†† Ten-gallon leakage is assumed.

¶ Valving error frequency assumed to be 2×10^{-3}/demand.

NOTE: Footnotes a-d are located on page I-22.

TABLE I-9. Offsite Shipments

Shipment Description	Annual[d] Distance, mi	Assumed Probability/mi for an Accident with Release	Estimated Frequency of Release/yr for the SRP		Assumed[c] Release, Ci	Expected Value Release x Frequency		
			Incidents During Normal Operations[b]	Accidents		Ci/yr	MPI/Ci[d]	Shipment Hazard Index
Californium shipments-special form	~300	3.1×10^{-8}*		9×10^{-6}	ES	ES	—	ES
Irradiated fuel RBOF ~100 trips/yr	1000	3.1×10^{-8}*		3×10^{-5}	Small	ES	—	ES
UNH Trailer	3000	4.3×10^{-8}**		1.3×10^{-4}	0.1 10	1.3×10^{-5} 1.3×10^{-3}	4.4×10^{6} 1×10^{5}	57 130

* Probability of a severe truck accident.
** Probability of a tank truck accident is 6.4×10^{-6}/truck mile.
Conditional probability of location near UTRC is 1/10.
Conditional probabiolity of location near contents is 1/15.

NOTE: Footnotes a-d are located on page I-22.

TABLE I-10. Package Gases

Shipment Description	Annual[a] Distance, mi	Assumed Probability/mi for an Accident with Release	Estimated Frequency of Release/yr for the SRP		Assumed[c] Release, Ci	Expected Value Release x Frequency		
			Incidents During Normal Operations[b]	Accidents		Ci/yr	MPI/Ci[d]	Shipment Hazard Index
Blanket gas samples in evacuated metal samples	~3000	1.5×10^{-7}***		4.5×10^{-4}	Small*	**	—	**

* Contains 75 cc of reactor blanket gas.
** Very small compared to moderator samples carried on the same truck.
*** Probability of an accident more severe than minor.

NOTE: Footnotes a-d are located on page I-22.

TABLE I-11. Liquids for Reprocessing (See Note)

Shipment Description	Annual[a] Distance, mi	Assumed Probability/mi for an Accident with Release	Estimated Frequency of Release/yr for the SRP: Incidents During Normal Operations[b]	Estimated Frequency of Release/yr for the SRP: Accidents	Assumed[c] Release, Ci	Expected Value Release x Frequency: Ci/yr	Expected Value Release x Frequency: MPI/Ci[d]	Shipment Hazard Index
D_2O in drums	~2000	3.1×10^{-8}***		6.2×10^{-5}	1000 T*	6.2×10^{-2} T*	1.6×10^{3}	100
					Small	ES	—	ES
Neptunium solution from 200-F Area to 200-H Area	<100	3.1×10^{-8}**		3×10^{-6}	1×10^{-2} α	3×10^{-8}	3×10^{7}	0.9
					$<10^{-4}$ α	ES	—	ES

* These drums were tested per ERDA 0529 hypothetical accident tests and survived puncture and 30 ft drops. They would not survive an intense, long duration fire. Under conditions of onsite transport, the credible leakage after an accident is assumed to be about 10 gal.

** Package is double-walled and a very severe accident is required to cause leakage. Assume 10% of contents leaks to environs. Probability of a severe accident is 3.1×10^{-8}/truck mile.

*** Probability of a severe accident is 3.1×10^{-8}/truck mile.

NOTE: Consequences and risks resulting from accidents involving the release of D_2O drum contents are analyzed in the transportation safety analysis.

Footnotes a-d are located on page I-22.

TABLE I-12. **Solid Products for Fabrication of Experiments (See Note)**

Shipment Description	Annual[a] Distance, mi	Assumed Probability/mi for an Accident with Release	Estimated Frequency of Release/yr for the SRP: Incidents During Normal Operations[b]	Estimated Frequency of Release/yr for the SRP: Accidents	Assumed[c] Release, Ci	Expected Value Release x Frequency: Ci/yr	Expected Value Release x Frequency: MPI/Ci[d]	Shipment Hazard Index
Plutonium-aluminum and neptunium-aluminum billets	~1500	$3.1x10^{-8}$	ES	$4.7x10^{-5}$	<0.06α*	$2.8x10^{-6}$	$5.9x10^{7}$	160
					ES	ES	—	ES
Uranium-aluminum billets	<20	$3.1x10^{-8}$*		$6.2x10^{-7}$		ES	—	ES
			ES		ES	ES	—	ES
Neptunium oxide, HB to Building 235-F	400	$3.1x10^{-9}$†††		$1.2x10^{-6}$	0.1**	$1.2x10^{-7}$	$3x10^{7}$	3.6
			Small	ES				
Pu-239 oxide in Type B to Building 235-F	<50	$2.6x10^{-11}$***		$1.3x10^{-9}$	2†	$2.6x10^{-9}$	$5.9x10^{7}$	0.2
			Small		Small	ES		
Pu-239 oxide in Type B to Building 773-A from F Area	<100	$2.6x10^{-11}$***		$2.6x10^{-9}$	0.1††	$2.6x10^{-10}$	$5.9x10^{7}$	0.02
Pu-238 oxide in 5320 cask to Building 773-A from HB	<500	$2.6x10^{-11}$***		$1.3x10^{-8}$	20††	$2.6x10^{-7}$	$5x10^{7}$	13

TABLE I-12. **Solid Products for Fabrication of Experiments (See Note)** (Continued)

Shipment Description	Annual[a] Distance, mi	Assumed Probability/mi for an Accident with Release	Estimated Frequency of Release/yr for the SRP: Incidents During Normal Operations[b]	Estimated Frequency of Release/yr for the SRP: Accidents	Assumed[c] Release, Ci	Expected Value Release x Frequency: Ci/yr	Expected Value Release x Frequency: MPI/Ci[d]	Shipment Hazard Index
Neptunium or plutonium oxides in small packages in 200-H Area - sample truck	<300	$3x10^{-10}$¶		$9x10^{-8}$	2α¶¶	$1.8x10^{-7}$α	$5x10^{7}$	9
Small casks on stake-body truck - misc. shipments to Building 773-A (sludge, etc.)	<200	10^{-7}¶¶¶		$2x10^{-5}$	0.1α	$2x10^{-6}$α	$5x10^{7}$	100

* These billets contain the plutonium-aluminum or neptunium-aluminum core inside welded Al designed for extrusion. For this analysis, no more than 1 g of alpha emitter is assumed to be dispersed into the air if the billets were directly subjected to fire in an accident environment. Probability of ≥ severe accident is $3.1x10^{-8}$/truck mile.

** A release of about 10% of contents and roundoff up is assumed.

*** Probability of ≥ severe truck accident 30-50 mph, with fire.

† A release of about 1% of contents is assumed.

†† Batch sizes of 100 g with a 1% loss of contents is assumed.

††† Probability of a moderate accident is $1.5x10^{-7}$, P (dislodge) is 0.1, P (overturn) = 0.2.

TABLE I-12. **Solid Products for Fabrication of Experiments (See Note)** (Continued)

Shipment Description	Annual[a] Distance, mi	Assumed Probability/mi for an Accident with Release	Estimated Frequency of Release/yr for the SRP	Assumed[c] Release, Ci	Expected Value Release x Frequency

¶ Oxides are assumed to be packaged in DOT specification 2R or equivalent primary containers. Maximum activity per package is 10 g of Pu-238 oxide. Probability of a moderate accident is 1.5×10^{-7}, P (dislodging package) is 0.1 and P (overturn) is 0.2, P (Breach of container) is 0.1.

¶¶ Release of 1% of the contents is assumed when 10 to 15 g of Pu-238 is shipped.

¶¶¶ Probability of release assumed to be 1×10^{-7}/truck mile.

NOTE: Consequences and risks resulting from accidents involving small casks on stake body trucks are analyzed in the transportation safety analysis.

Footnotes a-d are located on page I-22.

TABLE I-13. **Miscellaneous Shipment**

Shipment Description	Annual[a] Distance, mi	Assumed Probability/mi for an Accident with Release	Estimated Frequency of Release/yr for the SRP		Assumed[c] Release, Ci	Expected Value Release x Frequency		
			Incidents During Normal Operations[b]	Accidents		Ci/yr	MPI/Ci[d]	Shipment Hazard Index
A-Line depleted uranium to onsite storage			Small		Very small	ES*	—	ES
Radioactive items in clean waste area		Not estimated	Small		Very small	ES	—	ES
Radioactive items on nonradioactive vehicles and controls noneffective			Current 10^{-4}**		10^{-3}	10^{-7}	$5x10^{7}$	5

* Very low specific activity material.

** Special Hazards Incident No. 289 - truck contaminated by waste package from HB-Line; incomplete monitoring results. Items later transported to 703-A and to off plant shippers facilities which were contaminated. As a result, truck usage and procedural controls were improved.

NOTE: Footnotes a-d are located on page I-22.

TABLE I-14. **Wastes and Obsolete Equipment**

Shipment Description	Annual[a] Distance, mi	Assumed Probability/mi for an Accident with Release	Estimated Frequency of Release/yr for the SRP		Assumed[c] Release, Ci	Expected Value Release x Frequency		
			Incidents During Normal Operations[b]	Accidents		Ci/yr	MPI/Ci[d]	Shipment Hazard Index
Equipment to storage pads	A few miles at low speeds	$1.3x10^{-6}$*		$\sim 2x10^{-6}$	Small	ES	—	ES
Wastes and obsolete equipment to Burial Ground								
Derailment	300	$1.3x10^{-6}$*		$3.9x10^{-4}$	<1 Ci**	$4x10^{-4}\beta$-γ $<4x10^{-8}\alpha$	$1x10^5$ $5x10^7$	40β-γ 2
Contamination along roadbed			0.2†		$<10^{-3}$**	$2x10^{-4}\beta$-γ $2x10^{-8}\alpha$	$1x10^5$ $5x10^7$	20β-γ 1α

* Estimated probability/train mile of derailment severe enough to dislodge the load.
** The β-γ to α ratio is assumed to be about 10^{-4}:1 from DPSTSY-200-1 dissolver solution data.
† Historical frequency - a maximum value because equipment and procedures have been improved.
NOTE: Footnotes a-d are located on page I-22.

TABLE I-15. **Offsite Shipment by Rail**

Shipment Description	Annual[a] Distance, mi	Assumed Probability/ mi for an Accident with Release	Estimated Frequency of Release/yr for the SRP		Assumed[c] Release, Ci	Expected Value Release x Frequency		
			Incidents During Normal Operations[b]	Accidents		Ci/yr	MPI/Ci[d]	Shipment Hazard Index
Shipments of of products*								
Currently none	0 to 50**					ES	—	
Waste from offsite* in ATXM-500 or 600 cars	0 to 100**		Not estimated					
Irradiated fuel in casks to RBOF	0 to 100**					ES	—	

* Certified Type B packaging that complies with DOE Order 5480.3, Hypothetical Accident Tests.
** None to a few each year - travel <15 miles on SRP railroad/shipment.

a See Appendix B for shipment data.
b See Appendix E for normal operations incident rates.
c Assumed releases were developed using sensitive national security information. Analyses that the document assumed release values are recorded in Du Pont files.
d See Appendix F.

TABLE I-16. Risk Release Calculations by Operation

Description of Shipment	Expected Release Values α, Ci/yr	β γ, Ci/yr	T, Ci/yr	MPI/yr
Truck - Irradiated Targets				
Target casks - 100 Areas + 200-H Area*			$2x10^{-7}$	$3x10^{-4}$
Irradiated element sections to Building 773-A		$3.6x10^{-6}$		0.4
Solid Wastes to Burial Ground				
TRU wastes (See Note)	$1.6x10^{-6}$			78
Load lugger pans	$1.8x10^{-8}$	$1.8x10^{-4}$		19
Boxes wastes	$4.5x10^{-8}$	$4.5x10^{-5}$		7
Contaminated equipment	$5x10^{-8}$	$5x10^{-5}$		8
100-Area scrap metal	ES**	ES		ES
RBOF scrap metal	ES**	ES		ES
Spent melts from Building 232-H*			$1x10^{-5}$	$2x10^{-2}$
Analytical Samples				
100-Area routine samples			$6.8x10^{-3}$	11
Routine samples - 200-H Area to 200-F Area (See Note)	$2.7x10^{-6}$	$2.7x10^{-5}$		143
Other samples on H-Area sample truck	$7.2x10^{-7}$	$7.2x10^{-6}$		37

TABLE I-16. Risk Release Calculations by Operation (Continued)

Description of Shipment	Expected Release Values α, Ci/yr	β-γ, Ci/yr	T, Ci/yr	MPI/yr
Unshielded Tank Trailers (See Note)				
100-C Area to Building 211-F	1×10^{-6}	5×10^{-5}		65
Basin sludge 100 Areas to Building 241-F in bottom dumping trailer	5×10^{-5}	5×10^{-3}		3.5×10^{3}
Building 776-A low-level wastes	6×10^{-6}	6×10^{-6}		300
Shielded Tanks on Trailers				
High-level waste trailer (See Note) Building 776-A to Building 211-F	4×10^{-7}	8×10^{-7}		20
Solvent Trailer	1×10^{-8}	1×10^{-6}		0.6
100-Areas deionizer casks		2×10^{-4}		20
Product Offsite Shipments*				
Casks containing alpha products	$<4 \times 10^{-8}$			2
Packages containing tritium			$<7 \times 10^{-4}$	1
UNH trailers (See Note)	1.3×10^{-5}	1.3×10^{-3}		187
Liquids for Reprocessing				
D_2O in drums (See Note)			6.2×10^{-2}	100
Neptunium solution 200-F to 200-F Areas	3×10^{-8}			0.9

TABLE I-16. Risk Release Calculations by Operation (Continued)

Description of Shipment	Expected Release Values α, Ci/yr	β-γ, Ci/yr	T, Ci/yr	MPI/yr
Solid Products for Fabrication or Experiments				
Neptunium-aluminum, plutonium-aluminum, and uranium-aluminum billets	2.8×10^{-6}			160
Neptunium oxide HB to Building 235-F	1.2×10^{-7}			3.6
Pu-239 oxide to Building 235-F and Building 773 A	2.6×10^{-9}			0.2
Pu-238 oxide HB to Building 773-A	2.6×10^{-7}			13
Small packages neptunium or plutonium oxides on 200-H Area sample truck	1.8×10^{-7}			9
Small casks on stake-body truck (See Note)	2×10^{-6}			100
Unirradiated fuel elements* (including criticality potential)	ES	ES	ES	ES
Miscellaneous				
A-Line product to storage	ES	ES	ES	ES
Radioactive items on nonradioactive vehicles and controls are noneffective	10^{-7}	Not estimated	Not estimated	5

TABLE I-16. **Risk Release Calculations by Operation** (Continued)

Description of Shipment	Expected Release Values α, Ci/yr	β-γ, Ci/yr	T, Ci/yr	MPI/yr
Radioactivity into Upper Three Runs Creek (low- and high-level waste trailers from Building 736-A and H-Area sample truck to Building 773-A)	3.2×10^{-7}	8.4×10^{-7}		15
Rail				
Irradiated fuel element casks*	5×10^{-9}	2×10^{-6}	8×10^{-4}	2
Wastes and obsolete equipment	6×10^{-8}	6×10^{-4}		63
Offplant shipments				
Outgoing (very few)	ES	ES	ES	ES
Incoming	ES	ES	ES	ES
Totals	8.1×10^{-5}	7.5×10^{-3}	7.0×10^{-2}	4.9×10^{3}

* Frequency of shipments and analysis of risk will be documented in a classified supplement to this SAR.
** ES - extremely small

† (U) means radioactivity of uranium radionuclides.

NOTE: Because of the relative values of the hazard index, Maximum Permissible Intake/year (MPI/yr), accidents analyzed were those that would potentially involve these noted shipments.

TABLE I-17. Distances Between Areas (from the SRP Site Map)

Trip Description	Distancce, mile	
100-K Area to Burial Ground	8-1/2	
100-C Area to 100-K Area	4	
100-C Area to 100-P Area	8-1/2	
100-K Area to 100-P Area	8	
100-K Area to Building 232-H	6-3/4	Average 6.5
100-C Area to Building 232-H	4-1/2	
100-P Area to Building 232-H	8-1/4	
F Area to 100-K, 100-C Area, and 100-P Area	3/4 greater than the distance to Building 232-H	
300-M Area to 100-P Area	15-1/4	Average 13
300-M Area to 100-C Area	10-1/2	
300-M Area to 100-K Area	13	
Building 241-F to 100-C Area	5-3/8	
400 Area to 100-P Area	13-1/4	
400 Area to 100-C Area	9-1/2	
400 Area to 100-K Area	7	
Maximum trip 100-K Area to 100-C Area to 100-P Area to 400 Area	25	
UNH Trailer to weight station	10	
Building 773-A trailers to Building 221-F	7-3/4	
Building 772-F to Building 773-A	7-1/2	
200-H Area to Building 772-F; samples, etc., also 200-F Area to 200-H Area, neptunium solution	2-1/2	
200-H Area to Building 235-F	2-3/4	

TABLE I-17. Distances Between Areas (from the SRP Site Map) (Continued)

Trip Description	Distance, mile
Building 235-F to Building 321-M	7-1/2
Building 777-M to 400-Area	11
Building 777-M to Building 710-U	4
Plant boundary toward Jackson, SC by highway	
100-F Area	13-3/4
100-C Area	9
100-K Area	11-1/2
200-F Area	9-1/4
200-H Area	9-1/4
3/700 Area	3-3/8
<u>Solvent Trailers</u>	
200-F Area to Burial Ground	2-1/4
200-H Area to Burial Ground	1-3/4
Building 773-A to 200-H Area	9-3/8 RBOF 9-3/4 south loading dock
Building 773-A to Burial Ground	8
Building 773-A to Building 221-F	7-1/4
200-F Area to Burial Ground	2
200-H Area to Burial Ground	1-1/2
Building 773-A to Building 221-F to Building 221-H to Burial Ground	12
200-F Area to 200-H Area to Burial Ground	5
<u>Rail</u>	
100-C Area to 200-H Area	10-1/2

TABLE I-17. Distances Between Areas (from the SRP Site Map) (Continued)

Trip Description	Distance, mile
100-C Area to 200-F Area	13-1/4
100-K Area to 200-H Area	11-1/2
100-K Area to 200-F Area	14-1/4
100-P Area to 200-H Area	9-1/2
100-P Area to 200-F Area	12-1/4
Average of the three areas to 200-H Area	10-1/2
Overall average of rail trips	12

APPENDIX J

METEOROLOGICAL DISPERSION FACTORS

SAFETY ANALYSIS

(Appendix to Chapter 5.0)

APPENDIX J. METEOROLOGICAL DISPERSION FACTORS

The meteorological dispersion factors used to perform the dose calculations for accident consequences are explained in this Addendum. For a more detailed explanation of procedures, computer codes, and parties involved refer to A. J. Garrett and D. D. Hoel's June 4, 1982, Technical Division Savannah River Laboratory (SRL) Memorandum DPST-82-512, which is addressed to T. V. Crawford. For documentation of the adjustments to the meteorological data taken at the SRP, see D. D. Hoel and S. J. Garrett's August 6, 1982, memorandum to T. V. Crawford: "Wind rose statistics used in the L-Reactor SAR Calculations" (no document number given). Memorandum DPST-82-512 is summarized below.

For 5 years (1975-1979) a series of samples were collected of 5-second bursts of wind data from the C, K, P, F, and H Areas 61 m meteorological towers. The samples generated information on wind speed and wind direction. Standard deviations of the fluctuations in the horizontal and vertical wind components were then calculated based on 15-minute averages.

The data and calculations have been checked, and limiting values were used to screen problem data sets. Many of the data were rejected, with the result that about 3.3 years (67%) of good data were selected by the quality assurance codes for use from the 5 years of records for all towers.

These data were originally gathered for use in the SRP WIND Emergency Response System and now are archived for use in research and safety analysis applications. During the process of gathering the data, several computer codes were written to insure the quality of and manipulate the data.

One such computer code, called WINDROSE, statistically manipulated the data that is reflected in the Wind Rose Data Plots seen in the Addendum to this Appendix.

For the SAR, 1- and 2-hour averages of the 15-minute data were required both for the dose calculations and for model validation. Since the averaging procedure differs according to the variable, it is described in detail below.

The 15-minute averages, from which the 1- and 2-hour averages were derived, are defined by the following equations. The 15-minute average wind direction is

$$\theta_i = \frac{1}{J} \sum_{j=1}^{J} \theta_j , \qquad (1)$$

where J is the number of observed wind directions, θ_j. The wind speed is defined in the same manner as in Equation 3 below. The standard deviation of the horizontal wind fluctuations is defined as

$$\sigma_{\theta i} = \left[\frac{1}{J} \sum_{j=1}^{K} \theta_j^2 - \left(\frac{1}{J} \sum_{j=1}^{J} \theta_j \right)^2 \right]^{1/2}. \qquad (2)$$

A similar equations, obtained by replacing θ_j by ϕ_j in Equation 2, is used for the standard deviation of the vertical wind fluctuations, $\sigma_{\theta j}$. The notation, ϕ, represents the departure of the total wind velocity vector from the horizontal plane.

For the 1- and 2-hour averages, the simplest variable to average is U, the scalar wind speed. If N is the number of 15-minute averages, and $\overline{U}$ is the 1- or 2-hour average, then

$$\overline{U} = \frac{1}{N} \sum_{i=1}^{N} U_i. \qquad (3)$$

Average wind direction must be computed by breaking the average wind vectors for a 15-minute period into u and v scalar components such that

$$u_i = U_i \cos \theta_i$$

$$v_i = U_i \sin \theta_i, \qquad (4)$$

where θ_i is the average wind direction for the 15-minute period--thus,

$$\overline{u} = \frac{1}{N} \sum_{i=1}^{N} u_i$$

$$\overline{v} = \frac{1}{N} \sum_{i=1}^{N} v_i. \qquad (5)$$

The average components are recombined to give the mean wind direction $\overline{\theta}$ over a 1- or 2-hour period as

$$\overline{\theta} = \tan^{-1} \left(\frac{\overline{v}}{\overline{u}} \right) \qquad (6)$$

The standard deviations of the fluctuations in the horizontal and vertical components of the wind direction, σ_θ and σ_ϕ, computed as described by Garrett and Murphy[1] must be averaged in a way that includes the meander of the mean wind over successive 15-minute intervals. That is, the contributions of variations of θ_i ($i = 1, 2, \ldots N$) to $\overline{\sigma}_\theta$ must be included. It can be shown that $\overline{\sigma}_\theta$ is defined by

$$\bar{\sigma}_{\kappa} = \left(\frac{1}{N} \sum_{i=1}^{N} [\sigma_{\theta i}^{2} + (\bar{\theta} - \theta_{i})^{2}] \right)^{1/2}. \quad (7)$$

Equation 5 is used to find σ_ϕ simply by replacing θ by ϕ. Although the average vertical components of the wind direction is zero over long time periods over flat terrain, it can be significantly different from zero over 15-minute intervals, so Equation 7 must be used.

Note that atmospheric stability is computed using σ_θ and σ_ϕ rather than dT/dz[2] since direct measurement of σ_θ and σ_ϕ is more accurate than estimating atmospheric stability from dT/dz.

Pasquill stability wind roses for 2-hour averaged meteorological data, which is used as input for the computer codes, shown here for the D, K, P, F, and H production areas on the Savannah River Plant. The SRP site map in Figure 1 shows the relative locations of each of these areas. For each of these areas, nine wind rose plots are included--one for each of the seven Pasquill stability classes, one for data that could not be classified into a particular stability class, and an overall summary rose that includes all stabilities. The Pasquill stabilities determined from σ_θ (or σ_ϕ if σ_θ is not available) by Pendergast[3] for SRP are as shown in Table 1.

TABLE 1. Pasquill Stability Wind Rose

Pasquill Stability	Turbulence Limits		Classification
A	$\sigma_\theta \geq 23$	$\sigma_\phi \geq 12$	Extremely Unstable
B	$18 \leq \sigma_\theta < 23$	$9 < \sigma_\phi \leq 12$	Moderately Unstable
C	$13 \leq \sigma_\theta < 18$	$7 < \sigma_\phi \leq 9$	Slightly Unstable
D	$8 \leq \sigma_\theta < 13$	$4 < \sigma_\phi \leq 7$	Neutral
E	$4 \leq \sigma_\theta < 8$	$2 < \sigma_\phi \leq 4$	Slightly Stable
F	$2 \leq \sigma_\theta < 4$	$1 < \sigma_\phi \leq 2$	Moderately Stable
G	$\sigma_\theta < 2$	$\sigma_\phi \leq 1$	Extremely Stable

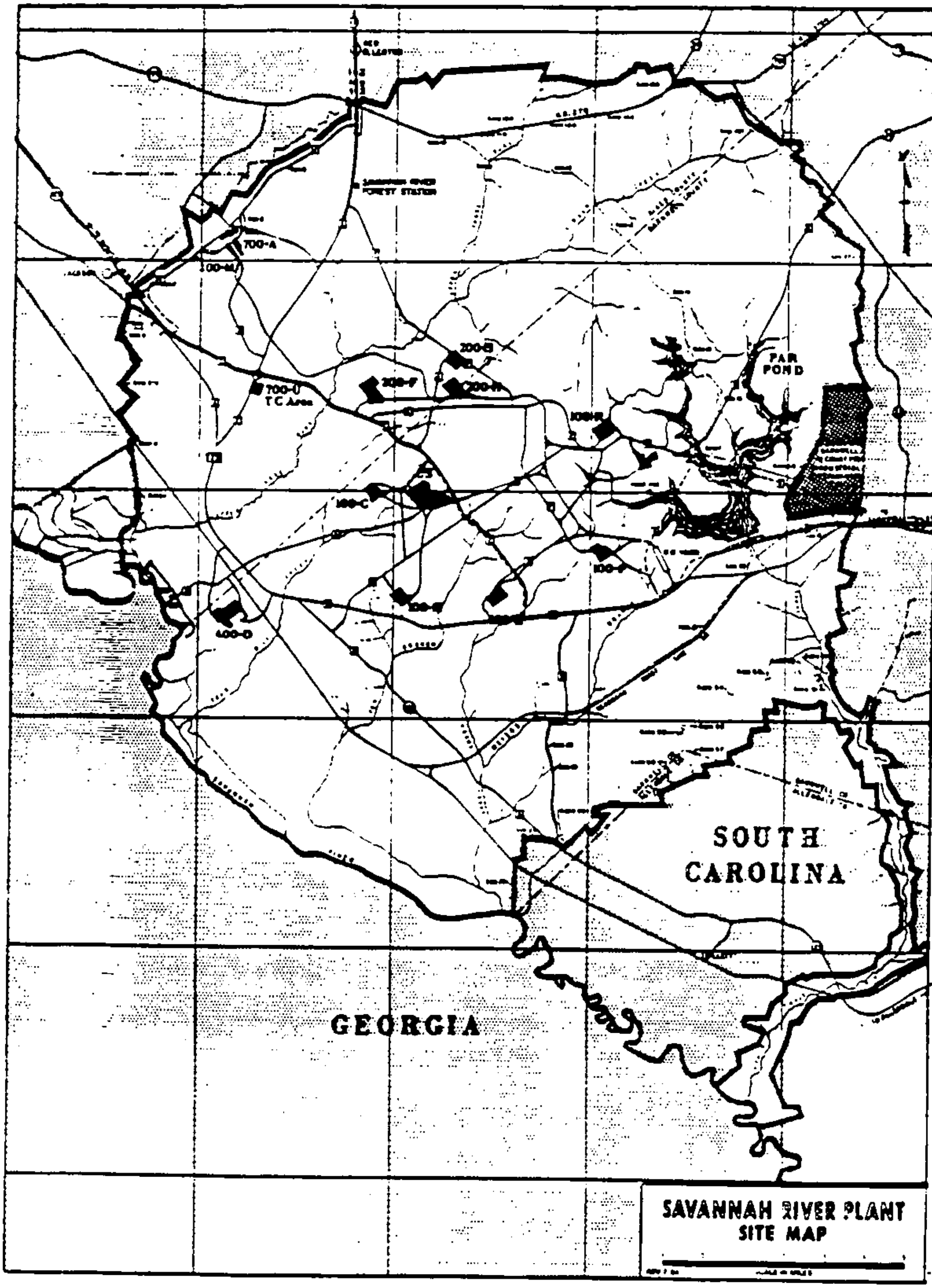


FIGURE 1. Savannah River Plant Site Map

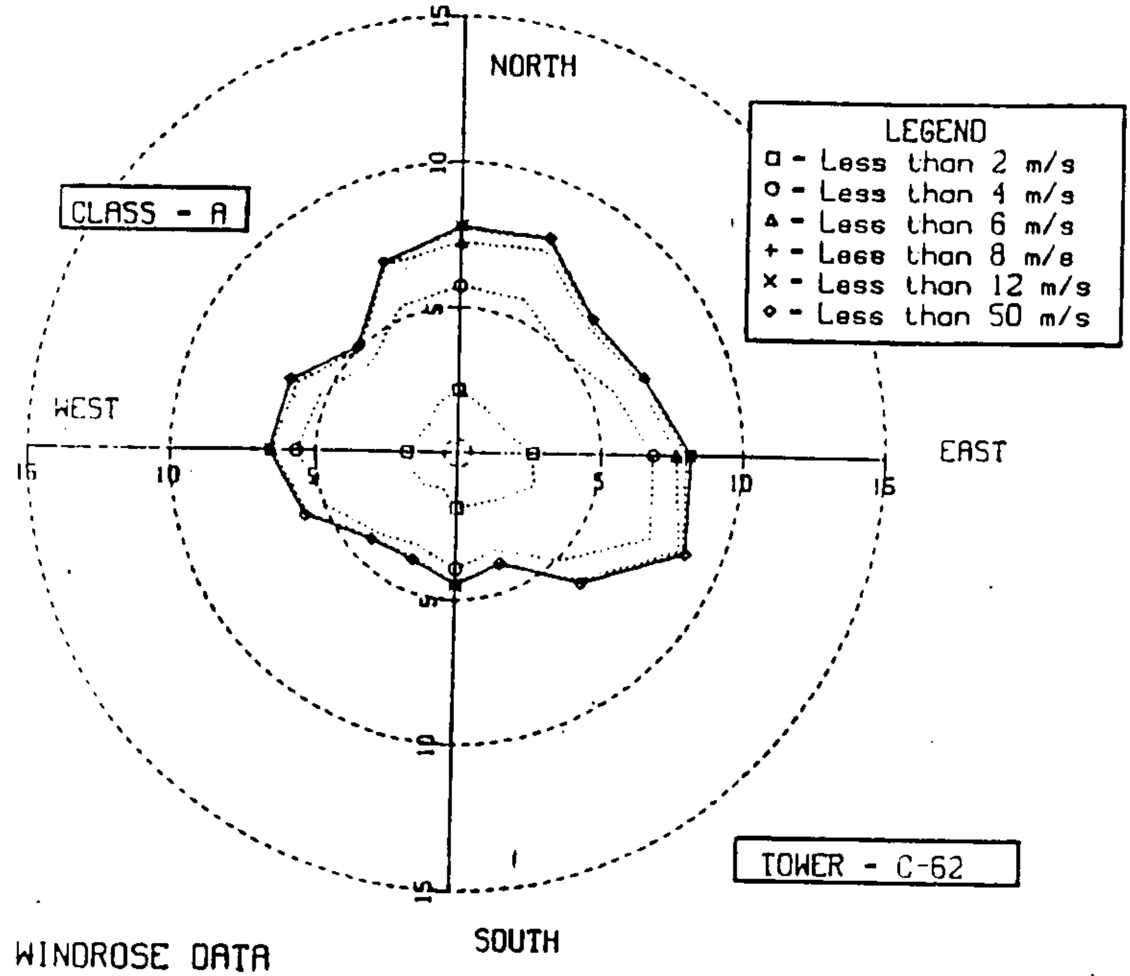
REFERENCES

1. Garrett, A. J. and Murphy, C. E., Jr. A Puff-Plume Atmospheric Deposition Model for Use at SRP in Emergency Response Situations. U.S. DOE Report DP-1595. Savannah River Laboratory, Aiken, SC, 29808.

2. Pendergast, M. M. and Crawford, T. V. Actual Standard Deviations of Vertical and Horizontal Wind Directions Compared to Estimates from Other Measurements. Symposium on Atmospheric Diffusion and Air Pollution, Santa Barbara, CA, September 9-13, 1974, pages 1-6.

3. Pendergast, M. M. Existing Diffusion Coefficients for Meteorological Data. U.S. DOE Report DP-MS-76-64. Savannah River Laboratory, Aiken, SC, 29808.

