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Energy Division

Methodologies For Estimating One-Time Hazardous Waste Generation For Capacity Assurance Planning

B. E. Tonn
Ho-Ling Hwang
Steve Elliott

Jean Peretz[†]
Robert Bohm[†]
Barbara Jendrucko[†]

[†]University of Tennessee, Knoxville

April 1994

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Bruce Tonn
Ho-Ling Hwang
Steve Elliott
Oak Ridge National Laboratory

Jean Peretz
Robert Bohm
Barbara Jendrucko
University of Tennessee, Knoxville

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Prepared for
U.S. Environmental Protection Agency

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ABBREVIATIONS AND ACRONYMS

AMC	Army Materiel Command
ARB	Air Reserve Base
ARS	Air Reserve Station
BDAT	best demonstrated available technology
CAMU	corrective action management unit
CAP	capacity assurance plan
CARS	corrective action report system
CE	U.S. Army Corps of Engineers
CFR	Code of Federal Regulation
CORA	Cost of remedial action
DERP	Defense Environmental Restoration Program
DLA	Defense Logistics Agency
DOE	U.S. Department of Energy
DoD	U.S. Department of Defense
EPA	U.S. Environmental Protection
ERNS	emergency response notification system
FS	feasibility study
FUSRAP	Formerly Utilized Sites Remedial Action Program
IAP	Installation Action Plan
IRP	Installation Restoration Program
ITRI	Inhalation Toxicology Research Institute
LDR	land disposal restrictions
MAP	Management Action Plan
NPL	National Priorities List
ORNL	Oak Ridge National Laboratory
OU	Operable Unit
OUST	Office of Underground Storage Tanks
PCB	polychlorinated biphenyls

ABBREVIATIONS AND ACRONYMS (Continued)

RA	remedial action
RCRA	Resource Conservation and Recovery Act
RD	remedial design
RFA	RCRA facility assessment
RFI	RCRA facility investigation
RI	remedial investigation
RIA	regulatory impact analysis
ROD	Record of Decision
RTI	Research Triangle Institute
SACM	Superfund Accelerated Cleanup Model
SARA	Superfund Amendments and Reauthorization Act of 1986
SI	site investigation
S/S	solidification/stabilization
SWMU	solid waste management unit
TCLP	toxicity characteristic leaching procedure
TRU	transuranic
TSCA	Toxic Substances Control Act
TSD	treatment, storage and disposal
TSDFs	treatment, storage and disposal facilities
TSDR	treatment, storage, disposal, and recycling facilities
UMTRA	Uranium Mill Tailings Remedial Action
UST	underground storage tanks
UT	University of Tennessee
UTK	University of Tennessee, Knoxville
VOC	volatile organic chemicals
WAG	waste area grouping

ABSTRACT

This report contains descriptions of methodologies to be used to estimate the one-time generation of hazardous waste associated with five different types of remediation programs: Superfund sites, RCRA Corrective Actions, Federal Facilities, Underground Storage Tanks, and State and Private Programs. Estimates of the amount of hazardous wastes generated from these sources to be shipped off-site to commercial hazardous waste treatment and disposal facilities will be made on a state by state basis for the years 1993, 1999, and 2013. In most cases, estimates will be made for the intervening years, also.

INTRODUCTION

This report contains descriptions of the methodologies developed by Oak Ridge National Laboratory (ORNL) and the University of Tennessee-Knoxville (UTK) to estimate the one-time generation of hazardous wastes due to the *remediation* of hazardous waste sites (e.g., Superfund sites, RCRA regulated treatment, storage, and disposal facilities). This project is being funded and managed by the Waste Management Division of the Office of Solid Waste of the U.S. Environmental Protection Agency.

The results of this project will be input into the National Hazardous Waste Capacity Assurance Planning (CAP) process. This process has been instituted at the direction of the U.S. Congress to ensure that each state has made arrangements to dispose of hazardous wastes generated through recurrent and one-time only processes within its borders. For the current capacity assurance planning exercise, estimates of hazardous waste generation will be made on a state by state basis for the years 1993, 1999, and 2013, with a focus on the volume of hazardous wastes that could be shipped to commercial hazardous waste facilities. The volumes estimated from the one-time remediation of hazardous waste sites will be combined with estimates developed by each state for the recurrent generation of hazardous wastes to produce a state by state profile of commercial hazardous waste facility capacity demands.

Conceptually, this project has been broken into five areas that correspond to major hazardous waste remediation programs. The five areas are Superfund, RCRA Corrective Action, Federal Facilities, Underground Storage Tanks (UST), and State and Private Programs. The methodologies are described in Sections 1.0 to 5.0, respectively. Each section explicitly describes data to be used, analytical approaches, and major uncertainties.

The methodologies associated with Superfund, RCRA and UST are based in part on previous research conducted by ORNL and UTK on the costs of remediating hazardous waste sites. The RCRA methodology has been enhanced by the addition of new data and results produced as part of EPA's Regulatory Impact Analysis (RIA) of RCRA Corrective Action. New methodologies have been developed for Federal Facilities, and State and Private Programs.

1.0 ONE-TIME HAZARDOUS WASTE GENERATION DUE TO SUPERFUND CLEANUP ACTIONS

1.1 INTRODUCTION

This section presents the methodology used to estimate the total amount of one-time hazardous wastes generated by the remediation of Superfund sites for the years 1993, 1999, and 2013 on a state-by-state basis. Only those hazardous wastes requiring offsite commercial treatment or disposal capacity are included in this study. Two existing data bases developed from an earlier UTK project (Colglazier, *et al.*, 1991) provide the foundation for this project. To complement these data bases, extensive effort was spent gathering usable data items from Environmental Protection Agency (EPA) publications and other reports. Several additional data bases developed by other organizations were also explored. A short description of each of these data sources is provided in Section 1.2. A tabulated summary for these data sources is given in Appendix 1.1.

The methodology reported in this section was based upon these assumptions:

1. Sites contained in the National Priorities List (NPL) as of October, 1992, were included in this study, except for federal facility sites, which are considered separately in this project (see Section 3.0);
2. Sites or operable units that only encompass groundwater and/or surfacewater treatments, as specified in the Records of Decision (RODs), are excluded from this study, because it is assumed that these liquid wastes will be treated onsite or at offsite non-hazardous wastewater treatment plants;
3. It is assumed that EPA's new Superfund Accelerated Cleanup Model (SACM) will have no impact on the waste volume generated from NPL sites that are currently under investigation; and
4. All hazardous wastes, except wastewater, generated from emergency removal at Superfund sites are shipped offsite for treatment or disposal.

Other assumptions and decision rules used in determining the total amount of one-time hazardous wastes demanding commercial management for each NPL site are discussed later in this section.

1.2 DATA SOURCES AND DATA ACQUISITION PROCESSES

The following is a listing of major data sources used in this study. A general description of each of the data sources, as well as its affiliation to the current project, is also given. Information extracted from these data sources was assembled to form new data bases that were used later to produce volume estimations. See Section 1.3 for discussions on these new data bases.

HAZDATA

This data base contains information drawn from 231 RODs that were signed during the 1987 to early 1990 time frame. This data base was created as part of the previous UTK hazardous waste project and contains data items such as: site name; location and type; date of signing the ROD; site hydrogeological and geological information; contamination sources and volumes; remediation approaches recommended; types of contaminants, their concentration, and cleanup goals; and the projected cost of the remediation effort. When the volume of wastes generated by a given site was not provided in the ROD, an estimation was calculated based on the site size given in the ROD. Based on professional experience, Colglazier, Cox, and Davis (1991) estimated the amount of wastes by assuming that 10% of the site area with a depth of 20 feet was contaminated. The first assumption was adopted in the current project; the depth, however, was modified to three to five feet. This modification was mainly due to critiques made during the review process of earlier drafts of this report.

BASECOST

This data base was also compiled as part of the earlier UTK project. It contains volume and cost information for individual remediation technologies associated with the sites or operable units reported in the HAZDATA data base. A total of 548 records comprise the BASECOST data base. It also includes estimates for the duration of the cleanup effort under the recommended remediation technology. Among the 548 records, only 31 identified the use of offsite treatment or disposal for the wastes that were generated. Therefore, this data base alone was not considered sufficient to yield satisfactory estimates for the total waste volumes that will be commercially managed.

SUMROD

This data base was based on data extracted from US EPA RODs signed between 1983 and early 1990. The data base was compiled by the Ontario Ministry of the Environment to supplement the study of soil cleanup criteria. As such, the data base's 4,221 records were organized on a compound-by-compound basis. Data elements contained in SUMROD include: site name and location; date ROD was signed; media type; cleanup goal; and name of compound. The absence of remediation technologies in this data base resulted in its limited application to this study.

NPL Technical Data Files

This data base contains information for approximately 1,200 NPL sites as of February, 1990. The four major categories of data are: Hazard Ranking System (HRS) scoring data; site documentation data; administrative data; and auxiliary data. Data elements include: site name and location; site activities; media type; classes of compounds; contamination impact; remediation technology; site ownership; and the date that the site was added to the NPL. The data base was used as one of the resources in the creation of HAZDATA and BASECOST data bases for the previous UTK study. Because an attempt to obtain a copy of the updated data base was not successful, this data source was used sparingly in this project.

ROD Text File

This text file contains reports for all RODs signed from 1982 to early 1990. It was used originally as a source of information for the HAZDATA and BASECOST data bases. An attempt to acquire the updated file was unsuccessful. ROD abstracts from EPA reports were used instead.

US EPA ROD Annual Report, FY1990 and US EPA ROD Annual Report, FY1991 (Volumes 1 & 2)

RODs and ROD Amendments for all Superfund sites, including federal facilities, signed within a reporting year are documented in the corresponding annual report. Annual reports for 1990 and 1991 were obtained and used extensively by this project. Summary tables provided in these annual reports also include overviews of site problems, selected remedies, cleanup criteria, and estimated costs for all RODs signed between 1982 and 1989. Each abstract for RODs signed in 1990 and 1991 was reviewed, and those containing the keywords 'Offsite Treatment' or 'Offsite Disposal' were selected. For RODs signed during 1982-1989, the keyword search was applied to the summary tables to identify those that recommended offsite treatment or disposal as their remedial technologies. RODs for all federal facilities, as well as those operable units that deal with groundwater or surfacewater only, were excluded from the set. Earlier sites, especially those RODs that were signed prior to 1986, were checked against EPA's reports, and sites that had completed their cleanup efforts or had been deleted from the NPL were removed from the final set. This process resulted in a total of 224 RODs which were compiled into a new data base (discussed later in Section 1.3).

92-93 Guide to Superfund Sites

This report was compiled and edited by R. C. DiGregorio and published by Pasha Publications, Inc., Arlington, Virginia. It is comprised of status reports for over 1,200 sites listed in the NPL, as of the end of 1991. Site history and technical information such as the recommended remedial technologies are provided in this document. This publication was used considerably by the project team in conjunction with the EPA ROD Annual Reports to yield information on site size, waste types, waste volumes, etc. In the event that discrepancies among the sources were found, information reported in the EPA ROD Annual Reports were utilized.

Emergency Response Notification System (ERNS) Data Tapes

This joint EPA-U.S. Department of Transportation (DOT) data system tracked emergency response actions for releases of hazardous substances. More than 160,000 records, with a record length of more than 1,200 characters, have been compiled since 1986. Data elements include site name and location, media type and volume, material spilled, and spill and response dates. It was anticipated that data could be extracted from these tape files and used to estimate the volumes of hazardous wastes shipped offsite from NPL sites prior to the signing of the RODs. Further investigation of these files found them computationally intensive and cumbersome to use. It was determined that the extra effort needed to search for a relatively small number of relevant data from this large data base was not cost-effective.

The CERCLIS Remedial Event Schedule (CRES) Data Base

This data base was prepared by Pasha Publications, Inc., and is available for purchase through the publisher. It contains information from the EPA SCAP11 Report and is available in DBF format. The CRES data base includes 3,152 records, each representing an event scheduled for the Superfund sites as of early 1992. A review of this data base indicated many errors and missing information. Considerable efforts were then made to correct the problems with this data base prior to the incorporation of this information into this study.

1.3 NEW DATA BASES ASSEMBLED FOR THE CURRENT PROJECT

The evaluation and review of available data bases and documentation resulted in the creation of two new data bases. Based on analyses conducted on these two data bases, along with decision rules developed by field experts, estimates of the waste volume projections were then derived. An overview of these two data bases is presented here.

SFLENGTH

This data base contains time intervals calculated from event schedules based on several above-mentioned data sources. With additional information on remedial action (RA) schedules obtained from EPA, ROD signing dates from the ROD Annual Reports (EPA, 1992, 1992a, 1991), and NPL dates from EPA's Intermittent Bulletins (EPA, 1992b), the CRES data base was modified, and a new event schedule data base organized by operable units was compiled. This enhanced data base contained event schedules for a total of 1,269 operable units at 956 non-federal-facility NPL sites. Based on calculations performed on this enhanced data base, time intervals between scheduled events were found, and the new data base 'SFLENGTH' was then created.

SFLENGTH consists of 1,269 records representing operable units for 956 NPL sites. It includes information on site name and location, operable unit number, estimated number of years between major Superfund events, and the estimated duration of those events. Data elements included in SFLENGTH, as well as their definitions, are listed in Appendix 1.2.

OFFCAP

OFFCAP was also created based on data sources identified earlier. This data base contains 224 observations representing operable units that met the assumptions set for this project. For ease of analysis, these sites were grouped by their major activities as described in the RODs. There are six site types: landfill, disposal, storage, manufacturing, recycling, and other. In addition to site types, these sites were also categorized by the type of wastes that were produced. Five classifications were used as waste types: soil or sediment, ash, debris, sludge or leachate, and drums or container. Contaminant types and remedial technologies suggested in RODs were also identified and grouped. Five major contaminant types were named: polychlorinated biphenyls (PCBs), volatile organic chemicals (VOCs), metals, organics, and dioxin. Treatment and disposal technologies recommended for these 224 operable units included only incineration and landfill. Approximately 70% of the 224 RODs recommended

using landfill as the major remedial technology. The remaining 30% suggested using offsite incineration treatments.

The OFFCAP data base includes information on the ROD-signed date, site name and location, site type, waste type, contaminant type, remedial technology recommended in the ROD, total waste volume given by the ROD, and the site size in acres. Additional fields in OFFCAP were created to accommodate three levels of estimates for waste volumes that will be shipped offsite. The basis for the decision rule used to produce different levels of estimates, as well as additional notes, was included as a memorandum in the OFFCAP data base. Data elements for the OFFCAP data base and their definitions are presented in Appendix 1.3.

1.4 TIME INTERVALS FOR REMEDIATION OF SUPERFUND SITES

The Superfund process begins with the discovery of a site by EPA. If the contamination found at the site is extensive and presents a risk to human health and/or the environment, the site may be added to the NPL. Once on the NPL, a series of events are scheduled.

One of the first major events to take place at the site (or operable unit) is a comprehensive remedial investigation and feasibility study (RI/FS). The objective of the RI/FS is to determine the nature and extent of the contamination for all affected media, and to develop and evaluate alternatives for remediating the site. Results from the RI/FS are documented in a ROD. A ROD provides a brief history, describes the decision about the site (or operable unit), and when possible, provides the data supporting that decision. After the ROD is signed, the next event in the process is the remedial design (RD). During this phase, technical specifications and drawings for the selected cleanup remedy are prepared by engineers. The last step is the remedial action (RA), which refers to the actual implementation of the cleanup activity for the operable unit(s).

Comments from experts in the area of Superfund cleanup projects reported that the RI/FS process for a Superfund site generally takes about one to four years to complete. The design phase (*i.e.*, RD) was reported to take from approximately six months to two years to complete. Furthermore, the experts also reported that the actual remediation process (*i.e.*, RA) could last from one year up to many decades depending upon which cleanup technologies were used for the site (*e.g.*, groundwater monitoring). Under the scope of this study, however, only incineration and landfill treatment technologies are considered. These remedial activities would generally be completed in one to three years.

Using data contained in the SFLENGTH data base, distributions of the durations for each of the distinctive cleanup activities were found. Analyses conducted on the available data indicated the following results:

1. The average length of time between the signing of a ROD and the beginning of RA was 2.7 years;
2. The average duration for the RA process was 2.2 years;
3. It took an average of 5.1 years for a site that entered the NPL to reach the ROD signing stage; and
4. When considering the ROD signing and RA processes together as a whole, the average number of years needed from the date that ROD was signed to the RA completion date is 4.8 years.

These results seem to confirm those reported by the field experts and cited above.

Figures 1.1-1.4 present distributions for these four kinds of time intervals. Figure 1.1 shows the distribution for the number of years required for a site with a signed ROD to reach the beginning of the RA process. The distribution of the duration of the RA process is shown in Figure 1.2. Figure 1.3 displays the distribution for the number of years required for a site to reach the ROD signing stage from the date that it entered the NPL. Figure 1.4 presents the distribution of the number of years required when combining the last two processes, *i.e.*, counting from the ROD-signed date to the completion of RA operation.

From the above results, approximately five years would be needed for a given operable unit to proceed from the date that its ROD is signed to the completion of its required remedial action. In addition, it would require slightly more than two years to complete the remedial action on a given site (operable unit). Based on these results, in order to estimate the total amount of waste that would be generated during a given year, for example 1993, those RODs that were signed during the three-year period of 1988 to 1990 would need to be considered.

Furthermore, for the sake of simplicity, it was assumed that waste volumes generated during the duration of cleanup activity are produced at a constant rate. Therefore, based on the average duration of 2.2 years for the RA process, it was assumed that 45%, 45%, and 10% (due to the 0.2 year) of the total waste volumes identified by the RODs signed within a three-year period beginning at year $x - 5$ would be generated by a given site (operable unit) during year x . For instance, the total volume of wastes generated during 1993 by a site would be calculated by adding 45% of the total volumes identified by the 1988 and 1989 RODs to 10% of the volumes given by the 1990 RODs for that given site (operable unit).

1.5 VOLUME ESTIMATION METHODS

Oftentimes, the total amounts of hazardous wastes estimated to be generated from Superfund remedial actions were addressed during the RI/FS phases, and the results were documented in the RODs. Although these volumes were usually found to be different from those occurring

when actual remediation action begins, they do provide a basis for projecting the amount of waste generated in the future. Because only a very small group of NPL sites have completed their cleanup activities so far, it is difficult to determine what the valid underestimate or overestimate adjustment factor for the volume estimates given by RODs should be. Doty, Crotwell, and Travis (1991) reported in a cost-related study that volume estimates given in RODs were underestimated by 66.5% for those sites that used high intensity treatment technologies (based on five sites), by 61.1% for those that used low intensity treatment technologies (on seven sites), and by 2.8% for sites that used in-situ treatment technologies (on four sites). Due to the large variations found among sites included in these small data sets, the project team determined that such results should not be applied as adjustment factors to volumes collected in the OFFCAP data base. Thus, volumes provided by RODs were used without any adjustments in this study.

In the event that the total volume of hazardous wastes generated from a site was not specified in the ROD, it was estimated from the site size given by the RODs. Total waste volumes in these cases were generally estimated by assuming that the hazardous waste comprises 10% of the site area at a depth (*i.e.*, thickness) of three to five feet. The only exception was if the site size was more than 1,000 acres, 1% of the site area was used, instead of 10%. This approach provided a conservative estimate of waste volumes for Superfund sites. The depth of three to five feet was chosen based on suggestions provided by field experts. The decision of using either three or five feet for each individual case of the OFFCAP observations was determined by using the decision rules that are discussed in the next section.

Note that the methodology developed above addresses only the amount of wastes that will be generated by Superfund cleanup activities. Those generated from the Superfund removal activities were not considered. It was anticipated earlier in the project that, if resources permitted, records related to emergency removal incidents occurring at Superfund sites would be extracted from the Emergency Response Notification System (ERNS) data base. Analysis of this data base could be used to derive estimates for waste volumes generated from Superfund sites during the pre-ROD periods. Trends appearing in the 1987-1992 data could then be used to produce projections for 1993 and 1999. Project resources, however, did not permit the study of the ERNS data base. Therefore, it was assumed that the pre-ROD volumes stayed at the 1988 and 1989 levels as given in EPA's Draft 1993 CAP Guidance (EPA, 1993).

1.6 DECISION RULES FOR VOLUMES REQUIRING OFFSITE TREATMENT OR DISPOSAL

The information as to whether the wastes generated from a site were to be treated onsite or shipped offsite for treatment was generally not well documented in the RODs. In order to determine the amount of hazardous wastes to be shipped offsite for treatment or disposal (landfill) during the post-ROD remedial actions, a heuristic approach was used. Under this approach, decision rules were generated from available historical data and expert judgments. Site characteristics—such as waste type, site type, contaminant type, and proposed treatment technologies—were considered when forming these decision rules. Certain rules used in the HAZRAM Model (Peretz, 1992) were also adopted to provide estimates on the percent of

volume reduction and percent of reduction in hazardous level for wastes receiving treatment prior to offsite shipment.

The decision rules were expressed in terms of IF-THEN statements. The IF portion contains conditions for which a site would be evaluated, and the THEN part indicates the fraction of the total volume of hazardous wastes to be assumed as being moved offsite for treatment or disposal. Appendix 1.4 presents a list of the decision rules that were used in determining the offsite volumes for this project. Three levels of estimates (high, medium, and low) were provided for each of the 224 operable units in the OFFCAP data base. In the event that volumes shipped offsite were explicitly stated in the RODs, all levels were set to the same given value.

1.7 METHODS TO ESTIMATE THE NUMBER OF RODs BEYOND YEAR 1992 AND TOTAL VOLUMES

The main approach for estimating one-time generation of Superfund wastes was to use information provided by the RODs to project the total waste volumes to be generated from Superfund sites. As discussed previously, the 1993 total was estimated from RODs that were signed during the three-year period, 1988 to 1990. With the same rationale, the 1999 projection should be estimated from RODs that will be signed during the 1994-1996 period. Because this information was not available, estimates needed to be made.

A simple linear regression approach was used to estimate the number of RODs to be signed in the near future. Based on historical data, the total number of RODs signed per year exhibits a positive straight-line relationship. The simple linear regression model had a R-square value of 0.96, which means that approximately 96% of the variation existing among the data can be explained by this model. From Figure 1.5, it can be easily seen that the straight-line model fits the data reasonably well. Using this model, the total number of RODs to be signed in years 1994, 1995, and 1996 are estimated to be 257, 279, and 301, respectively.

Because only those RODs recommending the use of offsite treatment or disposal technologies were considered in this study, it was necessary to estimate the proportion of the RODs pending signature that would meet this requirement. The number of RODs signed per year and the number of RODs included in the OFFCAP data base for each of these years are listed in Table 1.1. On average, about 24% of the total number of RODs were included in the OFFCAP data base. This percentage was used to estimate the number of RODs that would have been selected as the offsite RODs for the future years. Total volumes to be identified by these RODs were then estimated by multiplying the number of offsite RODs with the average volumes per ROD obtained from historical data. Based on data included in the OFFCAP data base, the average volumes per ROD are 0.006, 0.011, and 0.019 million cubic yards for the low, medium, and high estimates, respectively.

1.8 METHODS TO ESTIMATE THE 1999 PROJECTED VOLUMES BY STATE

The 1999 national projection was generated using the estimated number of RODs and the average volume per ROD from historical data, as discussed in the previous subsection. State-

level projections for 1999 were estimated using a similar method. The number of RODs that would be signed per year for each state, however, were estimated using a different method.

With the time interval findings reported earlier, Superfund sites should have gained NPL status between 1989 and 1991 so their RODs would be signed within the three-year period beginning 1994 in order to produce offsite shipments in 1999. Using the distribution of NPL sites identified for each state during 1989-1991, the estimated number of RODs for 1994-1996 were divided by state (Table 1.3). Without the availability of more accurate information, management categories were broken down using the percentages of landfill or incineration sites in each state, based on historical data.

1.9 CALCULATING RESULTS

Based on information collected from the above-mentioned data sources, 224 RODs were collected and compiled to form the new OFFCAP data base. These 224 RODs were for operable units located at non-federal facility sites and were signed during 1982-1991. Only those RODs that suggested the use of "offsite treatment" or "offsite disposal" as remedial technologies are included in this data base. Decision rules were applied, case-by-case, to obtain three levels of estimates (high, medium, and low) for each operable unit included in OFFCAP.

The 1993 national- and state-level waste volume projections were obtained by methods described earlier using information from the 1988-1990 RODs. Waste volumes were broken down by their management categories (landfill and incineration) as required by EPA. Table 1.2 presents a list of these state-level projections for 1993. 1999 projections were estimated by methods discussed in section 1.8 and were given in Table 1.3. National projections are also presented at the bottom of each table. Because of the high level of uncertainty in projecting the future number of Superfund sites and the highly site-specific nature of Superfund characteristics, it is very difficult to produce accurate long-term projections for the hazardous waste volumes to be generated from Superfund sites. Therefore, the 2013 projections were assumed to be at the same level as 1999. That is, the total volumes of hazardous wastes generated from Superfund sites during 1999 to 2013 will be constants.