C-AREA TOWER 1975-1979



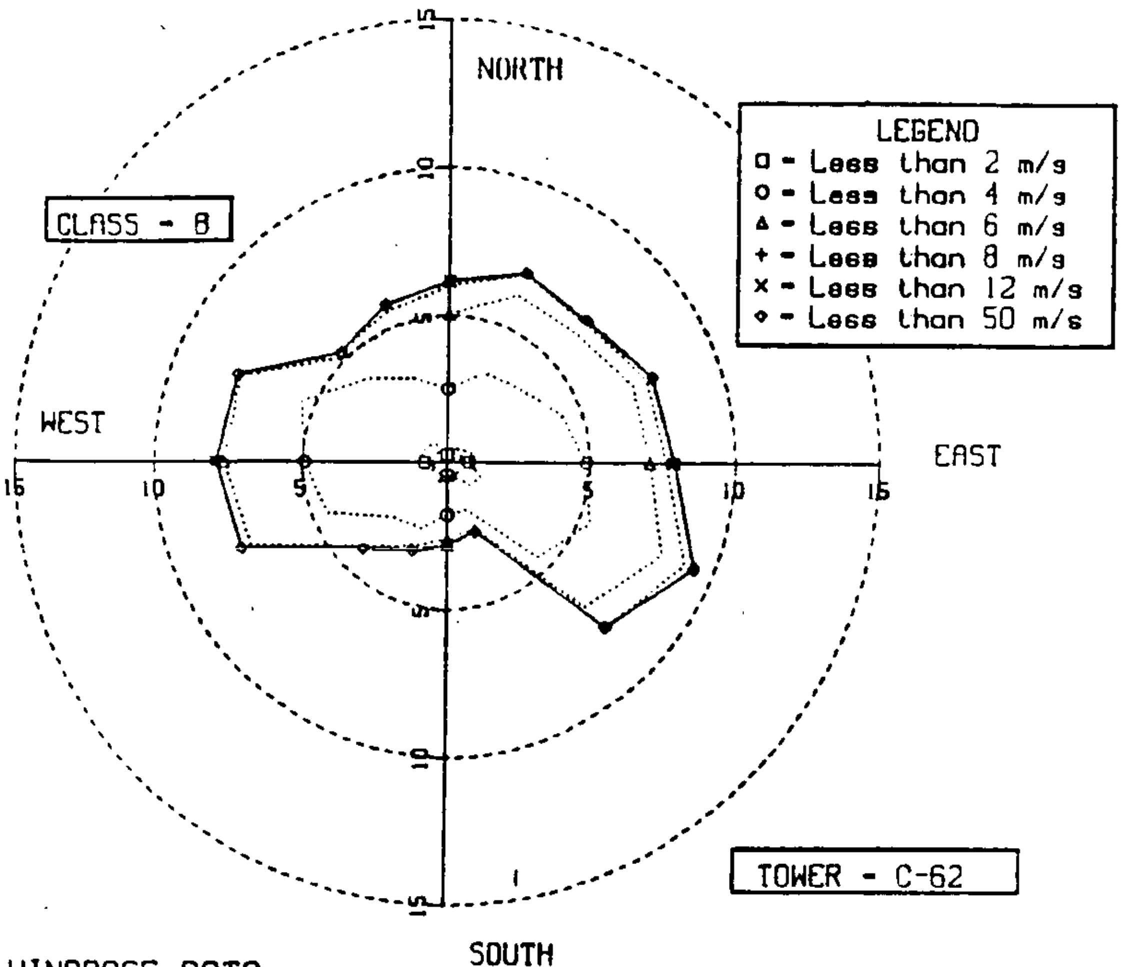
WINDROSE DATA

MINIMUM DATE MMDDYY 10175
MINIMUM TIME ZULU 0000
ENTRIES ALL CLASSES 14725

MAXIMUM DATE MMDDYY 123179
MAXIMUM TIME ZULU 2400
ENTRIES THIS CLASS 3118

DIRECTION	SPEED IN METERS/SEC 0-2	2-4	4-6	6-8	8-12	>12	AVERAGE SPEED	TOTAL TOT	PERCENT TIME WIND @ SPEED 0-2	2-4	4-6	6-8	8-12	>12	TOTAL
N	59	64	15	2	0	0	1.87	140	1.89	2.05	.48	.06	0.00	0.00	4.49
NNE	41	66	14	2	0	0	1.93	123	1.32	2.12	.45	.06	0.00	0.00	3.95
NE	50	72	8	2	0	0	1.83	132	1.60	2.31	.26	.06	0.00	0.00	4.24
ENE	52	101	22	3	1	0	2.20	178	1.67	3.24	.71	.09	.03	0.00	5.74
E	55	122	27	2	0	0	2.24	208	1.77	3.92	.87	.06	0.00	0.00	6.61
ESE	45	118	28	7	1	0	2.23	198	1.44	3.79	.90	.22	.03	0.00	6.39
SE	44	92	18	4	0	0	2.21	158	1.41	2.95	.58	.13	0.00	0.00	5.07
SSE	58	111	47	3	1	0	2.37	220	1.88	3.58	1.51	.09	.03	0.00	7.08
S	60	111	48	14	3	0	2.32	244	2.18	3.58	1.54	.45	.09	0.00	7.83
SSW	58	121	58	12	2	0	2.42	251	1.88	3.88	1.86	.39	.06	0.00	8.06
SW	56	100	39	5	4	0	2.38	204	1.80	3.21	1.25	.18	.13	0.00	6.55
WSW	59	123	31	5	1	0	2.21	218	1.88	3.85	.89	.16	.03	0.00	7.00
W	81	132	25	11	4	1	2.01	254	2.60	4.24	.80	.35	.13	.03	8.15
WNW	89	140	33	5	3	0	2.01	270	2.88	4.49	1.06	.16	.09	0.00	8.66
NW	67	92	28	4	1	0	2.14	192	2.15	2.95	.90	.13	.03	0.00	6.16
NNW	58	53	15	0	0	0	1.63	126	1.88	1.70	.48	0.00	0.00	0.00	4.04
NO DIRECT	0	0	0	0	0	0	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	4.49
AVG SPEED	1.55	2.77	4.71	6.60	9.11	12.15	2.16								
TOT ENTRY	991	1618	456	81	21	1		3118							

C-AREA TOWER 1975-1979



WINDROSE DATA

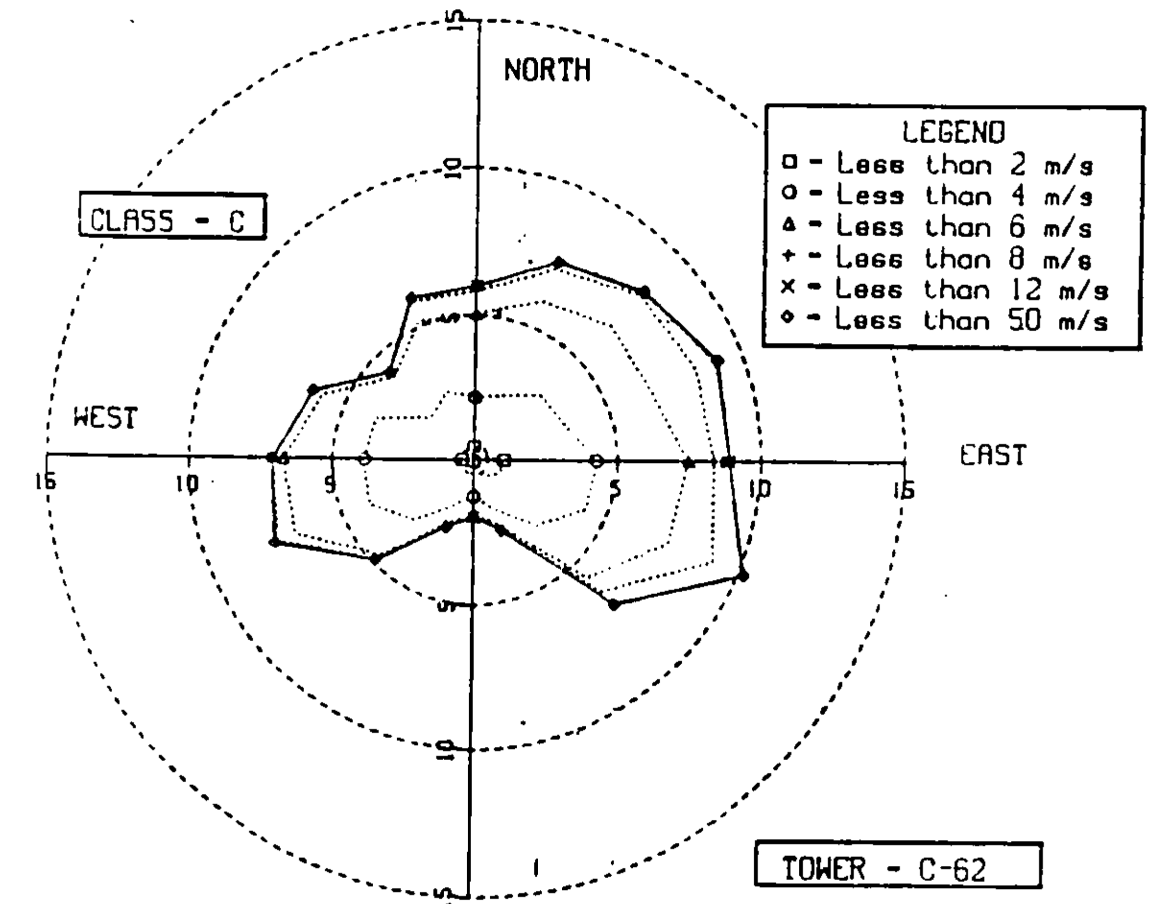
MINIMUM DATE MMDDYY 10175
MINIMUM TIME ZULU 0000
ENTRIES ALL CLASSES 14725

MAXIMUM DATE MMDDYY 123179
MAXIMUM TIME ZULU 2400
ENTRIES THIS CLASS 1741

DIRECTION	0-2	2-4	4-6	6-8	8-12	>12	AVERAGE SPEED	TOTAL TOT
	SPEED IN METERS/SEC							
N	8	23	14	4	0	0	2.47	49
NNE	14	28	11	3	0	0	2.35	56
NE	8	38	24	2	0	0	2.94	72
ENE	13	65	49	6	0	0	3.08	133
E	14	72	47	4	1	0	3.00	138
ESE	17	78	39	2	0	0	2.72	136
SE	15	55	18	4	0	0	2.53	92
SSE	12	42	33	10	4	0	3.13	101
S	5	39	44	17	3	0	3.71	108
SSW	10	48	50	13	1	0	3.45	122
SW	11	51	47	8	2	0	3.21	119
WSW	16	59	48	9	4	0	3.04	131
W	13	72	38	10	5	0	3.23	138
WNW	22	72	47	15	6	0	2.87	162
NW	19	59	42	17	0	0	2.65	137
NNW	9	21	12	2	0	0	2.32	44
NO DIRECT	0	0	0	0	0	0	0.00	0
AVG SPEED	1.21	2.98	4.74	6.66	8.97	0.00	2.98	
TOT ENTRY	[illegible]	[illegible]	561	128	28	0		1741

DIRECTION	0-2	2-4	4-6	6-8	8-12	>12	TOTAL
	PERCENT TIME WIND'S SPEED						
N	.46	1.32	.80	.23	0.00	0.00	2.81
NNE	.80	1.61	.63	.17	0.00	0.00	3.22
NE	.46	2.18	1.38	.11	0.00	0.00	4.14
ENE	.75	3.73	2.81	.34	0.00	0.00	7.84
E	.80	4.14	2.70	.23	.05	0.00	7.93
ESE	.98	4.48	2.24	.11	0.00	0.00	7.81
SE	.86	3.16	1.03	.23	0.00	0.00	5.28
SSE	.69	2.41	1.90	.57	.23	0.00	5.80
S	.29	2.24	2.53	.98	.17	0.00	6.20
SSW	.57	2.76	2.87	.75	.05	0.00	7.01
SW	.63	2.93	2.70	.46	.11	0.00	6.84
WSW	.92	3.39	2.64	.52	.23	0.00	7.70
W	.75	4.14	2.18	.57	.29	0.00	7.93
WNW	1.26	4.14	2.70	.86	.34	0.00	9.30
NW	1.09	3.39	2.41	.98	0.00	0.00	7.87
NNW	.52	1.21	.69	.11	0.00	0.00	2.53
NO DIRECT	0.00	0.00	0.00	0.00	0.00	0.00	2.81

C-AREA TOWER 1975-1979



WINOROSE DATA

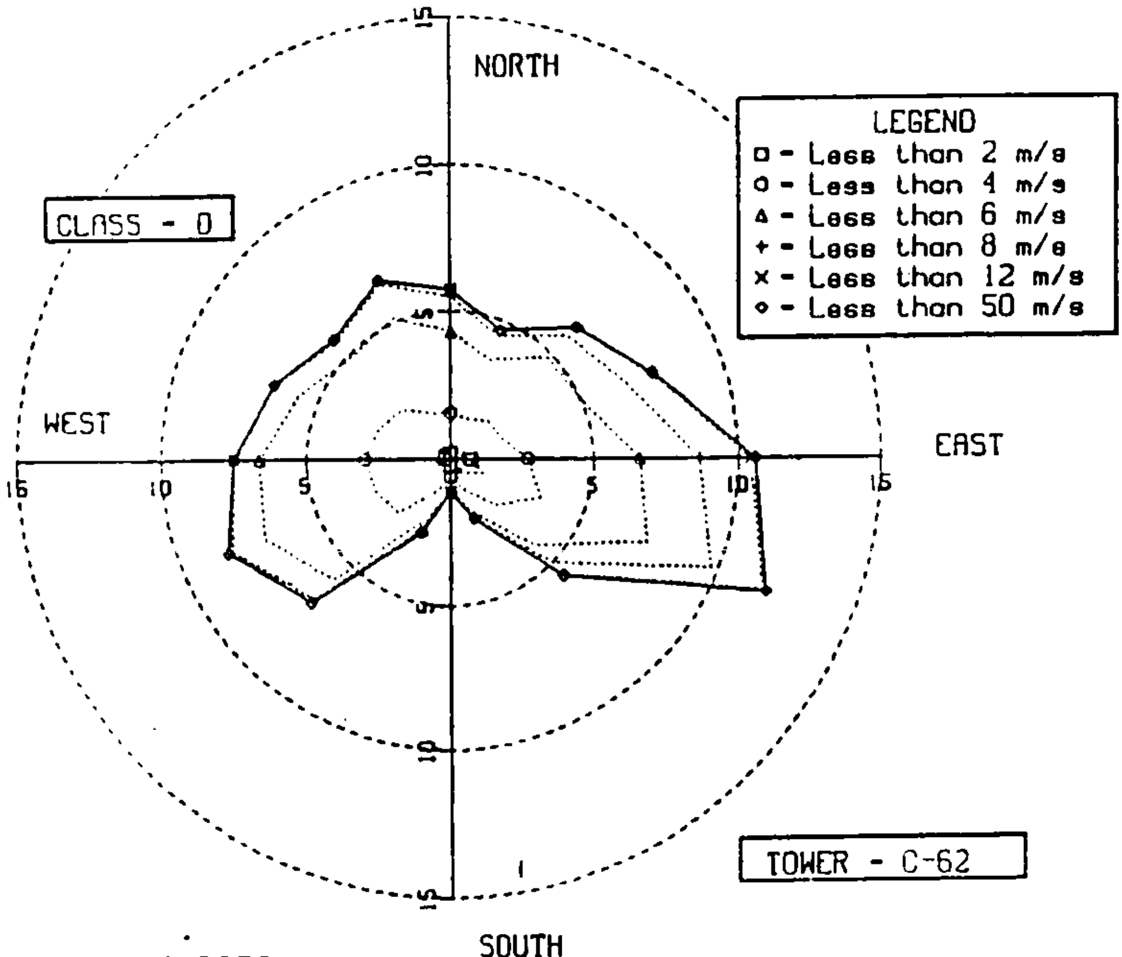
MINIMUM DATE MMDDYY 10179
MINIMUM TIME ZULU 0000
ENTRIES ALL CLASSES 14725

DIRECTION	0-2	2-4	4-6	6-8	8-12	>12	AVERAGE SPEED	TOTAL TOT
	SPEED IN METERS/SEC							
N	1	30	15	3	0	0	3.45	49
NNE	9	32	17	4	0	0	2.90	62
NE	12	61	43	6	1	0	3.23	123
ENE	14	88	71	17	3	0	3.48	191
E	11	87	72	9	1	0	3.31	180
ESE	10	86	51	9	0	0	3.31	156
SE	12	42	48	6	0	0	3.30	108
SSE	12	53	68	18	3	0	3.63	152
S	13	42	73	19	5	0	3.69	152
SSW	7	55	88	30	7	0	3.93	187
SW	18	65	88	37	4	0	3.61	208
WSW	10	75	81	43	18	2	4.05	229
W	27	81	79	23	14	0	2.98	224
WNW	26	81	78	42	29	1	3.34	257
NW	19	60	64	17	16	0	3.26	176
NNW	13	31	18	4	1	0	2.50	65
NO DIRECT	0	0	0	0	0	0	0.00	0
AVG SPEED	1.26	3.02	4.80	6.73	9.08	14.77	3.41	
TOT ENTRY	[illegible]	967	948	287	102	3		2519

MAXIMUM DATE MMDDYY 123179
MAXIMUM TIME ZULU 2400
ENTRIES THIS CLASS 2519

DIRECTION	0-2	2-4	4-6	6-8	8-12	>12	TOTAL
	PERCENT TIME WIND'S SPEED						
N	.04	1.19	.60	.12	0.00	0.00	1.95
NNE	.36	1.27	.67	.16	0.00	0.00	2.46
NE	.48	2.42	1.71	.24	.04	0.00	4.88
ENE	.56	3.41	2.82	.67	.12	0.00	7.58
E	.44	3.45	2.86	.36	.04	0.00	7.15
ESE	.40	3.41	2.02	.36	0.00	0.00	6.19
SE	.48	1.67	1.91	.24	0.00	0.00	4.29
SSE	.48	2.10	2.62	.71	.12	0.00	6.03
S	.52	1.67	2.90	.75	.20	0.00	6.03
SSW	.28	2.18	3.49	1.19	.28	0.00	7.42
SW	.84	2.58	3.41	1.47	.16	0.00	8.26
WSW	.40	2.98	3.22	1.71	.71	.07	9.09
W	1.07	3.22	3.14	.91	.56	0.00	8.89
WNW	1.03	3.22	3.10	1.67	1.15	.04	10.20
NW	.75	2.38	2.54	.67	.64	0.00	6.99
NNW	.52	1.23	.84	.16	.04	0.00	2.58
NO DIRECT	0.00	0.00	0.00	0.00	0.00	0.00	1.85

C-AREA TOWER 1975-1979



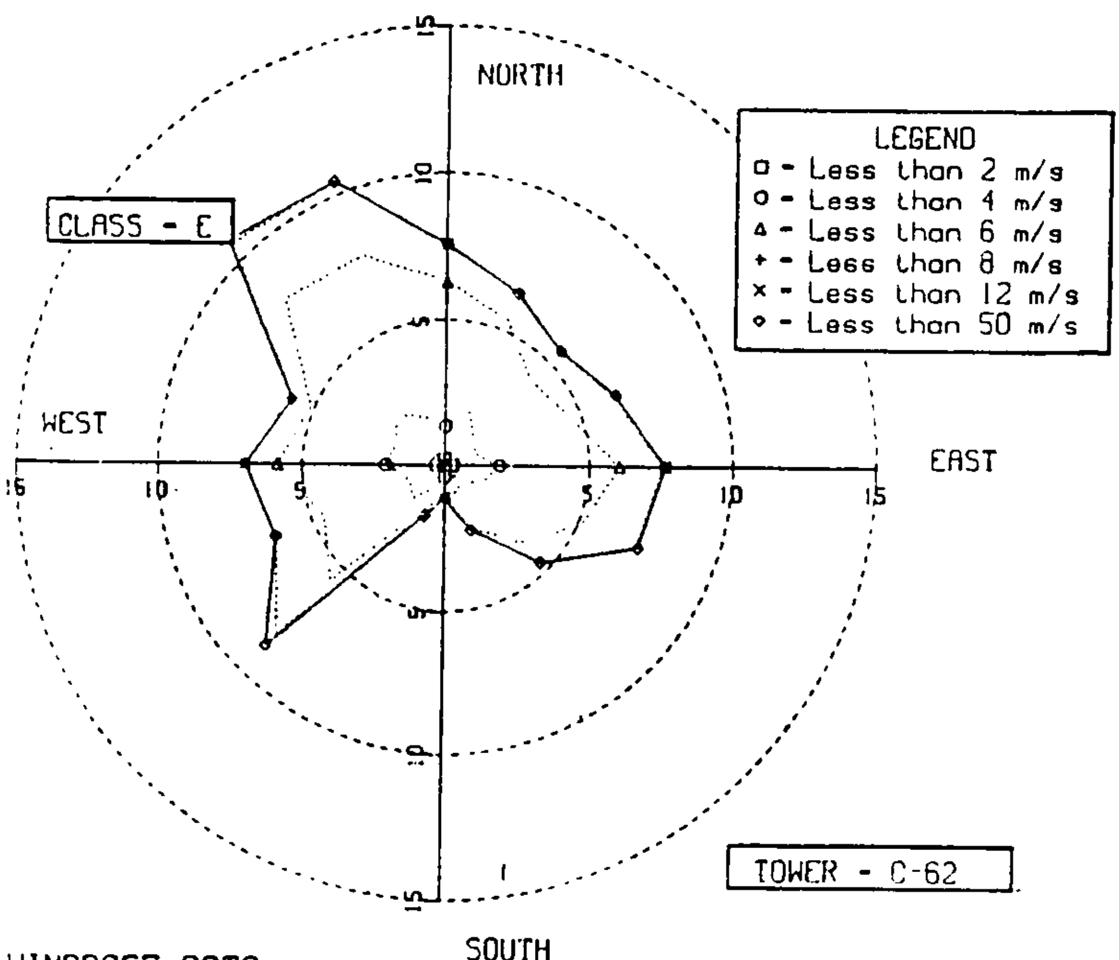
WINDROSE DATA

MINIMUM DATE MMDDYY 10175
MINIMUM TIME ZULU 0000
ENTRIES ALL CLASSES 14725

MAXIMUM DATE MMDDYY 123179
MAXIMUM TIME ZULU 2400
ENTRIES THIS CLASS 4181

DIRECTION	SPEED IN METERS/SEC 0-2	2-4	4-6	6-8	8-12	>12	AVERAGE SPEED	TOTAL TOT	PERCENT TIME WIND @ SPEED 0-2	2-4	4-6	6-8	8-12	>12	TOTAL
N	10	15	22	0	0	0	2.24	47	.24	.36	.53	0.00	0.00	0.00	1.12
NNE	7	42	43	18	4	0	3.81	112	.17	1.00	1.03	.38	.09	0.00	2.68
NE	8	100	134	38	6	1	3.98	287	.19	2.39	3.20	.91	.14	.02	6.86
ENE	23	95	174	50	3	4	3.67	349	.55	2.27	4.16	1.20	.07	.09	8.35
E	9	116	153	36	1	0	3.85	315	.22	2.77	3.66	.86	.02	0.00	7.53
ESE	11	102	125	38	1	0	3.77	277	.26	2.44	2.99	.91	.02	0.00	6.63
SE	8	92	104	31	4	0	3.90	239	.19	2.20	2.49	.74	.09	0.00	5.72
SSE	12	59	144	53	6	0	4.00	274	.29	1.41	3.44	1.27	.14	0.00	6.55
S	9	58	113	50	11	0	4.35	241	.22	1.39	2.70	1.20	.26	0.00	5.76
SSW	2	60	90	35	9	0	4.48	196	.04	1.44	2.15	.84	.22	0.00	4.69
SW	7	71	124	42	17	0	4.18	261	.17	1.70	2.97	1.00	.41	0.00	6.24
WSW	4	77	130	67	37	2	4.65	317	.09	1.84	3.11	1.60	.88	.04	7.58
W	30	84	162	85	76	6	4.11	443	.72	2.01	3.87	2.03	1.82	.14	10.60
WNW	51	91	167	99	82	6	3.11	496	1.22	2.18	3.99	2.37	1.96	.14	11.86
NW	27	67	78	36	25	2	2.89	235	.65	1.60	1.87	.86	.60	.04	5.62
NNW	16	29	35	10	2	0	2.87	92	.38	.69	.84	.24	.04	0.00	2.20
NO DIRECT	0	0	0	0	0	0	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	1.12
AVG SPEED	.96	3.13	4.87	6.70	9.13	13.57	3.74								
TOT ENTRY	[illegible]	1150	1798	[illegible]	[illegible]	21		4181							

C-AREA TOWER 1975-1979



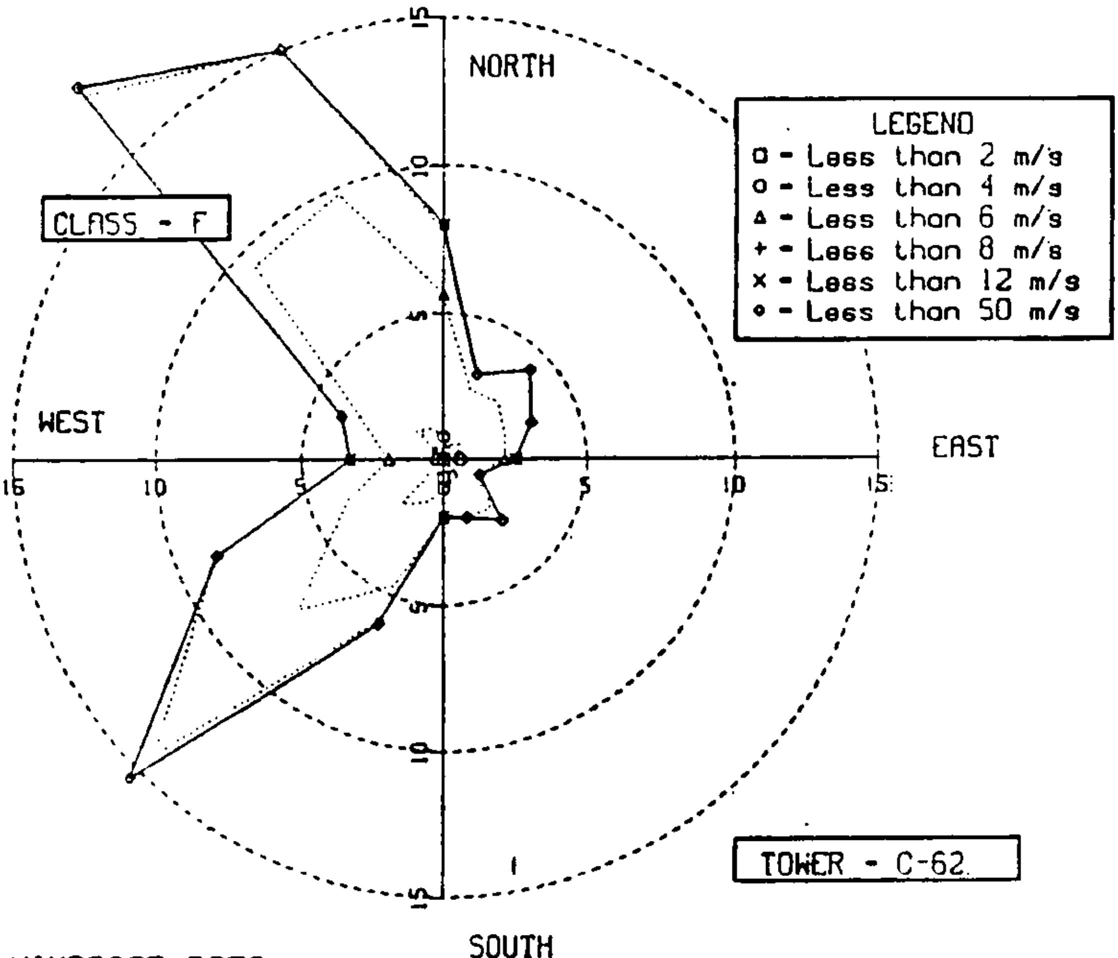
WINOROSE DATA

MINIMUM DATE MMDDYY 10175
MINIMUM TIME ZULU 0000
ENTRIES ALL CLASSES 14725

MAXIMUM DATE MMDDYY 123179
MAXIMUM TIME ZULU 2100
ENTRIES THIS CLASS 2534

	SPEED IN METERS/SEC						AVERAGE	TOTAL	PERCENT TIME WIND @ SPEED						
DIRECTION	0-2	2-4	4-6	6-8	8-12	>12	SPEED	TOT	0-2	2-4	4-6	6-8	8-12	>12	TOTAL
N	3	7	16	2	0	0	2.06	28	.12	.38	63	.07	0.00	0.00	1.10
NNE	2	19	17	8	1	0	3.72	47	.07	.75	.67	32	03	0.00	1.85
NE	4	35	103	66	14	0	4.77	222	.16	1.38	4.08	2.60	.55	0.00	8.76
ENE	7	27	82	46	0	0	4.25	162	.28	1.07	3.24	1.82	0.00	0.00	6.39
E	8	44	97	28	0	0	3.78	177	.32	1.74	3.83	1.10	0.00	0.00	6.99
ESE	2	45	83	18	0	0	4.22	148	.07	1.78	3.28	.71	0.00	0.00	5.84
SE	3	59	141	67	4	0	4.50	274	.12	2.33	5.56	2.64	.16	0.00	10.81
SSE	2	43	151	69	0	0	4.65	265	.07	1.70	5.96	2.72	0.00	0.00	10.46
S	6	28	126	31	1	0	4.50	192	.24	1.10	4.97	1.22	.03	0.00	7.58
SSW	2	50	85	25	0	0	4.25	162	.07	1.97	3.35	.99	0.00	0.00	6.39
SW	3	31	70	36	1	0	4.45	141	.12	1.22	2.76	1.42	.03	0.00	5.56
WSW	0	28	88	43	2	0	4.65	161	0.00	1.10	3.47	1.70	.07	0.00	6.35
W	6	41	106	39	2	0	4.19	194	.24	1.62	4.18	1.54	.07	0.00	7.66
WNW	8	28	94	51	2	0	3.87	183	.32	1.10	3.71	2.01	.07	0.00	7.22
NW	5	16	72	25	0	0	4.07	118	.20	.63	2.84	.99	0.00	0.00	4.66
NNW	2	23	32	3	0	0	3.81	60	.07	.91	1.26	.12	0.00	0.00	2.37
NO DIRECT	0	0	0	0	0	0	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	1.10
AVG SPEED	.65	3.22	4.95	6.57	8.47	0.00	4.38								
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]							

C-AREA TOWER 1975-1979



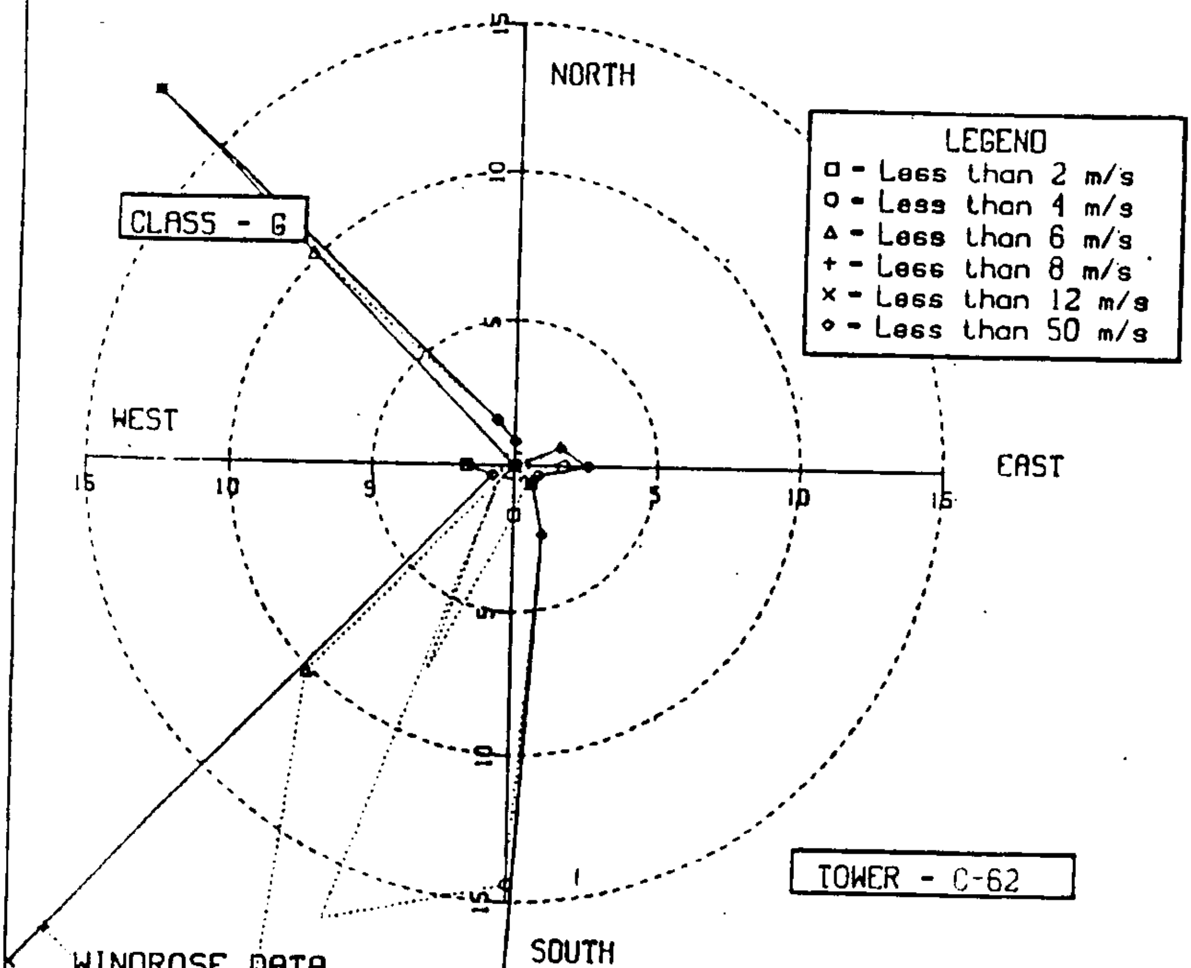
WINDROSE DATA

MINIMUM DATE MMDDYY 10175
MINIMUM TIME ZULU 0000
ENTRIES ALL CLASSES 14725

MAXIMUM DATE MMDDYY 123179
MAXIMUM TIME ZULU 2400
ENTRIES THIS CLASS 512

	SPEED IN METERS/SEC						AVERAGE	TOTAL	PERCENT TIME WIND:@ SPEED						
DIRECTION	0-2	2-4	4-6	6-8	8-12	>12	SPEED	TOT	0-2	2-4	4-6	6-8	8-12	>12	TOTAL
N	3	2	5	0	0	0	2.00	10	.59	.39	.98	0.00	0.00	0.00	1.95
NNE	0	8	16	6	1	0	4.41	31	0.00	1.56	3.13	1.17	.20	0.00	6.05
NE	1	10	26	36	6	0	5.29	79	.20	1.95	5.08	7.03	1.17	0.00	15.43
ENE	1	0	18	25	0	0	5.54	44	.20	0.00	3.52	4.88	0.00	0.00	8.59
E	1	0	9	7	0	0	5.01	17	.20	0.00	1.76	1.37	0.00	0.00	3.32
ESE	0	0	15	5	0	0	5.48	20	0.00	0.00	2.93	.98	0.00	0.00	3.91
SE	0	7	41	42	2	0	5.47	92	0.00	1.37	8.01	8.20	.39	0.00	17.97
SSE	1	5	44	27	0	0	5.15	77	.20	.98	8.59	5.27	0.00	0.00	15.04
S	0	4	25	11	1	0	5.34	41	0.00	.78	4.88	2.15	.20	0.00	8.01
SSW	1	2	10	3	0	0	3.95	16	.20	.39	1.95	.59	0.00	0.00	3.12
SW	0	4	10	8	0	0	5.20	22	0.00	.78	1.95	1.56	0.00	0.00	4.30
WSW	0	3	9	5	0	0	4.81	17	0.00	.59	1.76	.98	0.00	0.00	3.32
W	0	3	8	2	0	0	4.61	13	0.00	.59	1.56	.39	0.00	0.00	2.54
WNW	0	0	6	1	0	0	5.15	7	0.00	0.00	1.17	.20	0.00	0.00	1.37
NW	0	4	8	3	0	0	4.47	15	0.00	.78	1.56	.59	0.00	0.00	2.93
NNW	0	4	7	0	0	0	4.08	11	0.00	.78	1.37	0.00	0.00	0.00	2.15
NO DIRECT	0	0	0	0	0	0	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	1.95
AVG SPEED	1.18	3.11	5.12	6.64	8.51	0.00	4.95								
TOT ENTRY	8	56	257	101	10	0		512							

C-AREA TOWER 1975-1979



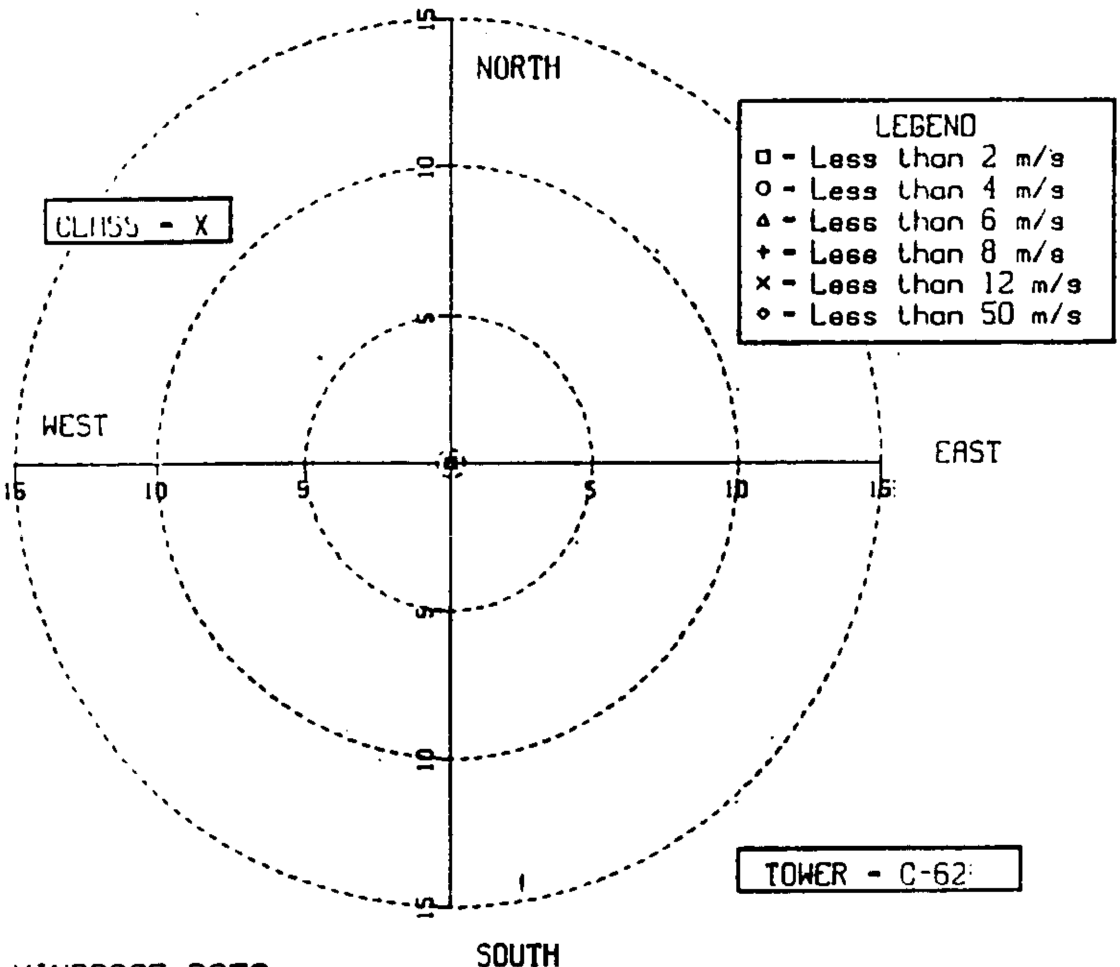
WINDROSE DATA

MINIMUM DATE MMDDYY 10175
MINIMUM TIME ZULU 0000
ENTRIES ALL CLASSES 14725

MAXIMUM DATE MMDDYY 123179
MAXIMUM TIME ZULU 2400
ENTRIES THIS CLASS 118

DIRECTION	0-2	2-4	4-6	6-8	8-12	>12	AVERAGE SPEED	TOTAL TOT	0-2	2-4	4-6	6-8	8-12	>12	TOTAL
	SPEED IN METERS/SEC								PERCENT TIME WIND @ SPEED						
N	2	15	4	0	0	0	2.19	21	1.69	12.71	3.39	0.00	0.00	0.00	17.80
NNE	9	11	9	0	1	0	2.04	30	7.63	9.32	7.63	0.00	.85	0.00	25.42
NE	1	0	11	15	2	1	5.35	30	.85	0.00	9.32	12.71	1.69	.85	25.42
ENE	0	0	0	1	0	0	6.37	1	0.00	0.00	0.00	.85	0.00	0.00	.85
E	2	0	0	0	0	0	1.79	2	1.69	0.00	0.00	0.00	0.00	0.00	1.69
ESE	0	0	0	0	0	0	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	.00
SE	0	4	8	9	0	0	5.08	21	0.00	3.39	8.78	7.63	0.00	0.00	17.80
SSE	0	0	2	0	0	0	5.31	2	0.00	0.00	1.69	0.00	0.00	0.00	1.69
S	0	0	1	0	0	0	4.58	1	0.00	0.00	.85	0.00	0.00	0.00	.85
SSW	0	0	0	0	0	0	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	.00
SW	0	0	0	0	0	0	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	.00
WSW	0	1	1	0	0	0	4.00	2	0.00	.85	.85	0.00	0.00	0.00	1.69
W	0	2	1	0	0	0	3.85	3	0.00	1.69	.85	0.00	0.00	0.00	[illegible]
WNW	0	0	0	1	0	0	6.42	1	0.00	0.00	0.00	.85	0.00	0.00	.85
NW	0	1	0	0	0	0	2.52	1	0.00	.85	0.00	0.00	0.00	0.00	.85
NNW	1	2	0	0	0	0	1.90	3	.85	1.69	0.00	0.00	0.00	0.00	2.54
NO DIRECT	0	0	0	0	0	0	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	17.00
AVG SPEED	.95	3.11	4.80	6.69	9.53	21.40	3.00								
TOT ENTRY	15	36	37	26	3	1		118							