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Table 1.1. Total Number of RODs Signed during 1982-1991 and
the Number of Offsite RODs

Year of ROD Signing	Number of RODs Signed	Number of RODs Included in OFFCAP
1982	4	2
1983	13	2
1984	38	9
1985	69	26
1986	84	20
1987	77	6
1988	153	31
1989	143	30
1990	168	39
1991	196	59
TOTAL	945	224

Table 1.2. Total Volumes of Wastes Projected for 1993 (in cubic yards)

State	High		Medium		Low	
	Landfill	Incinerator	Landfill	Incinerator	Landfill	Incinerator
AL	0	0	0	0	0	0
AR	2,125	1	1,075	1	25	1
CA	6,462	0	6,462	0	6,462	0
CO	450	7,403	450	7,403	450	7,403
CT	0	686	0	206	0	82
DE	16,970	20	8,877	20	3,733	20
FL	500	0	500	0	500	0
IA	90	380	90	380	90	380
ID	0	0	0	0	0	0
IN	0	564	0	282	0	0
IL	0	15,246	0	15,246	0	15,246
KY	10	0	10	0	10	0
MA	0	36,302	0	10,890	0	5,445
ME	10,575	990	5,288	495	2,644	248
MD	30,150	0	30,150	0	30,150	0
MI	5,490	1,121	4,365	1,121	3,240	1,121
MN	262	0	262	0	262	0
MO	26,216	5,787	20,793	5,787	4,316	5,787
MS	17,213	0	17,213	0	17,213	0
NC	0	0	0	0	0	0
NH	622	0	595	0	556	0
NJ	56,303	9,710	28,508	9,257	18,439	9,030
NM	444	0	266	0	53	0

Table 1.2. Total Volumes of Wastes Projected for 1993 (in cubic yards)

State	High		Medium		Low	
	Landfill	Incinerator	Landfill	Incinerator	Landfill	Incinerator
NY	35,263	22,048	17,123	11,540	8,788	1,122
OH	28,607	3,992	14,313	3,992	503	3,992
OK	0	20,850	0	13,900	0	6,950
OR	35,770	0	26,680	0	8,500	0
PA	14,907	2,445	12,090	1,429	10,819	1,211
PR	0	0	0	0	0	0
RI	55	0	55	0	55	0
TN	4,537	11,151	2,178	6,791	339	1,563
TX	14,018	0	8,280	0	2,543	0
UT	49,500	0	24,750	0	0	0
VA	4,180	450	4,180	450	4,180	450
WA	236	0	236	0	236	0
WI	735	0	735	0	735	0
WV	0	3,375	0	3,375	0	3,375
U.S. TOTAL	361,688	142,520	235,524	92,564	124,839	63,426

Table 1.3. Total Volumes of Waste Projected for 1999 (in cubic yards)

State	High		Medium		Low	
	Landfill	Incinerator	Landfill	Incinerator	Landfill	Incinerator
AK	6,073	2,603	3,516	1,507	1,918	822
AL	4,338	4,338	2,511	2,511	1,370	1,370
AR	5,726	2,950	3,315	1,708	1,808	932
AZ	6,073	2,603	3,516	1,507	1,918	822
CA	100,379	12,406	58,114	7,183	31,699	3,918
CT	0	30,365	0	17,580	0	9,589
DE	25,203	5,162	14,591	2,989	7,959	21,630
FL	52,055	0	30,137	0	16,438	0
GA	21,256	9,110	12,306	5,274	6,712	2,877
IA	34,356	17,699	19,890	10,247	10,849	5,589
ID	13,014	0	7,534	0	4,110	0
IN	0	47,717	0	27,626	18,630	4,658
IL	58,995	14,749	34,155	8,539	0	15,068
KS	12,146	5,205	7,032	3,014	3,836	1,644
KY	24,292	6,073	14,064	3,516	7,671	1,918
LA	12,146	5,205	7,032	3,014	3,836	1,644
MA	3,470	868	2,009	502	1,096	274
ME	6,941	1,735	4,018	1,005	2,192	1,735
MD	8,676	0	5,023	0	2,740	0
MI	41,644	27,763	24,110	16,073	13,151	27,763
MN	4,338	0	2,511	0	1,370	0
MO	12,363	9,326	7,158	5,400	3,904	9,326
NC	47,717	0	27,626	0	15,068	0

Table 1.3. Total Volumes of Waste Projected for 1999 (in cubic yards)

State	High		Medium		Low	
	Landfill	Incinerator	Landfill	Incinerator	Landfill	Incinerator
ND	3,037	1,301	1,758	753	959	1,301
NE	6,073	2,603	3,516	1,507	1,918	2,603
NH	8,676	0	5,023	0	2,740	0
NJ	35,918	16,137	20,795	9,342	11,342	16,137
NM	17,352	0	10,046	0	5,479	0
NV	3,037	1,301	1,758	753	959	411
NY	45,721	28,023	26,470	16,224	14,438	8,849
OH	3,904	434	2,260	251	1,233	137
OK	0	17,352	0	10,046	0	5,479
OR	13,014	0	7,534	0	4,110	0
PA	110,226	32,925	63,815	19,062	34,808	10,397
RI	4,338	0	2,511	0	1,370	0
SC	9,110	3,904	5,274	2,260	2,877	1,233
SD	6,073	2,603	3,516	1,507	1,918	822
TN	13,014	4,338	7,534	2,511	4,110	1,370
TX	21,689	0	12,557	0	6,849	0
UT	21,689	0	12,557	0	6,849	0
VA	32,404	6,637	18,760	3,842	10,233	2,096
VT	18,219	7,808	10,548	4,521	5,753	2,466
WA	29,281	9,760	16,952	5,651	9,247	3,082
WI	13,881	3,470	8,037	2,009	4,384	1,096
WV	3,037	1,301	1,758	753	959	411

Table 1.3. Total Volumes of Waste Projected for 1999 (in cubic yards)

State	High		Medium		Low	
	Landfill	Incinerator	Landfill	Incinerator	Landfill	Incinerator
U. S. TOTAL	920,893	345,774	533,148	200,185	290,808	109,192

Duration for Major Processes in Superfund Cleanup Activities

Figure 1.1. ROD Signed Date to The Beginning of Remedial Action

Figure 1.2. Duration of The Remedial Action Process

Duration for Major Processes in Superfund Cleanup Activities

Figure 1.3. Between Site Entered in NPL and the ROD Signing Date

* based on 1196 observations

Figure 1.4. ROD Signed to The Completion of Remedial Action

* based on 996 of the 1296 observations

Figure 1.5. Number of RODs Signed Per Year

2.0 ONE-TIME HAZARDOUS WASTE GENERATION DUE TO RCRA CORRECTIVE ACTIONS

2.1 INTRODUCTION

As part of the Resource Conservation and Recovery Act (RCRA) Corrective Action process, some percentage of the treatment, storage and disposal facilities (TSDFs) and other facilities falling under the RCRA regulatory framework will need to engage in remediation efforts. Due to the nature of the problem, remediation efforts at these facilities will mostly focus on soils and groundwater. With respect to soils, remediation activities can be broadly classified with respect to their goals: treatment or containment. Incineration and solidification are examples of the former, and soil and RCRA caps are examples of the latter. Groundwater contamination is typically handled through onsite pumping and treating, although other approaches, such as slurry walls, are also used.

Regarding capacity assurance planning, in order to estimate the amount of hazardous wastes that will leave TSDFs and other facilities for commercial hazardous waste treatment and disposal facilities as a result of RCRA corrective actions, the following should be known: the universe of TSDFs and other facilities, including in which state they are located; the number and types of solid waste management units (SWMUs) at each facility; the number of SWMUs at each facility that will need remediation; how each SWMU will be remediated; how much hazardous waste will be shipped offsite given the remediation approaches and what treatment it will receive; when remediations will commence; and how much time is needed to complete each particular remediation effort. Given this information, estimations can be made for yearly commercial hazardous waste generation on a state-by-state basis.

While this information is not completely available, many sources of good information are available and will be used in this analysis. This section discusses *two* methodologies that will be used to estimate the one-time generation of hazardous wastes from facilities regulated under RCRA. The first methodology to be presented builds upon the Environmental Protection Agency's (EPA) "Regulatory Impact Analysis (RIA) for the Final Rulemaking on Corrective Action for Solid Waste Management Units" (EPA, 1993). The RIA is the result of several years of intensive work to analyze the costs and benefits of RCRA Corrective Action. This methodology will be referred to in this report as the *RIA methodology*.

The second methodology builds upon previous work by Oak Ridge National Laboratory (ORNL) in its analysis of the costs of RCRA Corrective Action (Tonn, *et al.*, 1991). This methodology will be referred to here as the *ORNL methodology*.

The two methodologies take very different approaches toward estimating one-time generation of hazardous wastes from RCRA facilities. The RIA methodology is based on an in-depth analysis of a small number of RCRA facilities. The ORNL methodology is based on a mechanistic analysis of a large number of RCRA TSDFs. The two approaches rely on different data bases and possess different strengths and weaknesses. Since it is not presently known which approach

is more accurate, using two complementary approaches will provide a more definitive analysis of the estimates than if just one were used.

2.1.1 Introduction to RIA Methodology

In March 1993, EPA issued a draft report on its RIA for RCRA Corrective Action. After completing the draft RIA, the Regulatory Analysis Branch of the Office of Solid Waste offered to make available to this project its data base and results. The following sections present the RIA data to be used in this project; the methodology to estimate one-time hazardous waste generation on a state-by-state basis in the years 1993, 1999, and 2013; and major uncertainties.

2.1.2 RIA Data Base

The key methodological decision made in conducting the RIA was to conduct in-depth analyses of a small number of RCRA-regulated facilities and to generalize the results to the universe of RCRA-regulated facilities. Thus, the RIA data base described in this subsection contains a great deal of information on a small number of facilities.

To begin, the data base indicates that the RCRA universe contains 5,397 non-federal facilities (the RIA indicates there are 5,432 non-federal facilities; 35 in the original data base were subsequently found to be duplicates). This number was arrived at by analyzing records in the Hazardous Waste Data Management System (HWDMS) and two other data bases, the Corrective Action Reporting System (CARS) and the Resource Conservation and Recovery Information System (RCRIS). The universe is composed of: (1) permitted, operating facilities (currently managing RCRA-regulated hazardous wastes); (2) operating facilities seeking permits (interim status); (3) closing facilities that need a post-closure permit; (4) closing facilities that do not need a post-closure permit; (5) closed facilities with post-closure permits; and (6) others.

Seventy non-federal facilities were chosen for in-depth analysis in the following manner. First, the universe was divided into three strata: large facilities; not-large facilities having a RCRA Facility Assessment (RFA); and not-large facilities not having an RFA. The number of facilities in the sample by strata are 26, 27, and 17, respectively. The number of facilities in the universe are 87; 1,711; and 3,634; respectively. We refer to the former as "sample facilities" and the latter as "data base facilities." Using statistical sampling techniques, each sample facility has been assigned a sample weight (*i.e.*, how many data base facilities a sample facility represents).

Appendix H of the draft RIA contains facility and SWMU data forms that describe the data in the RIA data base. The data were collected primarily from the RFAs, with the above mentioned data bases, the two data bases detailed in Section 2.2.3, and expert judgments being used to fill in missing data. The data base covers a comprehensive range of variables that describes the facilities (*e.g.*, soils, climate, land use, surrounding populations, SIC code) and their SWMUs (*e.g.*, type, waste codes, reported releases, size, etc.).

Only a subset of the available data were used in this project. Variables used to describe each data base facility and sample facility are: strata, permit status, SIC code, and state. Four variables, measured in cubic yards, were used to describe waste volumes at each of the 70 sample facilities: incineration, solidification/stabilization, other treatments, and disposal. Two other variables were also used: the recommended number of Corrective Action Management Units (CAMUs) under both the expanded and proposed CAMU regulations (see discussion of CAMUs in next subsection).

2.1.3 RIA Methodology

The RIA covers many topics in its cost/benefit analysis. However, all of the various analyses are based on decisions about whether or not to remediate facilities, and if so, what remediation technologies to apply. The remediation decisions were made by three expert panels. One panel contained individuals whose expertise lie in the RCRA regulatory process. The other two panels contained expert environmental engineers. The panel process was arranged so that the "regulators" would provide guidance to the "technologists" in much the same way that the process actually happens in the field. The technologists used the guidance to develop appropriate remediation plans. All of these decisions were based on information contained in the RIA data base.

It should be noted that the remediation decisions were based on the availability of the CAMU option. It is proposed that CAMUs be allowed to be designated at a facility as a means of consolidating waste management and remediation activities. For example, such a policy would allow hazardous wastes to be lifted out of land-based SWMUs and replaced in the same or other land-based SWMUs within a CAMU without triggering the Land Ban Restrictions. Also, CAMUs would provide relief from the minimum technology requirements. The originally "Proposed" CAMU rules stipulated that CAMUs could contain only spatially contiguous SWMUs. However, under the "Expanded" CAMU rules discussed in the RIA, SWMUs within a CAMU would not have to be contiguous.¹

The RIA data base contains four categories of volumes created as a result of remediation activities: incineration, solidification/stabilization, other treatments, and disposal. The RIA methodology allowed for hazardous materials to move from one category to another. For example, in some cases, the experts could have decided first to incinerate soils and then stabilize them. Indeed, visual inspection of the data base indicates several instances where volumes moved from one category to another (*i.e.*, the volumes were exactly the same).

For the purposes of estimating offsite volumes, this situation causes a double-counting problem, and the data base does not provide guidance about how to resolve this problem. To handle double counting, the following revisions to the data base were made. In instances where incineration and solidification/stabilization (S/S) volumes were double counted (*i.e.*, volumes were exactly the same), the incineration volumes were included in a separate estimate for incineration, as were the S/S volumes, which were also multiplied by 1.5 to account for an increase in volume. Only the S/S volumes were used to produce total volume estimates. In cases where other treatments and disposal were double counted with either incineration or S/S, these volumes were

changed to zero. In the one case where other treatments and disposal were double counted, the disposal volume was changed to zero.

2.1.4 RIA Methodology Technical Approach

The challenges presented to this project are to generalize these volumes to the universe of data base facilities on a state-by-state basis and to make estimates for the target years of 1993, 1999, and 2013. The major technical problem associated with achieving these goals is that the RIA focused on developing national estimates, not state-by-state estimates. That is, the RIA exercise developed sampling techniques to generate a representative national sample of facilities, not a representative sample of facilities on a state-by-state basis.

Therefore, a methodology is needed to use estimates of the sample facilities' waste volumes to produce national estimates on a state-by-state basis. Several approaches were considered. One approach involved formulating the task as a constrained optimization problem. This approach proved to be too complex as it involved over 3,000 unknowns and several hundred constraints. Another approach was to simply randomly assign each data base facility to one of the 70 sample facilities, where each sample facility would be linked to a number of data base facilities equal to its sample weight. This approach was deemed inadequate because it does not draw upon potentially informative variables that describe both the sample facilities and the data base facilities.

The chosen approach uses *similarity comparisons*. Specifically, each of the 5,327 facilities not in the sample is compared to each of the sample facilities, using a similarity measure. The sample facility with the highest similarity score is matched to that data base facility. If two or more sample facilities tie for the highest similarity score, then one of them is chosen at random for the match. Then, the volumes of hazardous waste generated for offsite treatment for that sample facility are assumed to be the volumes generated from the data base facility for offsite treatment.

Four variables are used to create a similarity measure. They are, in order of importance: strata; SIC code; permit status; and state. There are three strata, as mentioned above, and more than 20 different SIC codes represented in the data base. There are six different permit status categories (see Section 2.1.2). All 50 states plus U.S. territories are also represented.

Following convention, the similarity measure ranges from 0.0 to 1.0. "Points" are assigned depending on how well a sample facility matches the data base facility on each variable. The similarity estimate is the sum of the four point assignments. With respect to strata, 0.501 points are assigned if the data base facility is the same stratum as the sample facility. Zero points are assigned if the data base facility is 'large' and the sample facility is 'not large,' with or without an RFA, and visa versa. If the data base facility is not large with an RFA and the sample facility is not large without an RFA, or visa versa, then 0.2 points are assigned.

Regarding the SIC code, if the data base facility and sample facility have the same SIC code, 0.3 points are assigned. If the data base facility and the sample facility are in the same SIC category (*i.e.*, first digit), 0.15 points are assigned. Otherwise, 0.0 points are assigned. If the data base

facility and sample facility are in the same permit category, 0.15 points are assigned. If the data base facility and sample facility are in related categories (*e.g.*, operating facility/permit candidate and RCRA permitted facility), between 0.1 and 0.11 points are assigned. Otherwise, 0.0 points are assigned. If the data base facility and sample facility are from the same state, 0.049 points are assigned; if they are from the same EPA region, 0.04 points are assigned. Otherwise, 0.0 points are assigned.

Thus, for example, if a data base facility and sample facility are of the same stratum, SIC code, permit status, and state, the similarity score is 1.0. The scoring method is devised to always match a data base facility with a sample facility from the same stratum because the RIA determined that this variable was the most important sampling variable. The SIC code was judged next in importance because facilities in the same or similar codes would be expected to have similar wastes and site characteristics. Permit status was considered third most important because permit status could be related to the potential for remediation. Matching by states was considered useful because sites in the same states might share similar soil, climate, and hydrological characteristics (these could influence remediation), and EPA regional administrations making remediation decisions. Other matching variables were not considered because they were not available for all the data base and sample facilities.

The assigned points reflect this priority ranking. Specifically, the points were arrived at by assuming that the most important variable would be "approximately twice" the weight of next most important variable, and so on. There are no documentation or statistical analyses to support this assumption. However, we believe the assumption is intuitively sound and internally consistent.

This assumption, combined with adopting the 0.0 to 1.0 scoring convention, and the decision to have the matching algorithm always match for stratum (*i.e.*, by making the weight greater than 0.50), leads one to the weighting scheme adopted here. Different assumptions about the relative importance of the four variables would lead to different point schemes.

To distribute the volumes over time, we will use the schedule developed from an EPA briefing entitled the "RCRA Pipeline." This is discussed in more detail in Section 2.2.5.

Two cases will be estimated. The base case assumes that CAMUs will not be used at the facilities. As a result, it is assumed that all volumes destined for incineration, solidification/stabilization, other treatments, and disposal, corrected for double counting, will ultimately be disposed offsite at commercial hazardous waste landfills. The RIA data base does not contain any information on the proportion of wastes that would stay onsite versus going offsite that would assist in making more detailed assumptions.

The second case assumes that the Expanded CAMU rule will be adopted. In this case, all wastes requiring disposal are assumed to be disposed of onsite in a CAMU.

Results from both cases will be as follows: cubic yards of incineration; cubic yards solidification/stabilization plus other treatments plus disposal; and total cubic yards for disposal offsite. These estimates will be done on a state-by-state basis for the years 1993 to 2013.

2.1.5 Uncertainties

The major uncertainty relates to the generalization process. Do the 70 sample facilities, which represent approximately 1.3% of the universe, adequately represent the larger universe? EPA has undertaken significant efforts to assure that this is the case, but it is conceivable that people could make arguments either way. One could have concerns that the sample rates for the not-large facilities with and without RFAs are too small and that the available data on these categories of facilities might have been too deficient to allow the expert panels to make the most informed remediation judgments.

Another uncertainty relates to the remediation methodologies arrived at using the two-panel process. This process represents a very good way to bring to bear a high level of expertise on a problem of this level of sophistication. Unfortunately, the RIA does not contain an explicit statement of the "rules of thumb" used by the experts to make these decisions. Thus, the process itself has not provided a record for others to review.

Another point is that it is unclear whether the process can be replicated. If the same experts were convened again to go over the same sample facilities, would they come up with the same results? Would a different set of experts with similar qualifications arrive at the same results? One could argue that the application of this area of expertise is not such a science that these questions can automatically be answered in the affirmative. On the other hand, it is also unclear whether different judgments at a site-by-site level would have a significant impact on state-level estimates.

A third uncertainty pertains to the arbitrary nature of the similarity measure described above. Conceptually, the approach is attractive. However, subjective judgments were needed to develop the similarity scores, and it is difficult to conclusively argue that one set of scores is superior to another. Subjective judgments on how to handle double counting in the data base and how to estimate offsite disposal in the two cases under consideration also add uncertainty to the estimates.

Lastly, toward the end of this project, continued quality assurance of the RIA data base facility list revealed the potential for as many as 700 facilities to be erroneously included on the list in error. In other words, many of the facilities included in the list may, in fact, not be subject to RCRA authority. At the time of this writing, it is not known which facilities need to be dropped from the data base. Because of this, we were not able to adjust our similarity comparison methodology to account for the uncertainty in the universe. It is likely that the results will be overestimated, but this is not likely to be a major problem because these facilities require little if any corrective action.

2.2 ORNL METHODOLOGY

2.2.1 Introduction to ORNL Methodology

This section discusses the ORNL methodology that will be used to estimate the one-time generation of hazardous wastes from RCRA TSDFs for the years 1993, 1999 and 2013. As

mentioned in the introduction to this section, the methodology is built upon a previous ORNL project that analyzed potential costs associated with RCRA Corrective Action (Tonn, *et al.*, 1991). This discussion has six parts: (1) definition of scenarios; (2) discussion of data bases; (3) definition of SWMU categories; (4) detailed definition of Base Case Scenario; (5) detailed definition of the two CAMU scenarios; and (6) major uncertainties.

2.2.2 Definition of Scenarios

In the ORNL methodology, there are three scenarios, to be known as Base Case, CAMU-restricted, and CAMU-unrestricted.

The Base Case assumes the following. Only SWMUs that will undergo incineration and solidification will produce hazardous wastes that could possibly require offsite disposal. As a corollary, this means that SWMUs receiving soil caps or undergoing soil vaporization and soil flushing are assumed not to generate potential offsite wastes. This also assumes that volumes associated with other management categories (*e.g.*, energy recovery) will be negligible. Finally, it is assumed that onsite pumping and treating of groundwater will not produce wastes that will need offsite commercial treatment and disposal.

The Base Case, most importantly, assumes that all residuals from incineration, whether treated onsite or offsite, and all solidified materials will be disposed of offsite in commercial hazardous waste treatment and disposal facilities. The residual factors to be used are 1.0 and 1.5 for incineration and solidification, respectively. These numbers were derived from the Hazardous Residuals Assessment Model (HAZ-RAM) developed at the University of Tennessee-Knoxville (UTK) (Peretz, *et al.*, 1991).

In addition to the Base Case scenario, this study will examine the potential impact of allowing the use of CAMUs (see Section 2.2.6 for additional discussion on CAMUs). Two CAMU scenarios are considered. Under the *CAMU-restricted scenario*, it is assumed that RCRA facilities with significant nearby populations and highly permeable aquifers will not be allowed to implement CAMUs. Under the *CAMU-unrestricted scenario*, it is assumed that all RCRA facilities will be allowed to implement CAMUs.

2.2.3 Data Base Descriptions

The EPA funded the creation of the two data bases used in ORNL methodology. Research Triangle Institute (RTI) managed the data collection process. The data bases contain information on the nation's TSDFs and a sample of the nation's hazardous waste generators.

2.2.3.1 National Survey of Hazardous Waste Treatment, Storage, Disposal, and Recycling Facilities (TSDR)

From January through November 1986, RTI conducted the 1986 National Screening Survey to identify and collect summary information from all hazardous waste treatment, storage, disposal, and recycling facilities in the United States. The primary objective of this census of more than 5,600 facilities was to gather enough of the same type of information from each TSDF to enable EPA to determine the best approach for a more detailed survey. Data collected included: TSDF RCRA status; volume of waste managed in units regulated under RCRA; volume of hazardous wastes managed in units exempt from RCRA; and available technologies for managing hazardous wastes.

From January through February 1987, RTI conducted a computer-assisted telephone interview follow-up of the 3,000 active TSDFs identified in the 1986 Screening Survey. These facilities were asked to verify and update the data they had provided previously. With this information, RTI developed an understanding of the types of technologies used to manage hazardous wastes at the TSDFs. This information served as the basis for distributing detailed questionnaires for the subsequent 1987 TSDR Survey.

All active TSDFs identified by the telephone follow-up as having treatment, disposal, or recycling technologies were contacted for the 1987 National Survey of Hazardous Waste Treatment, Storage, Disposal, and Recycling Facilities. If a facility only conducted storage operations, they were included in the National Survey of Hazardous Waste Generators, discussed below. In total, 2,600 facilities received a detailed package consisting of an instruction booklet and some combination of 15 different questionnaires, depending on the technologies the facility had onsite.

These questionnaires, totalling 328 pages with 801 questions plus multiple answer options, were developed over an 18-month period in small group meetings with government officials and industry trade associations. The questionnaires were tested in a pretest conducted from January through March 1987. Fifty-five facilities received the appropriate pretest questionnaires and 10 of those were visited. The questionnaires were revised using the results of the pretest.

Approximately 11,000 individual booklets were sent to the 2,600 TSDFs. Each questionnaire asked for details on the following for the particular type of process:

1. specific types of technologies employed onsite;
2. quantity managed;
3. process design and operating parameters for each unit;
4. maximum quantities that could be managed;
5. residuals generated;
6. planned changes in capacity for existing equipment;
7. planned changes in capacity for using new equipment and processes;
8. RCRA waste codes managed using the technology;

9. for commercial facilities, factors affecting the acceptance of waste for management and prices charged for waste management services, and
10. detailed information for each tank used to manage hazardous waste, placed on a Tank Description Form (TDF).

The initial TSDR survey was mailed in August 1987 with follow-ups for the next six months. As of May 1, 1989, approximately 99 percent of the questionnaires had been returned. Upon receipt, each questionnaire was reviewed for technical accuracy. If necessary, follow-up telephone calls were made to facilities. Prior to data entry, each facility's package was manually edited to facilitate efficient entry of the data. After data entry and 100 percent verification of the data entered, a computer-based edit program was used to check the data for inconsistencies, errors, and related problems. The resulting data base contains over 240,000 records that are organized into more than 60 distinct files.

One of the original purposes for this data base was to assist in the capacity assurance planning process. The data base is currently being used by EPA for several other purposes. No other comprehensive surveys of TSDFs exist. RTI should be contacted for more information about the TSDR (e.g., its survey design, designations of RCRA facilities, etc).

2.2.3.2 National Survey of Hazardous Waste Generators (GENSUR)

The information collected in the TSDR Survey is used in conjunction with the results from the 1987 National Survey of Hazardous Waste Generators (GENSUR). A survey population of approximately 41,000 hazardous waste generators was established based on information from the 1985 Biennial Reports, and a sample of 10,400 facilities was chosen for the GENSUR. The approximately 2,600 TSDFs in the TSDR were selected with certainty, as were the nation's 1,000 largest hazardous waste generators. Stratified random sampling was employed to select the balance of the sample, with the strata defined by state and the quantity of hazardous waste generated by a facility in 1985. Each selected generator received a survey package consisting of an instruction booklet and nine different questionnaires.

These questionnaires, which included 234 pages with 527 questions with multiple answer options, were developed over an eight-month period in consultation with government officials and industry trade associations. Each facility received all the questionnaires, except for the TSDFs, which received only booklets on General Facility Information and Hazardous Waste Characterization.

The detailed questionnaires were tested in a field pretest of nine facilities conducted in mid-1987. The surveys were mailed in December 1987. The resulting data base contains over 490,000 records on 10,400 facilities.

Data drawn from GENSUR for this study pertain to facility specific information: permeability of the aquifer, size of the facility in acres, and soil type.

2.2.4 Solid Waste Management Unit Categories

The two RTI data bases provide data on over 35,000 SWMUs located in more than 2,000, non-federal TSDFs around the country. As part of the previous study to estimate the costs of RCRA Corrective Action, each SWMU was placed in one of 17 remediation categories, which are broadly defined with respect to containment versus treatment remediation strategies. Each remediation category is composed of a set of remediation-related activities (*e.g.*, soil excavation followed by incineration followed by offsite disposal of residuals). Because the cost study used the Cost of Remedial Action (CORA) Model, developed by CH2M Hill (1989) for EPA, to estimate costs, remediation categories were defined with respect to remediation technologies encompassed in CORA.

Appendix 2.1 presents the potential remediation categories for landfills. For example, landfills that fall into category 1A would only require a soil cap and groundwater monitoring. On the other hand, landfills that fall into category 6A would require soil excavation, onsite incineration, offsite disposal of residuals in a commercial RCRA landfill, and groundwater monitoring as well as activities associated with pumping and treating of groundwater—groundwater extraction, air stripping, and groundwater reinjection. Appendix 2.2 presents the remediation categories developed for waste piles, land treatment units, and surface impoundment. Appendix 2.3 presents the categories developed for tanks and tank systems. Appendix 2.4 presents categories developed for container storage and satellite accumulation areas. (Note: These eight types of SWMUs represent more than 95% of the SWMUs in the RTI data bases and represent the SWMU types included in this study.)

As mentioned above, only SWMUs requiring incineration or solidification are assumed to have the potential to generate offsite demands. These SWMUs correspond to categories 5A, 6A, 6B, 7A, and 8A, five of the 17 categories indicated in Appendices 2.1-2.4. The original ORNL methodology did not estimate the proportions of incineration and solidification that would be performed onsite versus offsite. This methodological shortcoming is addressed in the next subsection.

The variables extracted from the RTI data bases for use in the ORNL methodology are listed in Table 2.1. The top of Table 2.1 presents the names of variables used later on in the analysis. The remainder of the table defines the variables in the following way. First, the variable name is given. Then values which the variable may assume are given. Next, a word description of how the value should be interpreted is provided. Lastly, information which documents the genesis of the variable to specific questions in the RTI questionnaires is provided if appropriate (*e.g.*, in cases where the variable has been constructed from other variables in the RTI data bases).

The variables listed in Table 2.1 were used to create IF-THEN rules that would specify the remediation category into which a SWMU would fall, given its characteristics. The IF-THEN rules are based on expert judgments that were greatly informed by remediation decisions contained in hundreds of Records of Decision (RODs). The IF-THEN rules used in this analysis are similar in function and form to rules used in expert systems that capture human expertise in such diverse fields as medicine and law.

Table 2.2 shows the rules used in the Tonn, *et al.* (1991), study to categorize landfills. For example, if a landfill is greater than six acres in size, presents a low risk to surrounding populations, does not have a high level of waste, and has a good liner, then categorization rule 1A comes into play and stipulates a soil cap. The basic difference between those landfills categorized as requiring caps (rules 1A through 4C) versus those requiring treatment (rules 5A through 8A) is size. Table 2.3 shows the rules for waste piles, land treatment units, and surface impoundments. Table 2.4 shows the rules for tanks. Table 2.5 shows the rules for tank systems. Table 2.6 shows the rules for container storage and satellite accumulation areas.²

2.2.5 Base Case Scenario

Appendix 2.5 presents a more detailed view of this study's Base Case scenario. The first step entails estimating the number of TSDFs and SWMUs requiring remediation. The recent RIA states that approximately 45% of the facilities will require some type of remediation (p. 4-15). At these facilities, approximately 50% of the landfills, 45% of the surface impoundments, 33% of the waste piles, and 10% of the tanks will require remediation.

This information, together with discussions held with expert environmental engineers as part of ORNL's previous project (Tonn, *et al.*, 1992), provide the foundation for the following assumptions: 80% of the facilities will require remediation; 50% of landfills and land treatment units; 33% of waste piles and tank areas; 45% of surface impoundments; and 10% of tanks, satellite areas, and container areas.

The first estimate is more conservative than the RIA estimate. The SWMU assumptions are consistent with the findings in the RIA. These assumptions reflect a compromise between the results reported in the RIA and interviews with other experts. In the interviews, most of the experts believed that eventually almost every SWMU will require remediation because containment approaches will not work indefinitely. To take these convictions into account, it was decided to assume that a higher percentage of facilities will need remediation, rather than a higher percentage of SWMUs at a relatively small percentage of facilities.

The second step entails estimating corrective action starts over time. Table 2.7 shows these assumptions, which were based on a recent EPA study of corrective action starts. As can be seen, prior to 1991, fewer than 1% of all TSDFs had progressed through the RCRA pipeline to initiate corrective actions. It is estimated that the pace will pick up in the next few years. The estimates for the years 1992-2001 and 2002-2013 in Table 2.7 are attributable to this project, not to EPA.

In the third step, it is assumed that the rate of corrective action starts for each state will be the same rate as for that state's EPA region. This assumption is justifiable because the EPA regions greatly influence the overall pace of remediation activities within the states.

The fourth step entails estimating average volumes for incineration and solidification per TSDF by state. This step is accomplished by calculating the amount of volume associated with each 5A-8A SWMU category for each TSDF in a state, summing the volumes, and dividing by the

number of TSDFs in the state. These volume estimates are derivable directly from the methodology used in the previous ORNL project (Tonn, *et al.*, 1992). In that project, volumes of soil to be excavated were calculated for each SWMU type and category requiring incineration and solidification. The volumes were calculated by multiplying the surface area of the SWMU as reported in the RTI data bases by an average excavation depth of five feet.

Residual factors are then applied in step 5 to produce average volumes that would potentially require offsite disposal. As noted above, these factors are 1.0 and 1.5 for incineration and solidification, respectively.

The sixth step is to calculate volumes potentially disposable offsite over time. To do so, the corrective action start times presented in Table 2.7 are used. Subjective judgments were used to spread corrective action start times over the two time periods, 1992-2001 and 2002-2013. It is assumed that, on average, it will take two years to complete the remedial activities associated with incineration and solidification. This estimate is based on information in the RIA.

The last two steps entail adjusting the outputs from step six. In step seven, there is the opportunity to adjust the amount of volumes associated with incineration and solidification that is estimated to go offsite, after the residual factors are applied. The initial assumptions for the base case, as stated above, are 1.0 for both incineration and solidification.

The final step allows adjustments for factors associated with the universe and other aspects of the data base. For example, from the previous study, Tonn, *et al.* (1992), observed that inconsistencies in reporting SWMUs among various questions in the two RTI data bases suggest that the number of SWMUs represented in the data bases is underestimated by at least 20%. It was surmised that the sheer effort of completing the detailed booklets for each SWMU prompted many TSDFs to not fill out booklets for all of their SWMUs. Because of this observation, volumes are multiplied by 1.2 in this step.

Also, there is a discrepancy between the RTI count of TSDFs and number of facilities falling under RCRA as reported in the RIA methodology section. It appears that one difference is that EPA included in its analysis facilities in the process of closing under RCRA regulations that were not part of the RTI data base. It is unclear how to adjust the results at this step in the analysis to account for a difference in universe estimates between the RTI and RIA data bases. This is because facilities not in the RTI data bases are, presumably, not like the facilities that are presented. Therefore, no adjustments are made. Instead, this point will be important in assessing the results of the two methodologies for a consensus estimate.

The Base Case, from the point of view of capacity assurance planning, estimates greater demand than the other cases. All of the residuals from two major treatment activities are assumed to eventually be shipped to commercial hazardous waste landfills. A large number of TSDFs and SWMUs are assumed to eventually require remediation. Adjustments made in the Base Case are conservative in order to produce a firm upper bound for RCRA hazardous wastes for the ORNL methodology.

2.2.6 Corrective Action Management Unit Scenarios

The two CAMU scenarios will yield smaller volumes of RCRA hazardous wastes to be shipped to commercial hazardous waste treatment and disposal facilities, since it is generally assumed that residuals from incineration and solidification will be disposed of onsite in CAMUs. Appendix Figure 2.6 presents the steps associated with the CAMU-restricted case. Each of the TSDFs in the data base is processed through the four-step logic.

First, it is determined whether a TSDF has any SWMUs that fall into the incineration or solidification categories. If not, then that TSDF is eliminated from further analysis. The second step entails determining whether a TSDF is CAMUable.³ In an analysis of potential cost reductions due to CAMU regulations for EPA, Tonn, *et al.* (1992), developed criteria involving risk to surrounding populations (*i.e.*, if RISK is high) and permeability of aquifers (*i.e.*, if PERM is high) to indicate whether a TSDF might be allowed to use CAMUs. If a TSDF is determined to be not CAMUable, then it will be included in the pool of TSDFs to be treated using Base Case assumptions.

The third step entails determining whether a CAMUable TSDF has any landfills. This step is used because it is assumed that landfills will form the foundation for CAMUs at a TSDF. It is possible that TSDFs could build new landfills to host CAMUs, but this strategy was found through analysis to be a rather cost inefficient solution. If a TSDF does not have any landfills, then that TSDF will be placed in the Base Case pool.

The last step in the logic is to determine whether a TSDF would actually build one or more CAMUs, given its mix of SWMUs. Because maps of the TSDFs were not available, Tonn, *et al.* (1992), developed a two-part quadratic equation to produce this estimate. The equation is based on the observation that a facility with more SWMUs could have more CAMUs, but only up to a certain point, where the SWMUs will become so numerous that it would be possible to group the SWMUs into fewer but larger CAMUs. In those cases where one or more CAMUs could be expected to be designated, it is assumed that all volumes will be kept onsite. These assumptions are consistent with the Expanded CAMU rule supported by EPA. Otherwise, the TSDF is placed in the Base Case pool.

For the CAMU-unrestricted case, the second step is eliminated. Tonn, *et al.* (1992), found that this restriction eliminated over 70% of the TSDFs from having CAMUs, so the CAMU-unrestricted case will greatly increase the volumes of hazardous wastes to be kept onsite.

2.2.7 Major Uncertainties

As is common with analyses of this type, there are major uncertainties that need to be explicitly stated and managed as best as possible. There are two major uncertainties associated with the RTI data bases. First, it is very likely that the number of SWMUs represented in the data bases is too low. It is possible that the SWMUs were under-reported by at least 20%, although there is no way to determine a more exact estimate without a rigorous follow-up field study. Volume

estimates were increased by 20% to account for this problem, but people could differ on the appropriateness of this assumption.

Second, the number of TSDFs in the data bases is smaller than the number contained in the recent EPA RIA and other documents. One source of the difference is that RTI sought to include only TSDFs that were intending to receive Part B RCRA permits, whereas EPA figures also include TSDFs in the closure process, and sometimes include federal facilities (which are handled separately in this project), and other kinds of facilities.

There are uncertainties associated with how many SWMUs will eventually be remediated, the pace of remediation, the validity of the SWMU categorization rules (*e.g.*, some may argue that they are too simplistic), the validity of the assumptions associated with the Base Case and the two CAMU cases, and EPA remediation policies. Each of these factors must be carefully considered when reviewing and using the ORNL methodology results.

There are other issues which at first seemed capable of causing uncertainties in the analysis but upon further analysis proved not to be problems. Captive sites is one such issue. There is no provision in the proposed CAMU regulations that allows companies to move hazardous wastes from SWMUs in one TSDF to a CAMU in another TSDF. Thus, captive sites is not an issue.

Another potential issue relates to offsite versus onsite incineration. The ORNL methodology is not able to incorporate an economic perspective to study this issue. Basically, it is assumed that if a facility is able to build a CAMU, it will dispose of its incineration residuals in the CAMU, which forces the assumption that incineration will be done onsite. If a facility is not going to make use of CAMUs, then the methodology does not make a distinction between onsite versus offsite incineration because no information is available in the data bases upon which to base the estimate. It could be argued that current trends indicate that mobile incinerators are facilitating more onsite incineration. In any case, it is assumed that residuals from incineration will need to be disposed of in hazardous waste landfills regardless of the site of incineration. Thus, from the perspective of capacity assurance planning, this limitation of the methodology does not seem to pose a large problem.

2.2.8 Combining Results from the Two Methodologies

It is anticipated that the results produced by the RIA methodology and the ORNL methodology will be used to construct a range of estimates both on a national level and on a state-by-state basis. For example, one way to produce a range would be to use the lowest estimate from the two methodologies as a lower bound and the highest estimate from the two methodologies as an upper bound. A conservative approach would be to use the highest lower estimate from the two methodologies as the lower bound and the highest estimate from the two methodologies as an upper bound.

There may be other ways to produce ranges, based more on an analysis of the strengths and weaknesses of the two methodologies, especially if it can be argued that the results are definitely biased to produce under- or overestimates, respectively. However, it should be emphasized

again that two sets of results, derived by using different approaches and different data bases, are better than having only one "opinion." Thus, it is recommended that any final decision on how to use the results seek to find consensus.

2.3 ENDNOTES

1. A recent issue of *Environmental Reporter* (1993) contains a detailed description of CAMUs and definitions for the "Proposed CAMU Rule" and the "Expanded CAMU Rule."
2. The approach in the ORNL methodology, to borrow a term from the artificial intelligence literature, is breadth-first as opposed to depth-first. Specifically, the approach calls for examining data from as many TSDFs and for as many SWMUs as possible and developing decision rules on how to estimate offsite hazardous wastes based on general descriptors of the TSDFs and SWMUs. The benefit of this approach is that the problem of generalizing results to the larger universe is kept to a minimum. A depth-first approach, on the other hand, would examine a small sample of TSDFs in much detail. Offsite decisions could be based on more specific information about the TSDF and SWMUs. Presumably, these decisions for the sample of sites would be more valid than those estimated in the breadth-first approach. The problem with the depth-first approach is in generalizing the results to the universe of TSDFs using even more general descriptors than used in the breadth-first approach. In the best of worlds, both approaches would be pursued to present a more informed range of estimates.
3. Indeed, one will not find 'CAMU' in the dictionary. Sometimes, one is forced to coin new terms in order to succinctly communicate a concept in jargon and acronym-filled contexts.

2.4 REFERENCES

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Table 2.1. Definitions for Variables Used in SWMU Categorization

<i>Variable Names</i>
<p>SIZE (acres)</p> <p>LINER (landfill liner type)</p> <p>PERM (permeability of the upper aquifer)</p> <p>RISK (measure of population exposure)</p> <p>LEVEL (measure of amount of contaminants at site)</p> <p>TYPE (type of hazardous wastes at site)</p> <p>SOIL (soil type)</p> <p>GSIZE (size of tanks in gallons)</p> <p>AGE (age of the SWMU in years)</p> <p>BUILD (is the SWMU in a building?)</p>
<i>Variable Definitions</i>
<p>SIZE = surface area of SWMU in acres</p> <p><i>LINER</i></p> <p>LINER=2 then assume good liner (e.g., if L11*=1,2,3,4 in RTI data base)</p> <p>LINER=1 then assume bad liner (e.g., if L11=5,6,7)</p> <p>conservative assumptions for missing variables is LINER=1</p> <p>*L11 refers to question 11 in the L booklet (LANDFILLS) of the RTI surveys. This and other booklets (e.g., GA) are available from RTI.</p> <p><i>PERM</i></p> <p>PERM=3 high permeability (e.g., if GA85a > .25 ft/day in RTI data base)</p> <p>PERM=2 medium permeability (e.g., if GA85a > 0.05 and <= 0.25 ft/day)</p> <p>PERM=1 low permeability (e.g., if GA85a < 0.05 ft/day)</p> <p>(GA85a is a question on permeability/hydraulic conductivity)</p>

Table 2.1. Definitions for Variables Used in SWMU Categorization

RISK

RISK=3 if high population exposure (e.g., if PEOPLE > 100) and (PRIVATE = Y OR N) and (PUBLIC = Y OR N)

RISK=2 if medium population exposure (e.g., if [(PEOPLE > 20 AND <= 100) and (PRIVATE = Y OR N) and (PUBLIC = Y OR N)] OR [(PEOPLE <= 20) and (PRIVATE = Y) and (PUBLIC = Y OR N)] OR [(PEOPLE <= 20) and (PRIVATE = Y OR N) AND (PUBLIC = Y) in RTI data base]

RISK=1 if low population exposure (e.g., if PEOPLE <= 20) and (PRIVATE = N) and (PUBLIC = N)

PEOPLE refers to question GA92, "Estimate the number of people who live within one mile of the edge of this area."

PRIVATE refers to question GA96, "Are any PRIVATE drinking water wells located within one mile downgradient of the edge of any area where hazardous waste is handled? YES or No"

PUBLIC refers to question GA100, "Are any PUBLIC drinking water wells located within one mile downgradient of the edge of any area where hazardous waste is handled? YES or No"

TYPE

TYPE = 1 if hazardous wastes are primarily volatiles

TYPE = 2 if hazardous wastes are primarily a wide range of organics

TYPE = 3 if hazardous wastes are primarily metals

(RCRA WASTE CODES B58-61, B65, and B68 are classified as volatiles
B62-64, B66, B67, B69-B90 as wide range organics
B01-B56 as metals)

LEVEL

LEVEL = 1 for low level/amount of waste in SWMU

LEVEL = 2 for medium level/amount of waste in SWMU

LEVEL = 3 for high level/amount of waste in SWMU

(This determination is made statistically for each SWMU type.)

Table 2.1. Definitions for Variables Used in SWMU Categorization

SOIL

SOIL = 1 if gravel (GA82 = 1 OR 2 in RTI data base)

SOIL = 2 if topsoil (GA82 = 3 OR 4)

SOIL = 3 if loam (GA82 = 5 OR 6)

SOIL = 4 if clay (GA82 = 7)

*G*SIZE= gallon capacity of the tank

AGE= age of the SWMU (years of existence)

BUILD

BUILD =1 if SWMU is in a building

BUILD =2 if SWMU is not in a building

Table 2.2. Remediation Categorization Rules for Landfills

CATEGORY NUMBER	VARIABLES					
	SIZE	PERM	RISK	LEVEL	TYPE	LINER
1A SOIL CAP OR	GE 6	1,2,3	1	1,2	1,2,3	2
	GE 6	1,2	1	1	1,2,3	1
2A + P&T*	GE 6	3	1	1,2	1	1
2B + P&T	GE 6	3	1	1,2	2	1
2C + P&T	GE 6	3	1	1,2	3	1
3A RCRA CAP OR	GT 2	1,2,3	1,2,3	1,2,3	1,2,3	2
	GT 2	1,2	1,2,3	1	1,2,3	1
4A + P&T	GT 2	3	1,2,3	1,2,3	1	1
4B + P&T	GT 2	3	1,2,3	1,2,3	2	1
4C + P&T	GT 2	3	1,2,3	1,2,3	3	1
5A INCINERATION OR	LE 2	1,2,3	2,3	2,3	1,2	2
	LE 2	1,2	2,3	2,3	1,2	1
6A + P&T	LE 2	3	1,2,3	1,2,3	1	1
6B + P&T	LE 2	3	1,2,3	1,2,3	2	1
7A SOLIDIFICATION OR	LE 2	1,2,3	2,3	3	3	2
	LE 2	1,2	2,3	3	3	1
8A + P&T	LE 2	3	2,3	2,3	3	1

*P&T refers to pump and treat. Therefore, "2a + P&T" refers to SOIL CAP plus pump and treat.

1 - permeability of aquifer -
 2 - risk to population of HW releases -
 3 - level of waste -
 4 - type of waste -
 5 - liner -

1=low, 2=med, 3=high
 1=low, 2=med, 3=high
 1=low, 2=med, 3=high
 1=volatiles, 2=organics, 3=metals
 1=bad, 2=good

Table 2.3. Remediation Categorization Rules for Waste Piles, Land Treatment Units, and Surface Impoundments

CATEGORY NUMBER	VARIABLES				
	SIZE	PERM	RISK	LEVEL	TYPE
1A SOIL CAP	GE 3	1	1	1,2	1,2,3
2A + P&T*	GE 3	2,3	1	1,2	1
2B + P&T	GE 3	2,3	1	1,2	2
2C + P&T	GE 3	2,3	1	1,2	3
3A RCRA CAP	GE 3	1	2,3	1,2,3	1,2,3
4A + P&T	GE 3	2,3	2,3	1,2,3	1
4B + P&T	GE 3	2,3	2,3	1,2,3	2
4C + P&T	GE 3	2,3	2,3	1,2,3	3
5A INCINERATION	LT 3	1	1,2,3	1,2,3	2
6A + P&T	LT 3	2	1,2,3	1,2,3	2
7A SOLIDIFICATION	LT 3	1	1	1,2,3	3
8A + P&T	LT 3	2,3	1,2,3	1,2,3	3
9A SOIL VAPORIZATION	LT 3	1	1	1,2	1
10A + P&T	LT 3	2,3	1,2,3	1,2,3	1
11A SOIL FLUSHING	LT 3	3	1,2,3	1,2,3	2

* pump & treat

- 1 - permeability of acquifer -
- 2 - risk to population of HW releases -
- 3 - level of waste -
- 4 - type of waste -

- 1=low, 2=med, 3=high
- 1=low, 2=med, 3=high
- 1=low, 2=med, 3=high
- 1=volatiles, 2=organics, 3=metals

Table 2.4. Remediation Categorization Rules For Tanks

CATEGORY NUMBER	VARIABLES				
	Gsize	PERM	RISK	TYPE	AGE
3A RCRA CAP	LE 2000	1,2,3	1,2,3	1,2,3	LE 10
OR	GT 2000	1,2	1	1,2,3	LE 10
OR	LE 2000	1	1	1,2,3	GT 10
5A INCINERATION	GT 2000	1,2	1	1,2	GT 10
OR	GT 2000	1,2	1,2	1,2	GT 10
OR	GT 2000	3	1,2,3	1,2	LE 10
OR	LE 2000	3	3	1,2	GT 10
6A + P&T*	GT 2000	3	1,2,3	1	GT 10
OR	GT 2000	1,2	3	1	GT 10
6B + P&T	GT 2000	3	1,2,3	2	GT 10
OR	GT 2000	1,2	3	2	GT 10
7A SOLIDIFICATION	GT 2000	1,2	1	3	GT 10
OR	GT 2000	3	1	3	LE 10
OR	LE 2000	3	3	3	GT 10
8A + P&T	GT 2000	3	1,2,3	3	GT 10

* pump & treat

1 - permeability of aquifer -

2 - risk to population of HW releases -

3 - type of waste -

1=low, 2=med, 3=high

1=low, 2=med, 3=high

1=volatiles, 2=organics, 3=metals

Table 2.5. Remediation Categorization Rules for Tank Systems

CATEGORY NUMBER	VARIABLES				
	Gsize	PERM	RISK	TYPE	AGE
3A RCRA CAP	LE .25	1,2,3	1,2,3	1,2,3	LE 10
OR	GT .25	1,2	1	1,2,3	LE 10
OR	LE .25	1	1	1,2,3	LE 10
5A INCINERATION	GT .25	1,2	1	1,2	GT 10
OR	GT .25	1,2	2	1,2	GT 10
OR	GT .25	3	1,2,3	1,2	GT 10
OR	GT .25	3	3	1,2	GT 10
6A + P&T*	GT .25	3	1,2,3	1	GT 10
OR	GT .25	1,2	3	1	GT 10
6B + P&T	GT .25	3	1,2,3	2	GT 10
OR	GT .25	1,2	3	2	GT 10
7A SOLIDIFICATION	GT .25	1,2	1	3	GT 10
OR	GT .25	3	1	3	LE 10
OR	GT .25	3	3	3	GT 10
8A + P&T	GT .25	3	1,2,3	3	GT 10

* pump & treat

1 - permeability of aquifer -

2 - risk to population of HW releases -

3 - type of waste -

1=low, 2=med, 3=high

1=low, 2=med, 3=high

1=volatiles, 2=organics, 3=metals

Table 2.6. Remediation Categorization Rules for Container Storage and Satellite Accumulation Areas

CATEGORY NUMBER	VARIABLES				
	SIZE	PERM	RISK	BUILD	TYPE
1A SOIL CAP	GE 3	1	1	2	1,2,3
2A + P&T*	GE 3	2,3	1	2	1
2B + P&T	GE 3	2,3	1	2	2
2C + P&T	GE 3	2,3	1	2	3
3A RCRA CAP	GE 3	1	2,3	2	1,2,3
4A + P&T	GE 3	2,3	2,3	2	1
4B + P&T	GE 3	2,3	2,3	2	2
4C + P&T	GE 3	2,3	2,3	2	3
5A INCINERATION	LT 3	1	1,2,3	2	2
6A + P&T	LT 3	2	1,2,3	2	2
7A SOLIDIFICATION	LT 3	1	1	2	2
8A + P&T	LT 3	2,3	1,2,3	2	2
9A SOIL VAPORIZATION	LT 3	1	1	2	1
10A + P&T	LT 3	2,3	1,2,3	2	1
11A SOIL FLUSHING	LT 3	3	1,2,3	2	2
12A DO NOTHING	GE 0	1,2,3	1,2,3	1	1,2,3

* pump & treat

1 - permeability of aquifer -

2 - risk to population of HW releases -

3 - building

4 - type of waste -

1=low, 2=med, 3=high

1=low, 2=med, 3=high

1=in a building, 2=not in building

1=volatiles, 2=organics, 3=metals

Table 2.7. Estimated Corrective Action Start Over Time (% of Total)

EPA Region	Estimated # of TSDs requiring corrective action*	% remediations started prior to 1992*	Estimated starts 1992 - 2001 (%)	Estimated starts 2002 - 2013 (%)
I	233	0	4	14
II	274	2	6	22
III	412	0.5	5	18
IV	531	1	7	17
V	708	0.5	5	18
VI	510	1	8	19
VII	287	1	4	14
VIII	111	3	5	18
IX	366	0.5	5	18
X	112	0.5	12	24

*Taken from EPA document entitled "RCRA Implementation," December 1991, p. 45.