C-AREA TOWER 1975-1979



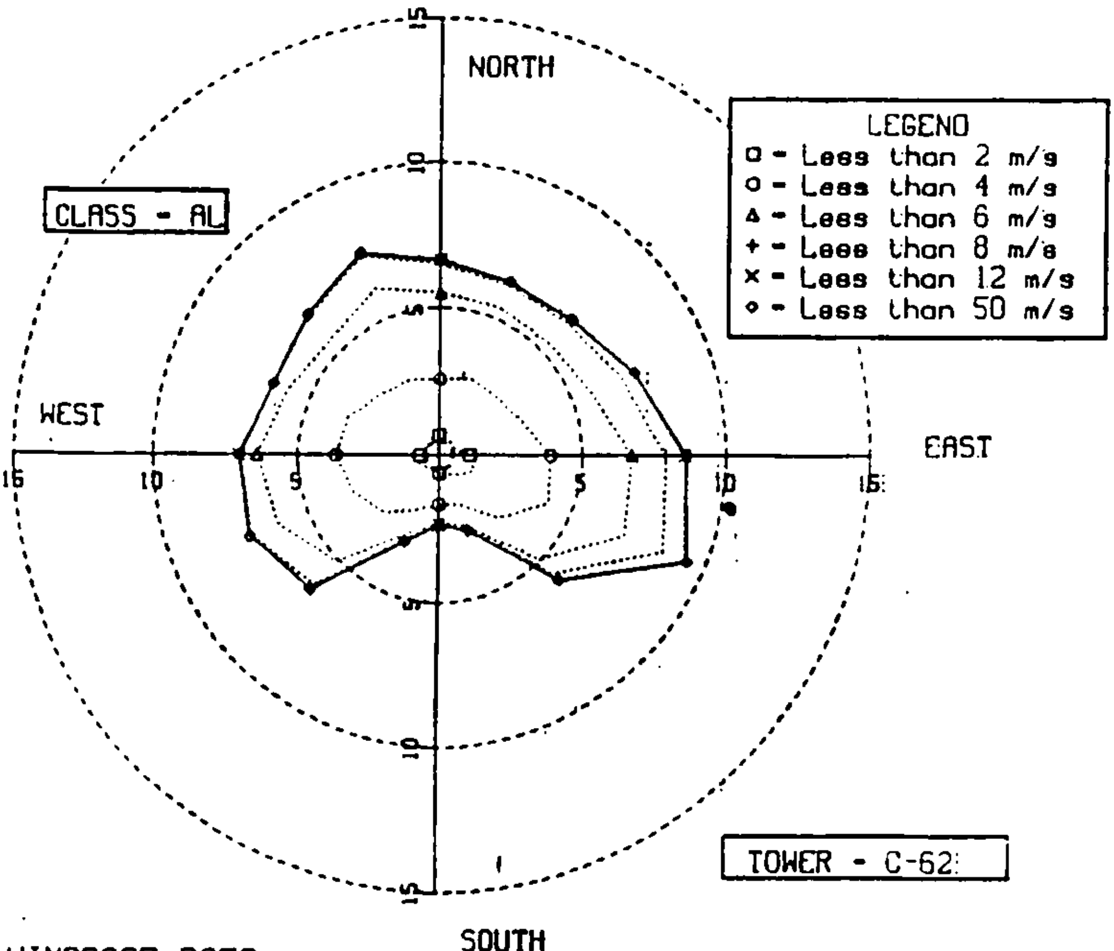
WINDROSE DATA

MINIMUM DATE MMDDYY 10175
MINIMUM TIME ZULU 0000
ENTRIES ALL CLASSES 14725

MAXIMUM DATE MMDDYY 123179
MAXIMUM TIME ZULU 2400
ENTRIES THIS CLASS 4

DIRECTION	SPEED IN METERS/SEC 0-2	2-4	4-6	6-8	8-12	>12	AVERAGE SPEED	TOTAL TOT	PERCENT TIME WIND @ SPEED 0-2	2-4	4-6	6-8	8-12	>12	TOTAL
	0	0	0	0	0	0		0	0	0	0	0	0	0	
N	0	0	0	0	0	0	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	.00
NNE	0	0	0	0	0	0	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	.00
NE	0	0	0	0	0	0	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	.00
ENE	0	0	0	0	0	0	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	.00
E	0	0	0	0	0	0	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	.00
ESE	0	0	0	0	0	0	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	.00
SE	0	0	0	0	0	0	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	.00
SSE	0	0	0	0	0	0	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	.00
S	0	0	0	0	0	0	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	.00
SSW	0	0	0	0	0	0	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	.00
SW	0	0	0	0	0	0	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	.00
WSW	0	0	0	0	0	0	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	.00
W	0	0	0	0	0	0	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	.00
WNW	0	0	0	0	0	0	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	.00
NW	0	0	0	0	0	0	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	.00
NNW	0	0	0	0	0	0	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	.00
NO DIRECT	3	0	1	0	0	0	1.34	4	75.00	0.00	25.00	0.00	0.00	0.00	.00
AVG SPEED	1.08	0.00	4.95	0.00	0.00	0.00	1.34								
TOT ENTRY	3	0	1	0	0	0		4							

C-AREA TOWER 1975-1979



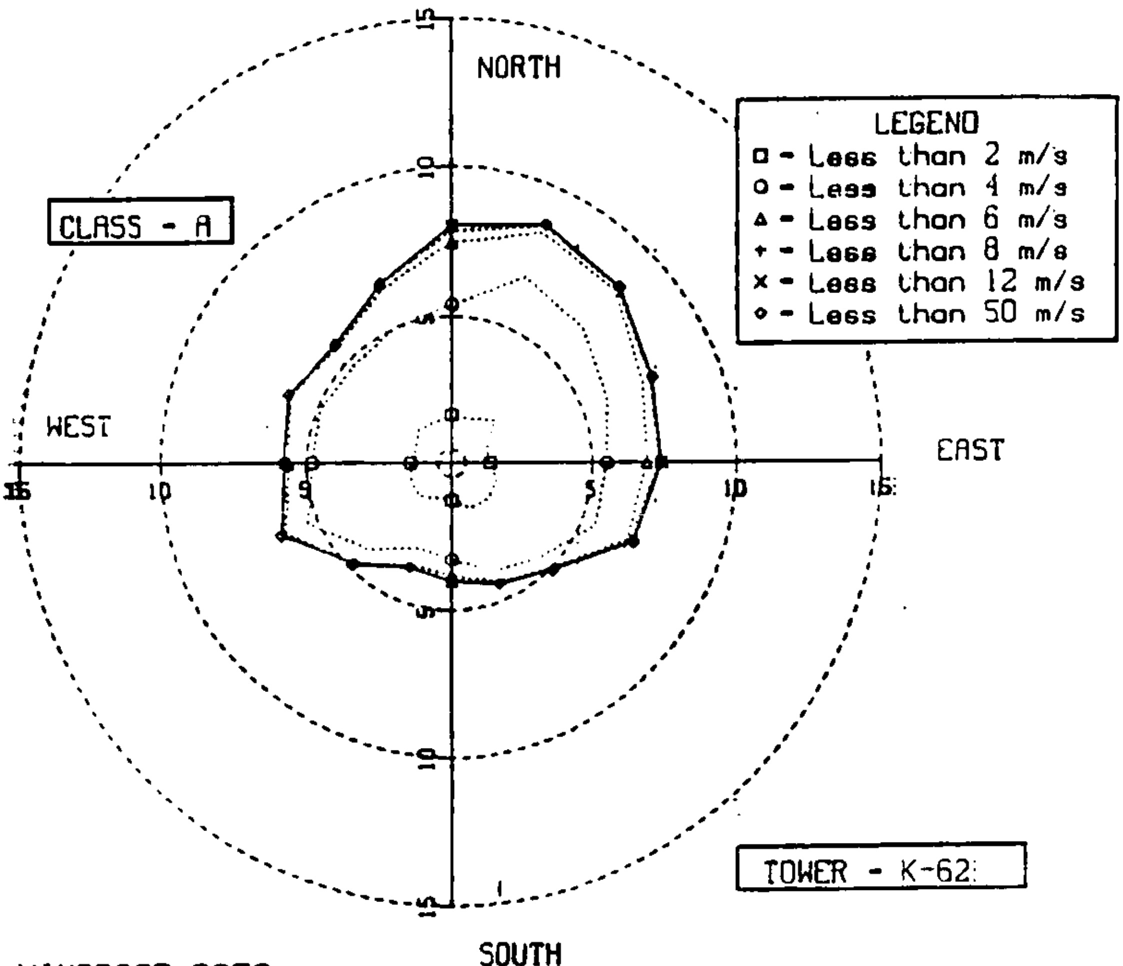
WINDROSE DATA

MINIMUM DATE MMDDYY 10175
MINIMUM TIME ZULU 0000
ENTRIES ALL CLASSES 14725

MAXIMUM DATE MMDDYY 123179
MAXIMUM TIME ZULU 2400
ENTRIES THIS CLASS 14725

DIRECTION	0-2	2-4	4-6	6-8	8-12	>12	AVERAGE SPEED	TOTAL TOT	0-2	2-4	4-6	6-8	8-12	>12	TOTAL
	SPEED IN METERS/SEC								PERCENT TIME WIND @ SPEED						
N	86	158	91	11	0	0	2.18	344	.58	1.08	.62	.07	0.00	0.00	2.34
NNE	82	208	127	39	7	0	2.64	461	.56	1.40	.86	.26	.04	0.00	3.13
NE	84	316	349	165	29	2	3.50	945	.57	2.15	2.37	1.12	.20	.01	6.42
ENE	110	374	418	148	7	4	3.31	1059	.75	2.54	2.83	1.01	.04	.02	7.19
E	100	441	405	86	3	0	3.10	1035	.68	2.99	2.75	.58	.02	0.00	7.03
ESE	85	429	341	78	2	0	3.14	936	.58	2.91	2.32	.54	.01	0.00	6.36
SE	82	351	378	163	10	0	3.47	984	.56	2.38	2.57	1.11	.06	0.00	6.68
SSE	97	313	487	180	14	0	3.57	1091	.66	2.13	3.31	1.22	.09	0.00	7.41
S	101	282	430	142	24	0	3.40	978	.69	1.92	2.92	.96	.16	0.00	6.65
SSW	80	336	381	118	19	0	3.42	934	.54	2.28	2.59	.80	.13	0.00	6.34
SW	93	322	378	136	28	0	3.43	955	.63	2.19	2.55	.92	.19	0.00	6.49
WSW	88	366	386	172	62	4	3.54	1078	.60	2.49	2.62	1.17	.42	.02	7.32
W	157	415	419	170	101	7	3.16	1269	1.07	2.82	2.85	1.15	.69	.04	8.62
WNW	196	412	425	214	122	7	2.89	1376	1.33	2.80	2.89	1.45	.83	.04	9.34
NW	137	299	292	102	42	2	2.88	874	.93	2.03	1.98	.69	.29	.01	5.94
NNW	93	163	117	19	3	0	2.39	401	.67	1.11	.79	.13	.02	0.00	2.72
NO DIRECT	3	0	1	0	0	0	1.34	4	.02	0.00	.00	0.00	0.00	0.00	2.34
AVG SPEED	1.18	2.97	4.88	6.65	9.05	13.83	3.18								
TOT ENTRY	1680	5181	5421	1944	473	28		14725							

K-AREA TOWER 1975-1979



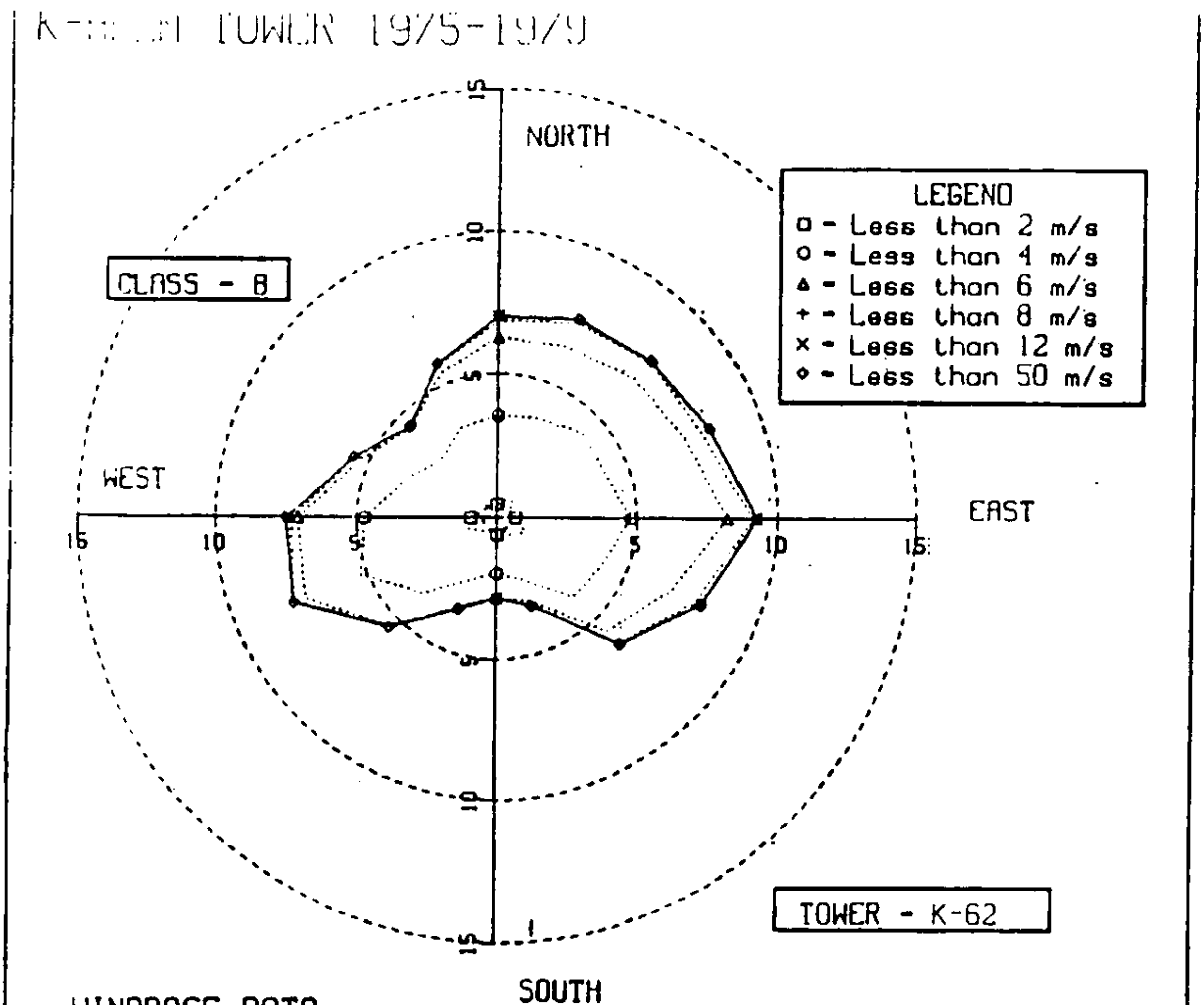
WINDROSE DATA

MINIMUM DATE MMDDYY 10175
MINIMUM TIME ZULU 0000
ENTRIES ALL CLASSES 14878

MAXIMUM DATE MMDDYY 123179
MAXIMUM TIME ZULU 2400
ENTRIES THIS CLASS 3388

DIRECTION	SPEED IN METERS/SEC 0-2	2-4	4-6	6-8	8-12	>12	AVERAGE SPEED	TOTAL TOT
N	43	68	18	7	0	0	2.08	136
NNE	44	61	21	3	0	0	1.97	129
NE	54	85	24	0	0	0	2.04	163
ENE	52	130	27	4	1	2	2.25	216
E	48	115	28	4	1	0	2.31	196
ESE	45	121	38	2	1	0	2.27	207
SE	55	106	29	2	0	1	2.11	193
SSE	52	119	45	6	1	0	2.48	223
S	57	126	71	13	6	1	2.56	274
SSW	56	175	55	8	1	1	2.50	296
SW	72	150	57	5	1	0	2.25	285
WSW	45	157	46	10	2	0	2.57	260
W	45	142	48	14	3	0	2.58	252
WNW	58	129	41	3	4	1	2.22	236
NW	59	93	17	2	0	1	2.01	172
NNW	56	78	13	3	0	0	1.88	150
NO DIRECT	0	0	0	0	0	0	0.00	0
AVG SPEED	1.23	2.82	4.67	6.72	8.83	18.35	2.28	
TOT ENTRY	841	1855	578	86	21	7		3388

PERCENT TIME WIND @ SPEED 0-2	2-4	4-6	6-8	8-12	>12	TOTAL
1.27	2.01	.63	.21	0.00	0.00	4.01
1.30	1.80	.62	.08	0.00	0.00	3.81
1.59	2.51	.71	0.00	0.00	0.00	4.81
1.53	3.84	.80	.12	.03	.05	6.38
1.42	3.39	.83	.12	.03	0.00	5.79
1.33	3.57	1.12	.05	.03	0.00	6.11
1.62	3.13	.86	.05	0.00	.03	5.70
1.53	3.51	1.33	.18	.03	0.00	6.58
1.68	3.72	2.10	.38	.18	.03	8.09
1.65	5.17	1.62	.24	.03	.03	8.74
2.13	4.43	1.68	.15	.03	0.00	8.41
1.33	4.63	1.36	.30	.06	0.00	7.67
1.33	4.19	1.42	.41	.08	0.00	7.44
1.71	3.81	1.21	.08	.12	.03	6.97
1.74	2.74	.50	.05	0.00	.03	5.08
1.65	2.30	.38	.08	0.00	0.00	4.45
0.00	0.00	0.00	0.00	0.00	0.00	4.01

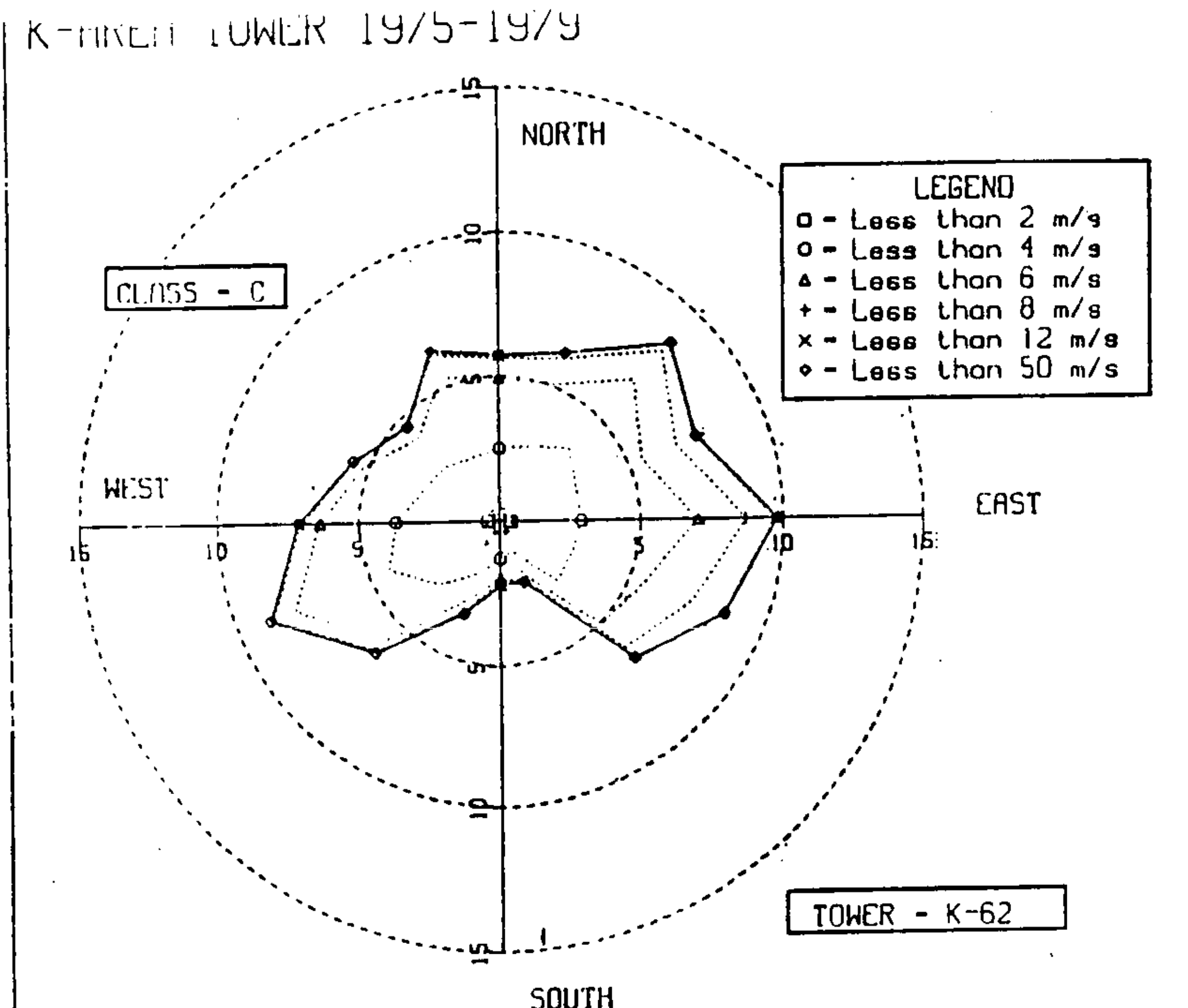


WINDROSE DATA

MINIMUM DATE MMDDYY 10175
MINIMUM TIME ZULU 0000
ENTRIES ALL CLASSES 14676

MAXIMUM DATE MMDDYY 123179
MAXIMUM TIME ZULU 2400
ENTRIES THIS CLASS 1854

DIRECTION	SPEED IN METERS/SEC 0-2	2-4	4-6	6-8	8-12	>12	AVERAGE SPEED	TOTAL TOT	PERCENT TIME WIND @ SPEED 0-2	2-4	4-6	6-8	8-12	>12	TOTAL
N	11	25	16	0	0	0	2.73	52	.59	1.35	.86	0.00	0.00	0.00	2.80
NNE	9	34	19	2	0	0	2.84	64	.49	1.83	1.02	.11	0.00	0.00	3.45
NE	12	57	31	1	0	0	2.85	101	.65	3.07	1.67	.05	0.00	0.00	5.45
ENE	20	77	40	8	0	0	2.95	145	1.08	4.15	2.16	.43	0.00	0.00	7.82
E	17	71	44	4	2	2	3.00	140	.92	3.83	2.37	.22	.11	.11	7.55
ESE	10	56	32	4	1	0	3.01	103	.54	3.02	1.73	.22	.05	0.00	5.56
SE	12	41	29	1	0	0	2.94	83	.65	2.21	1.56	.05	0.00	0.00	4.48
SSE	8	55	37	6	0	1	3.29	107	.43	2.97	2.00	.32	0.00	.05	5.77
S	9	57	51	10	3	0	3.48	130	.49	3.07	2.75	.54	.16	0.00	7.01
SSW	13	56	50	17	2	1	3.37	139	.70	3.02	2.70	.92	.11	.05	7.50
SW	15	63	49	15	1	0	3.21	143	.81	3.40	2.64	.81	.05	0.00	7.71
WSW	8	69	57	11	6	0	3.35	151	.43	3.72	3.07	.59	.32	0.00	8.14
W	12	77	63	17	3	0	3.42	172	.65	4.15	3.40	.92	.16	0.00	8.20
WNW	20	56	48	18	4	0	3.11	146	1.08	3.02	2.59	.97	.22	0.00	7.07
NW	19	53	32	11	1	0	2.72	116	1.02	2.86	1.73	.59	.05	0.00	6.26
NNW	9	34	15	3	1	0	2.48	62	.49	1.83	.81	.16	.05	0.00	3.34
NO DIRECT	0	0	0	0	0	0	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	2.80
AVG SPEED	1.35	2.95	4.78	6.61	9.18	16.21	3.08								
TOT. ENTRY	204	881	613	128	24	4		1854							

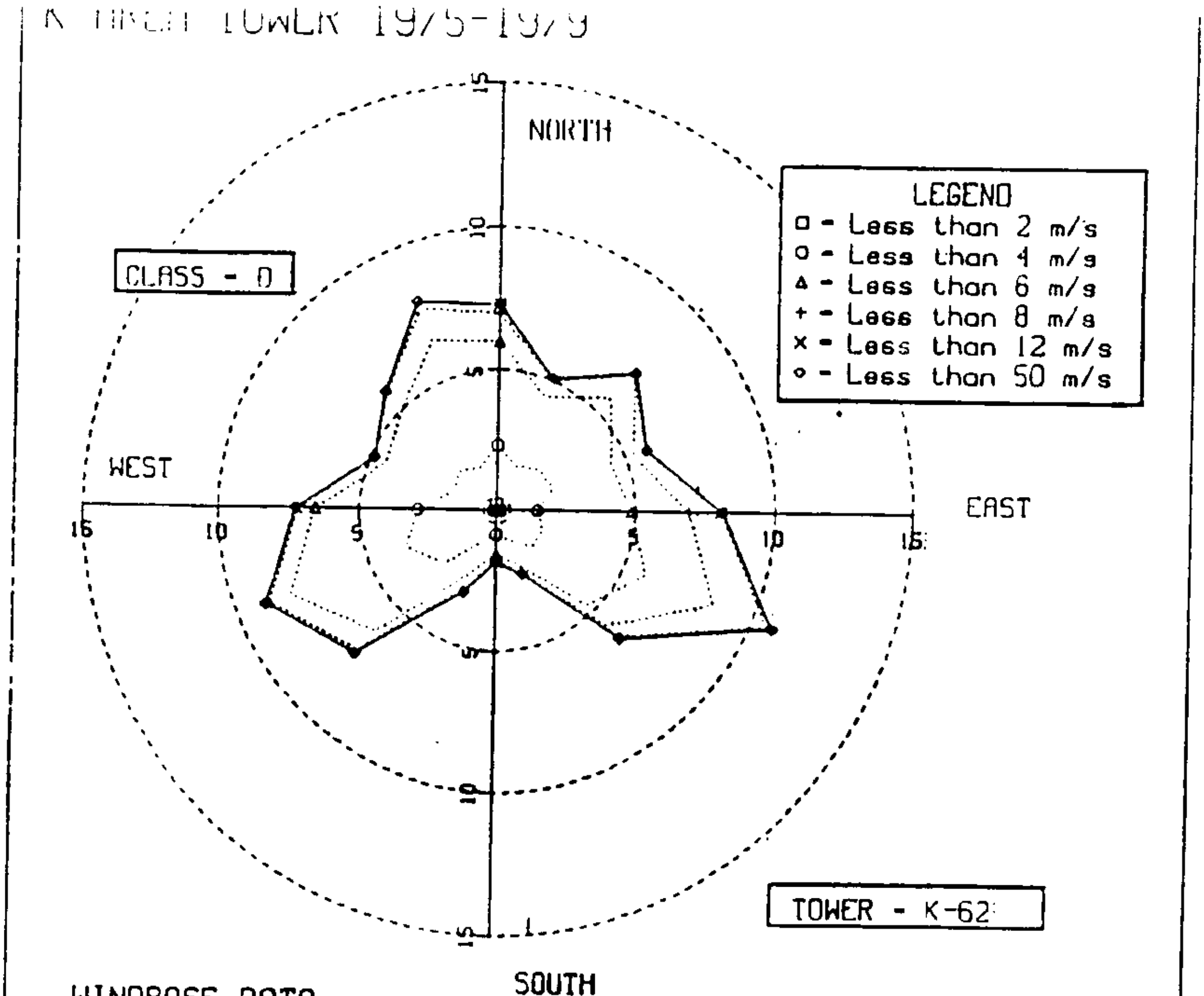


WINDROSE DATA

MINIMUM DATE MMDDYY 10175
MINIMUM TIME ZULU 0000
ENTRIES ALL CLASSES 14676

MAXIMUM DATE MMDDYY 123179
MAXIMUM TIME ZULU 2400
ENTRIES THIS CLASS 2923

DIRECTION	SPEED IN METERS/SEC 0-2	2-4	4-6	6-8	8-12	>12	AVERAGE SPEED	TOTAL TOT	PERCENT TIME WIND @ SPEED 0-2	2-4	4-6	6-8	8-12	>12	TOTAL
N	5	33	19	3	4	0	3.23	64	.17	1.13	.65	.10	.14	0.00	3.19
NNE	11	45	28	14	2	0	3.12	100	.38	1.54	.98	.48	.08	0.00	3.42
NE	10	79	78	16	2	0	3.43	185	.34	2.70	2.67	.55	.06	0.00	6.33
ENE	14	111	105	25	2	0	3.62	257	.48	3.80	3.59	.86	.06	0.00	8.78
E	13	95	79	18	3	1	3.38	209	.44	3.25	2.70	.62	.10	.03	7.15
ESE	9	77	65	12	0	1	3.54	164	.31	2.63	2.22	.41	0.00	.03	[illegible]
SE	13	65	41	16	0	0	3.42	135	.44	2.22	1.40	.55	0.00	0.00	4.62
SSE	6	64	87	25	5	0	4.04	187	.21	2.19	2.98	.86	.17	0.00	6.40
S	3	71	71	19	3	1	3.95	168	.10	2.43	2.43	.65	.10	.03	5.75
SSW	4	77	67	28	7	0	3.88	183	.14	2.63	2.29	.98	.24	0.00	6.26
SW	12	91	98	41	10	2	3.82	252	.41	3.11	3.20	1.40	.34	.06	[illegible]
WSW	8	79	73	38	21	1	4.08	220	.27	2.70	2.50	1.30	.72	.03	[illegible]
W	12	73	120	48	30	3	4.16	207	.41	2.50	4.11	1.64	1.03	.10	[illegible]
WNW	14	68	81	52	34	0	4.08	249	.48	2.33	2.77	1.78	1.16	0.00	8.52
NW	15	70	63	34	15	0	3.47	197	.51	2.39	2.16	1.16	.51	0.00	[illegible]
NNW	6	28	21	8	3	0	3.18	66	.21	.98	.72	.27	.10	0.00	2.20
NO DIRECT	0	0	0	0	0	0	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	2.19
AVG SPEED	1.30	3.08	4.83	6.69	9.24	15.21	3.72								
TOT ENTRY	155	1126	1034	308	141	9		2923							



WINDROSE DATA

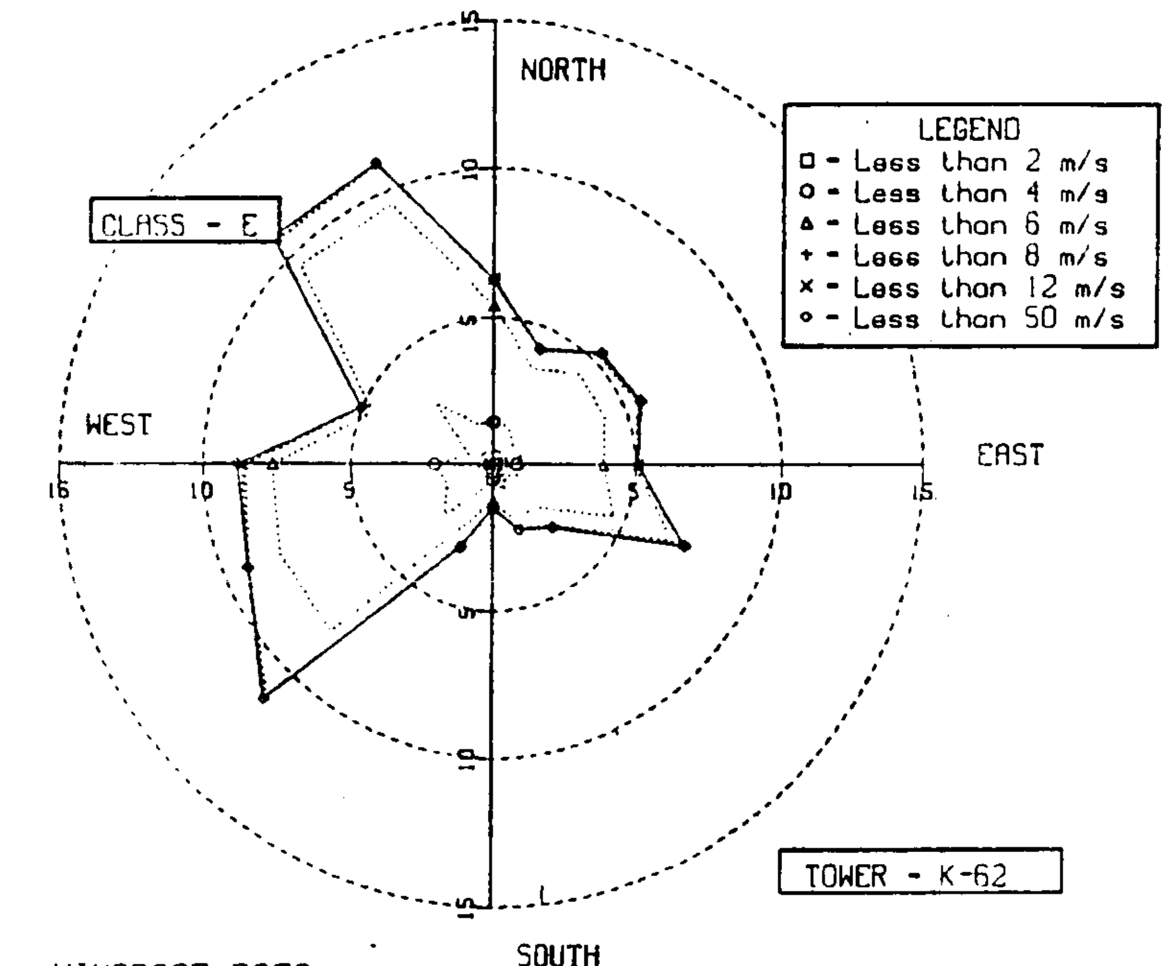
MINIMUM DATE MMDDYY 10175
MINIMUM TIME ZULU 0000
ENTRIES ALL CLASSES 14876

DIRECTION	0-2	2-4	4-6	6-8	8-12	>12	AVERAGE SPEED	TOTAL TOT
	0	0		0		0	0	0
	SPEED IN METERS/SEC							
N	3	32	28	10	2	0	3.78	75
NNE	6	43	48	24	6	0	3.85	127
NE	6	103	139	36	2	6	4.08	292
ENE	8	135	180	32	5	1	4.05	361
E	4	114	147	25	1	4	4.05	295
ESE	3	68	108	18	1	0	4.00	198
SE	9	70	123	32	2	0	3.99	236
SSE	3	64	195	48	10	0	4.44	320
S	9	84	149	39	13	0	4.21	294
SSW	1	68	107	27	2	0	4.18	205
SW	8	78	145	50	1	0	4.14	280
WSW	8	79	91	35	19	1	4.09	233
W	4	55	137	83	46	2	4.83	327
WNW	6	67	162	107	84	8	5.24	434
NW	5	68	116	42	21	3	4.31	255
NNW	3	44	37	14	1	0	3.83	99
NO DIRECT	0	0	0	0	0	0	0.00	0
AVG SPEED	1.36	3.16	4.84	6.69	9.20	14.91	4.28	
TOT ENTRY	36	1120	1810	622	216	25		4029

MAXIMUM DATE MMDDYY 123179
MAXIMUM TIME ZULU 2400
ENTRIES THIS CLASS 4029

0-2	2-4	4-6	6-8	8-12	>12	TOTAL
0	0		0	0		0
PERCENT TIME WIND @ SPEED						
.07	.78	.69	.25	.05	0.00	1.86
.15	1.07	1.19	.60	.15	0.00	3.15
.15	2.56	3.45	.89	.05	.15	7.25
.20	3.35	4.47	.79	.12	.02	8.96
.08	2.83	3.65	.62	.02	.09	7.32
.07	1.69	2.63	.45	.02	0.00	4.86
.22	1.74	3.05	.79	.05	0.00	5:88
.07	1.59	4.84	1.19	.25	0.00	7.94
.22	2.08	3.70	.97	.32	0.00	7.30
.02	1.68	2.66	.67	.05	0.00	5.08
.20	1.83	3.60	1.24	.02	0.00	6.95
.20	1.96	2.26	.87	.47	.02	5.78
.08	1.37	3.40	2.06	1.14	.05	8.12
.15	1.66	4.02	2.66	2.08	.20	11.77
.12	1.69	2.88	1.04	.52	.07	6.33
.07	1.08	.92	.35	.02	0.00	2.46
0.00	0.00	0.00	0.00	0.00	0.00	1.06

K-AREA TOWER 1975-1979

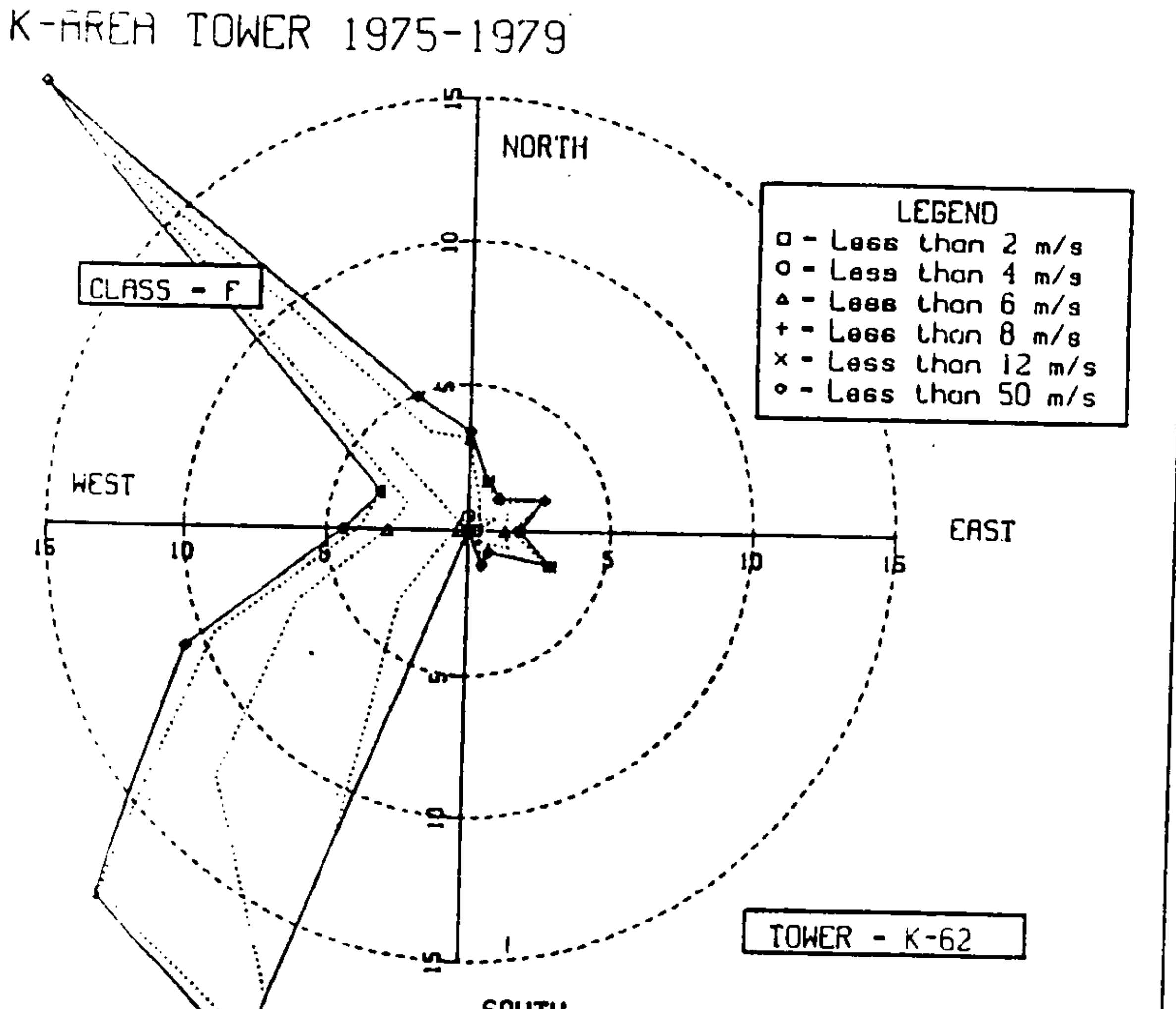


WINDROSE DATA

MINIMUM DATE MMDDYY 10175
MINIMUM TIME ZULU 0000
ENTRIES ALL CLASSES 14676

MAXIMUM DATE MMDDYY 123179
MAXIMUM TIME ZULU 2400
ENTRIES THIS CLASS 1808

DIRECTION	SPEED IN METERS/SEC 0-2	2-4	4-6	6-8	8-12	>12	AVERAGE SPEED	TOTAL TOT	PERCENT TIME WIND @ SPEED 0-2	2-4	4-6	6-8	8-12	>12	TOTAL
N	4	5	14	4	0	0	3.67	27	.22	.28	.78	.22	0.00	0.00	1.50
NNE	3	13	21	16	2	0	3.98	55	.17	.72	1.18	.89	.11	0.00	3.05
NE	1	43	101	55	2	1	4.74	203	.05	2.38	5.59	3.05	.11	.05	11.24
ENE	3	29	113	20	1	0	4.50	166	.17	1.61	6.26	1.11	.05	0.00	9.19
E	2	38	101	16	2	3	4.41	160	.11	1.99	5.59	.89	.11	.17	[illegible]
ESE	0	17	66	8	0	0	4.61	91	0.00	.94	3.65	.44	0.00	0.00	5.04
SE	0	53	120	21	3	0	4.39	197	0.00	2.93	6.64	1.16	.17	0.00	10.91
SSE	2	25	145	26	0	1	4.73	199	.11	1.38	8.03	1.44	0.00	.05	11.02
S	0	26	72	15	1	0	4.64	114	0.00	1.44	3.99	.83	.05	0.00	6.31
SSW	0	25	39	12	1	0	4.35	77	0.00	1.38	2.16	.66	.05	0.00	4.26
SW	2	15	61	17	2	0	4.58	97	.11	.83	3.38	.94	.11	0.00	5.37
WSW	0	19	57	23	1	1	4.77	101	0.00	1.05	3.16	1.27	.05	.05	5.59
W	2	13	55	20	2	0	4.84	92	.11	.72	3.05	1.11	.11	0.00	5.09
WNW	1	16	66	40	7	0	5.13	130	.05	.89	3.65	2.21	.39	0.00	7.20
NW	0	11	26	15	2	0	4.88	54	0.00	.61	1.44	.83	.11	0.00	2.99
NNW	2	15	20	6	0	0	3.89	43	.11	.83	1.11	.33	0.00	0.00	2.38
NO DIRECT	3	0	0	0	0	0	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	1.50
AVG SPEED	1.50	3.27	4.83	6.55	8.88	15.09	4.57								
TOT ENTRY	22	361	1077	314	26	6		1808							



WINDROSE DATA

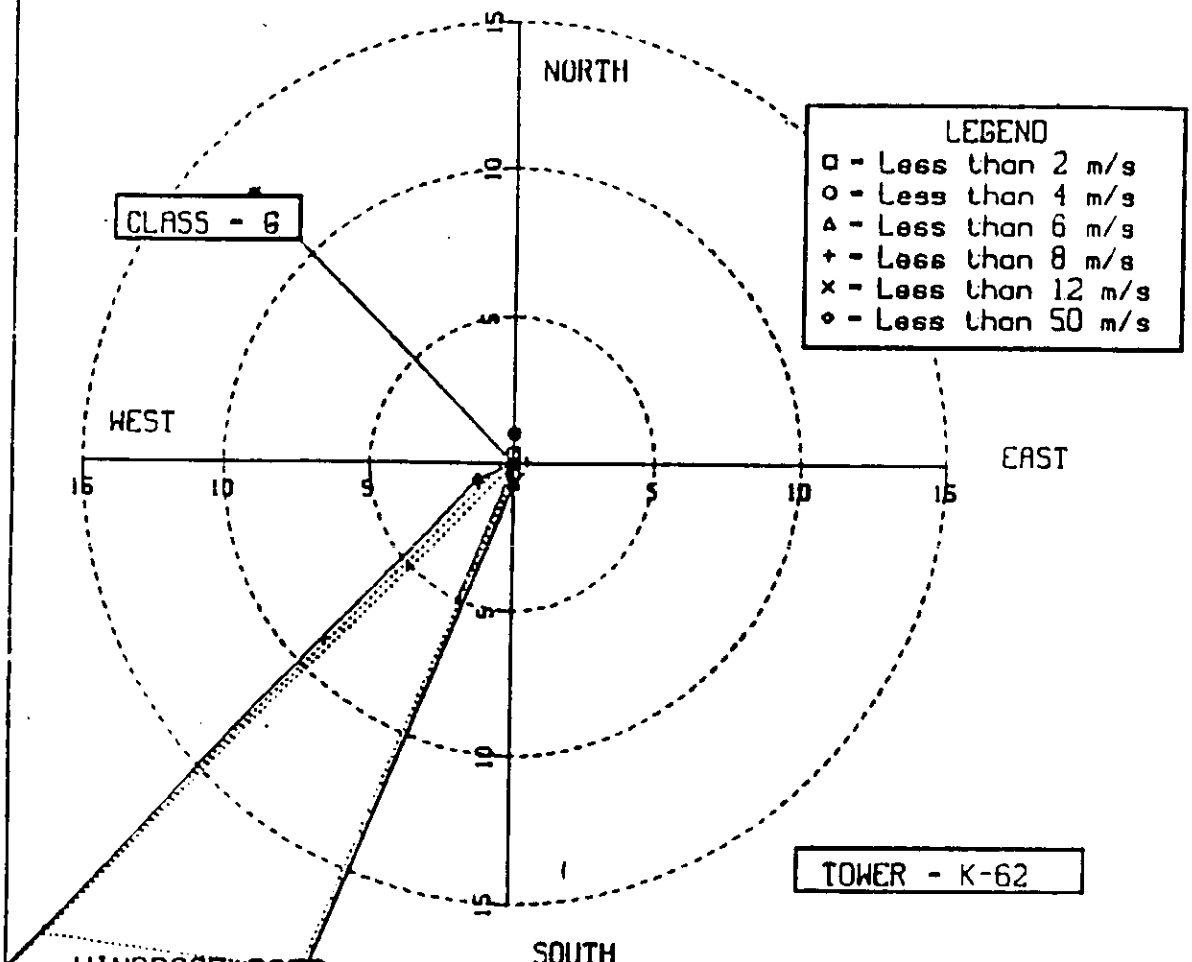
MINIMUM DATE MMDDYY 10175
MINIMUM TIME ZULU 0000
ENTRIES ALL CLASSES 14878

MAXIMUM DATE MMDDYY 123179
MAXIMUM TIME ZULU 2400
ENTRIES THIS CLASS 384

DIRECTION	0-2	2-4	4-6	6-8	8-12	>12	AVERAGE SPEED	TOTAL TOT
	SPEED IN METERS/SEC							
N	0	0	0	0	0	0	0.00	0
NNE	17	28	23	8	2	0	2.01	78
NE	0	13	34	22	1	0	4.99	70
ENE	0	3	22	12	4	0	5.45	41
E	0	1	10	4	2	0	5.55	17
ESE	0	0	9	4	0	0	5.77	13
SE	1	14	55	12	1	0	4.66	83
SSE	0	0	14	5	0	0	5.37	10
S	0	2	10	1	0	0	4.74	13
SSW	0	2	2	3	0	0	5.05	7
SW	0	0	2	3	1	0	6.12	6
WSW	1	3	2	5	0	0	3.73	11
W	0	1	1	1	0	1	5.41	7
WNW	0	2	4	5	1	0	5.36	12
NW	0	0	2	2	0	0	5.88	4
NNW	0	1	4	0	0	0	4.30	5
NO DIRECT	0	0	0	0	0	0	0.00	0
AVG SPEED	.81	3.09	5.03	6.67	9.18	13.38	3.86	
TOT ENTRY	13	70	197	85	12	1		384

DIRECTION	0-2	2-4	4-6	6-8	8-12	>12	TOTAL
	PERCENT TIME WIND @ SPEED						
N	0.00	0.00	0.00	0.00	0.00	0.00	.00
NNE	4.43	7.29	5.99	1.56	.52	0.00	19.79
NE	0.00	3.33	8.85	5.73	.26	0.00	10.23
ENE	0.00	.78	5.73	3.13	1.04	0.00	10.68
E	0.00	.26	2.60	1.04	.52	0.00	4.43
ESE	0.00	0.00	2.34	1.04	0.00	0.00	3.39
SE	.26	3.65	14.32	3.13	.26	0.00	21.61
SSE	0.00	0.00	3.65	1.30	0.00	0.00	4.95
S	0.00	.52	2.60	.26	0.00	0.00	3.39
SSW	0.00	.52	.52	.78	0.00	0.00	1.82
SW	0.00	0.00	.52	.78	.26	0.00	1.56
WSW	.26	.78	.52	1.30	0.00	0.00	2.06
W	0.00	.26	1.04	.26	0.00	.26	1.82
WNW	0.00	.52	1.04	1.30	.26	0.00	3.12
NW	0.00	0.00	.52	.52	0.00	0.00	1.04
NNW	0.00	.26	1.04	0.00	0.00	0.00	1.30
NO DIRECT	0.00	0.00	0.00	0.00	0.00	0.00	.00

K-AREA TOWER 1975-1979



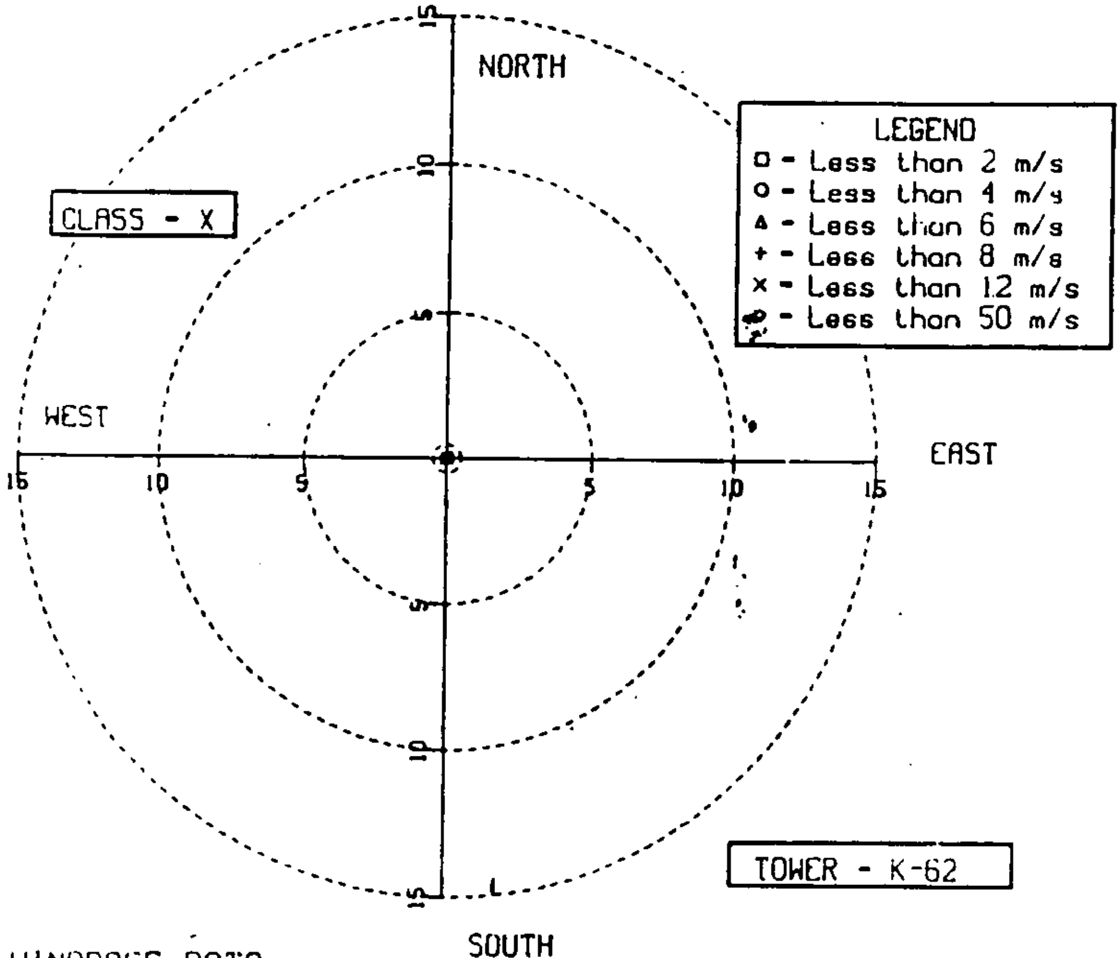
WINDROSE DATA

MINIMUM DATE MMDDYY 10175
MINIMUM TIME ZULU 0000
ENTRIES ALL CLASSES 14676

MAXIMUM DATE MMDDYY 123179
MAXIMUM TIME ZULU 2400
ENTRIES THIS CLASS 288

DIRECTION	SPEED IN METERS/SEC 0-2	2-4	4-6	6-8	8-12	>12	AVERAGE SPEED	TOTAL TOT	PERCENT TIME WIND'S SPEED 0-2	2-4	4-6	6-8	8-12	>12	TOTAL
N	0	1	1	0	0	0	3.94	2	0.00	.35	.35	0.00	0.00	0.00	.69
NNE	15	38	75	27	8	0	3.44	162	5.21	13.54	26.04	9.38	2.08	0.00	58.25
NE	0	68	11	3	0	0	3.02	80	0.00	22.92	3.82	1.04	0.00	0.00	27.78
ENE	0	0	2	2	0	0	5.68	4	0.00	0.00	.69	.69	0.00	0.00	1.39
E	0	0	0	0	0	0	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	.00
ESE	0	0	0	0	0	0	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	.00
SE	0	7	27	3	0	0	4.68	37	0.00	2.43	9.38	1.04	0.00	0.00	12.85
SSE	0	0	0	0	0	0	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	.00
S	1	2	0	0	0	0	1.12	3	.35	.69	0.00	0.00	0.00	0.00	1.04
SSW	0	0	0	0	0	0	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	.00
SW	0	0	0	0	0	0	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	.00
WSW	0	0	0	0	0	0	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	.00
W	0	0	0	0	0	0	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	.00
WNW	0	0	0	0	0	0	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	.00
NW	0	0	0	0	0	0	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	.00
NNW	0	0	0	0	0	0	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	.00
NO DIRECT	0	0	0	0	0	0	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	.00
AVG SPEED	.98	2.88	5.01	6.72	9.08	0.00	3.37		0.00	0.00	0.00	0.00	0.00	0.00	.09
TOT ENTRY	16	115	118	35	8	0		288							

K-AREA TOWER 1975-1979



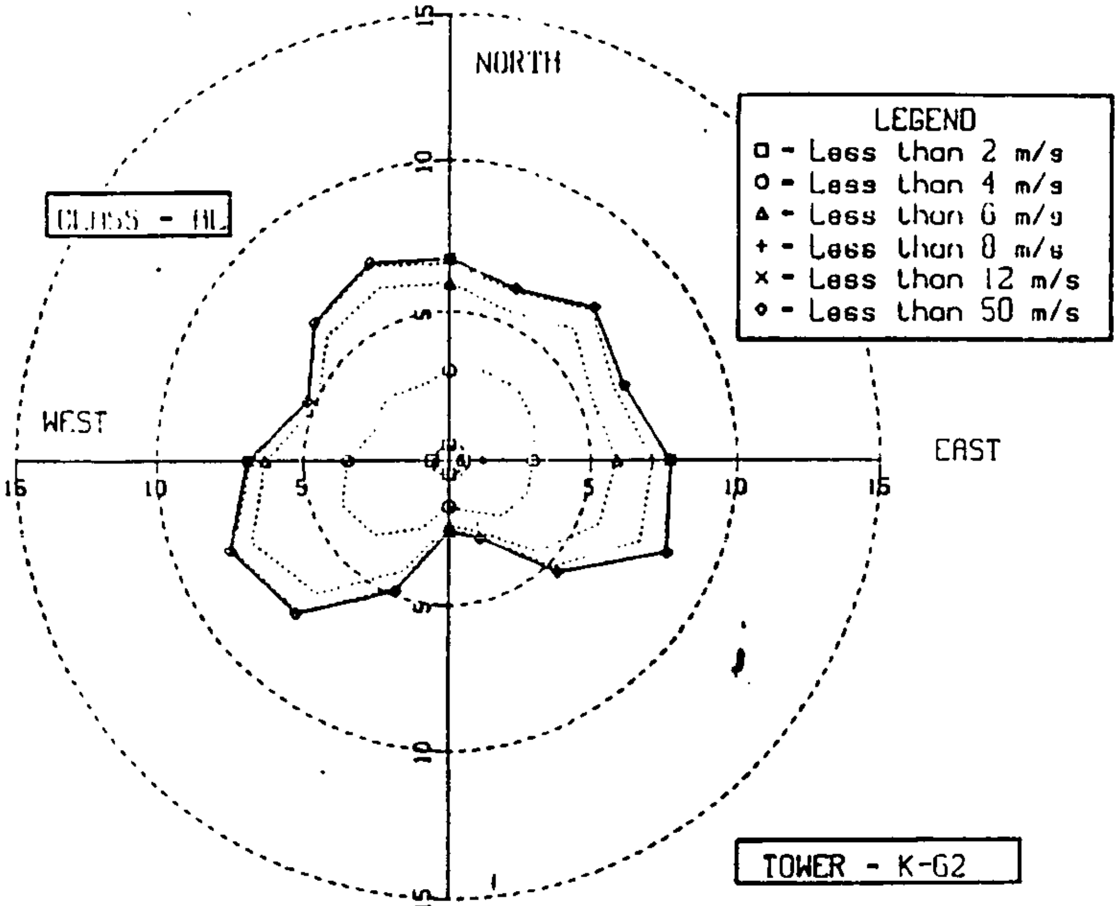
WINDROSE DATA

MINIMUM DATE MMDDYY 10175
MINIMUM TIME ZULU 0000
ENTRIES ALL CLASSES 14676

MAXIMUM DATE MMDDYY 123179
MAXIMUM TIME ZULU 2400
ENTRIES THIS CLASS 4

DIRECTION	SPEED IN METERS/SEC 0-2	2-4	4-6	6-8	8-12	>12	AVERAGE SPEED	TOTAL TOT	PERCENT TIME WIND @ SPEED 0-2	2-4	4-6	6-8	8-12	>12	TOTAL
N	0	0	0	0	0	0	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	.00
NNE	0	0	0	0	0	0	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	.00
NE	0	0	0	0	0	0	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	.00
ENE	0	0	0	0	0	0	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	.00
E	0	0	0	0	0	0	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	.00
ESE	0	0	0	0	0	0	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	.00
SE	0	0	0	0	0	0	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	.00
SSE	0	0	0	0	0	0	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	.00
S	0	0	0	0	0	0	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	.00
SSW	0	0	0	0	0	0	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	.00
SW	0	0	0	0	0	0	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	.00
WSW	0	0	0	0	0	0	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	.00
W	0	0	0	0	0	0	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	.00
WNW	0	0	0	0	0	0	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	.00
NW	0	0	0	0	0	0	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	.00
NNW	0	0	0	0	0	0	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	.00
NO DIRECT	2	1	1	0	0	0	1.02	4	50.00	25.00	25.00	0.00	0.00	0.00	.00
AVG SPEED	.58	3.44	5.03	0.00	0.00	0.00	1.02								
TOT [illegible]	2	1	1	0	0	0		4							

K-AREA TOWER 1975-1979



WINDROSE DATA

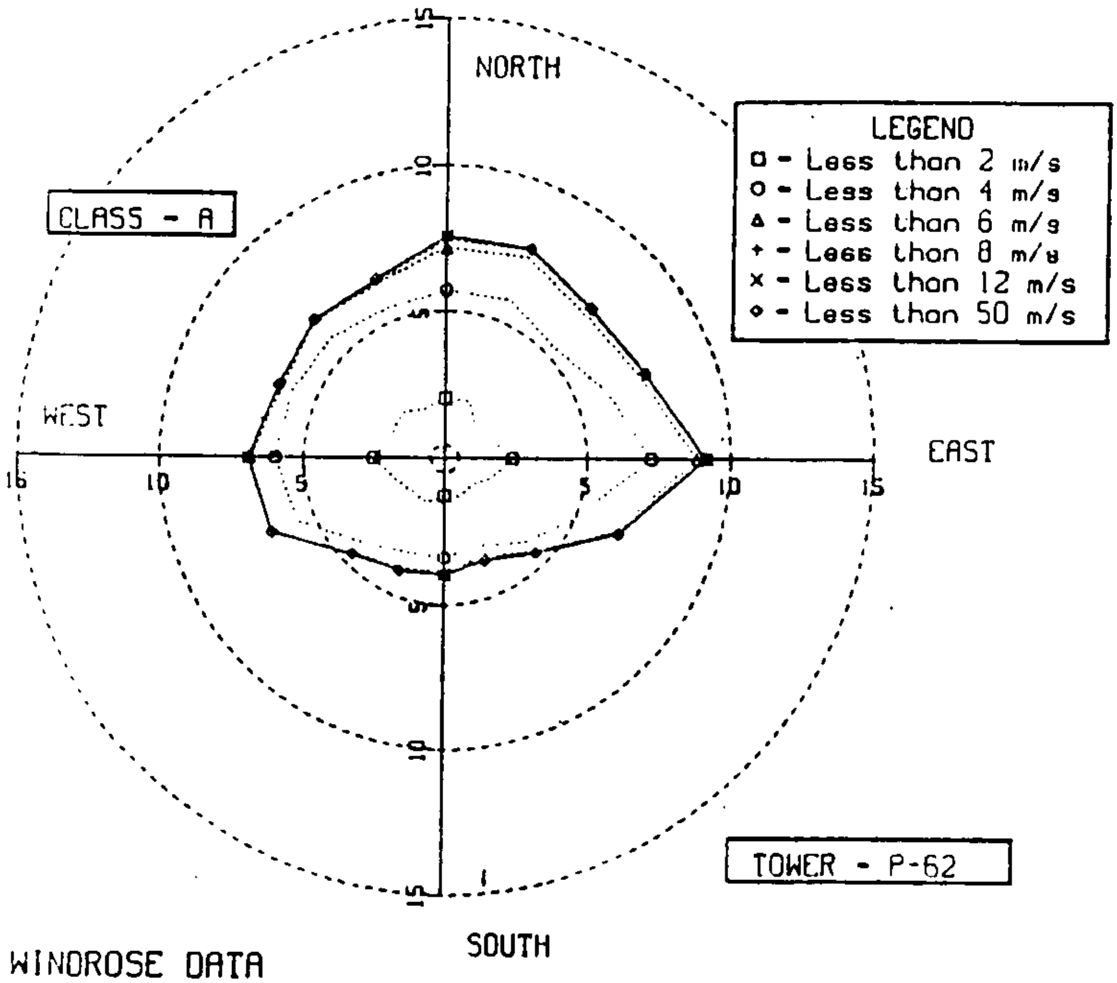
MINIMUM DATE MMDDYY 10175
MINIMUM TIME ZULU 0000
ENTRIES ALL CLASSES 14676

MAXIMUM DATE MMDDYY 123179
MAXIMUM TIME ZULU 2400
ENTRIES THIS CLASS 14676

DIRECTION	0-2	2-4	4-6	6-8	8-12	>12	AVERAGE SPEED	TOTAL TOT
	SPEED IN METERS/SEC							
N	66	164	98	24	8	0	2.69	356
NNE	105	263	235	92	18	0	2.83	713
NE	83	448	418	133	7	7	3.37	1084
ENE	97	485	480	103	13	3	3.40	1190
E	84	432	409	71	11	10	3.33	1017
ESE	67	339	316	48	3	1	3.19	774
SE	90	356	424	87	6	1	3.33	964
SSE	71	327	523	118	16	2	3.67	1055
S	79	368	424	97	26	2	3.47	996
SSW	74	403	320	95	13	2	3.35	907
SW	109	395	410	131	16	2	3.25	1063
WSW	70	408	326	122	49	3	3.47	978
W	75	361	427	184	84	6	3.73	1137
WNW	99	338	402	225	134	9	3.72	1207
NW	91	295	256	106	39	1	3.12	798
NNW	76	200	110	34	5	0	2.82	425
NO DIRECT	2	1	1	0	0	0	1.02	4
AVG SPEED	1.55	2.90	4.84	6.66	9.17	15.23	3.33	
TOT DIRECT	134[illegible]	5520	5046	1898	34[illegible]	52		14676

DIRECTION	0-2	2-4	4-6	6-8	8-12	>12	TOTAL
	PERCENT TIME WIND @ SPEED						
N	.45	1.12	.65	.16	.04	0.00	2.43
NNE	.72	1.79	1.60	.63	.12	0.00	4.86
NE	.57	3.04	2.85	.91	.04	.04	7.45
ENE	.66	3.30	3.33	.70	.08	.02	8.11
E	.57	2.94	2.79	.48	.07	.06	6.93
ESE	.46	2.31	2.15	.33	.02	.00	5.27
SE	.61	2.43	2.89	.59	.04	.00	6.57
SSE	.48	2.23	3.56	.79	.11	.01	7.19
S	.54	2.51	2.89	.66	.18	.01	6.79
SSW	.50	2.75	2.18	.65	.08	.01	6.18
SW	.74	2.69	2.79	.89	.11	.01	7.24
WSW	.48	2.77	[illegible]	.83	.33	.02	[illegible]
W	.51	2.46	2.91	1.25	.57	.04	7.75
WNW	.67	2.30	2.74	1.53	.91	.06	8.22
NW	.62	2.01	1.74	.72	.27	.02	5.44
NNW	.52	1.36	.75	.23	.03	0.00	2.90
NO DIRECT	.01	.00	.00	0.00	0.00	0.00	2.43

P-AREA TOWER 1975-1979



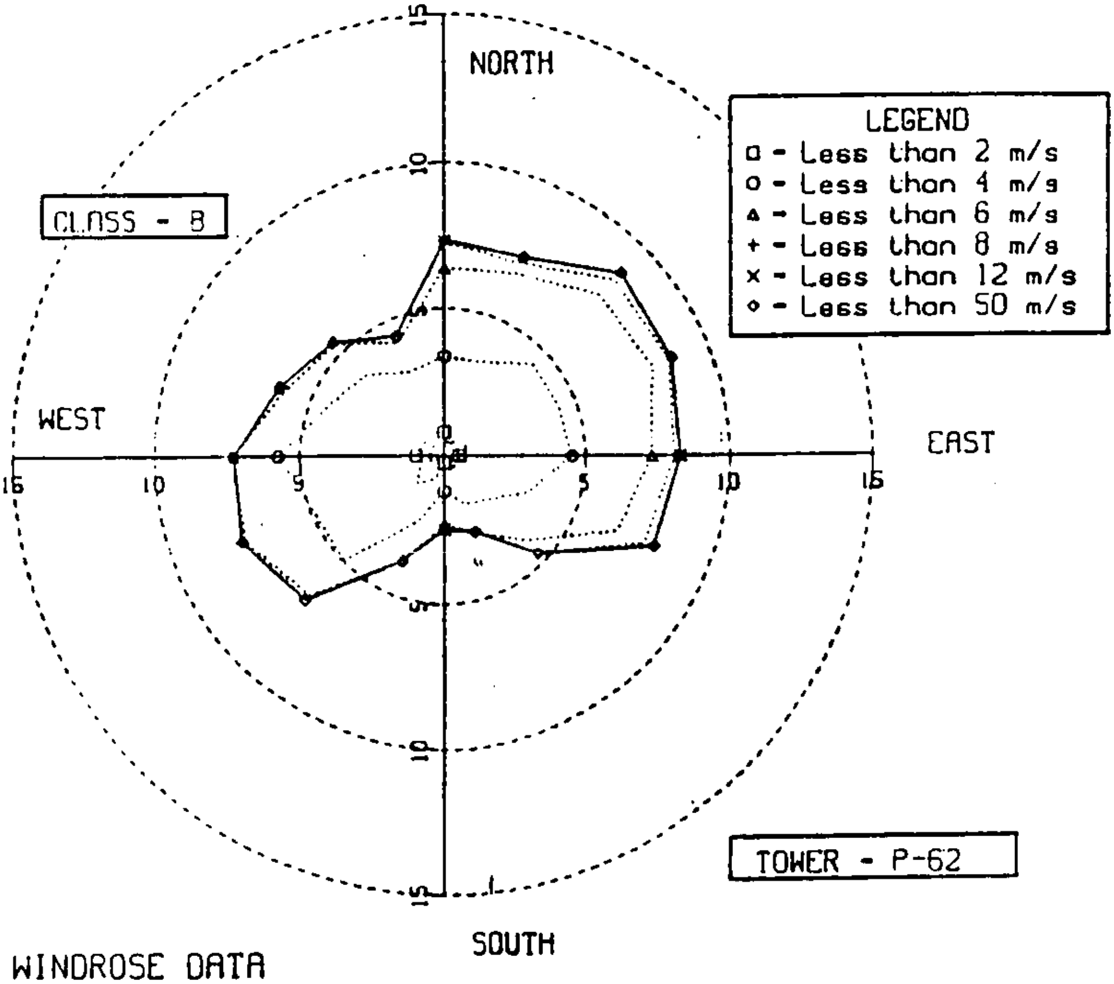
WINDROSE DATA

MINIMUM DATE MMDDYY 10175
MINIMUM TIME ZULU 0000
ENTRIES ALL CLASSES 14909

MAXIMUM DATE MMDDYY 123179
MAXIMUM TIME ZULU 2400
ENTRIES THIS CLASS . 3310

DIRECTION	SPEED IN METERS/SEC 0-2	2-4	4-6	6-8	8-12	>12	AVERAGE SPEED	TOTAL TOT	PERCENT TIME WIND SPEED 0-2	2-4	4-6	6-8	8-12	>12	TOTAL
N	42	70	16	4	0	0	2.11	132	1.27	2.11	.48	.12	0.00	0.00	3.99
NNE	54	81	20	2	1	0	1.87	138	1.83	1.84	.60	.06	.03	0.00	4.17
NE	53	82	17	1	0	0	1.98	153	1.60	2.43	.51	.03	0.00	0.00	4.62
ENE	62	124	33	0	0	0	2.03	219	1.87	3.75	1.00	0.00	0.00	0.00	6.62
E	84	115	29	3	0	0	2.08	231	2.54	3.47	.88	.09	0.00	0.00	6.98
ESE	68	127	12	5	0	0	2.05	212	2.05	3.84	.36	.15	0.00	0.00	6.40
SE	71	119	28	1	0	0	2.08	218	2.15	3.60	.85	.03	0.00	0.00	6.62
SSE	61	121	30	3	0	2	2.14	217	1.84	3.66	.91	.09	0.00	.06	6.56
S	67	122	48	9	5	0	2.30	251	2.02	3.80	1.45	.27	.15	0.00	7.58
SSW	69	124	52	9	1	0	2.44	255	2.08	3.75	1.57	.27	.03	0.00	7.70
SW	50	127	52	8	1	1	2.61	239	1.51	3.84	1.57	.24	.03	.03	7.22
WSW	59	142	42	6	1	0	2.45	250	1.78	4.29	1.27	.18	.03	0.00	7.55
W	78	161	53	9	2	0	2.33	303	2.36	4.86	1.60	.27	.06	0.00	9.15
WNW	58	110	45	4	1	0	2.28	218	1.75	3.32	1.36	.12	.03	0.00	6.59
NW	43	89	14	2	1	0	2.27	149	1.30	2.69	.42	.06	.03	0.00	4.50
NNW	48	60	13	4	1	0	1.92	124	1.39	1.81	.39	.12	.03	0.00	3.75
NO DIRECT	0	0	0	0	0	0	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	3.03
AVG SPEED	1.28	2.78	4.84	6.67	9.21	14.02	2.20								
TOT ENTRY	965	1754	504	70	14	3		3310							

P-AREA TOWER 1975-1979

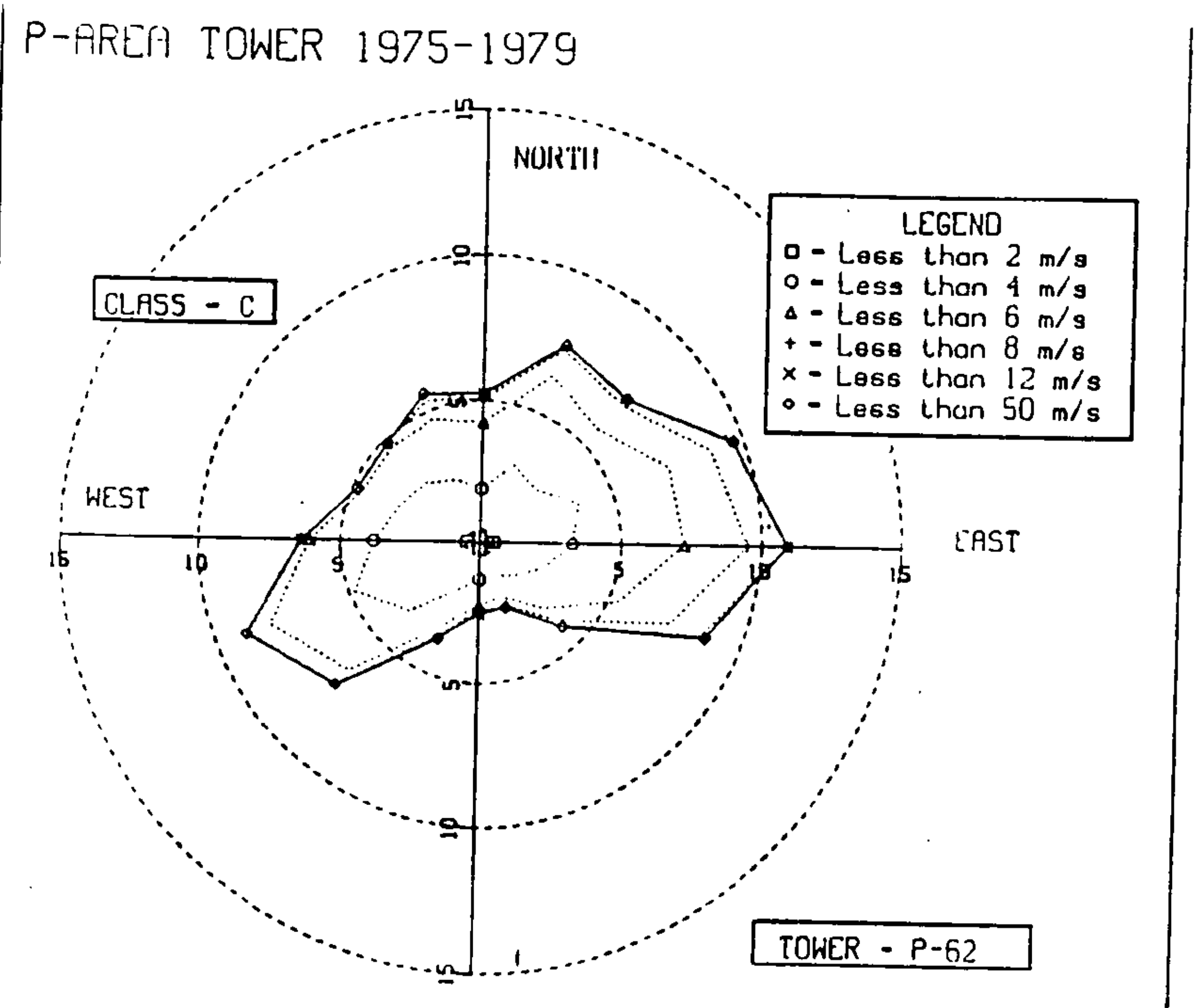


WINDROSE DATA

MINIMUM DATE MMDDYY 10175
MINIMUM TIME ZULU 0000
ENTRIES ALL CLASSES 14900

MAXIMUM DATE MMDDYY 123179
MAXIMUM TIME ZULU 2400
ENTRIES THIS CLASS 1755

	SPEED IN METERS/SEC								PERCENT TIME WIND @ SPEED						
DIRECTION	0-2	2-4	4-6	6-8	8-12	>12	AVERAGE SPEED	TOTAL TOT	0-2	2-4	4-6	6-8	8-12	>12	TOTAL
N	4	17	20	2	1	0	3.41	44	.23	.97	1.14	.11	.05	0.00	2.51
NNE	15	27	24	1	0	0	2.74	67	.85	1.54	1.37	.05	0.00	0.00	3.82
NE	23	64	29	3	1	0	2.47	120	1.31	3.65	1.65	.17	.05	0.00	6.84
ENE	16	70	45	2	0	0	2.89	133	.91	3.99	2.56	.11	0.00	0.00	7.58
E	17	84	27	0	0	0	2.74	128	.97	4.79	1.54	0.00	0.00	0.00	7.29
ESE	15	62	27	4	0	0	2.81	108	.85	3.53	1.54	.23	0.00	0.00	6.15
SE	14	54	28	2	0	0	2.62	96	.80	3.09	1.48	.11	0.00	0.00	5.47
SSE	15	39	18	4	0	0	2.53	77	.85	2.22	1.08	.23	0.00	0.00	4.39
S	14	45	54	15	1	0	3.33	129	.80	2.56	3.08	.85	.05	0.00	7.35
SSW	12	48	58	7	4	0	3.41	128	.68	2.74	3.30	.40	.23	0.00	7.35
SW	9	68	59	13	6	0	3.64	155	.51	3.87	3.36	.74	.34	0.00	8.83
WSW	16	61	62	11	2	0	3.18	152	.91	3.48	[illegible]	.63	.11	0.00	[illegible]
W	9	70	49	14	4	0	3.40	146	.51	3.99	2.79	.80	.23	0.00	8.32
WNW	11	45	60	18	6	0	3.71	140	.63	2.56	3.42	1.03	.34	0.00	7.98
NW	6	31	34	11	0	0	3.58	82	.34	1.77	1.94	.63	0.00	0.00	4.67
NNW	5	28	16	0	0	0	2.92	49	.28	1.48	1.03	0.00	0.00	0.00	2.79
NO DIRECT	0	0	0	0	0	0	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	2.51
AVG SPEED	1.31	2.98	4.78	6.65	8.96	0.00	3.07								
TOT ENTRY	201	811	611	107	25	0		1755							