3.0 ONE-TIME HAZARDOUS WASTE GENERATION FROM FEDERAL FACILITIES: DEPARTMENTS OF ENERGY AND DEFENSE

3.1 INTRODUCTION

This chapter describes the methodology used to estimate the one-time demand on offsite commercial hazardous waste treatment and disposal facilities due to remediation activities at federal facilities. Federal facilities can be differentiated from other remediation program areas (Superfund, RCRA corrective action, underground storage tanks, and state and private cleanups), by the methodology used in determining their commercial demand. In this research project, federal facilities are defined as the Department of Energy (DOE) reservations, those sites where Congress has directed DOE to do the cleanup (*e.g.*, the Formerly Utilized Sites Remedial Action Program (FUSRAP) and the Uranium Mill Tailings Remediation Action (UMTRA) Sites), and the Department of Defense (DoD) bases. This methodology is limited to these two federal agencies (DOE and DoD) because they represent the vast majority of federal facility sites and will most likely generate the greatest amount of one-time hazardous wastes, creating onsite and offsite demands for hazardous waste treatment and disposal capacity.

DOE manages about 4,000 contaminated sites at 35 installations (DOE, 1993, pp. iii and I-9). In addition to the traditional DOE-owned reservations, Congress has directed DOE to implement cleanup at sites previously used by the Department and its predecessors. FUSRAP and UMTRA were created by congressional mandates to DOE (Uranium Mill Tailings Radiation Control Act of 1978; Atomic Energy Act of 1954, as amended; 1984 and 1985 Energy and Water Development Appropriations Acts).

The potential of the DoD bases to create large volumes of wastes is a result of the implementation of a national policy to downsize the military and close several bases (Base Closure and Realignment Acts of 1988 and 1991). For example, 76 Army bases were identified for closure in the 1988 act. All told, 120 bases are slated for closure and another 62 installations are scheduled for realignment. These closures may accelerate the pace of cleanup as the federal government makes these bases available for other uses. Hence, the demand for capacity may actually occur faster than usually expected during the remediation process.

It is important to investigate the potential demand from these two federal departments. Although this project deals exclusively with commercial hazardous waste treatment and disposal capacity, all 50 states will be affected by remediation at DOE or DoD sites within their borders, regardless of whether waste is treated onsite or offsite. It is also important to distinguish DOE and DoD projection methodologies from other remediation programs discussed in this report. Specific justifications for separating these federal facilities from other remediation areas are provided in Appendix 3.1.

3.2 DEPARTMENT OF ENERGY

3.2.1 Data Collection Effort

DOE sites represent a remediation challenge and an even greater difficulty when projecting commercial demand for hazardous waste treatment and disposal capacity. Many of these sites have been in operation since the 1940s—not only the FUSRAP sites, but many of the DOE-owned reservations. Thus, during the last five decades, large volumes of various wastes have been generated. These include solid, hazardous, low-level radioactive, transuranic, mixed radioactive and hazardous, and high-level radioactive waste streams. This combination of waste streams will no doubt continue as DOE decommissions its weapons facilities. But with its changing mission, DOE has also initiated a large-scale program to clean up its sites. In March 1989, under then-Secretary of Energy James Watkins, DOE committed to a 30-year goal of cleaning up its reservations, based on a 1989 inventory of inactive sites (DOE, 1993, p. i).¹

Although DOE is making progress in environmental restoration, the actual restoration work is in its infancy. This leads to uncertainties in projecting commercial demand for hazardous waste treatment and disposal capacity. The task facing DOE is enormous. Furthermore, there are ten different DOE field offices working on restoration. Due to a desire to have a comprehensive yet centrally and consistently collected data base, the University of Tennessee (UT) requested hazardous waste remediation data from the Environmental Restoration Office at DOE headquarters, rather than collect data from the field offices.² In February 1993, UT requested the following from the Deputy Assistant Secretary for the Office of Environmental Restoration:

1. name and location of site (or reservation);
2. waste constituents (contaminants), waste types (EPA code), or waste description (drums of solvents, contaminated soil, etc.);
3. volumes of each waste type or constituent;
4. any reports or decisions on current management practices for these wastes;
5. any report on the status of site investigations (*i.e.*, how many have been completed and how many remain); and
6. any current policies within DOE on onsite versus offsite management practices.

Data Base

In May 1993, the Director of the Office of Program Support Environmental Restoration provided UT the results of a May 1992 data collection effort undertaken by the Office of Environmental Restoration (EM-40). The EM-40 goal was to "obtain estimates of the extent of contamination at environmental restoration sites" (Wisnabaker, 1993). Although reflecting DOE's *projected* volumes and types of contaminants, the data supplied by this office are dependent on the stage of site investigation. Therefore, in DOE's view, the numbers are *preliminary* (emphasis added). The data were compiled from DOE field offices and were used to support DOE's integrated data base and other EM-40 efforts (Wisnabaker, 1993).³

The data base includes installation name; types of media (groundwater, liquid, solid, sludge, or soils) that have hazardous contamination; waste class (all hazardous); contaminant types (halogenated volatiles, nonhalogenated volatiles, nonhalogenated semivolatiles, etc.); and *estimated* volume of the contaminated media. The data do not represent hazardous waste defined as such under the Resource Conservation and Recovery Act (RCRA). Instead, DOE supplied hazardous contamination data. Nevertheless, because DOE supplied its own projections of hazardous waste needing remediation, UT did not develop a methodology to make projections for DOE reservations or sites.

DOE provided reports from 21 DOE reservations (see Table 3.1). Unfortunately, the data base fails to elaborate on the status of site investigations, particularly important since these volumes represent DOE's *projected* volumes of hazardous waste requiring remediation. In addition, a review of the data base reveals omissions of several sites on the national priorities list (NPL). Table 3.2 lists NPL sites that may have hazardous remediation wastes along with an indicator of whether volume information was included in the DOE data base.⁴ Only four of the 16 NPL sites are included in the DOE data base.⁵

3.2.2 Parameters for Onsite/Offsite Treatment and Disposal Capacity and Time Schedule for Offsite Shipments

Four questions must be answered for capacity assurance planning purposes: will hazardous waste from DOE be shipped offsite; and if so, when, how much, and how will it be managed?

DOE provided projected volumes of hazardous waste for 21 sites; 20 of these are listed in Table 3.1 with the waste media. One FUSRAP site with hazardous waste was omitted from the data base. Although the waste class was listed as hazardous, the specific FUSRAP site, which allows for state identification, was omitted. The total projected volume was 1,300 gallons of liquid waste. One of UT's onsite versus offsite assumptions is that liquid waste would be treated onsite.

As shown in Table 3.1, 19 of the 20 sites contain contaminated groundwater or liquid waste. The only site in the DOE data base without one of these two media types is Los Alamos National Laboratory. Likewise, the only site with just one media—groundwater—is the Stanford Linear Accelerator Center.

DOE neither assigned a treatment or disposal option for any of these wastes, listed a preferred option for onsite versus offsite treatment and disposal, nor provided a schedule for remediation. Instead, when asked about the preferred option of offsite versus onsite treatment, DOE directed UT to the *Five-Year Plan*, the department's "official" policy report on remediation activities. DOE wrote that in response to specific information on current policies within DOE regarding onsite versus offsite management practices, "the best source for . . . this information is the . . . *Five-Year Plan*" (Wisenbaker, 1993).

Although UT relied heavily on the *Five-Year Plan*, UT set two restrictions on onsite versus offsite treatment and disposal of waste:

1. Media type. All groundwater and liquid wastes were assumed to be treated onsite.
2. Total volumes and contaminants. UT assumes that the total volumes listed in the data base would be treated either totally onsite or offsite. UT also assumes that the contaminants were spread across the entire volume of waste.

UT then developed a hierarchy of parameters that might influence the decision to treat waste at the DOE site or ship the waste to a commercial treatment or disposal facility.

1. Explicit site policy. Was the *Five-Year Plan* explicit about treatment practices?
2. Explicit field office policy. Does the DOE field office have a policy regarding treatment of its hazardous wastes?
3. Current capacity. Does the site have a RCRA permit for the management of recurrent hazardous waste generation?
4. Future capacity. Is the site undergoing a conceptual design or permitting process for a hazardous waste management facility?
5. Volumes. What are the volumes at each site—are they large (defined *randomly* here as 20,000 cubic yards) or small (defined, for example, as less than volumes in the 5,000 cubic yards)?⁶
6. Site location. Is the site at a university or other institutionally owned location (e.g., the Ames Laboratory at Iowa State University) or is the site a production operation (e.g., Savannah River)?

Treatment of groundwater onsite is the most technologically feasible option for DOE. Most of the projected volumes in the data base are, not surprisingly, very large. On groundwater, they vary from a low of 100 gallons to a high of 76 billion gallons. Shipping this large volume of groundwater offsite would likely be cost-prohibitive. In addition, groundwater typically has low concentrations and a limited number of contaminants, and installation of onsite treatment facilities is relatively straightforward from a technical perspective. Contaminated groundwater produced as a result of site remediation is generated over many years and the total quantity that must be treated to meet site cleanup goals is difficult to project. Therefore, groundwater is not considered a true "nonrecurrent" waste and installation of dedicated permanent onsite treatment facilities is generally most appropriate.

Regarding liquid wastes, there is also a wide range of projected volumes—from 1,000 to 29 million gallons. Although UT restricts liquid wastes to onsite treatment, there is always a possibility that this waste would go offsite. However, there would be little overall impact on commercial hazardous waste treatment capacity if this waste were shipped offsite. Using

100,000 gallons (*i.e.*, 20 tanker trucks) as a measure of whether to employ offsite versus onsite treatment capabilities, only six sites would ship liquid waste offsite (see Table 3.3).⁷

Regarding more specific parameters, as noted in its transmittal letter, DOE recommended the *Five-Year Plan* installation summaries as the *official* policy on offsite versus onsite waste management at specific sites.⁸ The *Five-Year Plan* noted that in some cases hazardous waste has always been shipped to commercial treatment and disposal facilities.⁹ The plan was somewhat ambiguous about other instances. For example, Los Alamos shipped 1,400 cubic meters of hazardous waste offsite for incineration, has a mixed waste incinerator at the site, and has reserved land for future development of waste management functions (which relates to the current and future capacity parameters listed above). Although the future capacity may be developed for recurrent generation, it might not prevent nonrecurrent generation from being managed at the site.

After UT made a decision on onsite versus offsite management where the *Five-Year Plan* was not explicit, UT went one step further. UT asked DOE field offices and sites to review and verify the assumptions made regarding *offsite* shipments.¹⁰ Volumes were also discussed with each DOE representative to determine whether large volumes would most likely be treated onsite. The Oak Ridge Office supports offsite disposal for hazardous waste for the five sites under its jurisdiction (the three Oak Ridge plants, Paducah, and Portsmouth). Albuquerque Operations prefers commercial treatment and disposal for its hazardous waste generated from remediation activities at Los Alamos National Laboratory. Likewise, the Idaho National Engineering Laboratory prefers offsite management of its remediation hazardous waste. Other field offices and some sites currently prefer onsite treatment (a notable correlation with sites with large volumes, like Argonne National Laboratory-East and Savannah River).

Regarding nos. 3 and 4 on the hierarchy, in most cases, the use of current capacity related more to treatment of groundwater than to contaminated soil (such as the Pantex Plant in Texas). Likewise, future capacity seemed more applicable to mixed (radioactive and hazardous) wastes (such as the Los Alamos incinerator).

Finally, UT assumes that waste at an institutionally owned site (such as the Ames site at Iowa State University) would be shipped to a commercial hazardous waste treatment and disposal facility.

The data base is not structured to provide breakdown of contaminants across volumes. Rather, the data base lists waste class (hazardous) and a quantity for each media. It then provides the contaminant types for the waste class. For example, the sludge media may be contaminated with three chemicals: (1) halogenated volatiles; (2) nonhalogenated volatiles; and (3) other (not specified). In some data entries, the contaminant is not identified or marked as "other." In others, it is other (not specified). Therefore, it was necessary to assume that the contaminants were spread across the entire volume of waste, which influences the treatment selection. UT recognizes the unlikelihood that every cubic yard of contaminated soil is contaminated with the many contaminants listed at some sites included in the data base. Rather, it is possible that a particular contaminant would be isolated in one segment of the

contaminated soil. However, due to the organization of the data base, there is no firm basis upon which to make an allocation of such a contaminant.

In addition, it is assumed (again by default, because of the structure of the DOE data base) that all wastes would either stay onsite or be shipped offsite. And due to the design of the data base, it is impossible to divide the waste treatment categories into different fractions for managing the waste.

By examining each of the above parameters, UT made the following determinations for commercial demand. These are summarized in Table 3.4, and include the state, site name, and premises for each decision. UT determined that 15 DOE sites would ship waste to commercial hazardous waste treatment and disposal facilities. The affected states are California, Florida, Idaho, Iowa, Kentucky, Missouri, New Mexico, New York, Ohio, and Tennessee. Based on the time schedule developed by UT, the shipments will occur between 1993 and 2005.

Treatment Time Schedule

UT developed specific assumptions about the time schedule for offsite shipments. Common throughout every assignment is the assumption that total volumes included in the data base will be shipped offsite; that waste contaminants are spread across the entire waste volume; and that each DOE site will meet the planned milestone status included in the installation summary accompanying the latest *Five-Year Plan*.

Each site has been grouped into three categories indicating the confidence UT has in the accuracy of the time schedules. Any interpretation of the schedule for offsite shipments should be based upon the following: high confidence of accuracy, medium confidence of accuracy, and low confidence of accuracy. Criteria for each accuracy designation are set forth in the following matrix. Although these confidence levels have been developed with as much attention as possible given to impartiality, there is always the potential that they could be interpreted as subjective. At the minimum, the underlying principle of the matrix is a set of questions (or as other chapters in this report have noted, IF-THEN scenarios).

Generally, sites in the high confidence category would conduct remediation action between 1993 and 1999; the one exception is the Ames Plant at Iowa State University. Moreover, five of the six sites in the high confidence ranking also have smaller volumes of contaminated soils—the bulk of the waste shipped offsite (see Figure 3.1). The one exception is the Kansas City Plant. All sites conducting remediation activity beyond 2000 are in the medium to low confidence of accuracy category.

	HIGH	MEDIUM	LOW
Is the <i>Five-Year Plan</i> explicit on offsite treatment method?			
(a) Yes	✓	✓	
(b) No			✓
Is there an easily identifiable area of possible contamination for waste volumes in the <i>Five-Year Plan</i> ?			
(a) Yes	✓		
(b) No		✓	✓
Are there short-term (1 to 2 years) milestones on closure plans in the <i>Five-Year Plan</i> ?	✓		
Does the site identify completion of RCRA feasibility investigation studies in			
(a) 1 to 2 years	✓		
(b) 3 to 4 years		✓	
(c) 5 years			✓
from January 1993 when the <i>Five-Year Plan</i> was printed?			
In the Installation Summary, does the site identify completion of records of decision (RODs) in			
(a) 1 to 2 years	✓		
(b) 3 to 4 years		✓	
(c) 5 years			✓
from January 1993 when the <i>Five-Year Plan</i> was printed?			
Was there confirmation or discussion with site or DOE field office on offsite treatment?			
(a) Yes	✓	✓	
(b) No			✓
Is the total volume of offsite waste less than 20,000 cubic yards? ¹¹			
(a) Yes	✓	✓	
(b) No			✓

There is, of course, overlap in some of the confidence levels. For example, Lawrence Berkeley Laboratory does not meet the short-term milestone on closure plan (this will occur in four years). However, (1) it has a low volume of waste; (2) the *Five-Year Plan* is explicit that waste will be shipped offsite; and (3) there is a RCRA closure schedule milestone included in the *Five-Year Plan* (for 1997). Therefore, UT considers this a high confidence of accuracy.

Oak Ridge National Laboratory (ORNL) is in the medium confidence grouping. ORNL has projected volumes considerably less than 20,000 cubic yards. The interim record of decision (ROD) for waste area grouping (WAG) 6 (which *might* account for the volume of waste included in the data base) is slated for completion in 1993. Assuming there is a three-year period between interim ROD and final ROD and another three years before removal action, this places initial cleanup activity in 1998, ending in 2000. Uncertainty on the time schedule arises since the *Five-Year Plan* also identifies interim RODs for WAG 5 and WAG 1 scheduled for completion in FY96 and FY97. If ORNL's projected volume applies to WAG 6, then there is a mid-level confidence that the projection schedule is accurate. If the waste is for WAGs 5 and 1, then the offsite shipment schedule slips into the 2004-2005 time frame for shipment.

On the far end, however, is the cleanup schedule for the Paducah Gaseous Diffusion Plant. The *Five-Year Plan* notes that 14 draft RCRA feasibility investigation (RFI) plans are set for completion between the end of 1992 and 1994.¹² Paducah's installation summary reflects a two-year period between RFI draft plans and final reports. Given this, the RFI final reports would be finished between 1994 and 1996. UT began its calendar of future activity in January 1997. Once the RFI reports are finalized, the site would go through RCRA permit modifications. As part of these modifications, environmental remediation would probably be required by the State of Kentucky. UT's methodology allows for a three-year period between RFI final reports and final preparation and approval of the permit modification (1997-1999). UT then allows another three years for removal action to begin (2000-2002). Shipment to offsite facilities would begin in January 2003 and continue through 2005. This shipment could be further delayed—at the minimum two to three years—if Paducah needs to prepare corrective measure studies after the RFI phase. Thus, this offsite schedule, coupled with the early premises that the wastes identified in the data base from DOE are the same wastes and volumes that would be identified in the draft RFIs, reflects a low confidence of accuracy for the offsite demand from Paducah.¹³

Of the 20 sites, six are in the high confidence of accuracy category on the time schedule for offsite shipments. They are located in California, Florida, Missouri, New Mexico, and Iowa. Only three sites are in the medium level confidence grouping. The affected states are Idaho, Ohio, and Tennessee. Finally, there are six low confidence sites. The states involved are Kentucky, New Mexico, New York, Ohio, and Tennessee, and Texas. The premises for individual site decisions regarding time schedules for offsite shipments are listed in Appendix 3.2. Treatment requirements for the offsite shipments are provided in Section 3.4.

3.2.3 Conclusion—DOE

Although it is appropriate to separate DOE from other program areas, DOE is such a complex organization that it is difficult to determine accurate onsite versus offsite demand for hazardous waste treatment and disposal capacity. The department is dealing with remediation of multiple waste streams, some with limited or no available disposal capacity. This lack of availability may force DOE to store these wastes onsite. Given that option and the fact that DOE has traditionally sent at least some hazardous waste to commercial facilities, the department may again need to consider using commercial facilities.

With any projection process, there are uncertainties. This is particularly true in the case of DOE's commercial hazardous waste treatment and disposal demand. Many of the sites are in the early stages of investigation, and UT heard repeated comments that the volumes listed in the data base are preliminary.¹⁴

UT accepts the projected volumes in the DOE data base and accepts without modification the milestone status set forth in the *Five-Year Plan*. UT does agree with DOE that the status of site investigations leaves open the question of whether the projected volumes are the final numbers.

UT acknowledges that the DOE *Five-Year Plan* asserts the department's plan to have "comprehensive treatment, storage, and disposal facilities in operation for all its waste streams by 2019" (DOE, 1993, p. I-10). UT concludes, however, that DOE may indeed need to use commercial hazardous treatment and disposal capacity before that date, particularly after discussions with DOE field offices where staff were adamant about their preference for offsite use. Unfortunately for capacity assurance planning, any assessment of the exact time schedule or waste volumes is, at this point, full of uncertainties.

3.3 DEPARTMENT OF DEFENSE

3.3.1 DoD Restoration Program Background

The Defense Environmental Restoration Program (DERP) is managed centrally by the Office of the Secretary of Defense. Although the Deputy Assistant Secretary of Defense (Environment) establishes restoration policy and issues broad guidelines for remediation goals and activities, each of the military departments (Air Force, Army, Navy, and the Defense Logistics Agency) and each individual installation is responsible for program implementation (DoD, Defense Environmental Restoration Program (DERP), Annual Report to Congress, 1993, p. 1). Remediation decisions are made on an installation-specific basis.

Although Installation Restoration Program (IRP) activities are underway at most installations in each military branch, progress and efforts vary. In the 1970s and early 1980s, studies to determine the extent of environmental pollution at military facilities were conducted at some sites; however, formal remediation activities began in 1984 under the IRP.

Funding for remediation activities under the IRP has risen dramatically since its inception in 1984, increasing from \$150 million in 1984 to approximately \$2 billion in 1992. Projected funding for remediation activities in 1993 is \$1.6 billion (see Figure 3.2). Funding for FY91 through FY93 includes funds for restoration work for both base closure and active military installations (Dod, *DERP*, 1993, p. 1). During FY92, Congress provided a total of \$443.5 million for environmental restoration at DoD installations scheduled for closure (DoD, *DERP*, 1993, p. 3).

In projecting costs of the Defense Environmental cleanup, DoD has set a goal to have all remedial cleanup activities underway by 2000, and anticipates that funding for these activities will increase until 1999. In projecting costs, DoD assumes that the remedial activities will take one year and that costs are incurred during that year. Funding will decrease dramatically as cleanups are completed.¹⁵ All activities and funding are expected to cease by 2012 (DoD, *DERP*, 1992, p. 28).

Each military branch is making efforts to meet the DoD goal for completed cleanup activities. Table 3.5 is a summary of progress toward completed cleanup of military facilities, by military branch. As shown in Figure 3.3, the majority of sites require the last phases of remedial activity; *i.e.*, remedial design and action (actual cleanup).

Levels of progress vary. For instance, the Air Force has stated in its 1991 directive that all cleanup activities will be completed by 2000. However, actual progress in meeting this goal is behind schedule. The Air Force goal for FY92 was to have completed remedial actions at 40% of IRP sites; the actual completion level is only 28% (DoD, Department of Air Force, 1993, p. 8).

In 1992 the Army required documented Installation Action Plans (IAPs) from a select group of 40 installations. The IAP program is expanding to cover 70 installations in 1993. Thus, information on cleanup efforts and remedial activities can be expected to improve as the data on each base are collected, coordinated, and disseminated.

In addition to congressional funding of environmental restoration, in 1992 DoD was explicitly directed by Senate Appropriations Act 102-154 to establish a Pilot Expedited Environmental Cleanup program. This program includes at least five major projects for each military branch. Pilot programs were established at the bases listed in Table 3.6. DoD has employed innovative technologies, advisory groups and cooperative committees, turnkey contracts, and other means to successfully accelerate cleanup actions at these installations.

Progress on DoD IRP cleanup activities may impact commercial hazardous waste treatment and disposal capacity. However, the specific level and location of the impact are fraught with uncertainties. DoD has no specific policy on offsite versus onsite waste treatment and/or disposal, nor, as will be discussed later, are data on volumes of waste available for each branch of the military. "However, the DoD environmental restoration program follows the National Contingency Plan guidance, which expresses a clear preference for onsite waste treatment and disposal" (Walker, 1993).