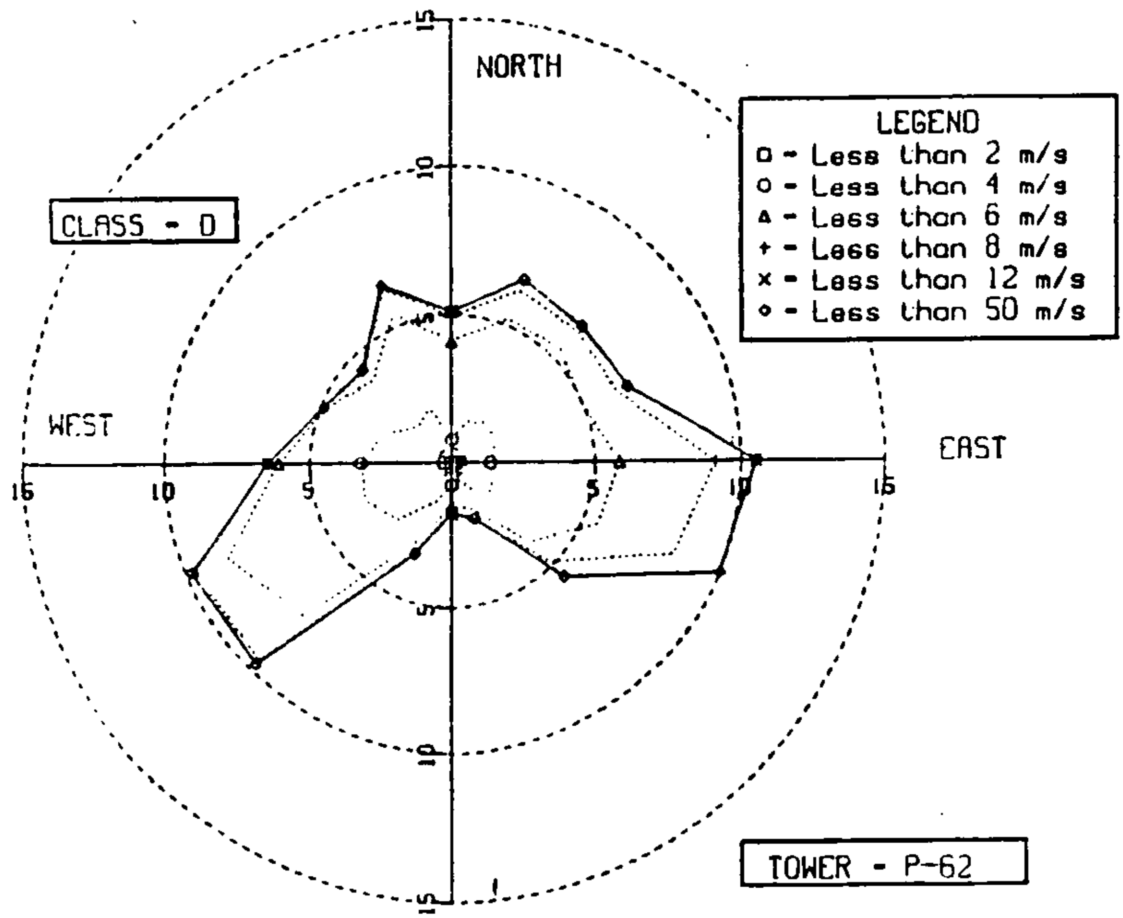
WINDROSE DATA

MINIMUM DATE MMDDYY 10175
MINIMUM TIME ZULU 0000
ENTRIES ALL CLASSES 14000

MAXIMUM DATE MMDDYY 123179
MAXIMUM TIME ZULU 2400
ENTRIES THIS CLASS 2737

DIRECTION	SPEED IN METERS/SEC 0-2	2-4	4-6	6-8	8-12	>12	AVERAGE SPEED	TOTAL TOT	PERCENT TIME WIND'S SPEED 0-2	2-4	4-6	6-8	8-12	>12	TOTAL
N	7	30	25	6	2	0	3.31	70	.28	1.10	.91	.22	.07	0.00	2.56
NNE	8	45	38	11	2	0	3.41	102	.22	1.64	1.39	.40	.07	0.00	3.73
NE	13	83	82	19	0	0	3.33	197	.47	3.03	3.00	.69	0.00	0.00	[illegible].20
ENE	17	115	87	23	2	0	3.41	244	.62	4.20	3.18	.84	.07	0.00	4.91
E	13	92	62	7	1	0	3.21	175	.47	3.36	2.27	.26	.03	0.00	6.39
ESE	9	78	38	8	0	0	3.11	132	.33	2.85	1.42	.22	0.00	0.00	4.82
SE	11	68	48	8	0	0	3.19	133	.40	2.48	1.75	.22	0.00	0.00	4.30
SSE	9	56	63	19	7	0	3.63	154	.33	2.05	2.30	.69	.26	0.00	5.63
S	5	47	64	22	5	0	4.07	143	.18	1.72	2.34	.80	.18	0.00	5.22
SSW	9	73	92	27	5	0	3.88	206	.33	2.67	3.36	.93	.18	0.00	7.53
SW	6	68	83	33	7	0	4.08	197	.22	2.48	3.03	1.21	.26	0.00	[illegible].20
WSW	13	89	94	44	22	1	4.04	263	.47	3.2[illegible]	3.43	1.61	.00	.03	9.81
W	13	78	108	62	39	0	4.25	280	.47	2.78	3.98	2.27	1.42	0.00	10.82
WNW	7	59	81	54	32	5	4.54	238	.28	2.16	2.96	1.97	1.17	.18	8.70
NW	5	41	44	16	9	0	3.89	115	.18	1.50	1.61	.58	.33	0.00	4.20
NNW	8	30	22	9	2	0	3.47	89	.22	1.10	.80	.33	.07	0.00	3.52
NO DIRECT	0	0	0	0	0	0	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	2.56
AVG SPEED	1.35	3.06	4.83	6.78	9.02	12.95	3.71								
TOT COUNT	149	1050	1033	384	135	[illegible]		2737							

P-AREA TOWER 1975-1979



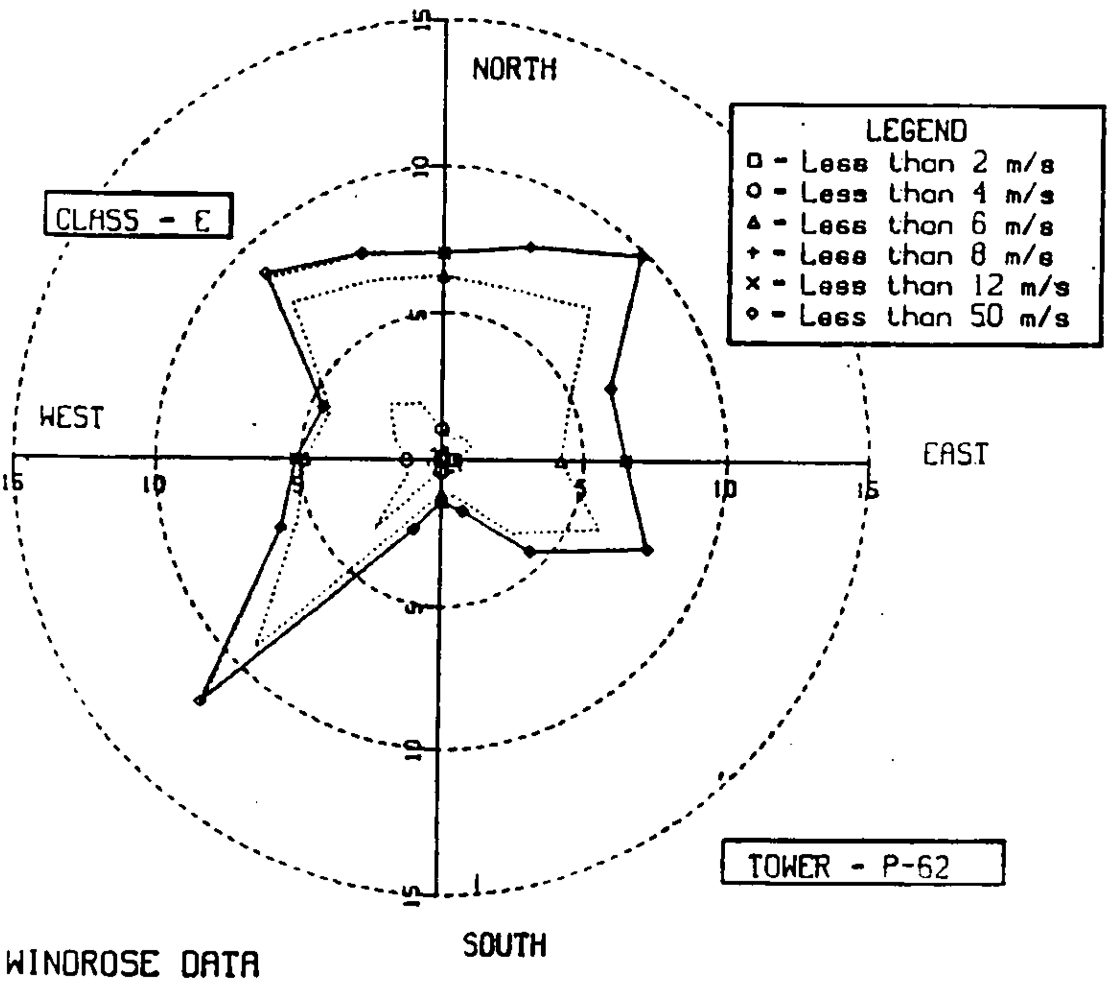
WINDROSE DATA

MINIMUM DATE MMDDYY 10175
MINIMUM TIME ZULU 0000
ENTRIES ALL CLASSES 14909

MAXIMUM DATE MMDDYY 123179
MAXIMUM TIME ZULU 2400
ENTRIES THIS CLASS 4111

DIRECTION	SPEED IN METERS/SEC 0-2	2-4	4-6	6-8	8-12	>12	AVERAGE SPEED	TOTAL TOT	PERCENT TIME WIND @ SPEED 0-2	2-4	4-6	6-8	8-12	>12	TOTAL
N	5	26	30	10	0	0	3.72	71	.12	.63	.73	.24	0.00	0.00	1.73
NNE	8	51	57	19	3	1	3.82	139	.19	1.24	1.38	.48	.07	.02	3.38
NE	11	102	192	88	6	1	4.24	400	.27	2.48	4.67	2.14	.15	.02	9.73
ENE	9	127	213	49	5	0	4.25	403	.22	3.09	5.18	1.19	.12	0.00	3.90
E	10	122	120	15	0	0	3.57	287	.24	2.97	2.92	.36	0.00	0.00	[illegible]
ESE	10	97	90	4	0	0	3.39	201	.24	2.36	2.19	.09	0.00	0.00	4.89
SE	10	59	93	19	2	0	3.78	183	.24	1.44	2.26	.46	.04	0.00	4.45
SSE	7	73	145	36	6	0	3.83	267	.17	1.78	3.53	.88	.15	0.00	[illegible]
S	0	32	137	35	7	0	4.79	211	0.00	.78	3.33	.85	.17	0.00	5.13
SSW	5	55	155	43	16	0	4.55	274	.12	1.34	3.77	1.05	.39	0.00	6.67
SW	8	67	147	35	8	1	4.15	266	.19	1.63	3.58	.85	.19	.02	6.47
WSW	8	59	138	49	17	0	4.31	271	.19	1.44	3.36	1.19	.41	0.00	[illegible]
W	6	50	182	135	59	1	6.20	433	.15	1.22	4.43	3.20	1.44	.02	[illegible]
WNW	10	54	162	114	69	2	5.05	411	.24	1.31	3.94	2.77	1.68	.04	10.00
NW	5	68	86	40	29	1	4.48	229	.12	1.65	2.09	.97	.71	.02	5.57
NNW	2	24	43	16	0	0	4.11	85	.04	.58	1.05	.39	0.00	0.00	2.07
NO DIRECT	0	0	0	0	0	0	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	1.73
AVG SPEED	1.25	3.18	4.88	6.70	9.13	13.42	4.27								
TOT ENTRY	114	1068	1890	707	227	7		4111							

P-AREA TOWER 1975-1979



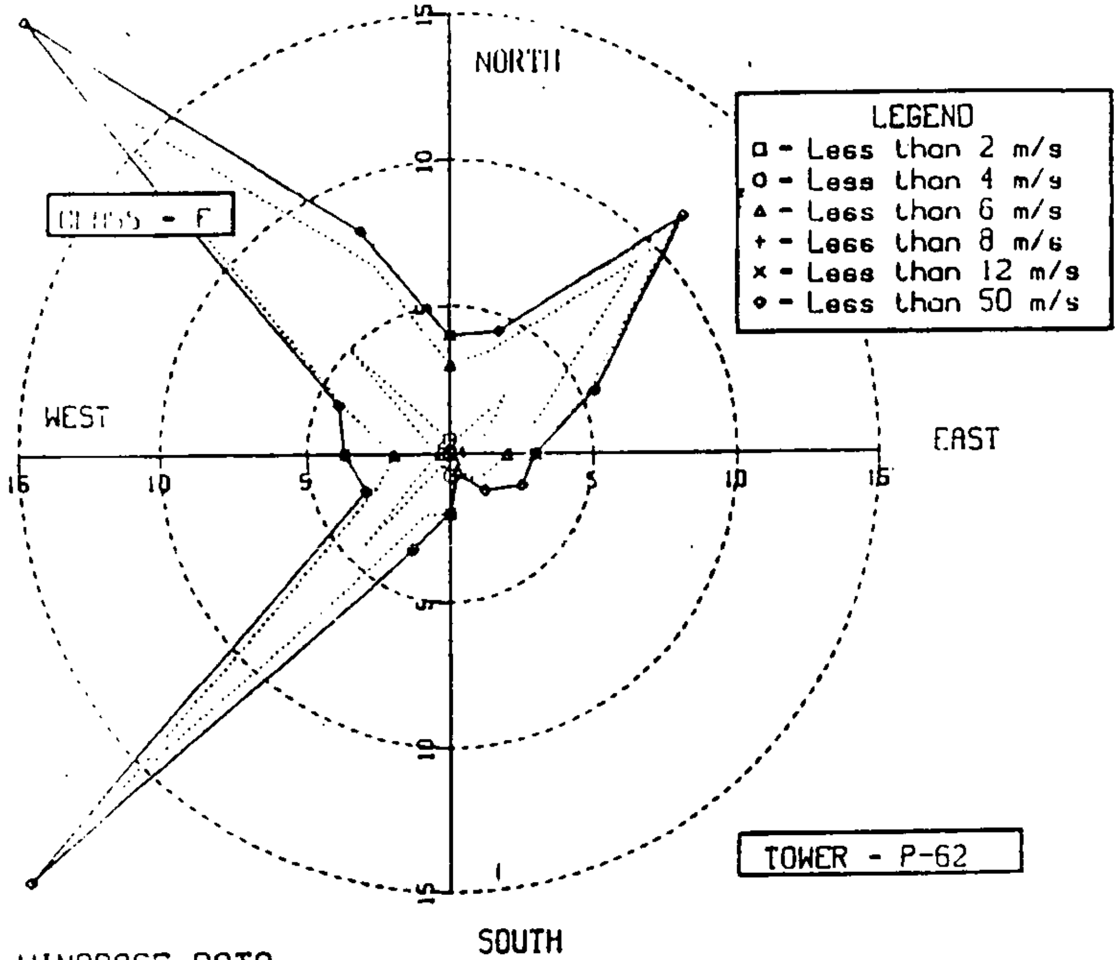
WINDROSE DATA

MINIMUM DATE MMDDYY 10175
MINIMUM TIME ZULU 0000
ENTRIES ALL CLASSES 14800

MAXIMUM DATE MMDDYY 123179
MAXIMUM TIME ZULU 2400
ENTRIES THIS CLASS 2450

DIRECTION	SPEED IN METERS/SEC 0-2	2-4	4-6	6-8	8-12	>12	AVERAGE SPEED	TOTAL TOT	PERCENT TIME WIND @ SPEED 0-2	2-4	4-6	6-8	8-12	>12	TOTAL
N	0	10	19	5	1	0	4.24	35	0.00	.41	.78	.20	.04	0.00	1.43
NNE	1	12	33	16	1	0	4.81	63	.04	.49	1.35	.65	.04	0.00	2.57
NE	3	79	142	61	5	0	4.38	290	.12	3.22	5.80	2.49	.20	0.00	11.84
ENE	1	32	102	15	0	0	4.54	150	.04	1.31	4.16	.61	0.00	0.00	6.12
E	1	30	88	8	0	0	4.38	127	.04	1.22	3.59	.33	0.00	0.00	5.18
ESE	2	42	61	7	0	0	4.00	112	.08	1.71	2.49	.29	0.00	0.00	4.57
SE	4	60	120	29	5	0	4.25	218	.16	2.45	4.80	1.18	.20	0.00	8.90
SSE	2	49	111	23	1	0	4.32	188	.08	2.00	4.53	.94	.04	0.00	7.59
S	3	23	128	18	0	0	4.50	173	.12	.94	5.22	.78	0.00	0.00	7.06
SSW	0	19	135	38	0	0	4.98	193	0.00	.78	5.51	1.59	0.00	0.00	7.88
SW	1	28	152	62	0	0	4.90	241	.04	1.08	6.20	2.53	0.00	0.00	9.84
WSW	1	28	91	38	1	0	4.78	157	.04	1.06	3.71	1.55	.04	0.00	6.41
W	2	9	92	56	0	0	5.08	158	.08	[illegible]	3.76	2.29	0.00	0.00	6.49
WNW	0	19	129	42	2	0	4.95	192	0.00	.78	5.27	1.71	.08	0.00	7.84
NW	0	14	72	22	0	0	5.02	108	0.00	.57	2.94	.90	0.00	0.00	4.41
NNW	1	9	23	13	0	0	4.73	48	.04	.37	.94	.53	0.00	0.00	1.88
NO DIRECT	0	0	0	0	0	0	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	1.43
AVG SPEED	1.47	3.21	4.84	6.53	8.64	0.00	4.60								
TOT ENTRY	22	459	1498	455	16	0		2450							

P-AREA TOWER 1975-1979

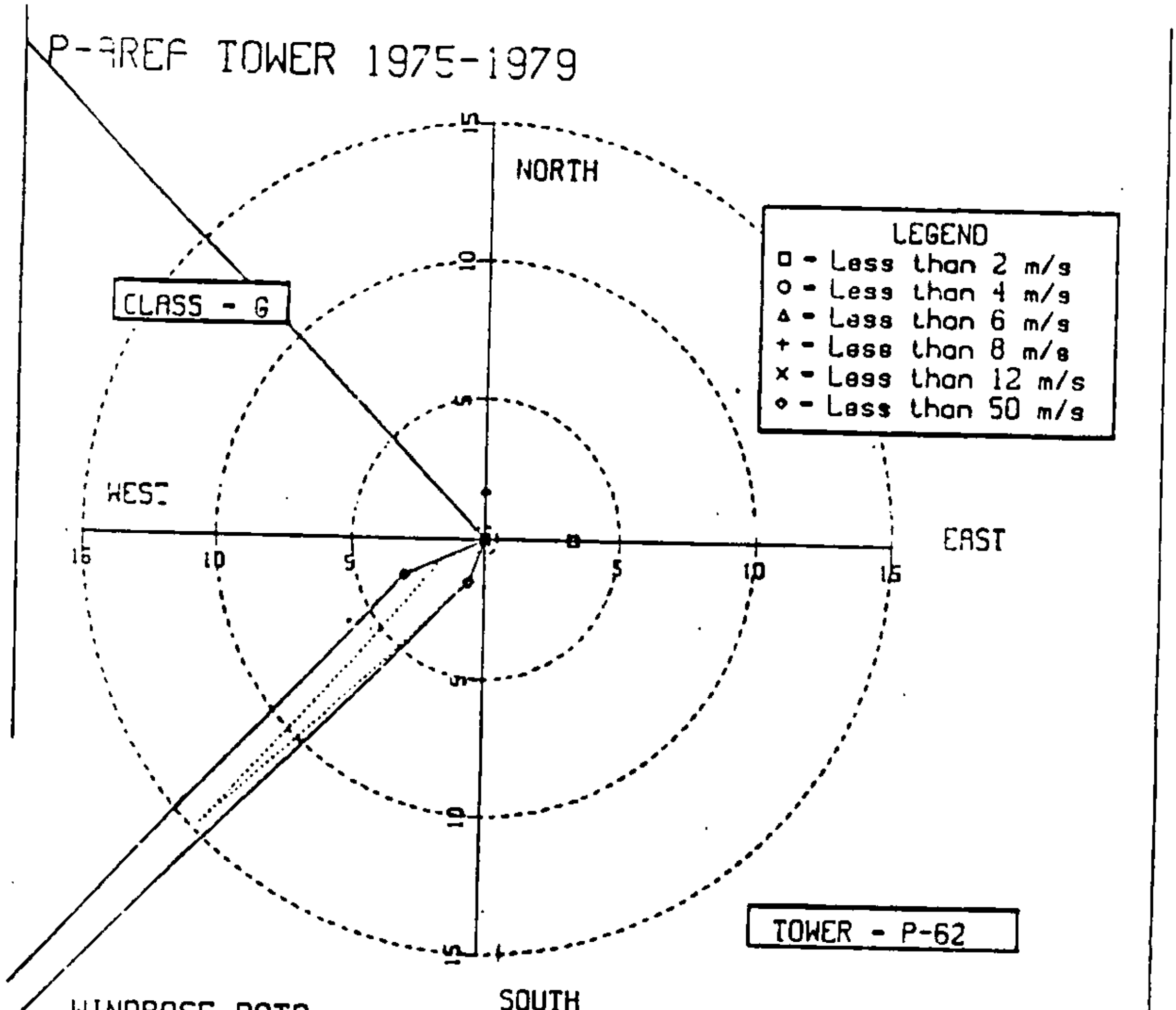


WINOROSE DATA

MINIMUM DATE MMDDYY 10175
MINIMUM TIME ZULU 0000
ENTRIES ALL CLASSES 14908

MAXIMUM DATE MMDDYY 123179
MAXIMUM TIME ZULU 2400
ENTRIES THIS CLASS 402

DIRECTION	SPEED IN METERS/SEC 0-2	2-4	4-6	6-8	8-12	>12	AVERAGE SPEED	TOTAL TOT	PERCENT TIME WIND @ SPEED 0-2	2-4	4-6	6-8	8-12	>12	TOTAL
N	0	3	5	0	0	0	4.10	8	0.00	.75	1.24	0.00	0.00	0.00	1.99
NNE	0	1	8	5	0	0	5.28	14	0.00	.25	1.99	1.24	0.00	0.00	3.48
NE	1	17	46	18	1	0	4.51	83	.25	4.23	11.44	4.48	.25	0.00	20.65
ENE	0	3	8	2	0	0	4.68	13	0.00	.75	1.99	.50	0.00	0.00	3.23
E	0	1	7	7	0	0	5.57	15	0.00	.25	1.74	1.74	0.00	0.00	3.73
ESE	0	3	13	1	0	0	4.60	17	0.00	.75	3.23	.25	0.00	0.00	4.23
SE	1	19	49	15	0	0	4.51	84	.25	4.73	12.19	3.73	0.00	0.00	20.90
SSE	0	3	25	5	0	0	5.07	33	0.00	.75	6.22	1.24	0.00	0.00	8.21
S	0	2	10	4	0	0	5.25	16	0.00	.50	2.49	1.00	0.00	0.00	3.98
SSW	0	2	13	3	0	0	4.78	18	0.00	.50	3.23	.75	0.00	0.00	4.48
SW	0	11	26	8	1	0	4.55	46	0.00	2.74	6.47	1.99	.25	0.00	11.44
WSW	0	5	9	7	1	0	5.10	22	0.00	1.24	2.24	1.74	.25	0.00	5.47
W	0	0	8	4	0	0	5.88	12	0.00	0.00	1.99	1.00	0.00	0.00	2.99
WNW	0	1	5	5	0	0	5.14	11	0.00	.25	1.24	1.24	0.00	0.00	2.74
NW	0	2	3	2	0	0	4.66	7	0.00	.50	.75	.50	0.00	0.00	1.74
NNW	0	0	2	1	0	0	5.84	3	0.00	0.00	.50	.25	0.00	0.00	.75
NO DIRECT	0	0	0	0	0	0	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	1.88
AVG SPEED	1.54	3.31	4.87	6.58	8.68	0.00	4.75								
TOT ENTRY	2	23	237	87	3	0		402							



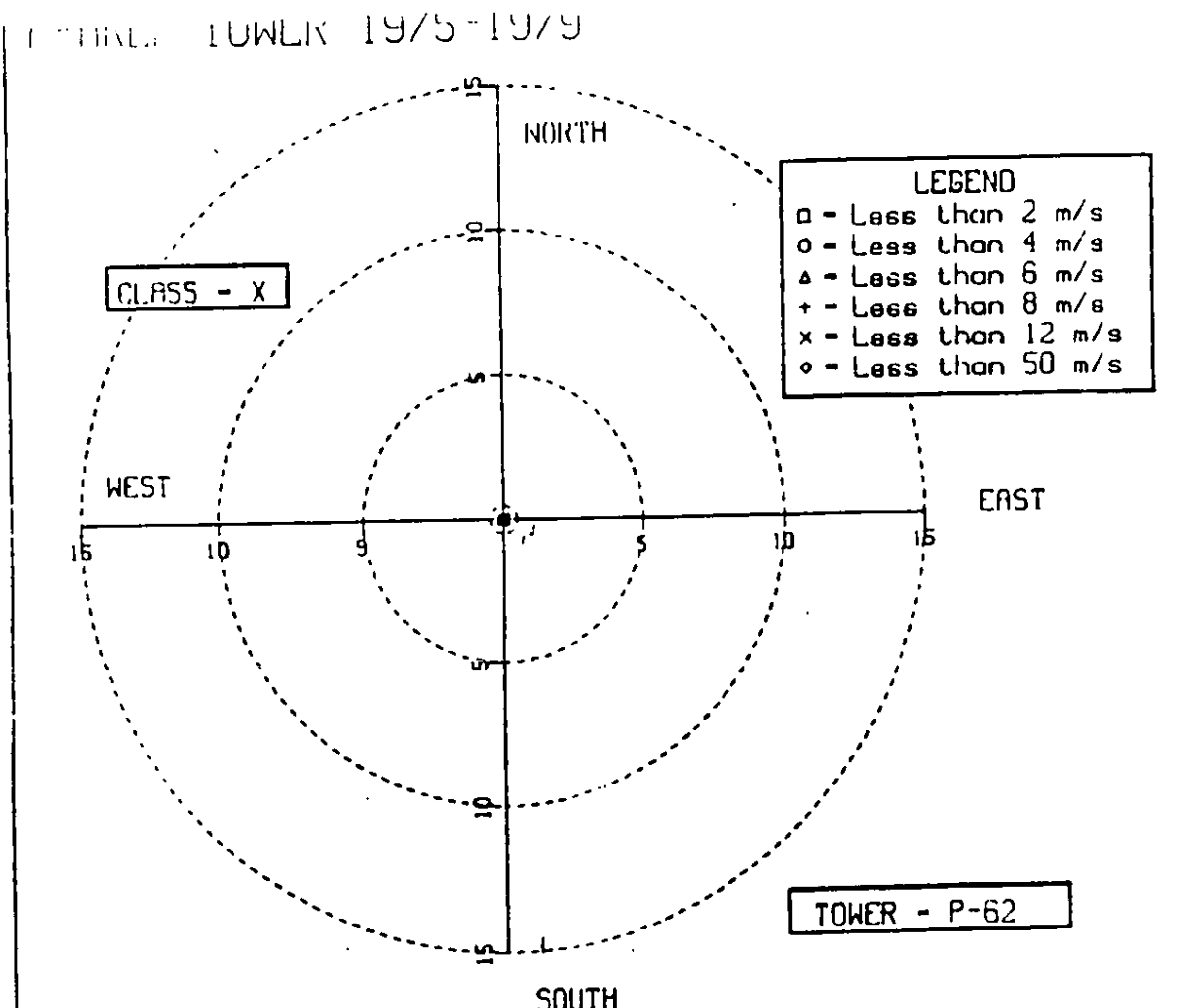
WINDROSE DATA

MINIMUM DATE MMDDYY 10175
MINIMUM TIME ZULU 0000
ENTRIES ALL CLASSES 14016

MAXIMUM DATE MMDDYY 123179
MAXIMUM TIME ZULU 2400
ENTRIES THIS CLASS 61

DIRECTION	SPEED IN METERS/SEC 0-2	2-4	4-6	6-8	8-12	>12	AVERAGE SPEED	TOTAL TOT
N	0	0	0	0	0	0	0.00	0
NNE	0	1	0	0	0	0	3.19	1
NE	0	9	24	2	0	0	4.50	35
ENE	1	0	1	0	0	0	2.67	2
E	0	0	0	0	0	0	0.00	0
ESE	0	0	0	0	0	0	0.00	0
SE	2	6	9	3	0	0	3.76	20
SSE	0	0	0	0	0	0	0.00	0
S	0	0	1	0	0	0	4.23	1
SSW	0	0	0	0	0	0	0.00	0
SW	0	0	0	0	0	0	0.00	0
WSW	0	0	0	0	0	0	0.00	0
W	2	0	0	0	0	0	.67	2
WNW	0	0	0	0	0	0	0.00	0
NW	0	0	0	0	0	0	0.00	0
NNW	0	0	0	0	0	0	0.00	0
NO DIRECT	0	0	0	0	0	0	0.00	0
AVG SPEED	1.28	3.43	4.77	6.28	0.00	0.00	3.64	
TOT ENTRY	5	9	35	5	0	0		61

PERCENT TIME WIND @ SPEED 0-2	2-4	4-6	6-8	8-12	>12	TOTAL
0.00	0.00	0.00	0.00	0.00	0.00	.00
0.00	1.64	0.00	0.00	0.00	0.00	1.64
0.00	14.75	39.31	3.28	0.00	0.00	57.38
1.64	0.00	1.64	0.00	0.00	0.00	3.28
0.00	0.00	0.00	0.00	0.00	0.00	.00
0.00	0.00	0.00	0.00	0.00	0.00	.00
3.28	9.84	14.75	4.92	0.00	0.00	32.79
0.00	0.00	0.00	0.00	0.00	0.00	.00
0.00	0.00	1.64	0.00	0.00	0.00	1.64
0.00	0.00	0.00	0.00	0.00	0.00	.00
0.00	0.00	0.00	0.00	0.00	0.00	.00
0.00	0.00	0.00	0.00	0.00	0.00	.00
3.28	0.00	0.00	0.00	0.00	0.00	3.28
0.00	0.00	0.00	0.00	0.00	0.00	.00
0.00	0.00	0.00	0.00	0.00	0.00	.00
0.00	0.00	0.00	0.00	0.00	0.00	.00
0.00	0.00	0.00	0.00	0.00	0.00	.00



WINDROSE DATA

MINIMUM DATE MMDDYY 10175
MINIMUM TIME ZULU 0000
ENTRIES ALL CLASSES 14000

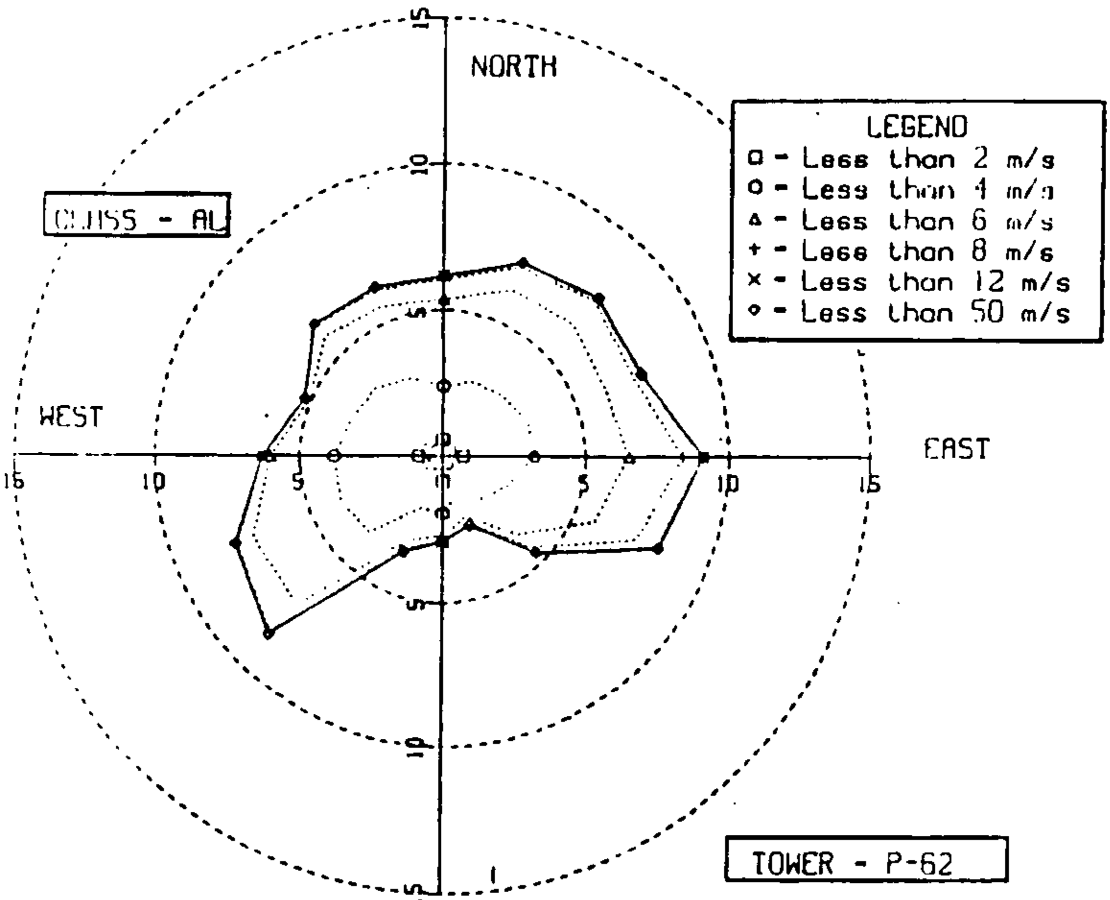
MAXIMUM DATE MMDDYY 123179
MAXIMUM TIME ZULU 2400
ENTRIES THIS CLASS 8

DIRECTION	0-2	2-4	4-6	6-8	8-12	>12	AVERAGE SPEED	TOTAL TOT
	0	0	0	0			0	0
N	0	0	0	0	0	0	0.00	0
NNE	0	0	0	0	0	0	0.00	0
NE	0	0	0	0	0	0	0.00	0
ENE	0	0	0	0	0	0	0.00	0
E	0	0	0	0	0	0	0.00	0
ESE	0	0	0	0	0	0	0.00	0
SE	0	0	0	0	0	0	0.00	0
SSE	0	0	0	0	0	0	0.00	0
S	0	0	0	0	0	0	0.00	0
SSW	0	0	0	0	0	0	0.00	0
SW	0	0	0	0	0	0	0.00	0
WSW	0	0	0	0	0	0	0.00	0
W	0	0	0	0	0	0	0.00	0
WNW	0	0	0	0	0	0	0.00	0
NW	0	0	0	0	0	0	0.00	0
NNW	0	0	0	0	0	0	0.00	0
NO DIRECT	4	2	1	0	0	1	1.16	8
AVG SPEED	.68	2.52	5.45	0.00	0.00	16.89	1.16	
TOT ENTRY	4	2	1	0	0	1		8