3.3.2 Data Collection Effort

DoD has neither a central location for data collection nor a standard practice for consistent collection and storage of data related to remedial activities. Hence, DoD has no comprehensive data base. After several telephone conversations with personnel at the Assistant Secretary of Defense (Environment) office and at their suggestion, UT requested data from the four military branches (Army, Air Force, Navy, and Defense Logistics Agency). Subsequently, in February 1993, UT requested data from the Deputy Assistant Secretary level of each military department. Letters were sent to:

1. Director, Defense Logistics Agency;
2. Deputy Assistant Secretary of the Air Force (Environment);
3. Assistant Secretary of the Navy; and
4. Deputy Assistant Secretary of the Army (Environment, Safety, and Occupational Health)

requesting the following information:

1. location of IRP site or installation location;
2. waste constituents (contaminants), waste type by EPA code, or a description of the waste;
3. volumes of each waste type or constituent;
4. reports or decisions on current management practices for the wastes;
5. any reports on the status of site investigations or remediation efforts; and
6. any DoD policies on onsite versus offsite management practices.

Responses from the branches varied.

3.3.3 Defense Logistics Agency

The Defense Logistics Agency (DLA) provides support services to the U.S. armed forces. These services include storage and distribution of materials (including clothing, food, supplies, equipment). The DLA IRP covers 34 installations¹⁶, four of which are NPL sites (see Table 3.7 for all DoD NPL sites). The Defense Logistics Agency is making substantial progress toward meeting DoD IRP goals, having completed restoration responses at 41% of identified sites in FY92 (see Table 3.5).

Data Collection

In February of 1993, UT began a formal data collection request to the Defense Logistics Agency regarding IRP activities by contacting the Director of the Agency. This office created a data collection form (see Form 1) which was sent to each DLA installation. In early May 1993, the results were submitted to UT.

The DLA installations provided UT with projections of wastes—including installation location, waste constituent, waste type, waste description, and waste volumes—which will require commercial hazardous waste treatment or disposal capacity. DLA anticipates that hazardous wastes requiring commercial capacity will be needed by only eight DLA installations located in six states. Table 3.8 shows the state, installation, and media of contaminants at each installation.

Assumptions on Time Schedule

DLA did not provide a specific time schedule for disposal of these wastes, nor did DLA indicate any treatment or disposal requirements for them. UT assigned commercial treatment and disposal requirements based on the assumptions discussed in Section 3.4. Time schedules for remediation activities and waste disposal were determined by the current phase of remediation activities and the volume of wastes that can be expected to be remediated per year. UT assumes that all remedial actions of less than 100,000 cubic yards will be completed in no more than two years. Sites with volumes of more than 100,000 cubic yards will be remediated at a level of 100,000 cubic yards per year. Annual cleanup levels per site are expected to be linear. Specific assumptions about time schedules are:

1. Since specific time schedules were not indicated, calculations of the average length of time for each process phase were used to determine estimated start year for waste remediation (remedial action (RA) phase).

SI	=	1 year average
RI/FS	=	2 years average
RD	=	1 year average
RA	=	2 years average (except for volumes of more than 100,000 tons)

2. Cleanup levels will be linear; that is, the same volume of waste will be remediated each year for multi-year cleanups.
3. Treatment or disposal methods were not indicated. Therefore, treatment and disposal methods were assigned based on current treatment and disposal technology for the listed waste characteristics.

The schedule for remediation activity for each site is provided in Table 3.9.

3.3.4 Air Force

The Air Force is charged with the strategic air defense and inter-continental missile defense of the United States. There are 88 active Air Force bases in the 50 states and Washington, D.C., and a total of 325 Air Force installations in the United States (which include Air Reserves and Air National Guard installations, weapons plants, and various other sites) under

the control of the Department of the Air Force. Of these installations, 32 are designated NPL sites (see Table 3.7).

Data Collection Efforts

In February 1993, UT requested data from the Deputy Assistant Secretary of the Air Force (Environment). In April 1993, that office responded that it did not maintain the requested information and suggested that inquiries for information be made to each of the ten Major Commands within the Air Force. The office did, however, state that the "current Air Force guidance emphasizes in-situ remediation. Offsite disposal is a "last resort" and only validated after all other remedial alternatives are ineffective or cost prohibitive" (Vest, 1993).

In April 1993, UT sent a letter requesting the data set forth above to the office designated as the point of contact for each Major Command:

MAJOR COMMAND	LOCATION
Air Combat Command	Langley AFB, VA
Air Training Command	Randolph AFB, TX
Air Force District of Washington	Bolling AFB, DC
Air University	Maxwell AFB, AL
Air Mobility Command	Scott AFB, IL
Air Force Reserve	Robins AFB, GA
Air Force Academy	USAF Academy, CO
Air Force Space Command	Peterson AFB, CO
Air Force Materiel Command	Wright-Patterson AFB, OH
Pacific Air Force	Hickam AFB, HI

UT received sporadic and inconsistent responses from the Major Commands and/or individual bases. In some cases, the Major Command requested the necessary data from the bases. The bases responded either directly to UT or through a central contact at the Major Command. The bases and Major Commands submitted projections of anticipated wastes requiring offsite disposal capacity, including installation location, waste type, waste constituent, waste description, and waste volumes. A total of 65 Air Force installations, including Air Force bases, weapons plants, and reserve bases, responded to the request for data. Some bases chose to provide, in narrative or letter format, their *projections* of wastes requiring *offsite* disposal. Other bases submitted a copy of their installation Management Action Plan (MAP).¹⁷

In many cases the MAP provided estimates of waste volumes for each site or operable unit on the base. In almost all cases, the MAP included a time schedule for IRP activities. Often, the treatment and/or disposal method was indicated in the data. Where treatment and disposal technology or method was not indicated, treatment and disposal decisions were made based on the established applicability for the particular waste characteristics (see Section 3.4).

From the data provided in the MAPs, UT developed an equation to estimate the volume of hazardous wastes to be remediated (via offsite treatment and disposal) at each Air Force Base

for which data were not available. A total of 35 bases (or 40%) had submitted adequate data in "t" to be used to develop the equation in the MAPs. Based on the available information, this equation estimated the volume per person employed at the installation.

To calculate the average offsite waste R_i at an individual Air Force Base (i) with E_i employees:

$$R_i = \beta(T_i)$$

$$T_i = \alpha(E_i)$$

where $\beta = \frac{\text{toff}}{T}$, for bases with data

toff = total offsite waste

T = total waste = $[\Sigma \text{toff} + \Sigma \text{ton}]$

ton = total onsite waste

$T_i = \Sigma \text{toff}_i + \Sigma \text{ton}_i$

$$\alpha = \frac{T}{E}$$

and E = number of all employees

This equation, utilizing volume per person, estimates an installation's offsite capacity requirements and is based on relative size of the installation (number of employees is an indicator of relative size). Using this equation, UT estimated the volume of wastes requiring commercial hazardous waste treatment and disposal capacity for each major Air Force installation not providing this information.

Certainly, volume per person is not an ideal variable for calculating waste volumes; a more accurate method would be to measure military activity or buildup over the installation's term of service.

As noted above, a few Air Force bases provided their own estimates of wastes requiring *offsite* hazardous waste disposal. A total of 10 bases provided such data. When these data are available, UT used these individual base projections in the calculations rather than projected volumes determined by the equation set forth above.

3.3.4.1 Air Force Reserve Bases

The Air Force Reserve bases (10), which are not considered major installations, were treated separately (Table 3.10). The Air Force Reserves Major Command (Environmental Quality Division, Directorate of Civil Engineering, Air Force Reserves) provided the following information on the 10 Air Force Reserve bases:

1. a projection, by installation, of the volume of restoration-derived hazardous wastes that will require offsite disposal;
2. waste constituents;
3. waste contaminants;
4. anticipated treatment and/or disposal method; and
5. the current phase of the site investigation/remediation process. Since the Air Force Reserve Major Command provided its own projections of wastes needing offsite disposal, UT was not required to calculate these projections.

The time schedule for remediation is given in Table 3.11.

3.3.5 Navy

The Navy provides sea and air defense for the United States. The Navy has 267 installations in 35 states and Washington, D.C. Of these 267 installations, 27 are designated as NPL sites (Table 3.7).

Data Collection Efforts

In February 1993, UT requested data for Navy installations from the Assistant Secretary of the Navy. The Director of the Environmental Protection, Safety and Occupational Health Division, submitted the data in June 1993. This office sent UT a data base of all oil and fuel spills which occurred at Navy installations during FY92. UT determined that this data were inappropriate for this study.

After receiving the oil and fuel spill data, UT asked for additional data. The response to inquiries revealed that information on the disposal of hazardous wastes at Navy installations may be included in a data base maintained by the DRMS-SHO in Battle Creek, Michigan. UT contacted the DRMS-SHO by telephone and letter in late June 1993 in an effort to obtain information. UT learned that this information is not readily accessible in the existing data base and was told that efforts would be made to provide the data. To date, UT has received no information from DRMS-SHO. Therefore, such data on Navy nonrecurrent hazardous wastes are unavailable.

3.3.6 Army

The Army provides ground and airborne troops for U.S. military operations around the world. There are a total of 1,142 Army installations in the United States, located in all 50 states and the District of Columbia. Thirty of these installations are designated as NPL sites and are shown in Table 3.7.

Data Collection Efforts

In February 1993, UT requested data on Army installations from the office of the Assistant Secretary of the Army. The Deputy Assistant Secretary of the Army for Environment, Safety, and Occupational Health responded to the inquiry. This office replied: [the] "Army does not maintain the installation and waste specific information requested" (Walker, 1993).

UT conducted further inquiries to determine whether the information was available from any other office within the Army. UT contacted many agencies, including the Army Corps of Engineers, the Army Environmental Policy Institute, and the Army Toxic and Hazardous Waste Materials Agency. No usable information was obtained from these agencies.

In June 1993, a final conversation with the Deputy Assistant Secretary of the Army revealed that some information in the form of an Installation Action Plan (IAP) was available for 40 Army installations. The Army has begun remediation efforts at its many facilities, and a pilot program to coordinate efforts and collect information on remediation processes produced IAPs at a select group of installations. UT received copies of these 40 Army IAPs in July 1993. These IAPs represent the Army's first attempt to collect comprehensive information on all remediation activities at its installations. Unfortunately, the IAPs do not contain sufficient information useful for this study.

Initially, 42 installations were selected by the Army for inclusion in the Installation Restoration Program Action Plan pilot program. Two failed to submit IAPs by July 1992. The 40 installations that submitted IAPs are listed in Appendix 3.3.

Installations were selected for the pilot IAP program using the following criteria:

1. NPL installation;
2. installations with off-post or suspected off-post contamination;
3. installations with over \$1 million in funded projects in the FY92 IRP workplan;
and
4. installations near high population densities and politically sensitive installations
(York, p. 2).

The Army directed each IAP to contain the following information:

1. a short chronological history of contamination studies on each installation;
2. sites and contaminants of concern;
3. response actions taken;
4. a schedule of future milestones;
5. cost estimates; and
6. identification of possible/future response actions.

The IAPs provided to UT by the Army for the 40 installations were a comprehensive history of the installation, possible sources of contamination, and response actions undertaken to date. The Action Plans also included information on the number and type of contaminated sites, and the contaminants of concern at the sites on each installation. The current investigative phase, past funding, future anticipated funding requirements, a schedule of estimated milestones for future responses, and identification of future response actions are also included. It is presumed that since much information is known about the IRP sites (such as site type, contaminants of concern, past response actions, future anticipated response actions, response action milestones, and anticipated funding requirements) that information is also available on the estimated volume of contaminated media at each site. Even though the Army IAPs are comprehensive studies and report on contamination at specific installations, volumes of contaminated media requiring remediation were not included in the plans.

The IAP program is expanding to cover 70 installations in 1993. It is expected this effort will produce documents representing a comprehensive compilation of Army remediation efforts.

According to the Army, the volume of nonrecurrent generation of remediation wastes requiring commercial hazardous waste treatment and disposal capacity will be relatively small. As stated in a letter of February 22, 1993, the DoD (and the Army) "environmental restoration program follows the National Contingency Plan guidance which expresses a clear preference for onsite waste treatment and disposal" (Walker, 1993).

3.3.7 Conclusion—DoD

The information provided by the Defense Logistics Agency and the Air Force bases provide a modest basis on which to conclude that some wastes from military installations will require commercial hazardous waste treatment and disposal capacity. It is unknown what the requirements for Army and Navy disposal capacity will be, since adequate data are unavailable to make a determination. Because there are so few installations providing data from the over 1,700 installations that exist, conclusions about total DoD disposal capacity cannot be made with a great deal of certainty (see Appendix 3.4 for all DoD installations per state).

3.4 TREATMENT TECHNOLOGY SELECTION

The offsite management options that were considered for each waste were selected from the list of capacity assurance plan (CAP) management categories shown in Table 3.12. Several of these categories were identified as candidates for the various nonrecurrent wastes at DOE and DoD sites. The candidate strategies include (1) metals recovery [for a small percentage; *i.e.*, 1% of Air Force waste]; (2) treatment by incineration or stabilization; (3) disposal by landfill; and (4) various combinations of these treatments.

A number of factors could be considered in determining the volume of each waste that would be subject to the management strategies in Table 3.12. The available waste characterization data specify media and contaminant type. However, neither DOE nor DoD provided concentration data with which to determine whether the waste was prohibited from land disposal under 40 C.F.R. § 280 and, therefore, required treatment to meet the land disposal restriction (LDR) standards. Furthermore, for soils contaminated with "not otherwise specified" chemicals, there is no basis to determine whether the soil would be prohibited from land disposal. Detailed characterization of the impacted soil is likely to indicate that portions of the total volume could be classified differently due to the distribution of various contaminants as they migrate from, or were placed in, the waste unit. One portion may be hazardous (contains a listed waste or is characteristic) and at concentrations that prohibit land disposal without treatment; one portion may be hazardous for the same constituent yet not prohibited; another portion may be hazardous and prohibited due to another constituent; and the remaining soil may be contaminated but not truly be hazardous (*e.g.*, does not contain a listed waste and is not a characteristic waste).

The LDRs defined in 40 C.F.R. § 268 specify treatment standards that must be met for hazardous wastes prior to disposal in a landfill or other land disposal facility. If a waste is classified as hazardous under 40 C.F.R. § 261, but the concentration of hazardous constituents below the treatment standards, land disposal is an acceptable management option. For wastes exhibiting toxicity characteristics due to leachable metals (D004 to D011), the criteria for hazardous classification are the same as the respective treatment standard. Therefore, a waste that is determined by standard analysis—toxicity characteristic leaching procedure (TCLP)—to be hazardous due to lead or other regulated metal(s) will require treatment prior to land disposal.

The LDR treatment standards are based on the application of the best demonstrated available technology (BDAT) as determined by EPA through waste-specific evaluations. For many listed hazardous wastes, treatment technologies are prescribed under 40 C.F.R. § 268 Subpart D. BDAT for such wastes include technologies which are not included in CAP management options. None of these particular wastes were identified in the nonrecurrent waste data for DOE. For other listed wastes, including spent solvents (F001-F005), as well as wastes classified as characteristic toxic waste due to presence of heavy metals (D004-D011), treatment technologies are not specified. (An exception is for wastes containing high concentrations of mercury, for which a treatment technology is prescribed.) Therefore, any appropriate RCRA-permitted technology or combination of technologies capable of meeting the treatment standard can be utilized.

The selection of treatment technologies for DOE and DoD nonrecurrent wastes was based on the established applicability of the technology or the characteristics of the particular waste. For example, wastes containing hazardous organic contaminants, such as halogenated volatiles or nonhalogenated semivolatiles, are treated by incineration. Wastes containing heavy metals, inorganic corrosives, or reactives (cyanides) are treated by stabilization/chemical fixation. Organic and metal combination streams are treated under two scenarios. The first has 100% of the volume going through incineration, with a portion (20%) followed by stabilization and landfill. UT assumes that 80% of the volume after incineration would meet the LDR for metals and could be directly landfilled. The second scenario has an equal split: 50% incineration followed by stabilization and landfill; the remaining 50% bypassing incineration.

The block flow diagrams in Appendix 3.5 illustrate each strategy. Where there are multiple steps in a particular waste category, these figures indicate the change in waste volume caused by each treatment step used to calculate the quantity flowing to the next step. Incineration of organically contaminated soils or solid wastes is not expected to measurably reduce the volume of soil. Incineration may reduce the mass/weight due to loss of moisture and organic content. However, adding moisture when thermally treating soil reduces dusting and aids in landfill compaction. Therefore, UT assumes no change in volume for soils.

Contaminated soil represents 89% of the nonrecurrent DOE wastes expected to be shipped offsite. At this time, the LDR treatment standards for soil contaminated with hazardous waste are the same as for the waste itself. EPA recognizes the difference in treating soils versus treating waste residues and has recently proposed separate standards for hazardous soils (*Federal Register*, 1993). Although incineration and stabilization remain proven cleanup technologies for soils, other innovative treatment technologies (*e.g.*, soil washing, thermal desorption) currently being developed for widespread commercial use are applicable for the treatment of the major portion of these soils. Promulgation of final LDR regulations governing hazardous soil treatment standards and identification of alternative technologies as BDAT will impact the offsite management of contaminated soils from nonrecurrent and recurrent sources. However, for this study, management strategies for hazardous soils have been assigned based on the current regulations and their inclusion in the CAP management categories.

For wastes treated by stabilization (adding cement, lime/fly ash, or other inorganic additives, for example), the mass and volume would increase. The amount of increase is dependent upon the characteristics of the waste and the treatment criteria, both in terms of the leachability of hazardous constituents and the strength, permeability, durability, and other physical properties related to meeting acceptable landfilling criteria. For the purposes of this study, the estimated volume increase for all stabilized waste is 150%, which is consistent with the value recommended in EPA's recent guidance document for the 1994 CAP submittal (EPA, 1993, p. 3-10).

3.5 UNCERTAINTIES IN DOE AND DoD PROJECTIONS

There are many uncertainties in projecting future commercial hazardous waste treatment and disposal demand by DOE and DoD. Although there seems to be consensus that DOE remediation hazardous solid waste will be shipped to a commercial hazardous waste treatment and disposal facility, this project did not necessarily conclude with any confidence what specific management scenarios would be employed or when disposal would occur. Only when dealing with smaller waste volumes was any realistic time schedule calculated. Conclusions on DoD's future management plan were more illusive to determine. The reasons for these uncertainties are explained below. Many of these reasons have been cited in earlier sections of this chapter.

3.5.1 Data

DOE

The data base provided to UT by DOE's Environmental Restoration Program omits many of the NPL sites. In fact, the data base (see Table 3.1) includes only four of the NPL sites with potential for hazardous waste. Yet, to dismiss the possibility of hazardous waste at those omitted sites is oversight at best, an error in data collection at worst.¹⁸

In addition, DOE acknowledges that the projected volumes are dependent upon the status of site investigations and are, therefore, preliminary. The considerable deviation in the volumes per site when sites are grouped confirms this fact.

For example, regarding soils, four sites have projected volumes between 40 and 1,000 cubic yards:

<u>Site Name</u>	<u>State</u>
Pinellas	Florida
Lawrence Berkeley Laboratory	California
Ames Laboratory	Iowa
Santa Susana Laboratory	California

Four sites have projected volumes between 61,000 and 220,000 cubic yards:

K-25 Plant	Tennessee
Mound Plant	Ohio
Paducah Gaseous Diffusion Plant	Kentucky
Argonne National Laboratory-East	Illinois

At the extreme is Savannah River with a projected 6.6 million cubic yards.¹⁹

UT did attempt to understand the deviation. Reviewing one conspicuous variable that might affect waste volumes—acreage—did not explain this disparity in volumes.

One theory is that the size of a facility might affect the volume of contaminated soil; *i.e.*, a smaller site would have less space on which to build an onsite landfill that might require remediation. The assumption that the first grouping of sites with less waste would parallel "smaller" sites has some credibility. Pinellas covers 99 acres; Lawrence Berkeley Laboratory, 130 acres; Ames Laboratory, 336,000 square feet; and Santa Susana, 290 acres. But when analyzing the second tier of waste volumes, this hypothesis is not validated. The Inhalation Toxicology Research Institute has 200,000 square feet. Oak Ridge National Laboratory is situated on 2,900 acres.

If anything, a comparison of size of facility and of the projected volumes in 1992 (when the data base was compiled) confirms DOE's position that the numbers are *preliminary* due to the status of site investigations. However, an inspection of the status of site investigation is complicated by the lack of "full" reporting. The DOE anecdotal reports that the sites are "early" in the site characterization stage are no doubt true. Few of the 20 sites in the DOE data base report any short-term (FY93 or FY94) proposed closure or treatment of waste. One that does—Santa Susana—has a small projected volume of waste. The Mound Plant in Ohio hopes to begin cleanup at Operable Unit 1 and initiate removal activity in Operable Unit 4 in FY93 (DOE, 1993, p. II-33). The Paducah Plant, on the other hand, is scheduled to complete draft RCRA facility investigation RFI reports between 1994 and 1996. As previously noted, removal activity would begin around the year 2000 if there are no postponements in milestone schedules.

DoD

The DoD's data from the Air Force and Defense Logistics Agency provide a modest basis on which to project offsite commercial hazardous waste treatment and disposal demand and determine a time schedule for that demand. The sites are in various stages of the site investigation/remediation process. For those sites in the remedial design or remedial action phase, the volumes of wastes requiring disposal are known. Thus, the disposal needs and time schedules possess a high degree of certainty. For those sites in the early investigative stages, however, the estimated volume of waste requiring disposal is less accurate. Finally, using current number of employees as a variable to project remediation demand for Air Force is hardly the best indicator of past environmental activities. A more accurate determinant would be level of military active at a base.

Moreover, the lack of any information from the Army and Navy leaves open the question of the need for commercial hazardous waste treatment and disposal facilities. It is difficult to make any broad generalizations that all of their wastes will be treated onsite; similarly it could be an error to assume that all their remediation wastes will be treated offsite. There is simply no basis on which to draw any conclusions about the volume of wastes requiring commercial capacity or the management of remediation wastes from the Army and Navy.

3.5.2 Time Schedule

UT selected its time schedule for DOE offsite shipments based on milestones set out in the *Five-Year Plan*. However, these time schedules proposed in the parameters for specific site removal are, again, based on uncertainty. There could be a misinterpretation of the data provided in the *Five-Year Plan*. The proposed milestones may be missed by sites (certainly the level of review of any cleanup, whether at a DOE or private-sector site, has increased over the last few years), or the milestones at a particular site may change due to reprioritization (an event that has occurred in the past). In addition, the Assistant Secretary for Environmental Restoration and Waste Management has questioned milestones set forth in tri-party compliance agreements. In testimony before the Senate Committee on Energy and Natural Resources, it was commented that the milestones should be more *realistic*, and DOE is working towards renegotiating the agreement on cleanup of the Hanford site in Washington (*Environment Reporter*, August 6, 1993, p. 590). Raising this issue over Hanford (one of the sites missing from our data base) cleanup addresses an important element in DOE's pace of cleanup. If the milestones set out in the installation summaries are "unrealistic," it is conceivable that these timetables could be missed or reworked.

The uncertainty about the time schedules may not be as critical for a reasonable assessment of national capacity needs for the Air Force and Defense Logistics Agency hazardous wastes. The data supplied by DLA indicated its projections of wastes requiring commercial hazardous waste treatment and disposal capacity. In addition, the data included the current phase of the IRP, which allows the determination of an approximate time frame for disposal needs, assuming the schedule for remediating DLA wastes is similar to schedules at NPL sites.

The Air Force responses, just as the DLA's, reflected a projection of hazardous wastes requiring commercial treatment and disposal capacity and, again, presented data concerning the current phase of the IRP for each site. Many of the MAPs provided by the Air Force included a time schedule for each contaminated site on an Air Force base. Assuming the time schedules are realistic and that milestones will be met or will slip only slightly, commercial hazardous waste treatment and disposal capacity needs can be determined with a moderate amount of certainty. Therefore, capacity requirements and approximate time schedules can be discerned from the Air Force data.

3.5.3 Other Policy Changes

A myriad of other policy-related changes could emerge over the next few years to alter the time schedule, onsite or offsite demand, or volumes. One such change would be in the offsite/onsite policies at any field office, reservation, or base. If the sites which indicate offsite treatment and disposal at this point discover that the contaminated volumes are higher than previously thought, the site may opt for onsite treatment.

Another factor could involve regulatory changes on cleanup standards. In other words, what will EPA accept for treatment levels at a particular site? Volumes of remediation waste at each site will depend on site-specific characteristics and cleanup goals.

For contaminated soil the increased application of a variety of treatment methods may lead to more cost-effective cleanups. EPA is emphasizing the use of innovative permanent solutions to soil and groundwater contamination. Environmental technology development—a new DOE goal—may result in the development of additional, cost-effective methods to treat contaminated soil, liquids, or sludge. There is an increasing use of a variety of mobile or semi-permanent treatment systems for remediation. Continued development efforts, both in DOE and DoD and the commercial sector, and field experience should improve technical and cost performance of treatment. This should reduce the volumes of wastes shipped to offsite commercial waste management facilities.

The Base Closure and Realignment Acts of 1988 and 1991 may have an impact on future commercial capacity requirements as closed military bases are cleaned up and made available for other uses. A small number of military installations have closed during 1992 and in previous years; others are scheduled for closure in the future. Decisions regarding the level of cleanup at a specific location may depend on the "existing and reasonably expected use of [the] property" (DoD, *DERP*, 1993, p. 3). Thus, closure, cleanup level, and onsite versus offsite decisions could have a profound impact on DoD commercial hazardous waste treatment and disposal capacity needs.