PERCENT TIME WIND @ SPEED

DIRECTION	0-2	2-4	4-6	6-8	8-12	>12	TOTAL
	0	0	0	0	0		
N	0.00	0.00	0.00	0.00	0.00	0.00	.00
NNE	0.00	0.00	0.00	0.00	0.00	0.00	.00
NE	0.00	0.00	0.00	0.00	0.00	0.00	.00
ENE	0.00	0.00	0.00	0.00	0.00	0.00	.00
E	0.00	0.00	0.00	0.00	0.00	0.00	.00
ESE	0.00	0.00	0.00	0.00	0.00	0.00	.00
SE	0.00	0.00	0.00	0.00	0.00	0.00	.00
SSE	0.00	0.00	0.00	0.00	0.00	0.00	.00
S	0.00	0.00	0.00	0.00	0.00	0.00	.00
SSW	0.00	0.00	0.00	0.00	0.00	0.00	.00
SW	0.00	0.00	0.00	0.00	0.00	0.00	.00
WSW	0.00	0.00	0.00	0.00	0.00	0.00	.00
W	0.00	0.00	0.00	0.00	0.00	0.00	.00
WNW	0.00	0.00	0.00	0.00	0.00	0.00	.00
NW	0.00	0.00	0.00	0.00	0.00	0.00	.00
NNW	0.00	0.00	0.00	0.00	0.00	0.00	.00
NO DIRECT	50.00	25.00	12.50	0.00	0.00	12.50	.00

P-AREA TOWER 1975-1979



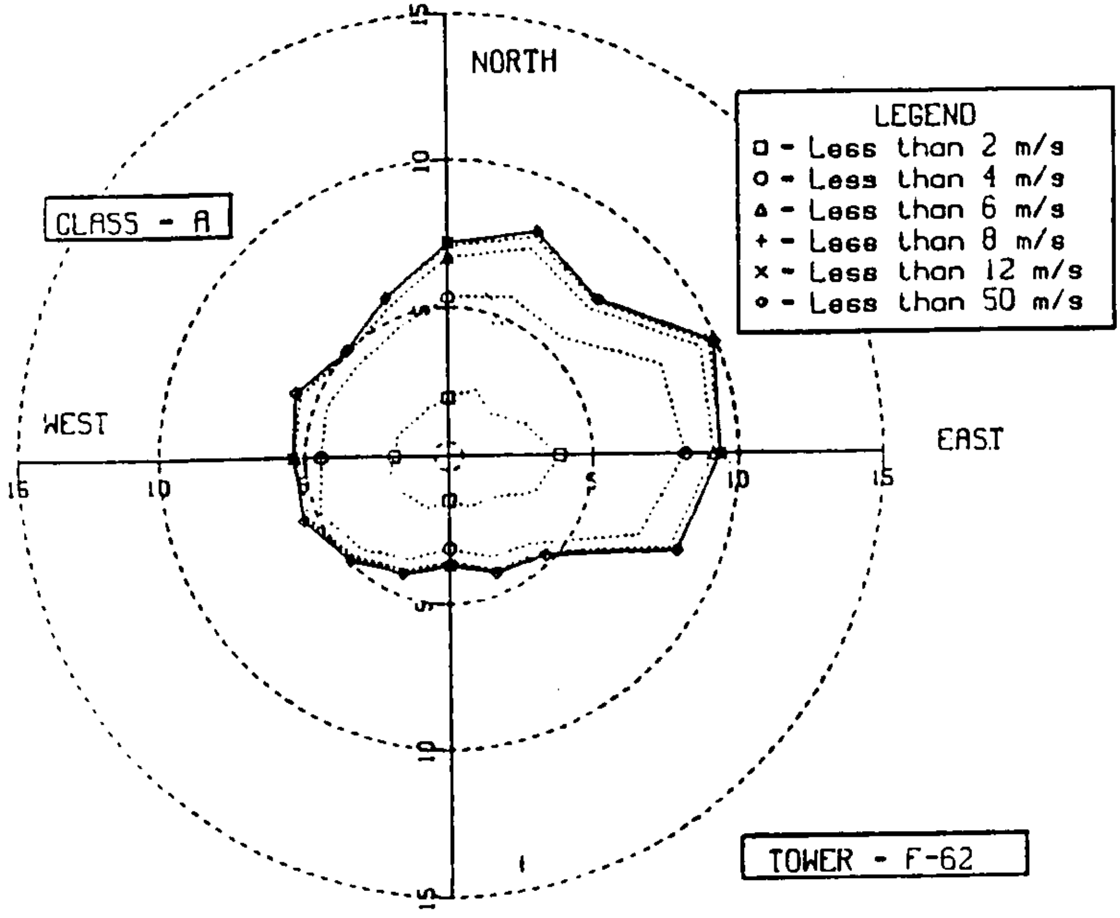
WINDROSE DATA

MINIMUM DATE MMDDYY 10175
MINIMUM TIME ZULU 0000
ENTRIES ALL CLASSES 14909

MAXIMUM DATE MMDDYY 123179
MAXIMUM TIME ZULU 2400
ENTRIES THIS CLASS 14909

DIRECTION	SPEED IN METERS/SEC 0-2	2-4	4-6	6-8	8-12	>12	AVERAGE SPEED	TOTAL TOT	PERCENT TIME WIND @ SPEED 0-2	2-4	4-6	6-8	8-12	>12	TOTAL
N	132	156	115	27	4	0	1.35	434	.89	1.05	.77	.18	.03	0.00	2.91
NNE	85	198	180	54	7	1	2.82	525	.57	1.33	1.21	.36	.04	.00	3.52
NE	104	438	532	192	13	1	3.44	1278	.70	2.92	3.57	1.29	.08	.00	8.57
ENE	106	471	489	91	7	0	3.26	1164	.71	3.16	3.28	.61	.04	0.00	7.81
E	125	444	333	40	1	0	2.98	943	.84	2.98	2.23	.27	.00	0.00	6.33
ESE	104	409	242	27	0	0	2.84	782	.70	2.74	1.62	.18	0.00	0.00	5.25
SE	113	365	373	75	7	0	3.10	853	.78	2.50	2.50	.50	.04	0.00	6.39
SSE	94	341	393	90	14	2	3.20	934	.63	2.29	2.64	.60	.09	.01	6.26
S	89	271	442	104	18	0	3.44	924	.60	1.82	2.96	.70	.12	0.00	6.20
SSW	95	321	505	128	28	0	3.61	1075	.64	2.15	3.39	.86	.17	0.00	7.21
SW	74	367	519	159	23	2	3.74	1144	.50	2.46	3.48	1.07	.15	.01	7.67
WSW	97	382	438	155	44	1	3.54	1115	.65	2.56	2.92	1.04	.30	.00	7.48
W	110	368	493	280	104	1	3.73	1354	.74	2.45	3.31	1.88	.70	.00	9.08
WNW	86	288	482	237	110	7	3.92	1210	.58	1.93	3.23	1.59	.74	.04	8.12
NW	59	245	253	93	39	1	3.51	690	.40	1.64	1.70	.62	.26	.00	4.63
NNW	60	149	121	43	3	0	2.84	376	.40	1.00	.81	.29	.02	0.00	2.52
NO DIRECT	4	2	1	0	0	1	1.18	8	.02	.01	.00	0.00	0.00	.00	2.88
AVG SPEED	1.15	2.99	4.88	6.68	9.08	13.51	3.23								
TOT ENTRY	1537	5231	5100	1205	420	12		14909							

F-AREA TOWER 1975-1979

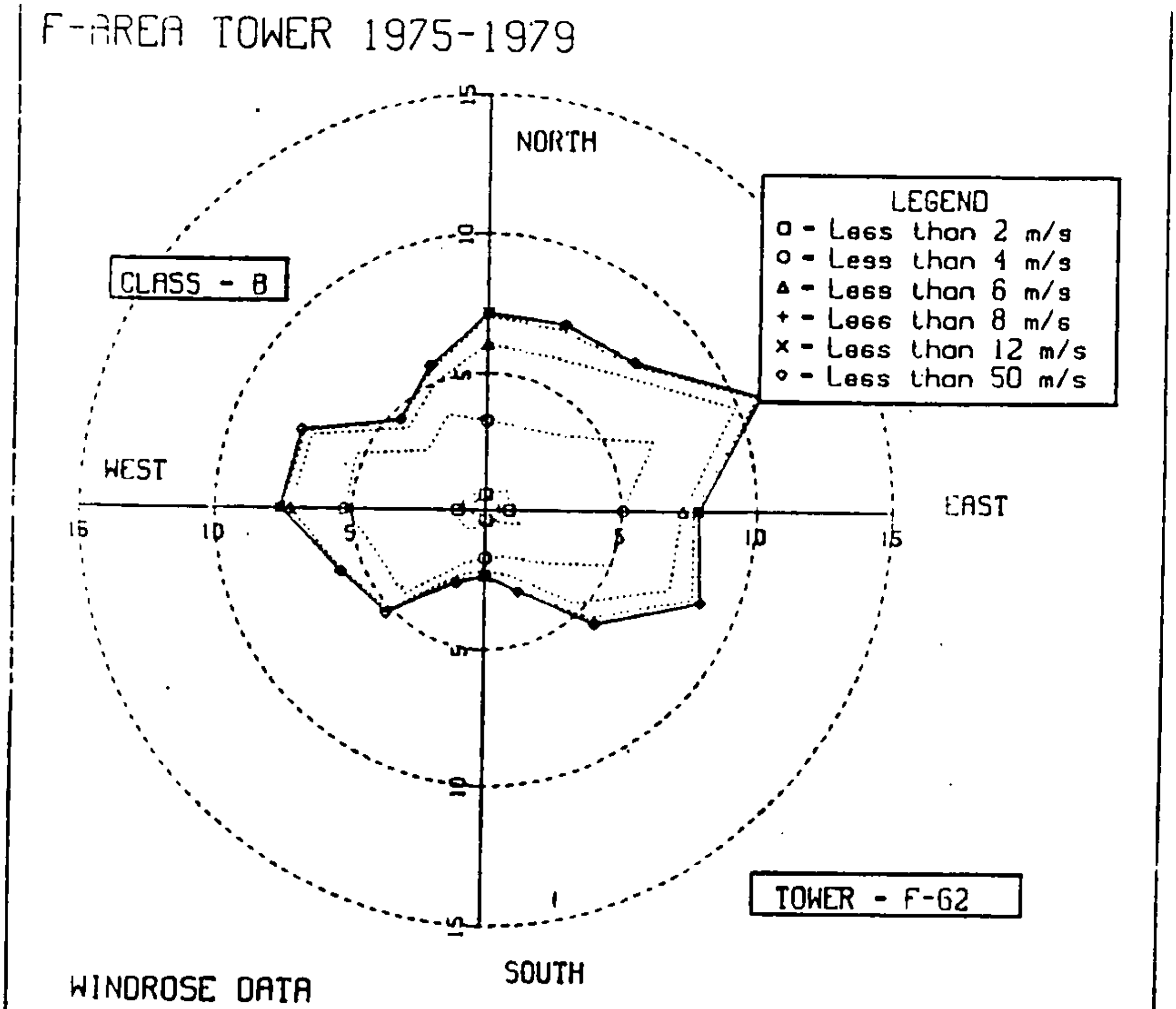


WINDROSE DATA

MINIMUM DATE MMDDYY 10175
MINIMUM TIME ZULU 0000
ENTRIES ALL CLASSES 13832

MAXIMUM DATE MMDDYY 123179
MAXIMUM TIME ZULU 2100
ENTRIES THIS CLASS 3267

DIRECTION	SPEED IN METERS/SEC 0-2	2-4	4-6	6-8	8-12	>12	AVERAGE SPEED	TOTAL TOT	PERCENT TIME WIND @ SPEED 0-2	2-4	4-6	6-8	8-12	>12	TOTAL
N	49	53	14	3	2	0	1.67	121	1.50	1.62	.43	.09	.06	0.00	3.70
NNE	62	60	13	4	1	0	1.12	140	1.90	1.84	.40	.12	.03	0.00	4.29
NE	63	80	11	3	4	0	1.74	161	1.93	2.45	.34	.09	.12	0.00	4.93
ENE	76	83	15	4	2	0	1.66	180	2.33	2.54	.46	.12	.06	0.00	5.51
E	63	83	29	1	1	0	1.79	177	1.93	2.54	.89	.03	.03	0.00	5.42
ESE	63	87	32	6	0	0	1.89	188	1.93	2.66	.98	.18	0.00	0.00	5.75
SE	55	90	18	3	1	0	1.71	165	1.68	2.75	.49	.09	.03	0.00	5.05
SSE	50	94	25	10	2	0	1.89	189	1.78	2.88	.77	.31	.06	0.00	5.79
S	65	110	45	12	4	0	2.37	238	1.99	3.37	1.38	.37	.12	0.00	7.22
SSW	80	109	59	13	7	0	2.29	268	2.45	3.34	1.81	.40	.21	0.00	8.20
SW	67	116	44	10	4	0	2.16	241	2.05	3.55	1.35	.31	.12	0.00	7.38
WSW	[illegible]	167	48	10	6	0	2.11	[illegible]	2.85	5.11	1.47	.31	.18	0.00	[illegible]
W	[illegible]	140	32	7	1	0	1.95	306	3.16	[illegible]	.98	.21	.03	0.00	[illegible]
WNW	105	126	37	8	1	0	1.84	277	3.21	3.85	1.13	.24	.03	0.00	8.48
NW	66	70	13	4	2	0	1.77	155	2.02	2.14	.40	.12	.06	0.00	4.74
NNW	60	61	15	2	1	0	1.71	139	1.84	1.87	.46	.06	.03	0.00	4.25
NO DIRECT	0	0	0	0	0	0	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	3.70
AVG SPEED	1.07	2.75	4.70	6.70	9.29	0.00	1.87								
TOT [illegible]	[illegible]	[illegible]	448	100	31	0		3267							



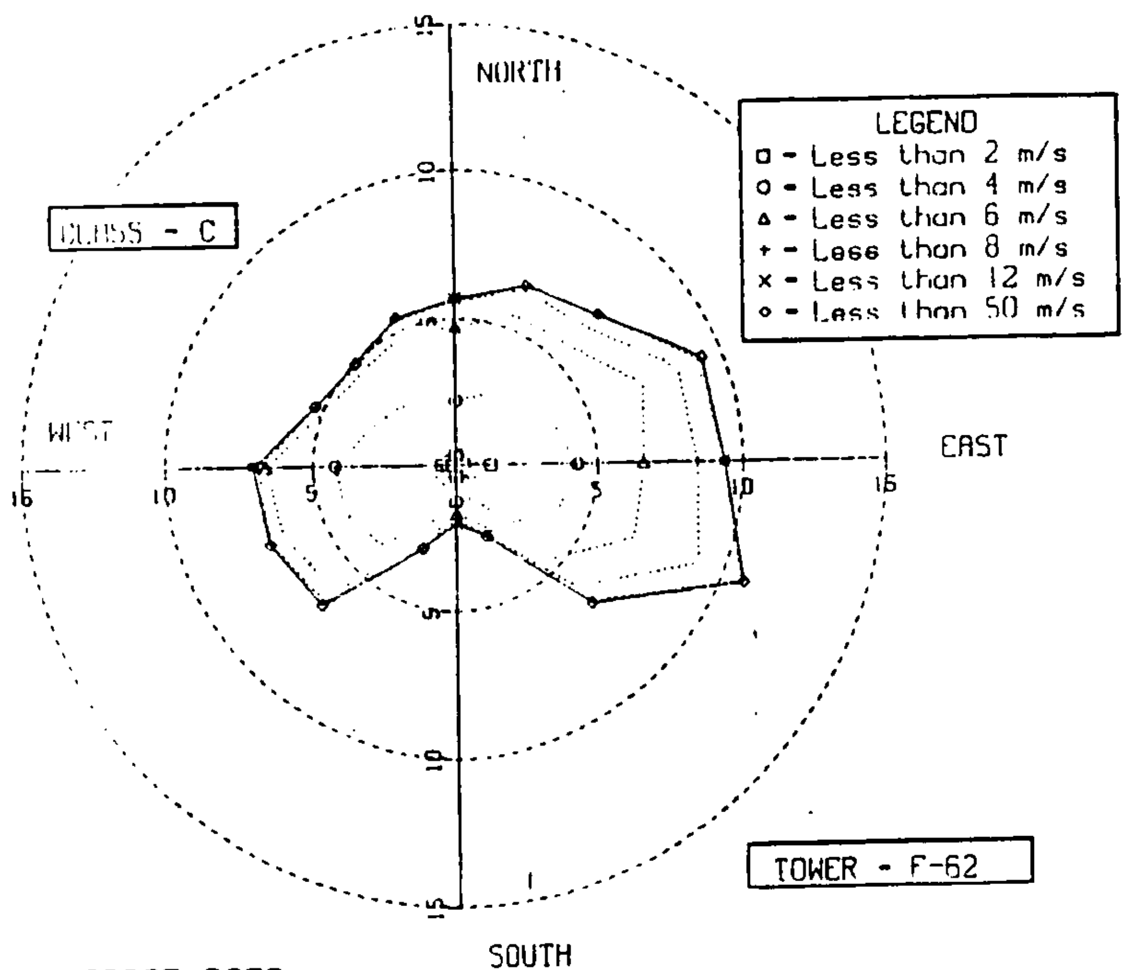
WINDROSE DATA

MINIMUM DATE MMDDYY 10175
MINIMUM TIME ZULU 0000
ENTRIES ALL CLASSES 13832

MAXIMUM DATE MMDDYY 123179
MAXIMUM TIME ZULU 2400
ENTRIES THIS CLASS 1640

DIRECTION	SPEED IN METERS/SEC 0-2	2-4	4-6	6-8	8-12	>12	AVERAGE SPEED	TOTAL TOT	PERCENT TIME WIND'S SPEED 0-2	2-4	4-6	6-8	8-12	>12	TOTAL
N	6	22	7	4	0	0	2.70	39	.38	1.34	.43	.24	0.00	0.00	2.37
NNE	12	22	7	3	2	0	2.01	46	.73	1.34	.43	.18	.12	0.00	2.79
NE	16	55	13	1	1	0	2.37	86	.97	3.34	.79	.06	.06	0.00	5.22
ENE	17	54	24	1	0	0	2.34	96	1.03	3.28	1.46	.06	0.00	0.00	5.83
E	17	70	33	5	1	0	2.78	126	1.03	4.25	2.00	.30	.06	0.00	7.65
ESE	15	72	29	5	2	0	2.58	123	.91	4.37	1.76	.30	.12	0.00	7.47
SE	12	39	18	6	1	0	2.69	76	.73	2.37	1.09	.36	.06	0.00	4.62
SSE	13	49	21	0	2	0	2.84	83	.73	2.98	1.28	.19	.12	0.00	5.65
S	10	44	46	16	2	0	3.44	118	.61	2.67	2.79	.97	.12	0.00	7.17
SSW	12	42	46	17	4	0	2.92	121	.73	2.55	2.79	1.03	.24	0.00	7.35
SW	17	47	51	9	2	0	3.22	126	1.03	2.86	3.10	.55	.12	0.00	7.65
WSW	15	94	54	14	3	0	3.00	180	.91	5.71	3.28	.85	.18	0.00	10.81
W	14	69	36	7	3	0	2.79	129	.85	4.19	2.19	.43	.18	0.00	7.84
WNW	23	60	38	15	5	0	2.61	141	1.17	3.65	2.31	.91	.30	0.00	8.57
NW	10	33	34	12	5	0	3.16	94	.61	2.01	2.07	.73	.30	0.00	5.71
NNW	6	23	13	10	0	0	2.92	52	.38	1.40	.79	.61	0.00	0.00	3.18
NO DIRECT	0	0	0	0	0	0	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	2.37
AVG SPEED	1.48	2.95	4.74	6.69	9.04	0.00	2.78								
[illegible]	[illegible]	[illegible]	470	133	31	0		1640							

F-AREA TOWER 1975-1979



WINDROSE DATA

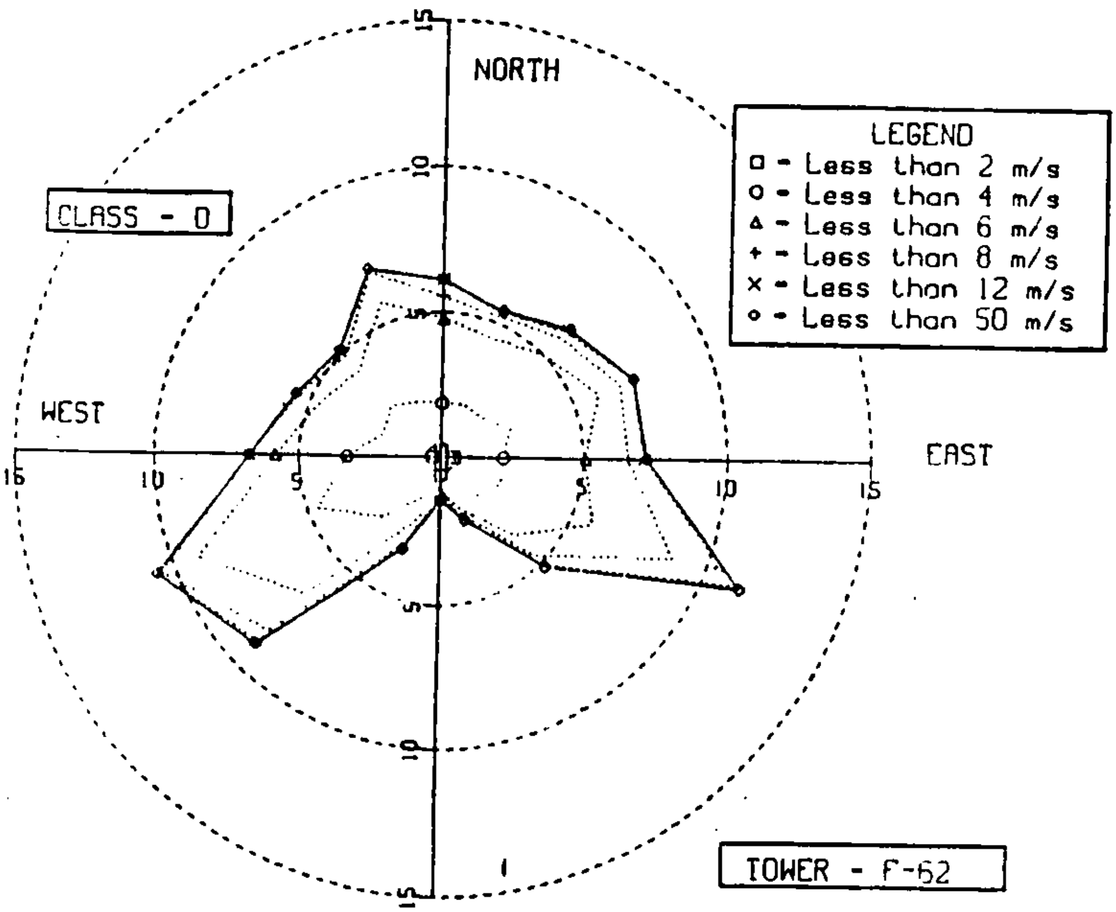
MINIMUM DATE MMDDYY 10175
MINIMUM TIME ZULU 0000
ENTRIES ALL CLASSES 13932

MAXIMUM DATE MMDDYY 123179
MAXIMUM TIME ZULU 2400
ENTRIES THIS CLASS 2478

DIRECTION	SPEED IN METERS/SEC 0-2	2-4	4-6	6-8	8-12	>12	AVERAGE SPEED	TOTAL TOT
N	10	21	10	5	4	0	2.34	50
NNE	17	34	20	5	0	0	2.50	76
NE	23	71	54	14	4	0	2.94	166
ENE	19	85	57	12	1	0	2.78	174
E	12	93	59	7	4	0	3.13	175
ESE	19	63	41	8	0	1	2.55	132
SE	20	50	44	6	3	0	2.76	123
SSE	14	46	60	14	2	0	3.11	136
S	9	48	62	22	2	0	3.25	141
SSW	14	51	72	22	5	0	3.22	164
SW	10	57	74	22	14	1	3.75	178
WSW	[illegible]	102	84	32	18	4	3.08	230
W	30	76	56	46	23	1	2.93	232
WNW	23	74	70	58	40	3	3.65	268
NW	17	53	44	33	18	2	3.08	167
NNW	8	23	25	8	2	0	2.95	66
NO DIRECT	0	0	0	0	0	0	0.00	0
AVG SPEED	1.18	2.99	4.81	6.79	9.04	13.38	3.11	
TOT COUNT	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		2478

PERCENT TIME WIND @ SPEED 0-2	2-4	4-6	6-8	8-12	>12	TOTAL
.40	.85	.40	.20	.16	0.00	2.02
.69	1.37	.81	.20	0.00	0.00	3.07
.93	2.87	2.18	.56	.16	0.00	6.70
.77	3.43	2.30	.48	.04	0.00	7.02
.48	3.75	2.38	.28	.16	0.00	7.06
.77	2.54	1.65	.32	0.00	.04	5.33
.81	2.02	1.78	.24	.12	0.00	4.96
.56	1.86	2.42	.56	.08	0.00	5.49
.36	1.86	2.50	.89	.08	0.00	5.69
.55	2.06	2.91	.89	.20	0.00	6.62
.40	2.30	2.99	.89	.56	.04	7.18
.40	3.31	3.39	1.29	.73	.16	9.28
1.21	3.07	2.26	1.86	.93	.04	9.36
.93	2.99	2.82	2.34	1.61	.12	10.82
.69	2.14	1.78	1.33	.73	.00	6.74
.32	.93	1.01	.32	.08	0.00	2.66
0.00	0.00	0.00	0.00	0.00	0.00	2.02

F-AREA TOWER 1975-1979



WINDROSE DATA

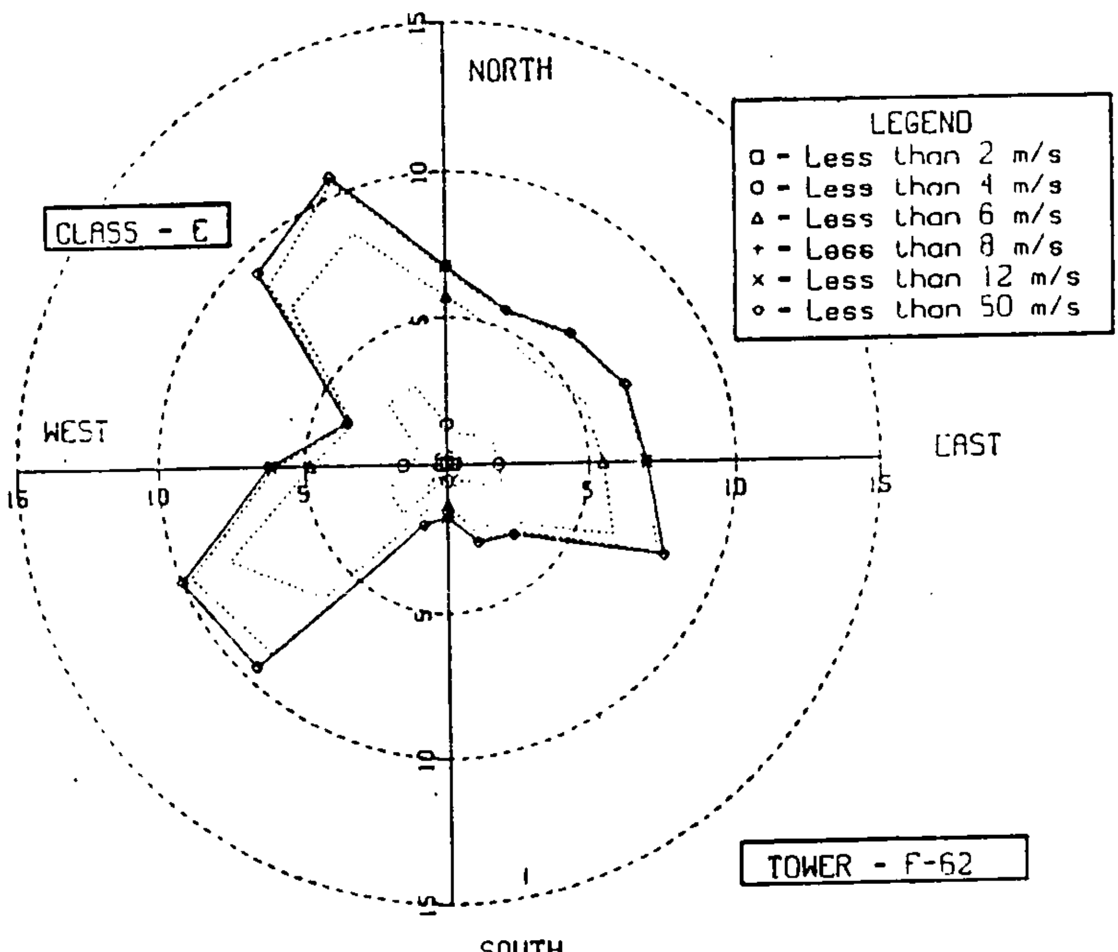
MINIMUM DATE MMDDYY 10175
MINIMUM TIME ZULU 0000
ENTRIES ALL CLASSES 13832

DIRECTION	0-2	2-4	4-6	6-8	8-12	>12	AVERAGE SPEED	TOTAL TOT
	SPEED IN METERS/SEC							
N	7	18	20	8	2	1	2.53	54
NNE	11	42	38	28	7	2	3.75	124
NE	29	78	138	65	19	5	3.62	332
ENE	25	146	164	50	5	0	3.11	390
E	11	111	92	33	0	0	3.61	247
ESE	6	74	92	28	3	0	3.71	204
SE	11	81	61	25	9	2	3.70	189
SSE	8	68	135	40	5	0	4.01	258
S	8	61	107	27	21	0	4.14	224
SSW	7	66	91	29	5	3	3.69	201
SW	9	64	111	31	11	4	3.09	230
WSW	21	74	122	30	18	0	3.34	265
W	17	63	106	54	21	[illegible]	3.69	263
WNW	[illegible]	59	129	111	84	10	3.91	417
NW	8	57	70	35	16	5	4.02	191
NNW	10	22	37	8	7	0	3.08	84
NO DIRECT	[illegible]	0	0	0	0	0	0.00	0
AVG SPEED	[illegible]	3.11	4.84	6.71	9.22	13.18	3.64	
TOT ENTRY	[illegible]	1000	1511	601	[illegible]	34		3671

MAXIMUM DATE MMDDYY 123179
MAXIMUM TIME ZULU 2400
ENTRIES THIS CLASS 3671

0-2	2-4	4-6	6-8	8-12	>12	TOTAL
PERCENT TIME WIND.@ SPEED						
.19	.44	.54	.22	.05	.02	1.47
.30	1.14	.98	.71	.19	.05	3.38
.79	2.07	3.78	1.77	.52	.14	9.04
.68	3.98	4.47	1.36	.14	0.00	10.62
.30	3.02	2.51	.90	0.00	0.00	6.73
.16	2.02	2.51	.79	.08	0.00	5.58
.30	2.21	1.66	.68	.25	.05	5.15
.22	1.85	3.60	1.09	.14	0.00	6.97
.22	1.66	2.91	.74	.57	0.00	6.10
.19	1.80	2.48	.79	.14	.08	5.49
.25	1.74	3.02	.84	.30	.11	6.2[illegible]
.57	2.02	3.3[illegible]	.82	.49	0.00	[illegible]
.46	1.73	2.09	1.47	.57	.05	[illegible]
.65	1.61	3.5[illegible]	3.0[illegible]	2.29	[illegible]	11.36
.22	1.55	1.91	.95	.44	.14	[illegible]
.27	.60	1.01	.22	.19	0.00	[illegible]
0.00	0.00	0.00	0.00	0.00	0.00	1.47

F-AREA TOWER 1975-1979



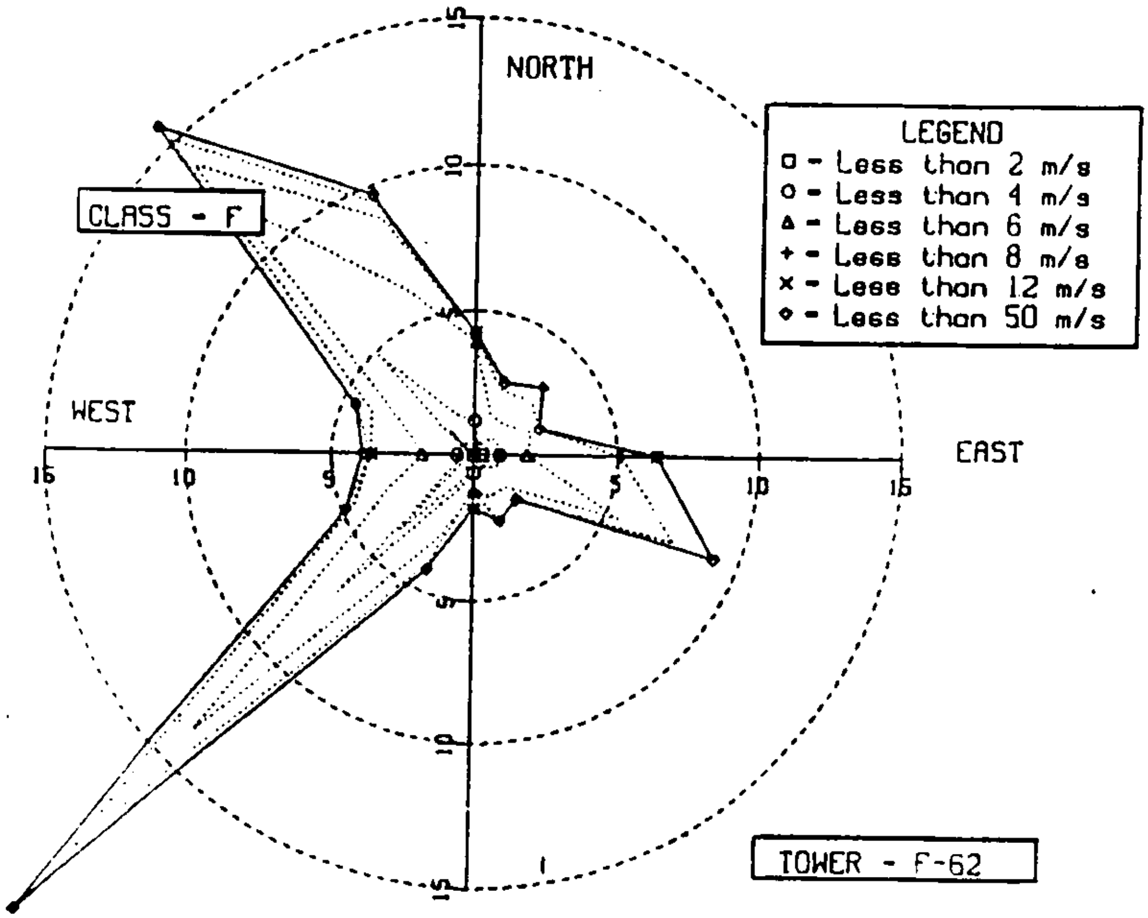
WINDROSE DATA

MINIMUM DATE MMDDYY 10175
MINIMUM TIME ZULU 0000
ENTRIES ALL CLASSES 13932

MAXIMUM DATE MMDDYY 123179
MAXIMUM TIME ZULU 2400
ENTRIES THIS CLASS 2403

DIRECTION	SPEED IN METERS/SEC 0-2	2-4	4-6	6-8	8-12	>12	AVERAGE SPEED	TOTAL TOT	PERCENT TIME WIND & SPEED 0-2	2-4	4-6	6-8	8-12	>12	TOTAL
N	0	13	18	10	1	0	4.48	42	0.00	.54	.75	.42	.04	0.00	1.75
NNE	6	10	20	16	0	0	3.91	52	.25	.42	.83	.67	0.00	0.00	2.16
NE	23	31	96	62	17	0	3.29	229	.96	1.29	4.00	2.58	.71	0.00	9.53
ENE	5	49	144	34	8	0	4.21	240	.21	2.04	5.99	1.41	.33	0.00	9.99
E	4	34	78	29	4	1	4.58	150	.17	1.41	3.25	1.21	.17	.04	6.24
ESE	0	24	63	3	2	0	4.39	92	0.00	1.00	2.62	.12	.08	0.00	3.83
SE	13	58	113	26	13	0	3.58	223	.54	2.41	4.70	1.08	.54	0.00	9.28
SSE	4	65	136	46	4	1	4.22	256	.17	2.70	5.66	1.91	.17	.04	10.65
S	2	31	105	21	3	0	4.27	162	.08	1.29	4.37	.87	.12	0.00	6.74
SSW	3	24	89	17	2	0	4.38	135	.12	1.00	3.70	.71	.08	0.00	5.62
SW	1	32	78	36	2	0	4.51	149	.04	1.33	3.25	1.50	.08	0.00	8.20
WSW	2	41	[illegible]	34	2	0	4.28	163	.08	[illegible]	3.50	1.41	.08	0.00	[illegible]
W	5	39	[illegible]	32	3	0	4.15	167	[illegible]	[illegible]	3.66	1.33	.12	0.00	[illegible]
WNW	10	41	100	39	5	0	3.99	195	.42	1.71	4.16	[illegible]	.21	0.00	8.11
NW	2	16	46	12	3	1	4.17	80	.08	.67	1.91	.50	.12	.04	[illegible]
NNW	3	15	40	9	1	0	4.18	68	.12	[illegible]	1.66	.37	.04	0.00	2.03
NO DIRECT	0	0	0	0	0	0	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	1.75
AVG SPEED	.97	3.16	4.89	6.63	9.12	12.35	4.08								
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	70	3		2403							