Finally, the level of funding Congress provides these federal agencies for environmental restoration could affect the time schedule. While Congress has increased funding for DOE environmental restoration over the last few years, this increase may reach a plateau due to other pressing national policies. The DoD is already projecting a decrease in funding for the IRP in FY99. As more and more installations move toward the remedial design/remedial action phase of the process, actual cleanup efforts may be delayed due to a lack of funding.

3.6 ENDNOTES

1. Congress is also responding to the need for cleanup at DOE reservations. DOE's budget for environmental restoration and waste management activities has tripled over the past three years (DOE, 1993, p. i). Although it is unlikely that this budget trend will continue, Congress has provided DOE with funding for initial cleanup work.
2. DOE field offices and reservations were contacted to verify parameters for onsite versus offsite decisions.
3. DOE is in the process of compiling another data base to support the department's programmatic environmental impact statement. However, as of September 1993, the data collection effort was still underway.
4. NPL sites undergoing remediation through FUSRAP and UMTRA are omitted from this list. The FUSRAP and UMTRA sites are much more likely to have radioactive waste streams, not hazardous ones.
5. There is one FUSRAP site included in the volume information supplied to UT. However, the DOE *Five-Year Plan* lists 31 FUSRAP sites undergoing remediation.

6. These cutoff volumes were chosen arbitrarily.
7. After the 100,000-gallon cutoff for economic feasibility to treat offsite, the next "smallest" projected volume is 340,000 gallons at the Savannah River site.
8. Overall policy within DOE is for onsite treatment.
9. These include Inhalation Toxicology Research Institute ("ITRI disposes of all hazardous waste at EPA-permitted commercial off-site disposal sites"); Kansas City Plant ("KCP performs no on-site waste disposal"); Mound Plant ("hazardous waste will continue to be sent to a commercial treatment, storage, and disposal vendor"); and Pinellas Plant ("offsite-disposal of hazardous . . . waste"). DOE, 1993, pp. II-10, II-15, II-30, II-43.
10. UT sent confirmation letters of onsite versus offsite management decisions to the San Francisco Office for Santa Susana Field Laboratory; Idaho National Engineering Laboratory; Argonne National Laboratory-East; Oak Ridge Operations (for K-25, Y-12, Oak Ridge National Laboratory, Portsmouth, and Paducah); Albuquerque Operations for Los Alamos and Pantex Plant; and Brookhaven National Laboratory.
11. The 20,000-cubic yard volume was chosen arbitrarily. Volumes of contaminated soil, for instance, range from 40 to 6.6 million cubic yards.
12. There is inconsistency in the *Five-Year Plan* between RCRA corrective action measures and environmental restoration. Some sites list RCRA corrective measure activities—such as RFIs—under corrective action. Other sites list corrective action under the environmental restoration category.
13. Implicitly UT is questioning the projected volumes of waste. UT did not attempt to make projections of waste at any DOE site. DOE provided its projected volumes of waste. UT does, however, question the validity of estimated volumes of sites where the RFIs are still in progress.
14. One could surmise from this comment that the volumes are either low or high.
15. Obviously, long-term operation of groundwater monitoring will generate costs beyond the one year cleanup phase.
16. Installations are defined as major facilities, minor facilities, plants, and any other facilities that perform functions under the auspices of DoD.
17. A Management Action Plan (MAP) is a document which summarizes the status of an individual installation's environmental restoration program, and provides a comprehensive long-range strategy for conducting the environmental restoration and associated compliance programs. In addition, the MAP defines the status of efforts to resolve technical issues so that continued progress and implementation of scheduled activities can occur. The MAP can be used to direct and monitor environmental

response actions, and to schedule needed activities to resolve technical, administrative, and operational issues.

18. DOE recognizes, however, that its data base of remediation waste is insufficient. The department is undertaking another data effort to support its programmatic environmental impact statement. When available, this report will hopefully provide more accurate projected volumes of waste at all its sites.
19. Only one site (Stanford Linear Accelerator Center) indicated it had no contaminated soil.

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Individual Army Installation Action Plans and Air Force Management Action Plans are listed in Appendix 3.6.

Table 3.1. DOE Data Base on Hazardous Waste¹

STATE	SITE NAME	MEDIA
California	Sandia National Laboratories-Livermore	Groundwater; Solid waste; Soils
	Lawrence Berkeley Laboratory	Liquid waste; Solid waste; Soils
	Stanford Linear Accelerator Center	Groundwater
	Santa Susana Field Laboratory	Liquid waste; Soils
Florida	Pinellas Plant	Groundwater; Soils
Idaho	Idaho National Engineering Laboratory	Liquid waste; Solid waste; Sludge; Soils
Illinois	Argonne National Laboratory-East	Groundwater; Liquid waste; Solid waste; Soils
Iowa	Ames Laboratory	Groundwater; Solid waste; Soils
Kentucky	Paducah Gaseous Diffusion Plant	Liquid waste; Solid waste; Soils
Missouri	Kansas City Plant	Groundwater; Liquid waste; Solid waste; Sludge; Soils
New Mexico	Inhalation Toxicology Research Institute	Groundwater; Sludge; Soils
	Los Alamos National Laboratory	Solid waste; Soils
New York	Brookhaven National Laboratory	Groundwater; Liquid waste; Solid waste; Sludge; Soils
Ohio	Mound Plant	Groundwater; Solid waste; Soils
	Portsmouth Gaseous Diffusion Plant	Liquid waste; Solid waste; Sludge; Soils
South Carolina	Savannah River Site	Groundwater; Liquid waste; Solid waste; Sludge; Soils

Table 3.1. DOE Data Base on Hazardous Waste¹

STATE	SITE NAME	MEDIA
Tennessee	Y-12 Plant	Groundwater; Liquid waste; Solid waste; Soils
	K-25 Site	Groundwater; Liquid waste; Solid waste; Soils
	Oak Ridge National Laboratory	Liquid waste; Solid waste; Soils
Texas	Pantex Plant	Groundwater; Liquid waste; Soils

¹DOE provided projections for one FUSRAP site. That site has been deleted from this data base since the specific site was not identified. According to the DOE *Five-Year Plan*, there are 31 FUSRAP sites undergoing remediation. The waste stream comprised 1,300 gallons of liquid waste.

Table 3.2. DOE Sites on National Priorities List with Potential
for Hazardous Waste Contaminants Versus Inclusion on DOE Data Base¹

STATE	SITE NAME	VOLUME INFORMATION SUPPLIED BY DOE
California	Lawrence Livermore National Laboratory-Main Site	
	Lawrence Livermore National Laboratory-Site 300	
Colorado	Rocky Flats Plant	
Idaho	Idaho National Engineering Laboratory	✓
Missouri	Weldon Spring Quarry and Feed Materials Plant and Raffinate Pits	
New York	Brookhaven National Laboratory	
Ohio	Mound Plant	✓
	Fernald Environmental Management Project	
South Carolina	Savannah River Site	✓
Tennessee	Oak Ridge Reservation (K-25, Oak Ridge National Laboratory, Y-12)	✓
Washington	Hanford Site	

¹This list deletes the five sites undergoing remediation through FUSRAP and UMTRA, where the waste streams are radioactive and beyond the scope of this project.

Table 3.3. DOE Sites with Liquid Hazardous Wastes Projected Volumes
of 100,000 Gallons or Less

STATE	SITE NAME	VOLUMES
California	Lawrence Berkeley Laboratory	48,000
	Santa Susana Field Laboratory	20,000
Idaho	Idaho National Engineering Laboratory	1,000
New York	Brookhaven National Laboratory	81,000
Tennessee	Oak Ridge National Laboratory	18,000
	Y-12 Plant	48,000

Table 3.4. Onsite versus Offsite Demand from DOE Data Base

STATE	SITE NAME	PREMISES FOR DECISION
California	Sandia National Laboratories-Livermore	Onsite—groundwater, solid waste, soils (DOE, <i>Five-Year Plan</i> , p. II-58)
	Lawrence Berkeley Laboratory	Onsite—groundwater; offsite—solid waste, soils (DOE, <i>Five-Year Plan</i> , p. II-213)
	Stanford Linear Accelerator Center	Onsite—groundwater
	Santa Susana Field Laboratory	Onsite—liquid waste; offsite—soils (small quantity; confirmation from DOE San Francisco Operations)
Florida	Pinellas Plant	Onsite—groundwater; offsite—soils (DOE, <i>Five-Year Plan</i> , p. II-43)
Idaho	Idaho National Engineering Laboratory	Onsite—liquid waste; offsite—solid waste, sludge, soils (policy of Idaho National Engineering Laboratory)
Illinois	Argonne National Laboratory-East	Onsite—groundwater, liquid waste, solid waste, soils (policy of Argonne National Laboratory-East)
Iowa	Ames Laboratory	Onsite—groundwater; offsite—solid waste, soils (small quantity, location of laboratory at university campus)
Kentucky	Paducah Gaseous Diffusion Plant	Onsite—liquid waste; offsite—solid waste, soils (policy of Oak Ridge Operations)
Missouri	Kansas City Plant	Onsite—groundwater, liquid waste; offsite—solid waste, sludge, soils (DOE, <i>Five-Year Plan</i> , p. II-15)

Table 3.4. Onsite versus Offsite Demand from DOE Data Base

STATE	SITE NAME	PREMISES FOR DECISION
New Mexico	Inhalation Toxicology Research Institute	Onsite—groundwater; offsite—sludge, soils (DOE, <i>Five-Year Plan</i> , p. II-10)
	Los Alamos National Laboratory	Offsite—solid waste, soils (policy of Albuquerque Operations)
New York	Brookhaven National Laboratory	Onsite—groundwater, liquid waste; offsite—solid waste, sludge, soils (policy of Brookhaven National Laboratory)
Ohio	Mound Plant	Onsite—groundwater; offsite—solid waste, soils (DOE, <i>Five-Year Plan</i> , p. II-30)
	Portsmouth Gaseous Diffusion Plant	Onsite—liquid waste; offsite—solid waste, sludge, soils (policy of Oak Ridge Operations)
South Carolina	Savannah River Site	Onsite—groundwater, liquid waste, solid waste, sludge, soils (large quantities; policy of Savannah River Office)
Tennessee	Y-12 Plant	Onsite—groundwater, liquid waste; offsite—solid waste, soils (policy of Oak Ridge Operations)
	K-25 Site	Onsite—groundwater, liquid waste; offsite—solid waste, soils (policy of Oak Ridge Operations)
	Oak Ridge National Laboratory	Onsite—liquid waste; offsite—solid waste, soils (policy of Oak Ridge Operations)
Texas	Pantex Plant	Onsite—groundwater, liquid waste, soils (policy of Pantex Plant)

Table 3.5. Installation Restoration Program Summary of Installations and Sites

COMPONENT	NUMBER OF INSTALLATIONS	NUMBER OF SITES	NUMBER OF ACTIVE SITES	SITES WHERE RESPONSE IS COMPLETE (RC) ¹	CLOSED OUT SITES (SC)
Army	1,144	10,603	4,216	6,387	5,944
Navy ²	290	3,258	2,481	777	615
Air Force	332	4,474	3,191	1,283	1,010
Defense Logistics Agency	34	460	270	190	75
Total	1,800	18,795	10,158	8,637	7,644

¹Response Complete (RC) is equivalent to the term Closed-Out (CO) in 1992 *DERP* report.

²Includes Marine Corps.

Source: U.S. Department of Defense. April 1993. *Defense Environmental Restoration Program, Annual Report to Congress for Fiscal Year 1992*, p. 7.

Table 3.6. DoD Sites Participating in Pilot Expedited Environmental Cleanup Program

ARMY	NAVY	AIR FORCE
The Presidio, CA	Camp Lejeune Marine Corps Base, NC	Castle Air Force Base, CA
Fort Devens, MA	29 Palms Marine Corps Air Ground Combat Center, CA	George Air Force Base, CA
Fort Sheridan, IL	Chase Field Naval Air Station, TX	Mather Air Force Base, CA
Fort Benjamin Harrison, IN	Davisville Naval Construction Battalion Center, RI	Myrtle Beach Air Force Base, SC
Fort Ord, CA	Long Beach Naval Shipyard, CA	Norton Air Force Base, CA

Source: U.S. Department of Defense. 1993. *Defense Environmental Restoration Program, Annual Report to Congress*, pp. 62-64.

Table 3.7. Department of Defense Sites on the National Priorities List

STATE	ARMY	NAVY ¹	AIR FORCE	DEFENSE LOGISTICS AGENCY
Alabama	Alabama AAP Anniston AD			
Alaska	Fort Wainwright		Eielson AFB Elmendorf AFB	
Arizona		Yuma MCAS	Luke AFB Williams AFB	
California	Fort Ord Riverbank AAP Sacramento AAP	Barstow MCLB Camp Pendleton MCB Concord NWS ² El Toro MCAS Moffett NAS Treasure Island NS	Castle AFB Edwards AFB George AFB March AFB Mather AFB McClellan AFB Norton AFB Travis AFB	Sharpe Site, DDRW Tracy Site, DDRW
Colorado	Rocky Mountain Arsenal	AFP PJKS		
Connecticut		New London NSB		
Delaware			Dover AFB	
Florida		Cecil Field NAS Jacksonville NAS Pensacola NAS	Homestead AFB	
Georgia		Albany MCLB	Robins AFB	

Table 3.7. Department of Defense Sites on the National Priorities List

STATE	ARMY	NAVY ¹	AIR FORCE	DEFENSE LOGISTICS AGENCY
Hawaii	Schofield Barracks	Pearl Harbor Naval Complex ²		
Idaho			Mountain Home AFB	
Illinois	Joliet AAP Savanna ADA			
Iowa	Iowa AAP			
Kansas	Fort Riley			
Louisiana	Louisiana AAP			
Maine		Brunswick NAS	Loring AFB	
Maryland	Aberdeen PG			
Massachusetts	Fort Devens		Otis ANG Base/Camp Edwards	
Minnesota	Twin Cities AAP	Fridley NIROP	Minneapolis-St. Paul Reserve Base	
Missouri	Lake City AAP			
Nebraska	Cornhusker AAP			
New Hampshire			Pease AFB	
New Jersey	Fort Dix ARDEC (Picatinny Arsenal)	Earle NWS Lakehurst NAWCAD		

Table 3.7. Department of Defense Sites on the National Priorities List

STATE	ARMY	NAVY ¹	AIR FORCE	DEFENSE LOGISTICS AGENCY
New York	Seneca AD		Griffiss AFB Plattsburgh AFB	
North Carolina		Camp Lejeune MCB		
Ohio			Wright-Patterson AFB	
Oklahoma			Tinker AFB	
Oregon	Umatilla AD			
Pennsylvania	Letterkenny AD Tobyhanna AD	Warminster NAWCAD		
Rhode Island		Davisville NCBC Newport NETC		
South Dakota			Ellsworth AFB	
Tennessee	Milan AAP			Defense Distribution Region Central ²
Texas	Lone Star AAP Longhorn AAP		AFP #4 (Gen. Dyn.)	
Utah	Tooele AD		Hill AFB	Ogden Defense Depot
Virginia		Dahlgren NSWC ² Yorktown NWS ²		Defense General Supply Center Richmond

Table 3.7. Department of Defense Sites on the National Priorities List

STATE	ARMY	NAVY ¹	AIR FORCE	DEFENSE LOGISTICS AGENCY
Washington	Fort Lewis	Bangor NSB Keyport NUWC Whidbey Island NAS	Fairchild AFB McChord AFB	
Wyoming			F.E. Warren AFB	

¹Includes Marine Corps

²Proposed for listing on the NPL

AAP = Army Ammunition Plant

AD = Army Depot

ADA = Army Depot Activity

AFB = Air Force Base

AFP = Air Force Plant

DDRW = Defense Distribution Region West

DLA = Defense Logistics Agency

MCAS = Marine Corps Air Station

MCB = Marine Corps Base

MCLB = Marine Corps Logistics Base

NAS = Naval Air Station

NAWCAD = Naval Air Warfare Center Aircraft Division

NCBC = Naval Construction Battalion Center

NETC = Naval Education & Training Center

NIROP = Naval Industrial Reserve Ordnance Plant

NS = Naval Station

NSB = Naval Submarine Base

NSWC = Naval Surface Warfare Center

NUWC = Naval Undersea Warfare Center

NWS = Naval Weapons Station

PG = Proving Ground

Source: Compiled from U.S. Department of Defense. April 1993. *Defense Environmental Restoration Program, Annual Report to Congress for Fiscal Year 1992*, Appendix B.

Table 3.8. Defense Logistics Agency Installations Requiring Commercial Hazardous Waste Treatment and Disposal Capacity

STATE	INSTALLATION	MEDIA
California	Sharpe Facility	Soils, sediment
	Tracy Facility	Soils
Louisiana	DNSC Baton Rouge	Soils
Ohio	Defense Electronics Supply Center	Residue
	Defense Construction Supply Center	Soils, solids
Pennsylvania	Defense Distribution Region East	Solids
Utah	Defense Distribution Depot Ogden	Soils
Virginia	Defense General Supply Center	Solids, liquids, sludge

**Table 3.9. Remediation Time Schedule for Defense Logistics Agency Installations
Requiring Commercial Treatment and Disposal Capacity**

STATE	INSTALLATION	BEGIN RA¹ (Year)	RA DURATION (# Years)
California	Sharpe Facility	1995	2
	Tracy Facility	1996	4
Louisiana	DNSC Baton Rouge	1997	2
Ohio	Defense Electronic Supply Center	1994	1
	Defense Construction Supply Center	1993	1
Pennsylvania	Distribution Region East	1994	1
Utah	Defense Distribution Depot Ogden	1996	2
Virginia	General Supply Center (OU 2) ²	1996	2
	General Supply Center (OU 4)	1997	2
	General Supply Center (OU 5)	1994	1
	General Supply Center (OU 6)	1996	2

¹RA = Remedial Action (actual cleanup phase)

²OU = Operable Unit

Table 3.10. Air Force Reserve Bases Requiring Commercial Hazardous Waste Treatment and Disposal Capacity

STATE	AIR FORCE RESERVE INSTALLATION
Georgia	Dobbins ARB
Massachusetts	Westover ARB
Wisconsin	General Mitchell ARS
Missouri	Richards-Gebaur ARS
Ohio	Youngstown ARS
Pennsylvania	Pittsburgh ARS
	Willow Grove ARS
New York	Niagara Falls ARS
Illinois	O'Hare ARS
Minnesota	Minneapolis-St. Paul ARS

ARB = Air Reserve Base

ARS = Air Reserve Station

**Table 3.11. Remediation Time Schedule for Air Force Reserves Requiring
Commercial Treatment Hazardous Waste and Disposal Capacity**

INSTALLATION	BEGIN RA¹ (Year)	RA DURATION (# Years)
Dobbins ARB, GA	N/A	N/A
O'Hare ARS, IL	N/A	N/A
Westover ARB, MA	N/A	N/A
Minneapolis-St. Paul ARS, MN	1994	1
Richards-Gebaur ARS, MO	1994	1
Niagara Falls ARS, NY	1994	1
Youngstown ARS, OH	N/A	N/A
Pittsburgh ARS, PA	N/A	N/A
Willow Grove ARS, PA	N/A	N/A
General Mitchell ARS, WI	N/A	N/A

¹RA = Remedial Action (actual cleanup phase)

ARS = Air Reserve Station

ARB = Air Reserve Base

N/A = Not Applicable (there will be no wastes requiring offsite commercial disposal)

Table 3.12. Management Categories for Capacity Assurance Plans

RECOVERY	TREATMENT	DISPOSAL
Metals Recovery	Stabilization/Chemical Fixation	Landfill
Inorganics Recovery	Incineration - Liquids and Gases	Deepwell/Underground Injection
Organics Recovery	Incineration - Sludges/Solids	Land Treatment/Farming
Energy Recovery- Liquids	Fuel Blending	
Energy Recovery - Sludges/Solids	Hazardous Wastewaters and Sludges Treatment	

Source: U.S. Environmental Protection Agency. 1993. *Guidance for Capacity Assurance Planning*, pp. 2-13.

FIGURE 3.1.
Range of Projected Contaminated Soils
at DOE Data Base Sites

ORNL - Oak Ridge National Laboratory
 ITRI - Inhalation Toxicology Research Institute
 INEL - Idaho National Engineering Laboratory

Figure 3.2

DEPARTMENT OF DEFENSE

Installation Restoration Program

Cleanup funding has grown steadily, from \$150 million in FY 1984 to over \$2 billion in FY 1992. FY 1992 investments included a supplemental appropriation of \$610.2 million for accelerating cleanup. FY 1991 through FY 1993 investments include funds for restoration work at base closure and active military installations.

Source: U.S. Department of Defense. April 1993. *Defense Environmental Restoration Program, Annual Report to Congress for Fiscal Year 1992*, p. 1.

Figure 3.3
DEPARTMENT OF DEFENSE
Installation Restoration Program

IRP Status by Program Phase

Source:

U.S. Department of Defense. April 1993. *Defense Environmental Restoration Program, Annual Report to Congress for Fiscal Year 1992*, p. 9.

Nonrecurrent Hazardous Waste Generation Survey

Name of Site (or Installation) _____
(several operable units at one installation may be combined)

Location (Town and State) _____

Any Reports or Decisions on Current Management Practices for These Wastes_____

Status of Site Investigations:

How Many Completed _____
How Many Remain _____

Types and Amounts of Wastes (projected) (Use extra sheets if necessary)

Waste Constituent (Contaminant)	Waste Type (EPA Code)	Waste Description (drums as solvents contaminated soil, etc.)	Volume
------------------------------------	--------------------------	---	--------

4.0 ONE-TIME HAZARDOUS WASTE GENERATION DUE TO TREATMENT AND DISPOSAL REQUIREMENTS FROM UNDERGROUND STORAGE TANK CLEANUPS

4.1 INTRODUCTION

The purpose of this chapter is to develop an aggregate simulation model of the demand for commercial hazardous waste treatment and disposal requirements resulting from Underground Storage Tank (UST) cleanups. The model is aggregate in the sense that it is initialized with data on the number of tanks in existence at a specific point in time (*i.e.*, year) and at a specific location (*i.e.*, state). Results are generated as annual tons of commercial hazardous waste treatment and disposal capacity required as a consequence of tank failure (*e.g.*, leaks) over a 23-year projection horizon (1990-2013).

The model is designed to be as transparent as possible; that is, the critical data elements and parameters that determine the magnitude of the projected capacity requirements are clearly identified and easily modified. This approach creates a user friendly model that can be run using a set of national or average defaults. As a result, every state need not have the same quality of data, and improvements in underlying data bases can be incorporated as they become available.

The sensitivity of the projections to a myriad of assumptions could be reduced by taking a more micro modeling approach and developing a comprehensive site-specific data base. Such an undertaking is beyond the scope, time frame, and budget of this effort.

4.2 MODELING METHODOLOGY

The model presented here is an extension of the recent work of Bueckman, Kumar, and Russell (1991).¹ In their analysis, a simulation model was developed that projected the cleanup cost of the Environmental Protection Agency (EPA) UST program through the year 2020. As illustrated in Figure 4.1, in their system total cleanup costs are a function of three variables: the number of underground storage tanks, the percentage of tanks requiring cleanup due to a leak or release, and the average cost of corrective action resulting from a leak or release. Each independent variable is a function of time and is analyzed separately by Bueckman, *et al.* Their results for the first two variables—the number of USTs and the percentage of USTs releasing—are incorporated in the present investigation. Their third variable is replaced with the volume of material released per site with a release requiring hazardous waste treatment or disposal.

The purpose of this section is to describe in detail the simulation model developed in this study to project the hazardous waste treatment and disposal requirements due to releases from USTs. Included will be a description of the elements "borrowed" from Bueckman, *et al.*, as well as the modifications necessary in order to reach a physical form result rather than a monetary result. Emphasis will be on the waste generating system. The following section will present the data used to develop parameters and initialize the model.

4.2.1 The Number of USTs

The USTs of concern for this analysis are those regulated under Subtitle I of the 1984 Hazardous and Solid Waste Amendments (HSWA) to the Resource Conservation and Recovery Act of 1976 (RCRA). Bueckman, *et al.*, concluded that the approximately 1.75 million regulated tanks counted in the EPA survey completed in December 1989 was the best estimate of the universe of USTs at that time. This survey was conducted for the EPA Office of Underground Storage Tanks (OUST) by CRM Associates annually through 1992.² The late 1989 survey formed the basis of the Bueckman, *et al.*, estimates and projections of the number of USTs with the late 1989 data taken as indicative of the number of regulated tanks in existence at the beginning of 1990.³

From the data collected by CRM Associates, it is possible to assign each reported tank to an age category and classify each reported tank by protection status. The age categories are: 0-5 years, 6-10 years, 11-15 years, 16-20 years, and > 20 years. A tank is considered protected if it is classified in the data base as having cathodic protection, an interior lining, fiberglass reinforced plastic, or other protection. If the tank's protection status is none or unknown, then it is classified as unprotected. The effective life of a tank is assumed to be 20-25 years, irrespective of protection status.

The number of tanks in each age-protection status cohort is then aged over the projection horizon by five year intervals. In doing so, each tank may be subjected to one of several actions; *i.e.*:

Protected tanks will either remain open (active or inactive), will close according to formal closure procedures, or may be replaced in the period under examination. An additional option is available to owners of unprotected tanks: they can add protection to the tank, redefining it into the protected category. The option to remain open for the unprotected USTs is only available during the time allowed for compliance, because all tanks must be in compliance by the regulatory deadlines. The base case scenario assumes all deadlines for compliance are met. After tank action is determined, the tanks can be advanced to the next age category and regrouped into protected and unprotected tanks.⁴

This process is illustrated schematically in Figure 4.2. In each age interval, a percentage of existing protected and unprotected tanks will be subject to one of the available actions. These percentages are presented in the Bueckman, *et al.*, report and are reproduced here as Appendix 4.1.

In efforts to extend and modify the Bueckman, *et al.*, model to permit the calculation of quantities rather than cost, the *aging algorithm* has been left totally intact. This decision was made for three reasons:

1. The *aging algorithm* is the core of the Bueckman, *et al.*, system. It is extremely complex and to modify it would be quite costly.
2. The *aging algorithm* is methodologically complete and correct.

3. The calculating parameters used in the *aging algorithm* are based on careful research and consideration of existing data. No internally consistent alternatives are available.

Accepting this algorithm results in the following: new tanks of age 0-5 are limited to replacements. "No significant growth in the demand for USTs is anticipated over the time period covered in this estimation."⁵ The majority of all closures (96%) will occur between 1990 and 1999 based on the assumption of compliance with existing regulations.⁶ After five years, 30% of all unprotected USTs will have been ungraded or replaced.⁷

4.2.2 The Percentage of USTs with Releases

Two alternative cases are considered: base case taken directly from Bueckman, *et al.*; and an alternative case which takes into consideration the implications of secondary containment of USTs.

Base Case

The release rates presented in Bueckman, *et al.*, assume that both age and tank protection will affect the probability of tank failure. Furthermore, "a release can occur from a spill, an overfill, or a leak and may be above or below the ground."⁸ Their analysis reveals that:

Speculation on the percentage of USTs releasing has been made by various private and public organizations with estimates ranging from 0% to 3% by some private sources, to close to 50% by others. Most estimates fall somewhere between 8% and 20%. However, the majority of sources also recognize that the actual percentage of releases is unknown.

Of the three variables estimated in the overall total cost equation, this variable has the least amount of detailed data available.⁹

The probabilities of a release presented in the Bueckman, *et al.*, report are shown in Table 4.1. These factors represent a synthesis of the data reviewed by Bueckman, *et al.*, with particular emphasis given to tank testing information and cause of release information.¹⁰

Secondary Containment¹¹

Secondary containment of USTs is required in a small number of locations.¹² Secondary containment does not reduce the risk of tank failure. Rather, it increases the speed of detection and hence could lead to a reduction in releases.

It is assumed for the purposes of this study that USTs containing hazardous substances are regulated under Subtitle I of RCRA and 40 CFR Part 280. For these tanks, secondary containment is not required, and as a result, alternative release factors are not computed.¹³

Calculating Treatment and Disposal Capacity Requirements

The third variable in the Bueckman, *et al.*, system is the average cost of a cleanup. Capacity assurance, of course, requires projections of the physical volume of material requiring commercial treatment and disposal. Fortunately, this conversion can be easily made within the context of the modeling framework developed by Bueckman, *et al.* Figure 4.3 depicts this revised system.

Starting with data on the number of tanks by age of tank in the base year, the first two variables in the Bueckman, *et al.*, system bring us to "number of tanks releasing" in Figure 4.3. When moving from releases to remediation, Bueckman, *et al.*, found that cleanups were site-rather than tank-specific. This convention is retained by means of a tanks-per-site conversion factor which allows computation of the number of sites with releasing tanks.

The Bueckman, *et al.*, system allowed for five forms of environmental degradation from UST releases. These are:

1. Environmental Assessment Only--No Further Action: The release poses no significant threat to human health or the environment and warrants only an environmental site assessment with no further follow-up action.
2. Simple Soil Contamination: The contaminant is primarily confined to the tank excavation zone (backfill area).
3. Complex Soil Contamination: The contaminant has migrated outside the tank excavation zone and may have reached the foundations of nearby buildings or underground structures, but has not entered groundwater in any significant amount.
4. Free Product: The contaminant has reached the groundwater but is still in the undissolved state.
5. Dissolved Phase in Groundwater: Product has reached the groundwater and some portion is in the dissolved state.¹⁴

These categories are mutually exclusive and exhaustive. Each site with releasing tanks must be assigned to one and only one.

The final steps in the model entail straightforward calculations. Based on the level of contamination per site, cubic yards of contaminated soil and gallons of contaminated water are computed. These are the only forms of waste generated. They are summed across contamination categories and assigned to either onsite or offsite management with offsite management synonymous with commercial management. Finally, the amount of offsite material is converted to tons and "sent" to the appropriate capacity assurance management method for treatment and disposal. Summing across both primary and secondary treatment and disposal requirements yields total commercial demand.

4.3 DEFAULT DATA BASE

The default data base is composed of two parts: the default "hazardous" UST population in the base year; and the default parameters.

4.3.1 The UST Population in 1990

Running the model described in the previous section requires data on the number of USTs containing hazardous material broken down by age of tank for 1990, the model base year. These data are reported in the CRM survey. The Bueckman, *et al.*, analysis relied on the data collected in 1989 to form an estimate of the 1990 total tank population. This procedure is followed in the current analysis as well for the subset of tanks falling into the category "hazardous."

The default assumption is that only tanks containing hazardous substances will generate a demand for hazardous waste treatment and disposal capacity. This assumption can be easily modified. For example, in Figure 4.3, if the percentage of petroleum and other USTs with releases managed as hazardous waste can be estimated, the additional "nonhazardous" USTs can be added in, as suggested by the dotted lines emanating from the "tanks containing petroleum" and "tanks containing other material" boxes.¹⁵

Note that the default input data on the number of tanks is state/hazardous specific. As the model's default parameters are essentially national averages for all USTs, the input data set represents the only "local" element present in the calculation of treatment and disposal capacity requirements prior to receiving state input and requests for modifications.

Following the Bueckman, *et al.*, procedure, the CRM Associates survey of USTs undertaken in 1991 is taken as indicative of the number of USTs present at the beginning of 1992. These "1992" data have been compared with the 1990 data as a check on consistency. When the two data sets did not appear to be consistent, the 1992 data were used to update and correct the 1990 data set used to initialize the model.¹⁶ This correction was required for California, Georgia, Kansas, Kentucky, Louisiana, Michigan, Minnesota, and New Jersey.¹⁷ The estimated number of tanks containing hazardous material in 1990 by state is presented in Appendix 4.2. These data are used to produce the results presented in the next section of this chapter.

4.3.2 Model Default Parameters

Two sets of default model parameters have already been introduced and discussed. These are the parameters needed to run the aging algorithm presented in Appendix 4.1 and the release

rates shown in Table 4.1. The additional parameters for which values are needed to use the system described by Figure 4.3 are as follows:

1. The average number of UST's per site.
2. A frequency distribution which assigns releasing sites to one of the five categories of contamination.
3. An estimate of the average amount of contaminated soil and average amount of contaminated groundwater generated per releasing site broken down by contamination category.¹⁸
4. The percentage of material managed onsite versus offsite.
5. The distribution of offsite material to capacity assurance plan (CAP) management categories.¹⁹

Fortunately, these parameters can be estimated from a survey of UST professionals conducted as part of the Bueckman, *et al.*, study.²⁰ This survey was directed at engineering consultants, major petroleum companies, and state UST programs. The objective of the survey was to develop a data set from which to estimate the average cost of a cleanup. However, since the denominator of average cost is a quantity variable, questions germane to the present investigation were included in the survey.

Reviewing the responses to the Bueckman, *et al.*, questionnaire, the data obtained from the engineering consultant group are the most complete and consistent with regard to the quantity variables of interest, and has formed the basis for most of the parameter estimates presented below. However, it must be recalled that even these data are broad national averages covering all types of USTs and that the sample size is relatively small.²¹

Table 4.2 provides the values of the default parameters. As can be seen, for projection years the default treatment and disposal technology is assumed to be incineration-stabilization-landfill of all contaminated soil. This differs from the base year which is derived from responses to the Bueckman survey. However, the important point to note at this juncture is that the choice of waste management method is the only parameter value to change over the modeling time horizon. All the others, *e.g.*, cubic yards per site, percent treated offsite, etc., are constant. A second point to highlight with regard to the default parameters is that offsite treatment of contaminated groundwater is assumed to be negligible. Hence, the only commercial treatment and disposal demand resulting from USTs is due to contaminated soil.

The average cubic yards of contaminated soil per site is a parameter of particular importance in the model, as results will be quite sensitive to its value. The problem encountered with this variable illustrates the impact of outliers on simple averages when sample sizes are relatively small.²² In Table 4.3, the number of questionnaire responses, *N*, and average cubic yards per site, *Y*, are shown for each contamination class. Eliminating all observations greater than two standard deviations from the mean yields an adjusted sample size, *N'*, and adjusted average cubic yards per site, *Y'*. The result of this procedure is significant in all cases but nothing short of dramatic in the dissolved phase case. Note that the adjusted figure, *Y'*, is employed as the model default as shown in Table 4.2. This same adjustment procedure is used in the case of liquid waste.

4.4 CONCLUSION

The ultimate purpose of this study has been two-fold. First, it has been designed to produce a set of estimates and projections of commercial hazardous waste treatment and disposal requirements resulting from underground storage tanks. Producing this set of estimates and projections requires making a considerable number of assumptions regarding behavior and technology based on very poor underlying data. Thus, the second and more important purpose has been to produce a model of waste generation from USTs that can be improved and upgraded as better data become available. The model is conceptually simple and easy to run. It is hoped that individual states will provide information superior to the default data base used to create the methodology presented here.

4.5 ENDNOTES

1. *Underground Storage Tanks: Resource Requirements for Corrective Action.* Knoxville, Tennessee: The University of Tennessee, 1991. This study has been reviewed extensively by EPA and in the private sector. Copies of the Bueckman, et al. report are available from the Energy, Environment and Resources Center, The University of Tennessee, 327 South Stadium Hall, Knoxville, Tennessee 37996.
2. "Annual Survey of Underground Storage Tanks," Office of Underground Storage Tanks, U.S. Environmental Protection Agency.
3. That is, they assume their 1990 base year population of USTs is accurately estimated by the EPA survey completed in December, 1989. See Bueckman, et al. (1991), p. 13.
4. Bueckman, et al. (1991), p. 21.
5. Bueckman, et al. (1991), p. 29.
6. Bueckman, et al. (1991), p. 27.
7. See Bueckman, et al. (1991), p. 25. The speed with which any action is taken over time is controlled by the figures presented in Appendix 4.1. For example, if expectations or new data suggest that the rate of upgrading or replacing unprotected tanks is greater than 30% in the 1990-1995 period, this can be reflected in the calculation of the number of tanks variable by changing the appropriate number in Appendix 4.1.
8. Bueckman, et al. (1991), p. 37.
9. Bueckman, et al. (1991), p. 36.

10. See for example "Causes of Release from UST Systems," EPA/OUST, September 30, 1987, "Summary of County/City Reports on Releases from Underground Storage Tanks, EPA/OUST, February 20, 1987; and the discussion Bueckman, *et al.* (1991), pp. 37-40.
11. Secondary containment generally refers to one of the following: "Enclosing the tank in a concrete vault or carbon steel box, surrounding the tank with an impermeable synthetic lining or using a double-walled tank." These definitions are taken from "Secondary Containment and Leak Detection: Costs and Other Considerations," *The Hazardous Consultant*, November/December, 1992, p. 17.
12. Personal communication with Donna S. Bueckman, September 22, 1993. Locations refer to specific counties in certain states, *e.g.*, California, Florida, New Jersey, etc.
13. Tanks containing hazardous waste are regulated under 40 CFR Parts 264 and 265. The implication of this assumption is that a tank would become a regulated hazardous waste storage facility rather than a regulated UST if its use is changed from the storage of hazardous substances to the storage of hazardous wastes.
14. Bueckman, *et al.* (1991), pp. 71-72.
15. These percentages would have to be determined on an age of tank/degree of protection basis.
16. In the states noted, the 1992 number of hazardous tanks reported was significantly larger than the 1990 number of tanks. The 1992 data are assumed to be relatively *more correct* than the 1990 data. Hence, it becomes necessary to adjust the 1990 input data set to be consistent with the 1992 data. This model calibration is necessary irrespective of any error in the 1990 data.
17. A minor adjustment in a single age category was required for Alaska, Hawaii, Maryland, Montana, Nevada, Puerto Rico, and Wisconsin.
18. Although not shown in Figure 4.3, the model is programmed to account for separate consideration of debris.
19. These are the minimum requirements to run the model. More detailed data, for example, a frequency of distribution across sites of cubic yards of contaminated soil generated would, perhaps, improve the accuracy of the results. If more detailed data become available, it can be incorporated into the system with minimal difficulty.
20. See Bueckman, *et al.* (1991), pp. 60-70, Appendices B-5, B-6, C.
21. Personal conversation with Donna S. Bueckman suggests that the percentage of "hazardous" tanks would be highest in this group of responses. No attempt was made to "scale up" the overall averages of the various parameter estimates to reflect some manner of "hazardous" only figure. The data base is not sufficiently rich to permit such an adjustment. Of course, individual states may have "hazardous" only data, and the model is designed specifically to allow these data to be incorporated.

22. The possible influence of outliers on parameters derived from the Bueckman, et al. survey results was pointed out helpful comments by John Ryabick of ICF Corporation (August 27, 1993).

4.6 REFERENCES

Bueckman, D.S., Kumar, S., and Russell, M.S. (1991). *Underground Storage Tanks: Resource ReqCorrective Action*. Knoxville, TN: University of Tennessee.

Code of Federal Regulations §264, §265, and §280.

U.S. Department of Energy. (1993). *Environmental Restoration and Waste Management five Year Plan, Fiscal Years 1994-1998*. Washington DC: Department of Energy.

Table 4.1. Release Rates for Underground Storage Tanks

Age Cohort	Release Rate (%) (years)	
	Protected Tanks	Unprotected Tanks
00-05	0.5	0.5
06-10	0.5	0.5
11-15	2.5	5.0
16-20	5.0	10.0
> 20	10.0	25.0

Source: Donna S. Bueckman, Sunita Kumar and Milton Russell. *Underground Storage Tanks: Resource Requirements for Corrective Action*. Knoxville, Tennessee: The University of Tennessee, 1991, page 39.

Table 4.2. UST Model Default Parameters

Parameter	Default Value	
1. Average Tanks per Site:	3.3	
2. Distribution of Sites by Contamination Category:		
No Contamination	14%	
Simple Soil Contamination	27%	
Complex Soil Contamination	24%	
Free Product	12%	
Dissolved Phase		23%
3. Average Cubic Yards of Contaminated Soil per Site:		
Simple Soil Contamination	153	
Complex Soil Contamination	645	
Free Product	849	
Dissolved Phase		1,099
4. Average Gallons of Contaminated Groundwater per Site:		
Free Product (000)	1,364	
Dissolved Phase (000)	1,490	
5. Percent Treated/Disposed Offsite:		
Soil		
Simple Soil Contamination	64%	
Complex Soil Contamination	50%	
Free Product	50%	
Dissolved Phase		50%
Groundwater		
Free Product	0%	
Dissolved Phase		0%
6. Commercial Management Method (Soil Only):		
Base Year		
Incineration-Stabilization-Landfill		1%
Incineration-Landfill	4%	
Stabilization-Landfill	8%	
Landfill Only	87%	
Projection Years		
Incineration-Stabilization-Landfill		100%

Table 4.3. Simple (Y) and Adjusted (Y') Average Cubic Yards of Contaminated Soil per Site

Contamination Category	N	Y	N'	Y'
Simple Soil	41	338	36	153
Complex Soil	38	1,501	33	645
Free Product	28	3,329	25	849
Dissolved Phase	26	40,280	23	1,099

Note: N = Number of Responses; N' = Adjusted Number of Responses

Figure 4.1
The Bueckman, *et al.* Model of UST Cleanup Costs:
A Function of Three Variables Over Time

Source: Donna S. Bueckman, Sunita Kumar and Milton Russell. Underground Storage Tanks: Resource Requirements for Corrective Action. Knoxville, Tennessee: The University of Tennessee, 1991, page 7.

Figure 4.2
The Bueckman, *et al.* Model of UST Cleanup Costs:
Schematic for Aging of Tanks

Source: Donna S. Bueckman, Sunita Kumar and Milton Russell. Underground Storage Tanks: Resource Requirements for Corrective Action. Knoxville, Tennessee: The University of Tennessee, 1991, page 20.

**FIGURE 4.3.
UST NONRECURRENT RCRA TSD DEMAND
ANALYSIS FLOW CHART**

5.0 ONE-TIME HAZARDOUS WASTE GENERATION DUE TO STATE AND PRIVATE PROGRAMS

5.1 INTRODUCTION

Estimating one-time hazardous waste generation from state and private programs presents a challenge to the analyst. Because there is no national data base in existence that contains this information, this portion of the project necessitated a compilation of data on a state-by-state basis. However, the data sources in each state were not uniform in the information they possess, nor the format in which they are reported. Thus, because there were gaps in this data, decision rules were developed to supply the missing information.

This chapter is divided into three sections. The first is this introduction to the issues, problems, and analysis. The second section is about the data collection techniques used in this methodology. Data analysis techniques are discussed in Section 5.3.

5.2 DATA COLLECTION

The key to this methodology is its flexibility in dealing with the uncertain quantity and quality of the input information. A letter was sent to each state's hazardous waste cleanup offices (or its equivalent) which discussed state and private one-time waste generation and explained the nature of the current project for the Environmental Protection Agency (EPA). The letter stated that the project team would be contacting representatives of each office to discuss this topic. To help the recipients prepare for the follow-up phone conversation, the letter detailed the issues that the research team wanted to discuss. These included: (1) the number of sites in the state that would ship waste offsite; (2) the volume of the waste involved; (3) where the waste was to be shipped; and (4) estimates of the rate of increase (or decrease) in the number of sites and or volume of waste. The letter also asked the recipient to forward any relevant reports that the state had compiled for either EPA or the state's legislature. While the team was aware that some states did not report or publish data in a readily usable format, it was believed that it could act as both a secondary source of data and a consistency check. A sample of this letter is shown in Figure 5.1.

The next phase of data collection was telephone conversations with each state. A form was used as a basis for this conversation. It must be emphasized that in no case did a state possess the data, and the data was used for discussion purposes only.

As noted, the information contained in the states' reports was used as a consistency check for the information elicited via telephone, and in some cases to fill in information that was not obtained during the phone conversation. In some cases, the reports were the only source of information, as no telephone conversation was possible.

A follow-up phone call was subsequently made to each state to discuss or solicit the states' estimations on how much one-time waste generation would be shipped offsite in the future, and to remind the state officials to send in the information they had promised. This second call was important in collecting information from more states; however, the information on

states' estimations of future offsite shipments was generally inconsistent and therefore not included in the analysis.

It was important to make sure that as much primary data could be collected as possible. The estimation technique described below provides more reliable results with greater quantities of primary data. For this reason it was determined ex-ante that data needed to include at least 25 states in order to use this estimation technique. With the first calls, the follow-up calls, and through reports mailed by various states, primary data was collected from 30 states; enough to satisfactorily conduct the estimations below. Table 5.1 lists these 30 states and their respective 1991 data in cubic yards.

All data that was obtained was entered into a computer data base. Along with this information, the data base includes information collected or developed in the other parts of this project, including UST, Superfund, and RCRA. As will be explained, this data will be used to estimate one-time waste generation for those states where data was neither available through direct phone conversation nor reports.

5.3 DATA ANALYSIS TECHNIQUES

The data analysis consisted of a two-part econometric process. The first step involves forming a complete data set of 1991 one-time hazardous waste managed at offsite treatment and disposal facilities. The second phase utilizes this completed data set to forecast estimates for each state from 1993 to 2013.

In the first step, the team utilized standard econometric techniques procedures to estimate the 1991 one-time hazardous waste transported offsite. It was assumed that the amount of state and private wastes could be related to the amount of hazardous waste produced in other areas (*i.e.*, UST, RCRA, and Superfund), and some state specific data that would indicate the state's inclinations toward environmental policy, in particular its hazardous waste and cleanup policy. A number of combinations of variables were studied in order to find the strongest possible statistical model. In the end, four variables were selected: 1991 RCRA and Superfund data generated from this project; and two indices of a state's hazardous waste cleanup activism. While there were a number of indices available to the team in this area, the most statistically significant relationship existed between one-time state and private project cleanup and the following two policy indicators: per capita state spending on hazardous waste cleanup, and an index on the state's hazardous waste policy's strength.¹

This statistical relationship for 1991 can be expressed as

$$\text{WASTE}_y = b_1\text{SF}_y + b_2\text{RCRA}_y + b_3\text{PCHZ}_y + b_4\text{HAX}_y$$

Where:

y	= State
WASTE _y	= Waste quantity in cubic yards for state y;
SF _y	= Superfund estimation in year x for state y;
RCRA _y	= RCRA cleanup state y ORNL methodology;
PCHZ _y	= Per Capita spending on hazardous waste cleanup in state y;
HAX _y	= Hazardous Waste Index for state y;

It is important to understand these variables before moving on. The first two variables in this model present the assumption that the state and private cleanup efforts are positively related to the amount of Superfund and RCRA offsite waste in the state. That is, we assume that if a state has a high (low) number of other cleanup transported offsite, it will have a high (low) amount of state and private hazardous waste transported offsite. We do not assume that this is a causal relationship; rather, an indicative one.

The model does not include UST data as this variable was not found to have significant predictive power in this modeling framework. Further, federal facilities are also not included. It was assumed that the placement of these sites is independent of many of the state and local conditions that may effect the number of state and private cleanup sites.

It should be noted that because the above inputs are dependent on the output of other sections of this project, the estimations necessarily embrace all relevant assumptions that were used in the other relevant sections. That is, not only do these estimates rely on the specific assumptions discussed above, they also implicitly rely on those made in the Superfund and RCRA corrective action (ORNL methodology) estimations. This should not be considered a weakness of this estimation technique, but rather a necessity due to the nature of the lack of data in state and private program areas.

Continuing with a discussion of the variables, this model assumes that one aspect of a state's one time cleanup now or in the future is a function of certain social and bureaucratic variables. In this equation this relationship is represented by the PCHZ and HAX variables; the more actively a state pursues hazardous waste cleanup, the more material will be transported offsite, all other things being equal. This assumption was developed in the course of discussions with the states where it was often pointed out that cleanup depended in many cases not on how many sites were found, but on each state's want and/or ability to undertake new projects. As noted above, while there are other indicators that can be used here, these two provided the most significant estimates for this model. Both of these indices are assumed to be constant through the course of the forecast period (1993-2013).

By estimating these b values using standard regression techniques for the states where we have all these data, we can estimate the missing WASTE data for the states where data were not originally collected. That is, because all the information on the right-hand side of the

equation exists for all the states, we can estimate the missing left-hand side data.² This then completes the 1991 data set.

In the second step of this procedure, estimations for the years 1993-2013 were made. The estimated relationships from the above model were used to estimate WASTE in each year of interest. In this estimation the relationship between WASTE in any given year and the various right-hand side variables of the same year was assumed to be constant. That is, the coefficients on each of the right-hand side variables were assumed to stay the same. Thus, for example, to estimate state and private hazardous waste for a given state in 1999, the 1999 RCRA corrective action and Superfund estimates are substituted for their 1991 counterparts in the earlier estimating model. They are multiplied by their respective coefficients (b) and added together along with effects of the constant policy variable. This is repeated for each state and year of interest to provide state-by-state and year-by-year estimates of state and private programs.

5.4 ENDNOTES

1. Both indices were found in Hall, Bob and Kerr, Mary Lee, *1991-1992 Green Index, A State-by-State Guide to the Nation's Environmental Health*, Washington DC, Island Press, 1991.
2. The actual estimation equation for both part one and part two relied on a log-log form in order to correct for heteroscedasticity in the data. The equation used in the text is thus an over-simplification of the actual model and is used for expository purposes. For a more detailed discussion of the assumptions underlying this technique, heteroscedasticity and use of this model specification, please see Robert S. Pindyck and Daniel L. Rubinfeld, *Econometric Models and Economic Forecasts*, New York, 1992.

5.5 REFERENCES

- Hall, B. and Kerr, M.L. (1991). *1991-1992 Green Index, A State-by-State Guide to the Nation's Environmental Health*, Washington DC: Island Press.
- Pindyck, R.S. and Rubinfeld, D.L. (1992). *Econometric Models and Economic Forecasts*. New York.