F-AREA TOWER 1975-1979



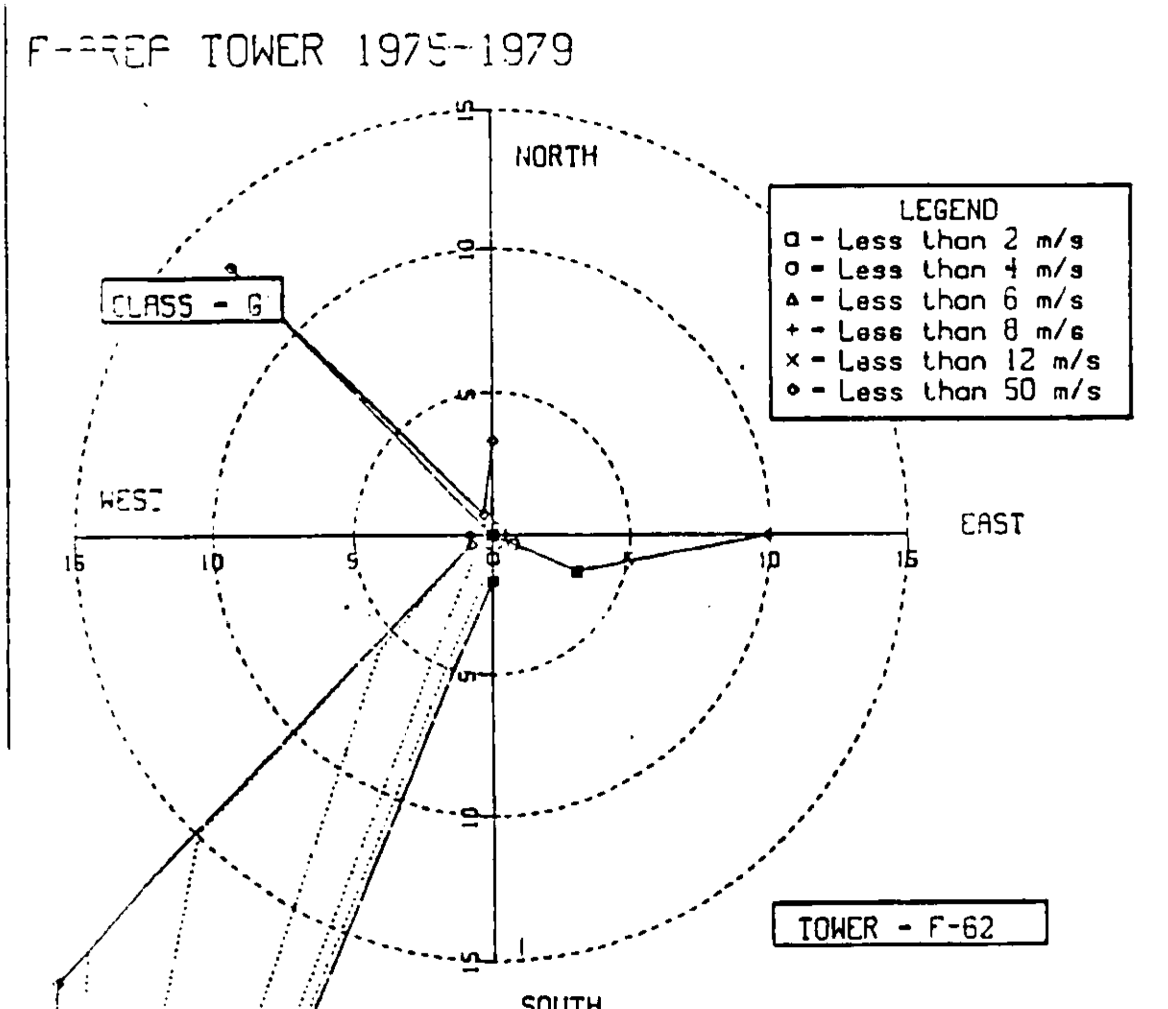
WINDROSE DATA

MINIMUM DATE MMDDYY 10175
MINIMUM TIME ZULU 0000
ENTRIES ALL CLASSES 13032

MAXIMUM DATE MMDDYY 123179
MAXIMUM TIME ZULU 2400
ENTRIES THIS CLASS 330

DIRECTION	SPEED IN METERS/SEC 0-2	2-4	4-6	6-8	8-12	>12	AVERAGE SPEED	TOTAL TOT
N	0	2	2	0	2	0	4.90	6
NNE	3	1	6	3	1	0	3.71	14
NE	12	10	23	19	10	0	3.29	74
ENE	1	1	9	4	1	0	3.37	16
E	0	2	4	6	0	1	5.65	13
ESE	0	1	8	4	2	0	5.28	15
SE	4	12	24	6	4	2	3.84	52
SSE	0	5	15	9	2	1	5.07	32
S	0	4	9	1	0	0	4.13	14
SSW	0	1	4	3	1	0	5.27	9
SW	0	3	2	4	2	0	4.83	11
WSW	0	3	4	1	0	0	4.33	8
W	1	2	3	11	4	0	4.16	21
WNW	2	1	15	7	5	0	4.99	30
NW	1	1	3	2	0	0	4.32	7
NNW	0	1	4	3	0	0	5.28	8
NO DIRECT	0	0	0	0	0	0	0.00	0
AVG SPEED	1.12	3.04	4.87	6.75	9.14	13.31	4.05	
TOT ENTRY	21	50	135	83	34	1		330

PERCENT TIME WIND @ SPEED 0-2	2-4	4-6	6-8	8-12	>12	TOTAL
0.00	.61	.61	0.00	.61	0.00	1.82
.91	.30	1.82	.91	.30	0.00	4.24
3.64	3.03	6.97	5.76	3.03	0.00	22.42
.30	.30	2.73	1.21	.30	0.00	4.85
0.00	.61	1.21	1.82	0.00	.30	3.94
0.00	.30	2.42	1.21	.61	0.00	4.55
1.21	3.64	7.27	1.82	1.21	.61	15.76
0.00	1.52	4.55	2.73	.61	.30	9.70
0.00	1.21	2.73	.30	0.00	0.00	4.24
0.00	.30	1.21	.91	.30	0.00	2.73
0.00	.91	.61	1.21	.61	0.00	3.33
0.00	.91	1.21	.30	0.00	0.00	2.42
.30	.61	.91	3.33	1.21	0.00	6.36
.61	.30	4.55	2.12	1.52	0.00	9.09
.30	.30	.91	.61	0.00	0.00	2.12
0.00	.30	1.21	.91	0.00	0.00	2.42
0.00	0.00	0.00	0.00	0.00	0.00	1.82



WINDROSE DATA

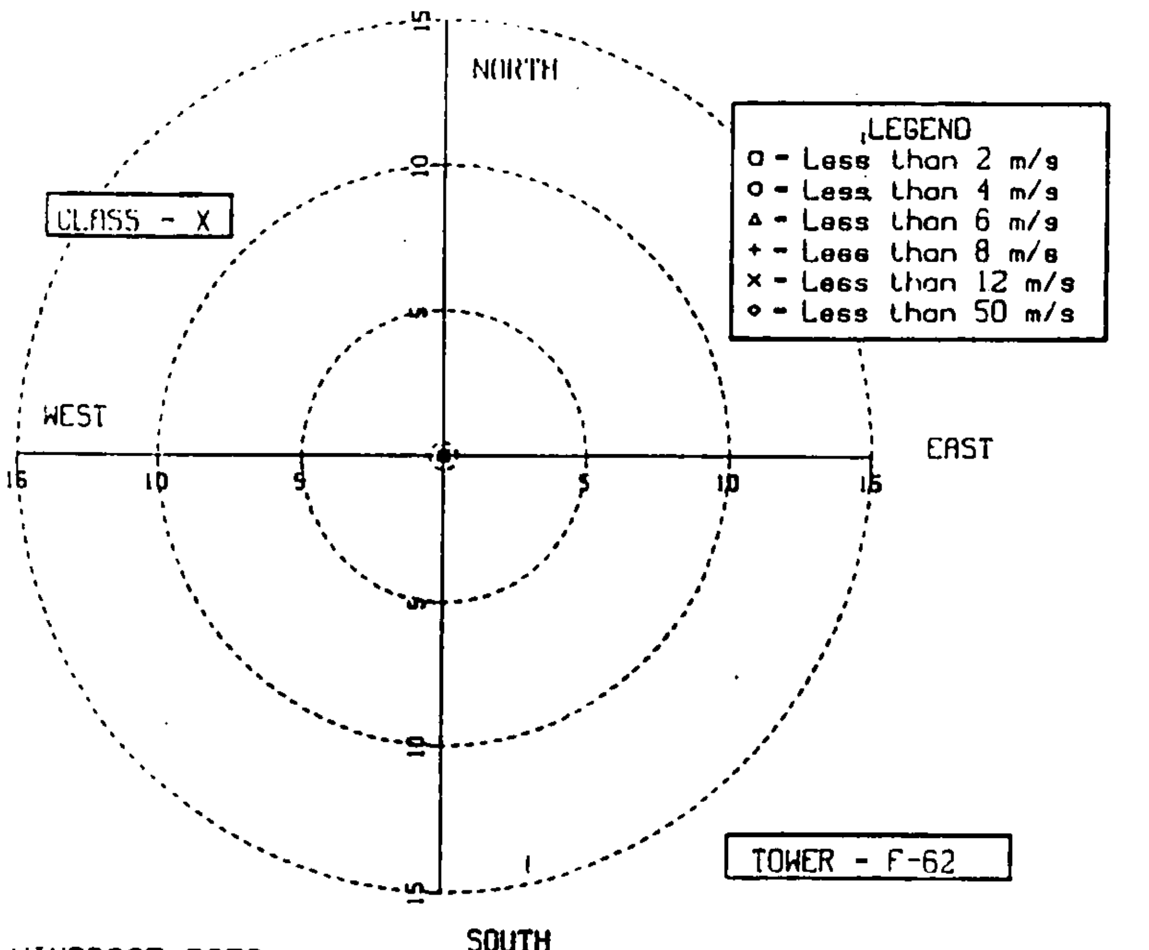
MINIMUM DATE MMDDYY 10175
MINIMUM TIME ZULU 0000
ENTRIES ALL CLASSES 13758

MAXIMUM DATE MMDDYY 123179
MAXIMUM TIME ZULU 2400
ENTRIES THIS CLASS 121

DIRECTION	SPEED IN METERS/SEC 0-2	2-4	4-6	6-8	8-12	>12	AVERAGE SPEED	TOTAL TOT
N	1	0	1	0	0	0	1.49	2
NNE	50	2	1	0	0	0	1.61	53
NE	1	[illegible]	11	7	2	0	4.24	27
ENE	0	1	0	0	0	0	2.14	1
E	0	1	0	0	0	0	2.32	1
ESE	0	0	0	0	0	0	0.00	0
SE	1	1	12	1	[illegible]	0	4.2[illegible]	16
SSE	0	0	1	0	0	0	4.63	1
S	2	1	1	0	0	0	1.83	4
SSW	0	0	0	0	0	0	0.00	0
SW	0	0	0	0	0	0	0.00	0
WSW	0	0	0	0	0	0	0.00	0
W	0	0	0	12	0	0	7.17	12
WNW	0	1	3	0	0	0	4.44	4
NW	0	0	0	0	0	0	0.00	0
NNW	0	0	0	0	0	0	0.00	0
NO DIRECT	0	0	0	0	0	0	0.00	0
AVG SPEED	1.54	2.47	4.81	6.62	8.[illegible]9	0.00	2.40	
TOT ENTRY	55	[illegible]	30	20	3	0		121

DIRECTION	PERCENT TIME WIND @ SPEED 0-2	2-4	4-6	6-8	8-12	>12	TOTAL
N	.83	0.00	.83	0.00	0.00	0.00	1.65
NNE	41.32	1.65	.83	0.00	0.00	0.00	43.80
NE	.83	4.96	9.09	5.79	1.65	0.00	22.31
ENE	0.00	.83	0.00	0.00	0.00	0.00	.83
E	0.00	.83	0.00	0.00	0.00	0.00	.83
ESE	0.00	0.00	0.00	0.00	0.00	0.00	.00
SE	.83	.83	9.92	.83	.83	0.00	13.22
SSE	0.00	0.00	.83	0.00	0.00	0.00	.83
S	1.65	.83	.83	0.00	0.00	0.00	3.31
SSW	0.00	0.00	0.00	0.00	0.00	0.00	.00
SW	0.00	0.00	0.00	0.00	0.00	0.00	.00
WSW	0.00	0.00	0.00	0.00	0.00	0.00	.00
W	0.00	0.00	0.00	9.92	0.00	0.00	9.92
WNW	0.00	.83	2.48	0.00	0.00	0.00	3.31
NW	0.00	0.00	0.00	0.00	0.00	0.00	.00
NNW	0.00	0.00	0.00	0.00	0.00	0.00	.00
NO DIRECT	0.00	0.00	0.00	0.00	0.00	0.00	1.65

F-AREA TOWER 1975-1979



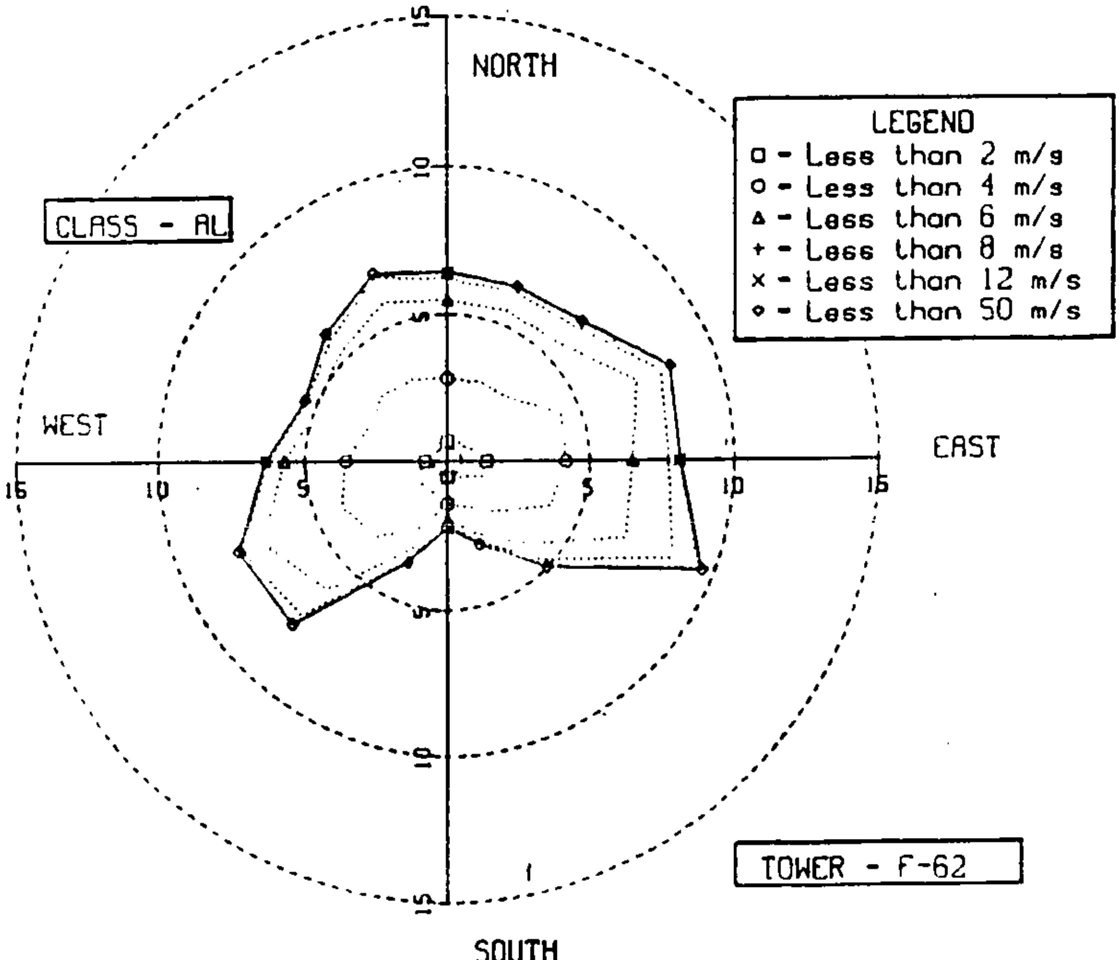
WINDROSE DATA

MINIMUM DATE MMDDYY 10175
MINIMUM TIME ZULU 0000
ENTRIES ALL CLASSES 13932

MAXIMUM DATE MMDDYY 123179
MAXIMUM TIME ZULU 2400
ENTRIES THIS CLASS 10

	SPEED IN METERS/SEC						AVERAGE	TOTAL	PERCENT TIME WIND @ SPEED						
DIRECTION	0-2	2-4	4-6	6-8	8-12	>12	SPEED	TOT	0-2	2-4	4-6	6-8	8-12	>12	TOTAL
N	0	0	0	0	0	0	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	.00
NNE	0	0	0	0	0	0	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	.00
NE	0	0	0	0	0	0	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	.00
ENE	0	0	0	0	0	0	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	.00
E	0	0	0	0	0	0	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	.00
ESE	0	0	0	0	0	0	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	.00
SE	0	0	0	0	0	0	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	.00
SSE	0	0	0	0	0	0	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	.00
S	0	0	0	0	0	0	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	.00
SSW	0	0	0	0	0	0	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	.00
SW	0	0	0	0	0	0	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	.00
WSW	0	0	0	0	0	0	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	.00
W	0	0	0	0	0	0	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	.00
WNW	0	0	0	0	0	0	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	.00
NW	0	0	0	0	0	0	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	.00
NNW	0	0	0	0	0	0	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	.00
NO DIRECT	3	0	2	4	0	1	2.68	10	30.00	0.00	20.00	40.00	0.00	10.00	.00
AVG SPEED	1.14	0.00	4.84	6.53	0.00	20.07	2.68								
TOT ENTRY	3	0	2	4	0	1		10							

F-AREA TOWER 1975-1979



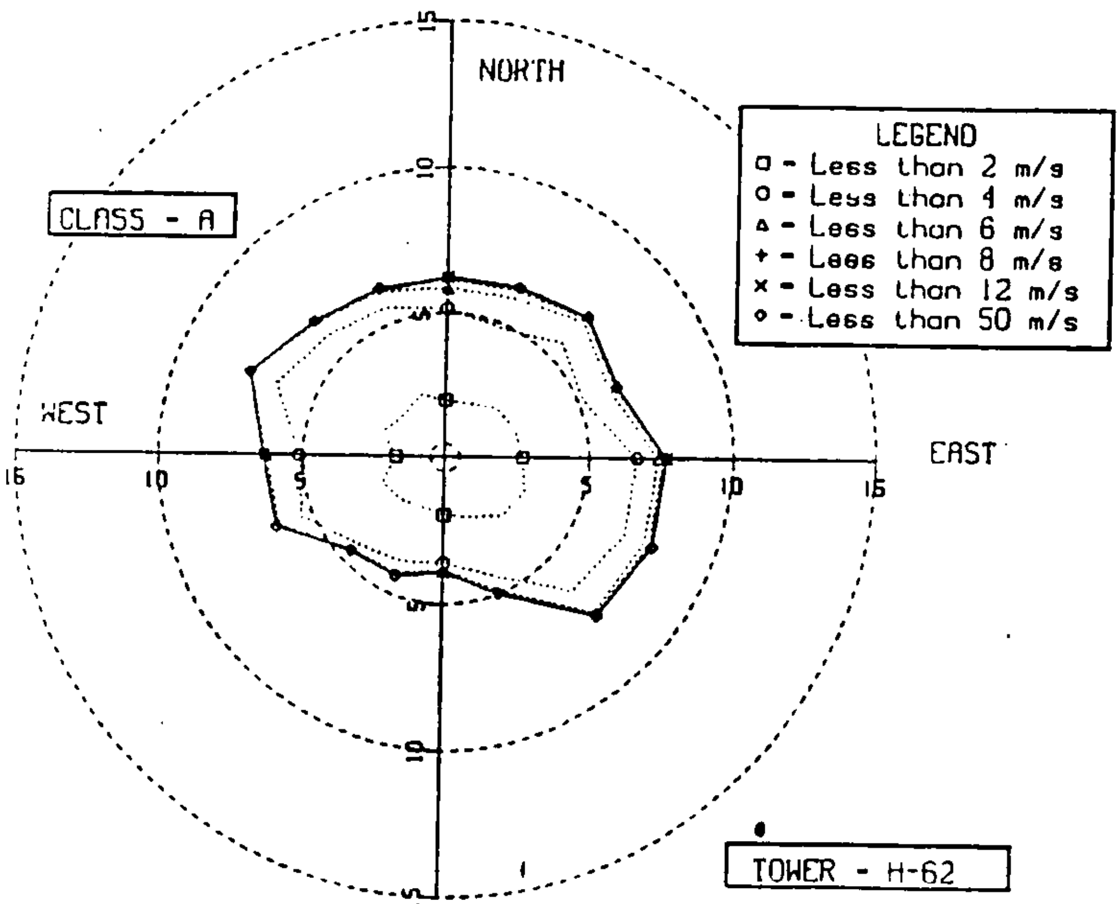
WINDROSE DATA

MINIMUM DATE MMDDYY 10175
MINIMUM TIME ZULU 0000
ENTRIES ALL CLASSES 13932

MAXIMUM DATE MMDDYY 123179
MAXIMUM TIME ZULU 2400
ENTRIES THIS CLASS 13932

DIRECTION	0-2	2-4	4-6	6-8	8-12	>12	AVERAGE SPEED	TOTAL TOT	0-2	2-4	4-6	6-8	8-12	>12	TOTAL
	SPEED IN METERS/SEC								PERCENT TIME WIND,@ SPEED						
N	73	127	72	30	11	1	2.22	314	.52	.91	.52	.22	.07	.00	2.25
NNE	161	171	103	57	11	2	1.93	505	1.18	1.23	.74	.41	.07	.01	3.62
NE	168	329	348	171	57	5	2.85	1078	1.21	2.38	2.48	1.23	.41	.03	7.72
ENE	143	419	413	105	17	0	2.74	1097	1.03	3.01	2.96	.75	.12	0.00	7.87
E	108	394	295	81	10	2	2.90	890	.78	2.83	2.12	.58	.07	.01	6.39
ESE	103	321	265	55	9	1	2.71	754	.74	2.30	1.90	.39	.06	.00	5.41
SE	119	331	288	73	32	4	2.78	847	.85	2.38	2.07	.52	.23	.02	6.08
SSE	97	327	393	127	17	2	3.13	963	.70	2.35	2.82	.91	.12	.01	6.91
S	96	297	375	88	32	0	3.27	899	.69	2.13	2.69	.71	.23	0.00	6.15
SSW	116	293	361	101	24	3	3.03	898	.83	2.10	2.59	.72	.17	.02	6.45
SW	104	319	360	112	35	5	3.20	935	.75	2.29	2.59	.80	.25	.03	6.71
WSW	141	461	398	121	47	4	2.90	1170	1.01	3.31	2.84	[illegible]	.34	.02	[illegible]
W	194	309	321	169	55	3	2.89	1131	1.39	2.79	2.30	1.21	.39	.02	[illegible]
WNW	187	362	392	238	140	13	3.02	1332	1.34	2.60	2.81	1.71	1.00	.09	[illegible]
NW	104	230	210	90	41	8	2.91	684	.75	1.65	1.51	.70	.32	.05	[illegible]
NNW	87	145	134	40	11	0	2.50	417	.62	1.04	.96	.29	.07	0.00	[illegible]
NO DIRECT	3	0	2	4	0	1	2.69	10	.02	0.00	.01	.02	0.00	.00	2.25
AVG SPEED	1.04	2.95	4.83	6.70	9.15	13.25	2.85								
TOT [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	54		[illegible]							

H-AREA TOWER 1975-1979



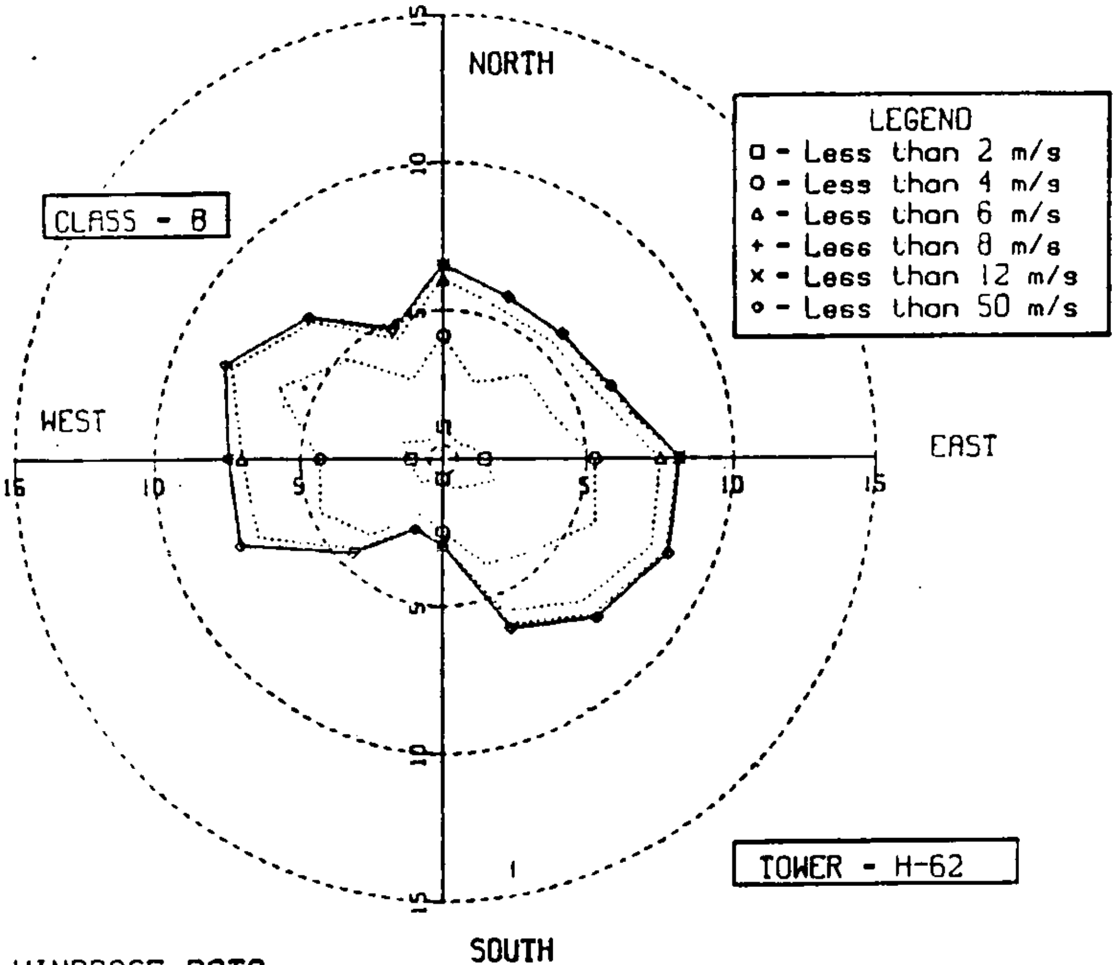
WINOROSE DATA

MINIMUM DATE MMDDYY 10175
MINIMUM TIME ZULU 0000
ENTRIES ALL CLASSES 14853

MAXIMUM DATE MMDDYY 123178
MAXIMUM TIME ZULU 2400
ENTRIES THIS CLASS 3561

DIRECTION	0-2	2-4	4-6	6-8	8-12	>12	AVERAGE SPEED	TOTAL TOT	0-2	2-4	4-6	6-8	8-12	>12	TOTAL
	SPEED IN METERS/SEC								PERCENT TIME WIND @ SPEED						
N	70	59	9	2	0	0	1.59	140	1.97	1.66	.25	.05	0.00	0.00	3.93
NNE	68	71	16	3	0	0	1.88	158	1.85	1.99	.45	.08	0.00	0.00	4.38
NE	74	77	11	1	0	0	1.51	163	2.08	2.16	.31	.02	0.00	0.00	4.58
ENE	83	110	30	4	0	0	1.89	227	2.33	3.09	.84	.11	0.00	0.00	6.37
E	61	121	41	4	0	0	2.11	227	1.71	3.40	1.15	.11	0.00	0.00	6.37
ESE	83	146	36	0	0	0	1.90	265	2.33	4.10	1.01	0.00	0.00	0.00	7.44
SE	72	138	23	2	0	0	1.98	235	2.02	3.88	.65	.05	0.00	0.00	6.60
SSE	83	118	22	2	1	0	1.83	224	2.33	3.28	.62	.05	.02	0.00	6.29
S	70	114	28	11	2	0	1.80	223	1.97	3.20	.73	.31	.05	0.00	6.28
SSW	71	102	40	10	5	0	1.85	228	1.99	2.86	1.12	.28	.14	0.00	6.40
SW	86	115	38	6	1	0	1.68	246	2.42	3.23	1.07	.17	.02	0.00	6.91
WSW	92	92	34	9	1	0	1.63	228	2.58	2.58	.95	.25	.02	0.00	6.40
W	95	142	27	7	2	0	1.75	273	2.67	3.99	.76	.20	.05	0.00	7.67
WNW	106	136	26	7	3	1	1.57	279	2.98	3.82	.73	.20	.08	.02	7.83
NW	99	128	37	4	1	0	1.74	269	2.78	3.59	1.04	.11	.02	0.00	7.55
NNW	78	77	19	3	1	0	1.81	178	2.19	2.16	.53	.08	.02	0.00	5.00
NO DIRECT	0	0	0	0	0	0	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	3.93
AVG SPEED	1.01	2.76	4.83	6.81	9.00	12.13	1.76								
TOT ENTRY	[illegible]	1744	435	75	17	1		3561							

H-AREA TOWER 1975-1979



WINDROSE DATA

MINIMUM DATE MMDDYY 10175
MINIMUM TIME ZULU 0000
ENTRIES ALL CLASSES 14883

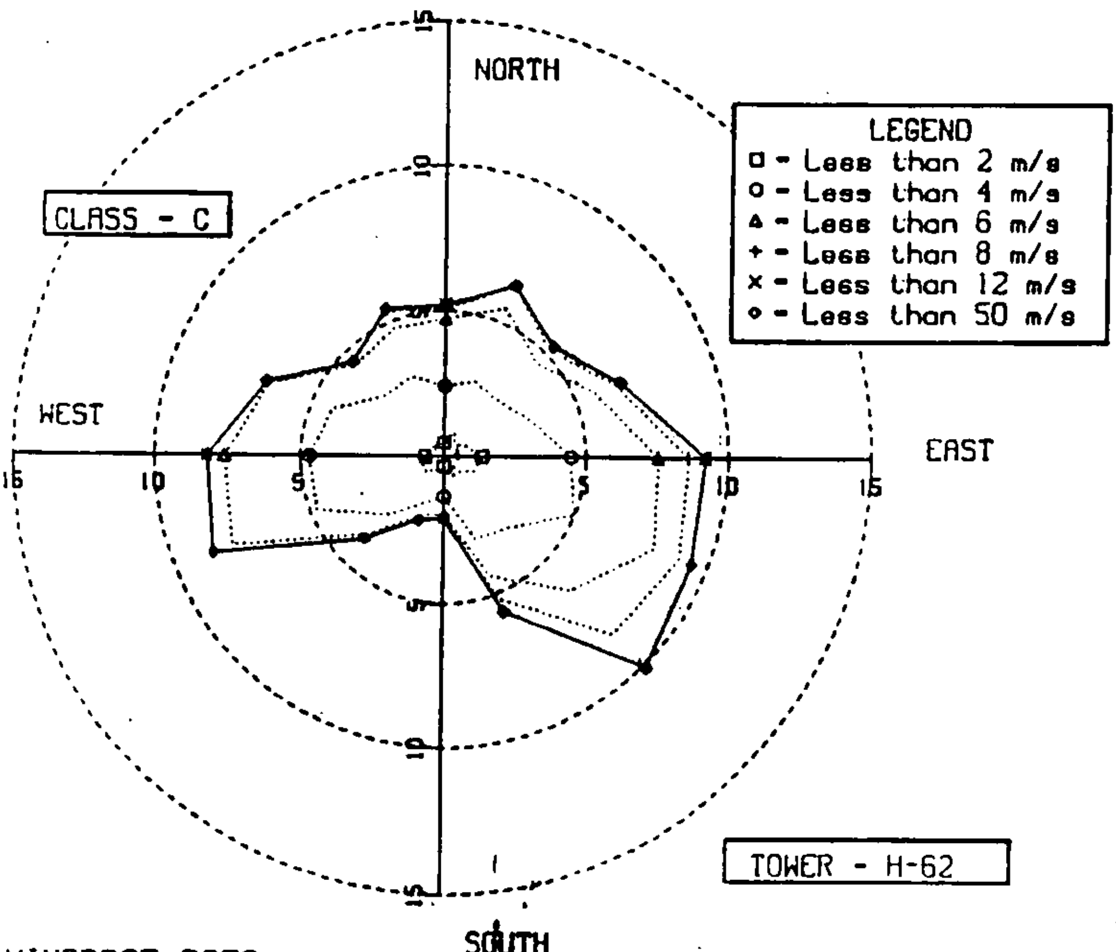
MAXIMUM DATE MMDDYY 123179
MAXIMUM TIME ZULU 2400
ENTRIES THIS CLASS 1868

0 0 0 0 0 0

DIRECTION	SPEED IN METERS/SEC 0-2	2-4	4-6	6-8	8-12	>12	AVERAGE SPEED	TOTAL TOT
N	13	33	8	1	0	0	2.41	55
NNE	13	24	10	1	0	0	2.10	48
NE	30	48	12	3	1	0	2.10	84
ENE	30	67	43	12	1	0	2.75	143
E	22	59	50	8	1	0	2.84	140
ESE	29	88	32	5	0	0	2.33	154
SE	17	71	33	4	0	0	2.58	125
SSE	14	40	27	4	3	0	2.68	88
S	20	57	36	9	0	0	2.38	122
SSW	15	37	49	8	1	0	2.10	110
SW	14	61	27	7	1	0	2.36	110
WSW	20	58	32	7	3	0	2.08	118
W	27	72	41	11	1	1	2.18	153
WNW	36	71	39	9	2	0	1.74	157
NW	24	59	45	11	3	0	2.24	142
NNW	20	52	32	9	3	0	2.04	116
NO DIRECT	0	0	0	0	0	0	0.00	0
AVG SPEED	.03	2.93	4.71	6.71	8.93	15.68	2.27	
TOT ENTRY	[illegible]	[illegible]	516	108	20	1		1885

DIRECTION	PERCENT TIME WIND SPEED 0-2	2-4	4-6	6-8	8-12	>12	TOTAL
N	.70	1.77	.43	.05	0.00	0.00	2.95
NNE	.70	1.29	.54	.05	0.00	0.00	2.57
NE	1.07	2.57	.64	.16	.05	0.00	4.50
ENE	1.07	3.59	2.31	.64	.05	0.00	7.67
E	1.18	3.16	2.68	.43	.05	0.00	7.51
ESE	1.55	4.72	1.72	.27	0.00	0.00	8.28
SE	.91	3.81	1.77	.21	0.00	0.00	6.70
SSE	.75	2.14	1.45	.21	.16	0.00	4.72
S	1.07	3.06	1.93	.48	0.00	0.00	6.54
SSW	.80	1.98	2.63	.43	.05	0.00	5.90
SW	.75	3.27	1.45	.38	.05	0.00	5.90
WSW	1.07	3.00	1.72	.38	.16	0.00	6.33
W	1.45	3.86	2.20	.59	.05	.05	[illegible]
WNW	1.93	3.81	2.09	.48	.11	0.00	8.42
NW	1.29	3.16	2.41	.59	.16	0.00	7.61
NNW	1.07	2.79	1.72	.48	.16	0.00	6.22
NO DIRECT	0.00	0.00	0.00	0.00	0.00	0.00	2.95

H-AREA TOWER 1975-1979



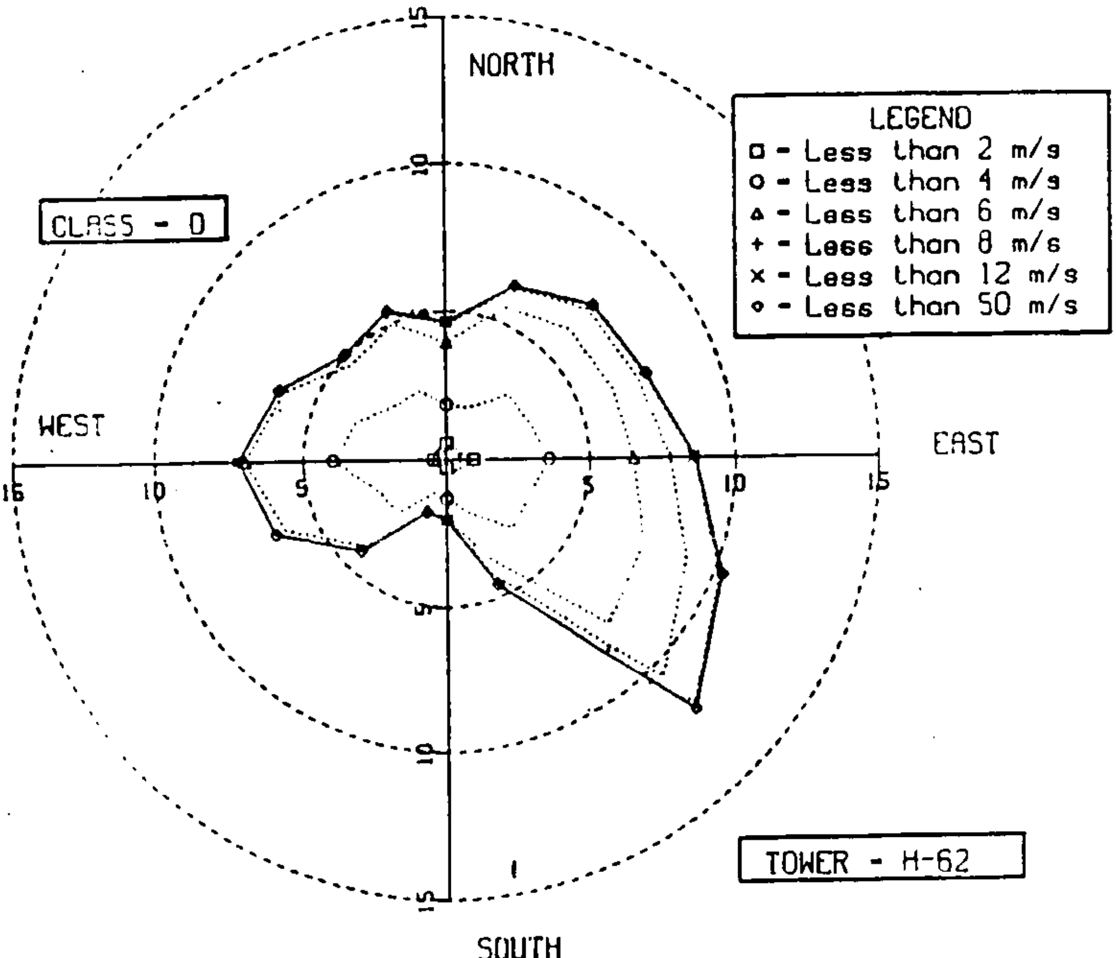
WINDROSE DATA

MINIMUM DATE MMDDYY 10175
MINIMUM TIME ZULU 0000
ENTRIES ALL CLASSES 14883

MAXIMUM DATE MMDDYY 123179
MAXIMUM TIME ZULU 2100
ENTRIES THIS CLASS 2995

DIRECTION	SPEED IN METERS/SEC 0-2	2-4	4-6	6-8	8-12	>12	AVERAGE SPEED	TOTAL TOT	PERCENT TIME WIND, @ SPEED 0-2	2-4	4-6	6-8	8-12	>12	TOTAL
N	10	30	18	4	1	0	2.50	63	.33	1.00	.60	.13	.03	0.00	2.10
NNE	8	42	14	5	0	0	3.01	69	.27	1.40	.47	.17	0.00	0.00	2.30
NE	24	59	28	6	1	0	2.42	118	.80	1.97	.93	.20	.03	0.00	3.94
ENE	24	119	94	21	0	0	2.92	258	.80	3.97	3.14	.70	0.00	0.00	8.61
E	20	121	87	17	1	0	3.15	246	.67	4.04	2.90	.57	.03	0.00	8.21
ESE	14	113	70	3	0	0	2.92	200	.47	3.77	2.34	.10	0.00	0.00	6.68
SE	11	77	45	4	0	0	2.86	137	.37	2.57	1.50	.13	0.00	0.00	4.57
SSE	13	76	53	20	2	0	2.98	164	.43	2.54	1.77	.67	.08	0.00	5.48
S	14	58	70	11	4	0	2.63	157	.47	1.94	2.34	.37	.13	0.00	5.24
SSW	28	56	82	24	1	0	2.44	191	.93	1.87	2.74	.80	.03	0.00	6.38
SW	17	64	55	19	6	0	2.58	161	.57	2.14	1.84	.63	.20	0.00	5.38
WSW	27	71	74	22	5	1	2.60	200	.90	2.37	2.47	.73	.17	.03	6.68
W	40	94	91	32	18	1	2.28	276	1.34	3.14	3.04	1.07	.60	.03	9.22
WNW	36	113	91	28	14	0	2.52	282	1.20	3.77	3.04	.93	.47	0.00	9.42
NW	21	79	91	63	47	2	3.60	303	.70	2.64	3.04	2.10	1.57	.06	10.12
NNW	22	68	41	25	14	0	2.80	170	.73	2.27	1.37	.83	.47	0.00	5.68
NO DIRECT	0	0	0	0	0	0	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	2.10
AVG SPEED	.80	3.03	4.79	6.70	9.12	13.38	2.75								
TOT ENTRY	329	1240	1004	304	114	4		2995							

H-AREA TOWER 1975-1979



WINDROSE DATA

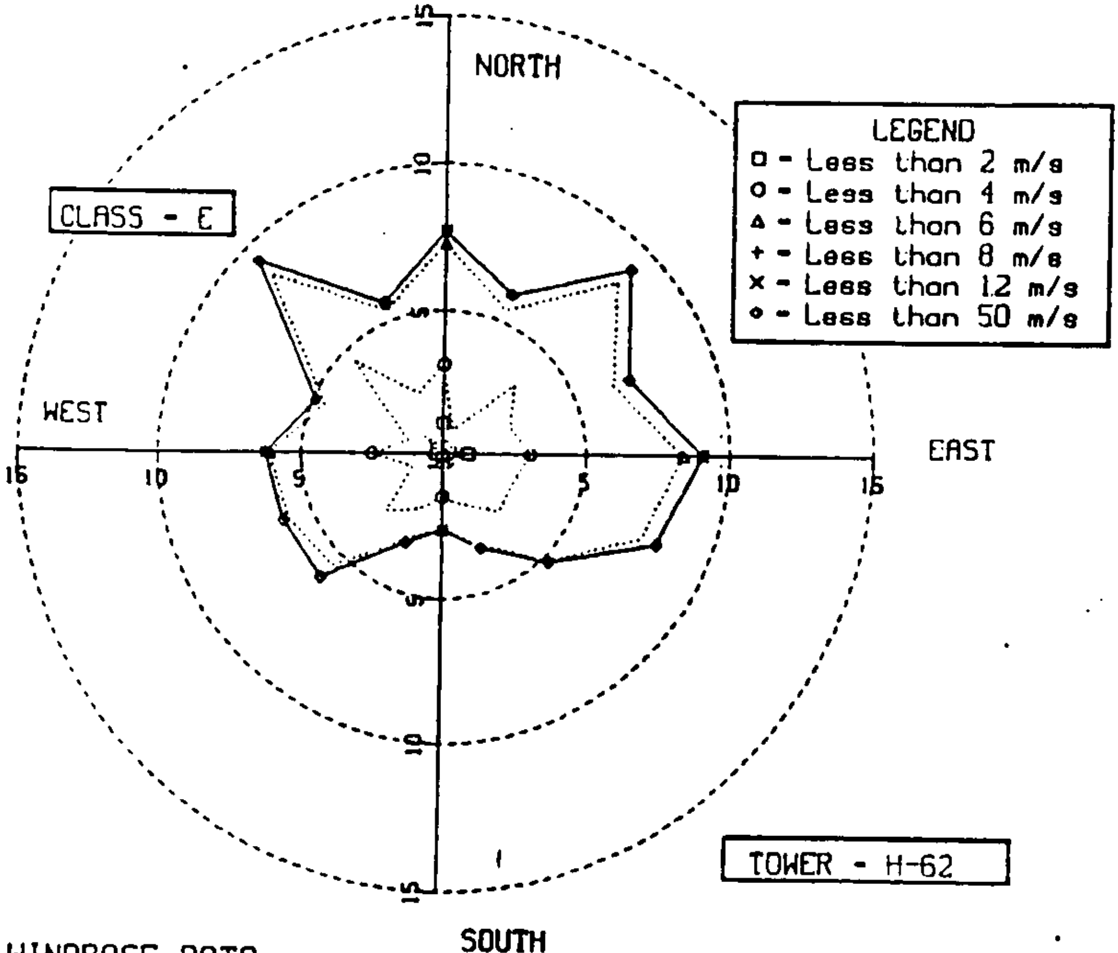
MINIMUM DATE MMDDYY 10175
MINIMUM TIME ZULU 0000
ENTRIES ALL CLASSES 14693

MAXIMUM DATE MMDDYY 123179
MAXIMUM TIME ZULU 2400
ENTRIES THIS CLASS 4027

DIRECTION	0-2	2-4	4-6	6-8	8-12	>12	AVERAGE SPEED	TOTAL TOT
	SPEED IN METERS/SEC							
N	12	42	25	3	0	0	2.51	82
NNE	9	40	28	1	0	0	2.92	78
NE	20	80	64	10	0	0	2.61	174
ENE	11	98	137	15	0	0	3.36	258
E	19	142	120	9	0	0	3.05	290
ESE	18	119	109	7	0	0	3.10	253
SE	18	89	82	16	1	0	2.95	204
SSE	10	92	99	17	1	0	3.14	218
S	23	52	85	23	4	0	2.89	187
SSW	17	59	147	30	3	0	3.40	256
SW	20	105	123	37	9	0	3.02	294
WSW	21	103	125	37	11	2	2.75	302
W	30	107	116	51	32	3	2.77	348
WNW	27	99	170	64	50	1	3.14	414
NW	19	112	107	105	60	1	4.08	407
NNW	15	62	85	27	15	0	3.31	184
NO DIRECT	0	0	0	0	0	0	0.00	0
AVG SPEED	.73	3.11	4.00	6.78	9.21	12.70	3.11	
TOT COUNT	[illegible]	[illegible]	1600	452	188	12		4027

0-2	2-4	4-6	6-8	8-12	>12	TOTAL
PERCENT TIME WIND @ SPEED						
.30	1.04	.62	.07	0.00	0.00	2.04
.22	[illegible]	.65	.02	0.00	0.00	1.89
.50	1.[illegible]	1.59	.25	0.00	0.00	4.32
.27	2.38	3.40	.37	0.00	0.00	6.43
.47	3.53	2.98	.22	0.00	0.00	7.20
.45	2.96	2.71	.17	0.00	0.00	6.28
.40	2.21	2.04	.40	.02	0.00	5.07
.25	2.28	2.46	.42	.02	0.00	5.41
.57	1.29	2.11	.57	.09	0.00	4.64
.42	1.47	3.65	.74	.07	0.00	6.36
.50	2.61	3.05	.92	.22	0.00	7.30
.60	2.56	3.10	.92	.27	.05	7.50
.94	2.66	2.88	1.27	.79	.05	8.[illegible]
.67	2.46	4.22	1.59	1.24	.09	10.28
.47	2.78	4.61	2.61	1.49	.09	12.09
.37	1.54	1.61	.67	.37	0.00	4.57
0.00	0.00	0.00	0.00	0.00	0.00	2.04

H-AREA TOWER 1975-1979



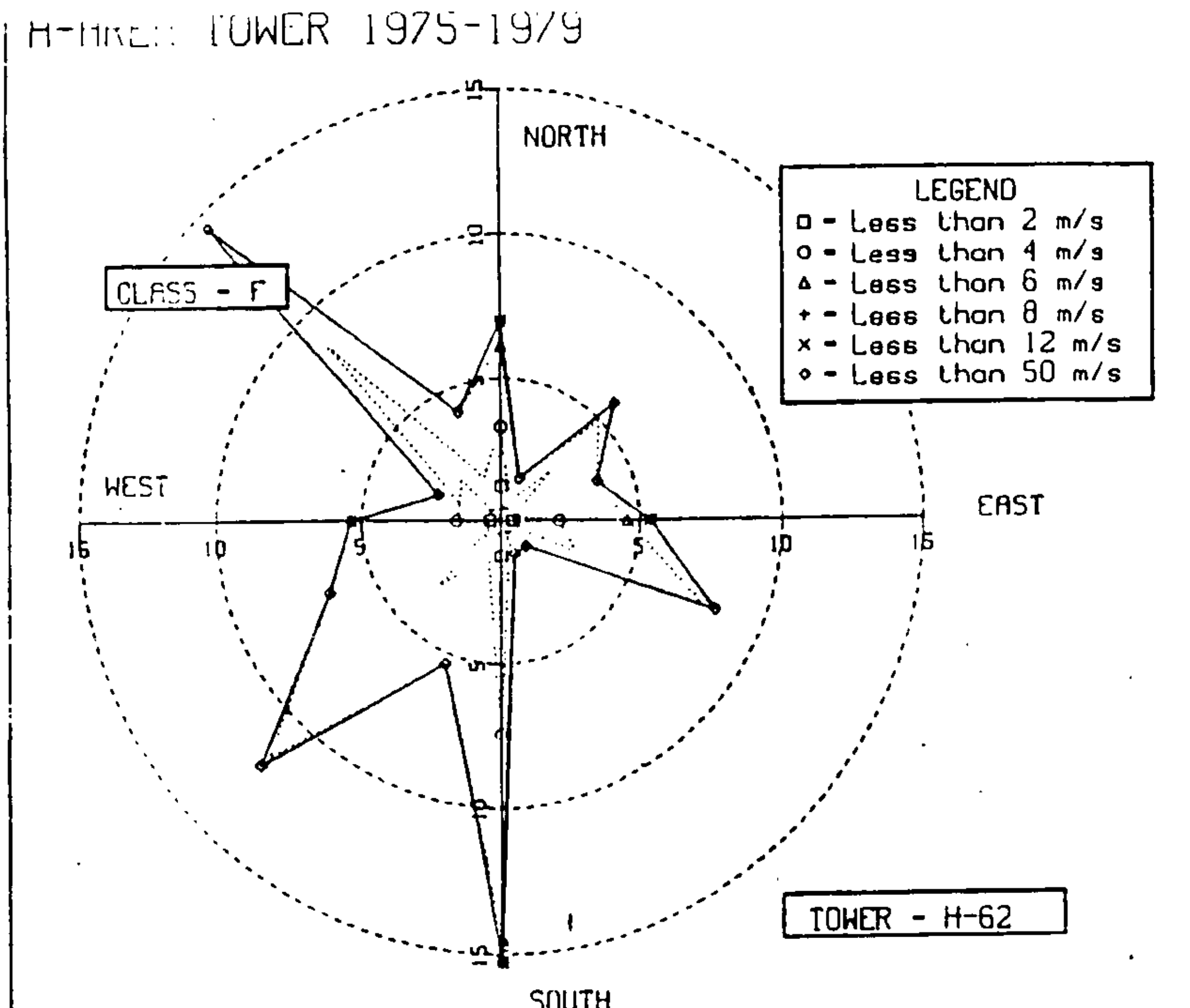
WINDROSE DATA

MINIMUM DATE MMDDYY 10175
MINIMUM TIME ZULU 0000
ENTRIES ALL CLASSES 14680

DIRECTION	0-2	2-4	4-6	6-8	8-12	>12	AVERAGE SPEED	TOTAL TOT
	SPEED IN METERS/SEC							
N	2	26	22	0	0	0	3.36	50
NNE	5	34	21	3	0	0	3.23	63
NE	14	39	52	10	1	0	3.08	116
ENE	5	17	90	4	0	0	4.02	116
E	4	44	69	3	0	0	3.48	120
ESE	4	21	62	7	0	0	3.21	94
SE	17	70	80	12	0	0	2.94	179
SSE	7	37	59	5	0	0	3.14	108
S	21	39	80	8	0	0	2.74	148
SSW	2	16	86	11	0	0	4.43	115
SW	8	58	96	12	0	0	3.35	174
WSW	7	41	74	11	0	0	3.21	133
W	17	41	102	13	0	0	3.28	173
WNW	7	43	93	10	1	0	3.50	154
NW	1	49	46	1	0	0	3.30	100
NNW	4	32	29	2	0	0	3.19	67
NO DIRECT	0	0	0	0	0	0	0.00	0
AVG SPEED	[illegible]	3.21	4.70	6.42	8.78	0.00	3.17	
[illegible]	1	608	1061	11?	[illegible]	0		1910

MAXIMUM DATE MMDDYY 123179
MAXIMUM TIME ZULU 2400
ENTRIES THIS CLASS 1910

PERCENT TIME WIND: 0-2	2-4	4-6	6-8	8-12	>12	TOTAL
.10	1.36	1.15	0.00	0.00	0.00	2.62
.28	1.78	1.10	.18	0.00	0.00	3.30
.73	2.04	2.72	.52	.05	0.00	6.07
.26	.89	4.71	.21	0.00	0.00	6.07
.21	2.30	3.61	.16	0.00	0.00	6.28
.21	1.10	3.25	.37	0.00	0.00	4.92
.89	3.68	4.19	.63	0.00	0.00	9.37
.37	1.94	3.09	.26	0.00	0.00	5.85
1.10	2.04	4.19	.42	0.00	0.00	7.75
.10	.84	4.50	.58	0.00	0.00	6.02
.42	3.04	5.03	.63	0.00	0.00	9.11
.37	2.15	3.87	.58	0.00	0.00	6.96
.89	2.15	5.34	.68	0.00	0.00	9.08
.37	2.2[illegible]	4.87	.52	.05	0.00	8.06
.21	2.57	2.41	.05	0.00	0.00	5.21
.21	1.88	1.52	.10	0.00	0.00	3.51
0.00	0.00	0.00	0.00	0.00	0.00	2.62



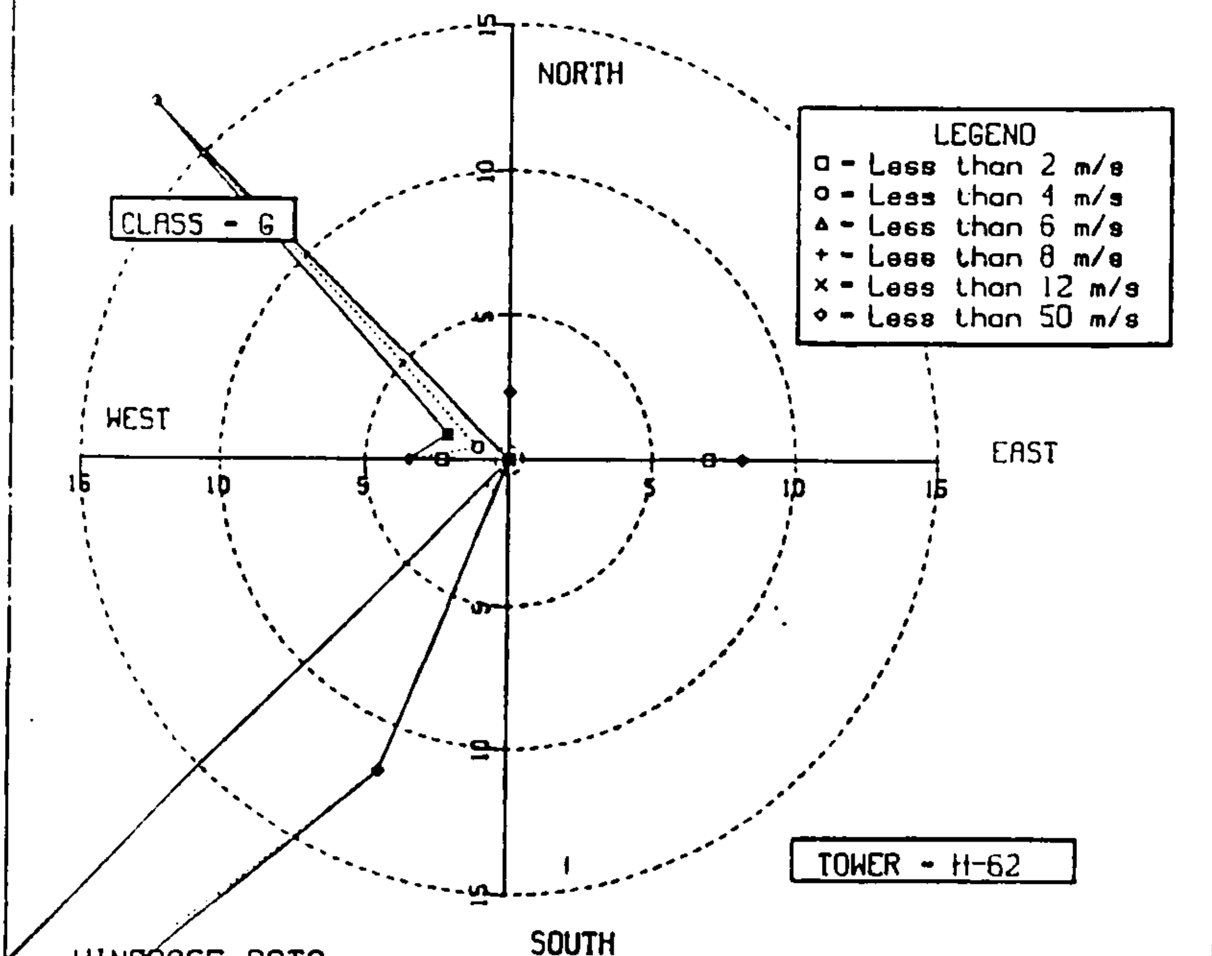
WINDROSE DATA

MINIMUM DATE MMDDYY 10175
MINIMUM TIME ZULU 0000
ENTRIES ALL CLASSES 14893

MAXIMUM DATE MMDDYY 123179
MAXIMUM TIME ZULU 2100
ENTRIES THIS CLASS 242

	SPEED IN METERS/SEC						AVERAGE	TOTAL	PERCENT TIME WIND SPEED						
DIRECTION	0-2	2-4	4-6	6-8	8-12	>12	SPEED	TOT	0-2	2-4	4-6	6-8	8-12	>12	TOTAL
N	3	15	17	1	1	0	2.81	37	1.24	6.20	7.02	.41	.41	0.00	15.29
NNE	0	3	10	0	0	0	4.07	13	0.00	1.24	4.13	0.00	0.00	0.00	5.37
NE	2	6	20	1	0	0	3.28	28	.83	2.48	8.26	.41	0.00	0.00	11.98
ENE	1	0	15	0	0	0	4.39	16	.41	0.00	6.20	0.00	0.00	0.00	6.61
E	1	3	9	0	0	0	3.67	13	.41	1.24	3.72	0.00	0.00	0.00	5.37
ESE	4	0	2	0	0	0	.77	6	1.65	0.00	.83	0.00	0.00	0.00	2.48
SE	5	16	14	0	0	0	2.48	35	2.07	6.61	5.79	0.00	0.00	0.00	14.48
SSE	0	4	6	0	0	0	4.28	10	0.00	1.65	2.48	0.00	0.00	0.00	4.13
S	3	5	7	2	0	0	2.45	17	1.24	2.07	2.89	.83	0.00	0.00	7.02
SSW	0	2	2	0	0	0	4.33	4	0.00	.83	.83	0.00	0.00	0.00	1.65
SW	0	6	6	2	0	0	4.08	14	0.00	2.48	2.48	.83	0.00	0.00	5.79
WSW	0	1	8	0	0	0	4.40	9	0.00	.41	3.31	0.00	0.00	0.00	3.72
W	1	4	6	2	0	0	3.29	13	.41	1.65	2.48	.83	0.00	0.00	5.37
WNW	1	6	12	1	0	0	4.04	20	.41	2.48	4.96	.41	0.00	0.00	8.26
NW	0	0	3	0	0	0	4.40	3	0.00	0.00	1.24	0.00	0.00	0.00	1.24
NNW	0	2	1	0	0	0	3.00	3	0.00	.83	.41	0.00	0.00	0.00	1.24
NO DIRECT	0	0	0	0	0	0	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	15.28
AVG SPEED	.79	3.11	4.79	6.40	8.77	0.00	3.01								
TOT ENTRY	21	73	130	[illegible]	1	0		242							

H-AREA TOWER 1975-1979



WINDROSE DATA

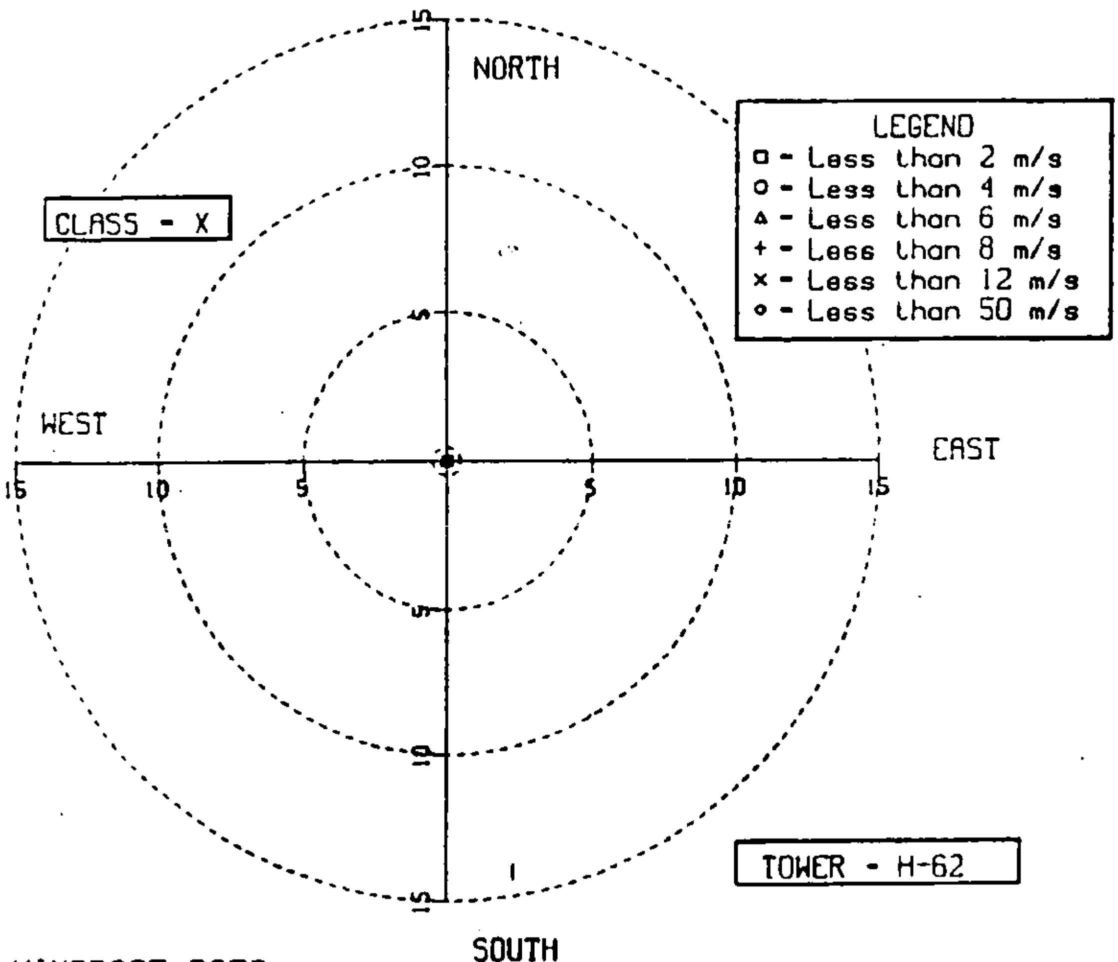
MINIMUM DATE MMDDYY 10175
MINIMUM TIME ZULU 0000
ENTRIES ALL CLASSES 14683

MAXIMUM DATE MMDDYY 123179
MAXIMUM TIME ZULU 2400
ENTRIES THIS CLASS 86

DIRECTION	0-2	2-4	4-6	6-8	8-12	>12	AVERAGE SPEED	TOTAL TOT
	SPEED IN METERS/SEC							
N	0	0	0	0	0	0	0.00	0
NNE	1	9	0	0	0	0	2.29	10
NE	1	39	7	0	0	0	3.01	47
ENE	0	0	0	0	0	0	0.00	0
E	2	1	0	0	0	0	1.88	3
ESE	0	1	1	0	0	0	3.99	2
SE	2	11	2	0	0	0	2.44	15
SSE	0	0	0	0	0	0	0.00	0
S	0	1	1	0	0	0	4.43	2
SSW	0	0	0	0	0	0	0.00	0
SW	0	0	0	0	0	0	0.00	0
WSW	0	0	0	0	0	0	0.00	0
W	6	0	0	0	1	0	.98	7
WNW	0	0	0	0	0	0	0.00	0
NW	0	0	0	0	0	0	0.00	0
NNW	0	0	0	0	0	0	0.00	0
NO DIRECT	0	0	0	0	0	0	0.00	0
AVG SPEED	[illegible]	2.83	4.62	0.00	8.24	0.00	2.39	
TOT (DIR)	[illegible]	[illegible]	11	0	1	0		86

0-2	2-4	4-6	6-8	8-12	>12	TOTAL
PERCENT TIME WIND @ SPEED						
0.00	0.00	0.00	0.00	0.00	0.00	.00
1.16	10.47	0.00	0.00	0.00	0.00	11.63
1.16	45.35	8.14	0.00	0.00	0.00	54.65
0.00	0.00	0.00	0.00	0.00	0.00	.00
2.33	1.16	0.00	0.00	0.00	0.00	3.49
0.00	1.16	1.16	0.00	0.00	0.00	2.33
2.33	12.79	2.33	0.00	0.00	0.00	17.44
0.00	0.00	0.00	0.00	0.00	0.00	.00
0.00	1.16	1.16	0.00	0.00	0.00	2.33
0.00	0.00	0.00	0.00	0.00	0.00	.00
0.00	0.00	0.00	0.00	0.00	0.00	.00
0.00	0.00	0.00	0.00	0.00	0.00	.00
6.98	0.00	0.00	0.00	1.16	0.00	8.14
0.00	0.00	0.00	0.00	0.00	0.00	.00
0.00	0.00	0.00	0.00	0.00	0.00	.00
0.00	0.00	0.00	0.00	0.00	0.00	.00
0.00	0.00	0.00	0.00	0.00	0.00	.00

H-AREA TOWER 1975-1979



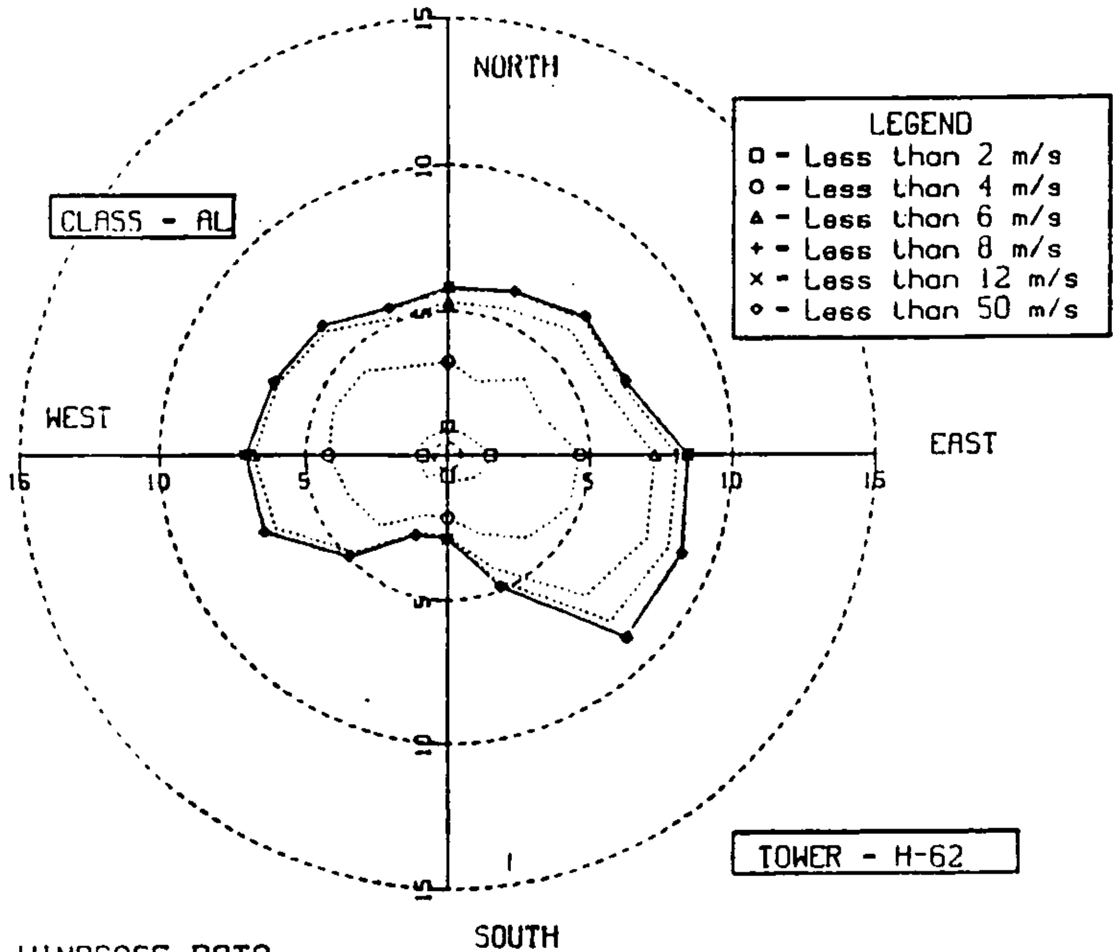
WINDROSE DATA

MINIMUM DATE MMDDYY 10175
MINIMUM TIME ZULU 0000
ENTRIES ALL CLASSES 14683

MAXIMUM DATE MMDDYY 123179
MAXIMUM TIME ZULU 2400
ENTRIES THIS CLASS 7

DIRECTION	SPEED IN METERS/SEC 0-2	2-4	4-6	6-8	8-12	>12	AVERAGE SPEED	TOTAL TOT	PERCENT TIME WIND @ SPEED 0-2	2-4	4-6	6-8	8-12	>12	TOTAL
N	0	0	0	0	0	0	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	.00
NNE	0	0	0	0	0	0	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	.00
NE	0	0	0	0	0	0	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	.00
ENE	0	0	0	0	0	0	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	.00
E	0	0	0	0	0	0	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	.00
ESE	0	0	0	0	0	0	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	.00
SE	0	0	0	0	0	0	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	.00
SSE	0	0	0	0	0	0	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	.00
S	0	0	0	0	0	0	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	.00
SSW	0	0	0	0	0	0	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	.00
SW	0	0	0	0	0	0	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	.00
WSW	0	0	0	0	0	0	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	.00
W	0	0	0	0	0	0	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	.00
WNW	0	0	0	0	0	0	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	.00
NW	0	0	0	0	0	0	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	.00
NNW	0	0	0	0	0	0	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	.00
NO DIRECT	1	2	3	1	0	0	3.30	7	14.29	28.57	42.86	14.29	0.00	0.00	.00
AVG SPEED	1.72	2.77	4.58	6.11	0.00	0.00	3.30								
TOT ENTRY	1	2	3	1	0	0		7							

H-AREA TOWER 1975-1979



WINDROSE DATA

MINIMUM DATE MMDDYY 10175
MINIMUM TIME ZULU 0000
ENTRIES ALL CLASSES 14683

MAXIMUM DATE MMDDYY 123179
MAXIMUM TIME ZULU 2400
ENTRIES THIS CLASS 14683

	SPEED IN METERS/SEC						AVERAGE	TOTAL	PERCENT TIME WIND @ SPEED						
DIRECTION	0-2	2-4	4-6	6-8	8-12	>12	SPEED	TOT	0-2	2-4	4-6	6-8	8-12	>12	TOTAL
N	110	205	98	11	2	0	2.17	427	.75	1.40	.67	.07	.01	0.00	2.91
NNE	102	223	97	13	0	0	2.40	435	.69	1.52	.66	.08	0.00	0.00	2.96
NE	155	348	194	31	3	0	2.25	731	1.05	2.37	1.32	.21	.02	0.00	4.98
ENE	144	408	408	56	1	0	2.78	1018	.98	2.78	2.78	.38	.00	0.00	6.94
E	129	491	378	41	2	0	2.81	1035	.88	3.34	2.58	.28	.01	0.00	7.07
ESE	152	488	312	22	0	0	2.48	974	1.03	3.32	2.12	.15	0.00	0.00	6.63
SE	140	472	278	38	1	0	2.54	930	.95	3.21	1.90	.26	.00	0.00	6.33
SSE	127	365	268	48	7	0	2.57	813	.86	2.48	1.81	.33	.04	0.00	5.53
S	151	328	305	64	10	0	2.37	858	1.03	2.22	2.08	.44	.06	0.00	5.83
SSW	133	272	408	83	10	0	2.54	904	.91	1.85	2.76	.56	.06	0.00	6.15
SW	145	409	345	83	17	0	2.45	999	.99	2.78	2.35	.56	.12	0.00	6.80
WSW	170	364	347	88	20	3	2.32	990	1.16	2.48	2.36	.59	.14	.02	6.74
W	224	460	383	116	54	4	2.22	1241	1.52	3.13	2.61	.79	.37	.03	8.45
WNW	213	468	431	119	70	5	2.34	1306	1.45	3.19	2.93	.81	.48	.03	8.89
NW	167	427	409	184	111	6	2.88	1304	1.14	2.91	2.78	1.25	.76	.04	8.87
NNW	139	293	187	66	33	0	2.35	718	.95	1.99	1.27	.45	.22	0.00	4.89
NO DIRECT	1	2	3	1	0	0	3.30	7	.00	.01	.02	.00	0.00	0.00	2.91
AVG SPEED	.88	2.98	4.77	6.70	9.15	13.01	2.47								
TOT. ENTRY	2012	6023	4848	1062	341	18		14683							