Table 5.1. States and 1991 Primary Data

State	1991 Offsite Estimations (cubic yards)
AK	1,398.60
AL	23,615.02
AR	97.83
AZ	2,113.64
CA	279,865.73
CO	1,706.48
CT	274.22
DE	78.59
FL	15,253.67
HI	0.00
IA	644.06
IL	210.00
IN	14,950.19
KS	57.23
LA	25,619.55
MN	4,659.24
MO	246.60
NC	224.85
NE	24.57
NH	112.99
NJ	146,000.00
NY	42,787.44
OK	704.88
PA	16,722.66
SC	83,192.00
TN	1,854.57
TX	14,742.80
VA	29,040.00
WV	263,941.62
WY	0.00

Figure 5.1. Generic Letter Sent to State Hazardous Waste Offices

OAK RIDGE NATIONAL LABORATORY
MANAGED BY MARTIN MARIETTA ENERGY SYSTEMS, INC.
FOR THE U.S. DEPARTMENT OF ENERGY

POST OFFICE BOX 2008
OAK RIDGE, TENNESSEE 37831

December 21, 1992

Dear Participant:

Section 104(c) (9) of CERCLA requires states to demonstrate adequate capacity for the treatment and disposal of hazardous wastes that will be generated within a state over 20 years. The Capacity Programs Branch of the Environmental Protection Agency's Office of Solid Waste, which is responsible for the implementation of this requirement, has asked the Oak Ridge National Laboratory and the University of Tennessee to assist with the national projections of one-time hazardous waste generation for the years 1993 and 1999. The projections will include estimates of the quantity of waste and the management categories of one-time waste requiring commercial management on a state by state basis. In the category of state and private cleanup programs, we recognize that state agencies are the best source of information for each state. Therefore, we are asking for your assistance in this research.

The information we are requesting will be used to develop estimates of the number and types of cleanups conducted in your state excluding those managed by the federal government or under federal clean-up (Superfund) programs. In other words, we are interested in clean up by private firms or by state programs. Past efforts to calculate state and private remediation have used limited data gathered from individual states and have used the state of New Jersey as a model for all states. While this method provided satisfactory results, we expect that more complete information received from each state will provide better estimates of the amounts of hazardous waste for each state.

In order to more accurately reflect the needs of your state for commercial demand by state and private cleanups, we will be telephoning your office in the next week or two to discuss the following items:

- (a) the number of sites in your state which have any one-time waste to be shipped off-site,
- (b) the volume and type of waste involved,
- (c) where this waste will be shipped,
- (d) estimated projections you may have of the rate of increase or decrease in the numbers of sites or volume of one-time hazardous waste in your state, and
- (e) any reports, data bases, or other sources of data you feel may be useful in this effort.

If your state prepares an annual report of one-time hazardous waste management, that information would be very valuable in preparing our estimates.

You will be given an opportunity to verify the information obtained during our telephone conversation before we begin our analysis. We are looking forward to talking with you sometime in the next two weeks. If you have any questions, please feel free to call me at (615) 574-5961 or Steve Elliott at (615) 574-8642.

Sincerely,

6.0 ACKNOWLEDGEMENTS

We would like to thank several individuals who contributed to the development of these methodologies. Kim Davis and Angela Gibson assisted in the development of the Superfund methodology, Tai-Lun Chiang the RCRA methodology, Pete Maynard the UST methodology, and Marjie Irby and Sara Kerr the State and Private Program methodology. We would also like to thank Linda Martin of EPA for providing the project with timely data from the RCRA RIA Project. Valuable comments on earlier drafts of the report were provided by Linda Malcom of EPA; ICF, Inc.; the state of Maine; and the University of Michigan. Comments received during presentations of the methodologies to groups convened by the National Governors' Association and the Western Governors' Association were also valuable. We would like to thank Robert Burchard of EPA for his comments and project management leadership. Lastly, we would like to thank Sheila Moore and Kelly Rose for preparing the many versions of this report and Debbie Feldman for editing the final version.

APPENDIX 1
Superfund

Appendix 1.1. Data Sources for Superfund Project

Data Base/ Report	Data Element	Years	Who Collected	Data Sources	Limitation of Data	Assumption
HAZDATA	site name site location site type ROD date site char. cont. sources cont. types volume remed. tech.	1987 to early 1990	ORNL/UTK	EPA RODs from "ROD Text File," "NPL Tech Data Files," & EPA contacts	collected for a different purpose (<i>i.e.</i> , cost est.): - many don't have vol. - < 15% for offsite tech. - for 1987-early 1990 only	when fits the criteria for the cap project (<i>i.e.</i> , offsite tech, non-FF, hazardous waste, non- liquid, etc.), non-missing values were used in the new data base: OFFCAP
BASECOST	site name volume remed. tech duration	1987 to early 1990	ORNL/UTK	same as HAZDATA (companion data base)	same as HAZDATA	same as HAZDATA
SUMROD	site name site location ROD date media type cont. types	1983 to early 1990	Ontario Ministry of the Environment	US EPA RODs	collected for soil cleanup study, no volumes provided	used only as a reference check for resources
NPL Technical Data Files	site name site location site activity media type cont. types remed. tech. date in NPL	as of February 1990	EPA		includes only sites added in NPL by 2/90	used only as a reference check for resources, used in creation of HAZDATA & BASECOST

Appendix 1.1. Data Sources for Superfund Project

Data Base/ Report	Data Element	Years	Who Collected	Data Sources	Limitation of Data	Assumption
ROD Text File	(keyword search needed to extract information) used as the basis for HAZDATA & BASECOST	1982 to early 1990	US EPA	RODs	text files (i.e., data items not identified, keyword search needed); no updated file provided	used only as a reference check for resources, used in creation of HAZDATA & BASECOST
ERNS Tapes	site name site location media type volume date spilled material	1986 to mid- 1992	EPA/DOT	emergency response reports	large files (over 160,000 records with length over 1200 each), very small portion related to SF incidents	
CRES (event schedule)	site name site location event type est. start yr est. end yr act. start yr act. end yr	1982 to early 1992	Pasha Publications	EPA RODs and EPA SCAP11 report	contain some errors and missing data	
Guide to Superfund Sites	(data has to be extracted from reading of the site descriptions) site name site size volume cont. type site type	1982 to early 1992	R. C. DiGregorio/ Pasha Publications	EPA RODs + EPA reports and contacts	does not always agree with EPA's annual reports	

Appendix 1.1. Data Sources for Superfund Project

Data Base/ Report	Data Element	Years	Who Collected	Data Sources	Limitation of Data	Assumption
EPA ROD Annual Reports	(data has to be extracted from reading of the abstracts or summary tables) site name site size volume cont. type site type remed. tech.	1982 - 1991	EPA	RODs	only brief summaries available for 1982-1989 RODs. Abstracts available for 1990 and 1991 RODs approximately 40% of the RODs gave estimate of volumes	

Appendix 1.2. Data Elements Included in the SFLENGTH Data Base

Field Name	Definition
REGION	EPA region number
SITE-NAME	Site name
EPA-ID	EPA NPL identification number
STATE	State where the site is located
OU-NUMBER	Operable unit number
NPL-YEAR	The year in which the site entered NPL
NPL2RIFS	Years between NPL-year and the beginning of RI/FS process
RIFSLEN	The duration of RI/FS process
ROD2RD	Years between the signing of ROD and the beginning of RD process
RDLENGTH	The duration of RD
RD2RA	Years between the end of RD and the beginning of RA
RALENGTH	Duration of RA process
NPL2ROD	Years between the NPL-year and the signing of ROD
ROD2RA	Years between the signing of ROD and the beginning of RA process

Appendix 1.3. Data Elements Included in the OFFCAP Data Base

Field Name	Definition
DATE	ROD signed date
NAME	Site name
REGION	EPA region number
STATE	State where the site resides
CITY	City name where the site is located
SITETYPE	Site type (landfill, disposal, storage, recycling, manufacturing, and other)
WASTETYPE	Type of wastes
WASTE-TYPE	Waste type group (A-soil/sediment, B-ash, C-contained/drum, D-debris, and E-sludge/leachate)
CONTTYPE	Contaminant types (PCB, VOC, metals, organic, and dioxin)
THCH	Remedial technologies (RHIT-incineration, and RL-landfill)
VOLUME	Total volumes as given in ROD
VOLUNIT	Units for the waste volume, generally in cubic yards
SITESIZE	Site size as stated in ROD
SIZEUNIT	Units for the site size, generally in acres
DESCRIP	Remarks and decision rules used in determining the amount for offsite
LOWVOL	Low estimate for amount shipped offsite
MEDVOL	Medium estimate for amount shipped offsite
HIGHVOL	High estimate (worst-case scenario) for amount shipped offsite

Appendix 1.4. Decision Rules

IF

THEN

I.	volume of waste given
and indicated offsite	high=medium=low= 100% vol. offsite
II.	volume given with possibility
of offsite or onsite	
a.	general	a. high= 100% vol. offsite
medium=50% vol. offsite
low=25% vol. offsite
b.	sludge/leachate
(assume dewatering first)	b. volume reduction to 25%
c.	debris	c. high=50% vol. hazardous offsite
medium=50% vol. hazardous offsite
low=10% vol. hazardous offsite
d.	ash	d. high=50% vol. hazardous offsite
medium=30% vol. hazardous offsite
low=10% vol. hazardous offsite
e.	incineration residues
for sludge/leachate	e. high=10% vol., 50% hazardous
medium=10% vol., 30% hazardous
low=5% vol., 10% hazardous
f.	incineration for
soil/sediment	f. high=30% hazardous
medium=20% hazardous
low=10% hazardous
g.	incineration for
drum/contained material	g. high=50% hazardous
medium=30% hazardous
low=10% hazardous
h.	drum/contained for landfill
dewatering first	h. high=50% vol., 100% hazardous
medium=50% vol., 80% hazardous
low=50% vol., 50% hazardous
i.	drum/contained for landfill
no dewatering	i. same as h. w/ 100% vol.
j.	stabilization	j. high=150% vol. 100% hazardous
medium=100% vol., 50% hazardous
low=100% vol., 25% hazardous

III. volume not given, estimated from site size
(apply rules in II. along with the following)

a. general	a. high=10% area with 5-ft depth
medium=low=10% area with 3-ft
b. drum/contained	b. high=medium=5% area with 3-ft
low=1% area with 3-ft
c. size > 1000 acres	c. same as in a. with 1% area instead

APPENDIX 2
RCRA CORRECTIVE ACTION

Appendix 2.1 Landfill Remediation Categories

SWMU CATEGORY NUMBER	SOIL CAP 101**	RCRA CAP 103	SOIL EXC 201	GW EXTR 206	ON-SITE INCINER 301	SOIL FLUSH 303	SOIL VAPOR 305	AIR STRIP 307	CARBON ABSOR 309	METAL PRECP 311	SOLID IFCA 316	OFF-SITE RCRA LANDFILL 401	GW REINJ 407	GW MONIT 503
1A-SOIL CAP	X													X
2A + P&T*	X			X				X					X	X
2B + P&T	X			X					X				X	X
2C + P&T	X			X						X			X	X
3A-RCRA CAP		X												X
4A + P&T		X		X				X					X	X
4B + P&T		X		X					X				X	X
4C + P&T		X		X						X			X	X
5A-INCINERATION			X		X							X		X
6A + P&T			X	X	X			X				X	X	X
6B + P&T			X	X	X				X			X	X	X
7A-SOLIDIFICATION			X								X			X
8A + P&T			X	X						X	X		X	X
9A-SOIL VAPORIZATION														
10A + P&T														
11A-SOIL FLUSHING														
12A-DO NOTHING														

* P&T MEANS PUMP AND TREAT - (e.g., 2C REFERS TO SOIL CAP PLUS PUMP AND TREAT).

** NUMBER REFERS TO CORA TECHNOLOGY NUMBER.

1 = Soil Extraction, 2 = Ground Water Extraction, 3 = On-Site Incineration, 4 = Soil Flushing, 5 = Soil Vaporization, 6 = Air Stripping,
7 = Carbon Absorption, 8 = Metals Precipitation, 9 = Off-Site RCRA Landfill, 10 = Ground Water Reinjection, 11 = Ground Water Monitoring

Appendix 2.2. Waste Pile, Land Treatment Unit, and Surface Impoundment Remediation Categories

SWMU CATEGORY NUMBER	SOIL CAP 101	RCRA CAP 103	SOIL EXC ¹ 201	GW EXTR ² 206	ON-SITE INCINER ³ 301	SOIL FLUSH ⁴ 303	SOIL VAPOR ⁵ 305	AIR STRIP ⁶ 307	CARBON ABSOR ⁷ 309	METAL PRECP ⁸ 311	SOLID IFCA 316	OFF-SITE RCRA ⁹ 401	GW REINJ ¹⁰ 407	GW MONITOR ¹¹ 503
1A-SOIL CAP	X													X
2A + P&T	X			X				X					X	X
2B + P&T	X			X					X				X	X
2C + P&T	X			X						X			X	X
3A-RCRA CAP		X												X
4A + P&T		X		X				X					X	X
4B + P&T		X		X					X				X	X
4C + P&T		X		X						X			X	X
5A-INCINERATION			X		X							X		X
6A + P&T			X	X	X			X				X	X	X
6B + P&T			X	X	X				X			X	X	X
7A-SOLIDIFICATION			X								X			
8A + P&T			X	X						X	X		X	X
9A-SOIL VAPORIZATION							X							X
10A + P&T				X			X		X				X	X
11A-SOIL FLUSHING				X		X		X					X	X
12A-DO NOTHING														

¹ P&T MEANS PUMP AND TREAT - (e.g., 2C REFERS TO SOIL CAP PLUS PUMP AND TREAT).

² NUMBER REFERS TO CORA TECHNOLOGY NUMBER.

1 = Soil Extraction, 2 = Ground Water Extraction, 3 = On-Site Incineration, 4 = Soil Flushing, 5 = Soil Vaporization, 6 = Air Stripping,
7 = Carbon Absorption, 8 = Metals Precipitation, 9 = Off-Site RCRA Landfill, 10 = Ground Water Reinjection, 11 = Ground Water Monitoring

Appendix 2.3 Tank and Tank System Remediation Categories

SWMU CATEGORY NUMBER	SOIL CAP 101	RCRA CAP 103	SOIL EXC 201	GW EXTR 206	ON-SITE INCINER 301	SOIL FLUSH 303	SOIL VAPOR 305	AIR STRIP 307	CARBON ABSOR 309	METAL PRECP 311	SOLID IFCA 316	OFF- SITE RCRA 401	GW REINI 407	GW MONIT 503
1A-SOIL CAP														
2A + P&T														
2B + P&T														
2C + P&T														
3A-RCRA CAP		X												X
4A + P&T														
4B + P&T														
4C + P&T														
5A-INCINERATION			X		X							X		X
6A + P&T			X	X	X			X				X	X	X
6B + P&T			X	X	X				X			X	X	X
7A-SOLIDIFICATION			X								X			X
8A + P&T			X	X						X	X		X	X
9A-SOIL VAPORIZATION														
10A + P&T														
11A-SOIL FLUSHING														
12A-DO NOTHING														

* P&T MEANS PUMP AND TREAT - (e.g., 2C REFERS TO SOIL CAP PLUS PUMP AND TREAT).

** NUMBER REFERS TO CORA TECHNOLOGY NUMBER.

1 = Soil Extraction, 2 = Ground Water Extraction, 3 = On-Site Incineration, 4 = Soil Flushing, 5 = Soil Vaporization, 6 = Air Stripping,
7 = Carbon Absorption, 8 = Metals Precipitation, 9 = Off-Site RCRA Landfill, 10 = Ground Water ReInjection, 11 = Ground Water Monitoring

Appendix 2.4 Container Storage and Satellite Accumulation Area Remediation Categories

SWMU CATEGORY NUMBER	SOIL CAP 101	RCRA CAP 103	SOIL EXC 201	GW EXTR 206	INCIN ER. 301	SOIL FLUSH 303	SOIL VAPOR 305	AIR STRIP 307	CARBON ABSOR 309	METAL PRECP 311	SOLID IFCA 316	OFF-SITE RCRA 401	GW REINI 407	GW MONIT 503
1A-SOIL CAP														
2A + P&T														
2B + P&T														
2C + P&T														
3A-RCRA CAP		X												X
4A + P&T		X		X				X					X	X
4B + P&T		X		X					X				X	X
4C + P&T		X		X						X			X	X
5A-INCINERATION			X		X							X		X
6A + P&T		X	X	X				X				X	X	X
6B + P&T			X	X	X				X			X	X	X
7A-SOLIDIFICATION			X								X			X
8A + P&T			X	X						X	X		X	X
9A-SOIL VAPORIZATION							X							X
10A + P&T				X			X		X				X	X
11A-SOIL FLUSHING				X		X		X					X	X
12A-DO NOTHING*														

* CHOSEN WHEN SWMU IS IN A BUILDING

* P&T MEANS PUMP AND TREAT - (e.g., 2C REFERS TO SOIL CAP PLUS PUMP AND TREAT).

** NUMBER REFERS TO CORA TECHNOLOGY NUMBER.

1 = Soil Extraction, 2 = Ground Water Extraction, 3 = On-Site Incineration, 4 = Soil Flushing, 5 = Soil Vaporization, 6 = Air Stripping,

7 = Carbon Absorption, 8 = Metals Precipitation, 9 = Off-Site RCRA Landfill, 10 = Ground Water Reinjection, 11 = Ground Water Monitoring

Appendix 2.5. Base Case

① Estimate % of TSDs
and SWMUs needing
remediation

② Estimate corrective action
starts for each EPA region
(% of total)

③ Estimate corrective action
starts for each state
(% of total)

④ Estimate average
volume of incineration
and solidification materials
per TSD by state

⑤ Apply residual factors
to incineration and
solidification volumes

⑥ Calculate volumes
disposable off-site
over time

⑦ Apply off-site
factors (initial assumption
= 1.0 in both cases)

⑧ Final sample size and
other adjustments

Appendix 2.6.

Corrective Action Management Unit (CAMU) - Restricted Case*

* For unrestricted CAMU case, eliminate Step B.

APPENDIX 3
FEDERAL FACILITIES

Appendix 3.1. Departments of Energy and Defense

3.2 DEPARTMENT OF ENERGY

A different cleanup methodology for DOE is warranted for several reasons. The following factors could significantly change the offsite demand for commercial treatment and disposal capacity from that observed in cleanups in other program areas.

3.2.1 Justification for Separating from Other Remediation Program Areas

The DOE methodology must be separated from other remediation projection processes for five reasons: (1) historic mission; (2) size and complexity of operations; (3) changing focus; (4) current capacity; and (5) waste streams. Each of these taken individually may not affect the demand for commercial treatment and disposal capacity. Indeed, the hazardous waste at a DOE site requiring remediation may not differ from that produced by the private sector, despite the mission, size of operations, changing focus, or current capacity. The hazardous waste streams, to be discussed in more detail below, include halogenated volatiles, nonhalogenated volatiles, and nonvolatile metals—waste streams that may be found at private-sector as well as DOE remediation sites.

Yet dismissing the first four categories and their interrelatedness to the fifth category (multiple waste types) would not accurately represent the thrust of DOE remediation activities. In addition, due to the enormous task of remediating these multiple types of wastes at DOE sites, the five factors taken collectively might affect the total national demand for commercial hazardous waste treatment and disposal capacity.

These five factors are interwoven, and all are related to one important phenomenon: DOE is a federal agency whose primary mission until the mid to late 1980s was national security.

Mission

Perhaps the most important reason to isolate DOE reservations is their mission. DOE is undertaking environmental restoration at 35 installations (with multiple contaminated sites), in addition to sites under Uranium Mill Tailings Remedial Action and Formerly Utilized Sites Remedial Action Program (DOE, 1993, p. I-9). Sixteen of these sites are on the National Priorities List (NPL).¹

Although the missions vary among the DOE sites on the NPL, they are nonetheless unique to the federal government, particularly those efforts connected to weapons production. In fact, much of DOE's and its predecessors' earliest mission was related to national security—weapons manufacturing, or activities that accompany national security operations.

The primary functions of the NPL sites listed in Appendix Table 3.1 confirm the uniqueness of DOE's mission and its unlikely duplication in the private sector.² For example, the Rocky Flats site in Colorado produced nuclear weapons components fabricated from plutonium and metals; Hanford produced plutonium. The Mound Plant in Ohio manufactures nonnuclear and tritium-containing components for DOE weapons. The Savannah River Plant produces nuclear materials,

and the K-25 plant on the Oak Ridge Reservation manufactured enriched uranium hexafluoride for defense purposes.

In addition, in those facilities where weapons production or support was not the primary focus, such as the national laboratories, the activities are still somewhat unique to the federal government and are probably not replicated in the private sector. Although not an NPL site but undergoing remediation activities anyway, Sandia National Laboratories-Livermore is a research and development laboratory devoting a significant portion of its work to energy-related programs (DOE, 1993, p. II-58).³ Oak Ridge National Laboratory and Brookhaven National Laboratory have research reactors and radio-chemical laboratories. Brookhaven performs research on low- and high-energy physics, life sciences, and nuclear medicine. And although there are private sector and university research and development centers which have reactors, few involve the capacity or research focus of those at DOE sites.

Size and Complexity of Operations

In addition to a unique mission, the DOE reservations are large and complex. The 800-plus total acreage at Idaho National Engineering Laboratory is dwarfed by Rocky Flats, which has 7,000 acres (DOE, 1993, pp. I-155 and I-161).⁴ Although Rocky Flats uses only 350 acres for actual operations, it nonetheless illustrates the immensity of the DOE reservations (DOE, 1993, p. I-161). In comparison, the average RCRA corrective action site included in this research project covers 486 acres (derived from RCRA corrective action data base used in Chapter 2). Superfund sites are much smaller, averaging 88 acres (derived from Superfund data base discussed in Chapter 1).

Individual plants or building spaces also vary in size. The Inhalation Toxicology Research Institute in New Mexico occupies only 200,000 square feet of laboratory space, but the Kansas City Plant covers 3.2 million square feet (DOE, 1993, pp. II-10 and II-15).

The complexity of the operations at DOE sites is also directly linked to DOE's mission. For example, the Savannah River plant has five reactors, two chemical separation facilities, and one reactor fuel manufacturing facility. Although chemical and pharmaceutical plants also have complex operations, these plants have different raw materials. Most have not worked with radioactive material. In addition, there are special processes for separating uranium isotopes (the mission at the Y-12 Plant in Oak Ridge). The intricacies of nuclear weapons production processes or nuclear reactor research are not found in the private sector. This complexity has led to the generation of multiple kinds of wastes.

Changing Focus

Due to global political changes, DOE has re-examined its primary mission. With the breakup of the Soviet Union, the U.S. has forged a national policy to phase out or consolidate weapons operations within DOE. Plant downsizing and weapons production reductions at DOE have caused the department to initiate remediation programs. The latest *Five-Year Plan*, DOE's official policy statement on environmental restoration, notes that more than 1,000 facilities could be transferred to DOE's environmental restoration program through decontamination and decommissioning as a result of downsizing and reductions in weapons complexes (DOE, 1993, p. I-23). The installation summaries prepared to support Volume I of the *Five-Year Plan* state that

the "primary mission before . . . was to produce nuclear weapons components The mission has now changed to environmental cleanup" on at least two sites (Rocky Flats and Hanford; direct quote from discussion on Rocky Flats site in Colorado; DOE, 1993, p. II-198).

Regarding the question of appropriate treatment of the hazardous waste demanding remediation, the reduction in weapons production and changing missions on DOE reservations have given these facilities the power to examine alternative cleanup remedies. As downsizing at each reservation continues and emphasis shifts towards environmental cleanup, DOE is examining alternative treatment technologies for its waste. One of DOE's current research interests is in specific-technology solutions. This effort is, of course, enhanced by the national laboratories' ability to perform technological research. Current research includes robotics characterizations at Fernald and in-situ vitrification at Oak Ridge—both onsite activities (DOE, 1993, pp. I-19 and I-20). In fact, technology development (and transfer) to improve waste management and environmental restoration is receiving increased attention and funding within DOE. Although the increases are not as large percentage-wise as the increases in waste management or environmental restoration funding, DOE estimates a funding increase each year from FY92 to FY98 (DOE, 1993, p. I-44).

Current Capacity

Several DOE reservations already manage some of their hazardous and mixed wastes onsite or are in the conceptual design phase for developing onsite treatment facilities. This flexibility in adding onsite treatment capacity could affect the commercial demand for treatment and disposal capacity and the projection methodology necessary to calculate this demand. At least seven DOE sites have either obtained or are in the process of obtaining permits for waste treatment facilities, or are in the conceptual design phase for developing RCRA or TSCA waste treatment facilities. As shown in Appendix Table 3.2, some of these facilities are being built for waste management (*i.e.*, recurrent generation) and corrective action activities. Although these facilities are being constructed under these conditions, this does not preclude the future management of remediation waste at these facilities.

Due to a lack of commercial availability, other facilities have been constructed to handle the backlog of mixed (hazardous and radioactive) waste.⁵ In fact, some of these facilities were built to deal solely with a backlog of stored mixed waste. The K-25 (Oak Ridge Reservation) TSCA incinerator is currently incinerating mixed *liquid* waste that has been stored at K-25, Paducah, and Portsmouth during the last several years. Los Alamos National Laboratory also has a mixed waste incinerator.

Regarding hazardous waste, adding more onsite RCRA facilities, modifying current facilities constructed to deal with mixed waste (if possible from an engineering perspective), or consolidating hazardous waste management within a few DOE sites, rather than incurring disposal charges or liability when shipping waste to commercial treatment and disposal facilities, may be options at DOE facilities. This may become particularly attractive when waste volumes are large.

On the other hand, when volumes are small, DOE may opt for commercial treatment or disposal rather than incurring the costs of developing or expanding onsite treatment. Because DOE is striving to manage so many types of waste, the department may find it more practical to use the

services of commercial treatment and disposal facilities for its hazardous wastes. This is particularly true when considering that the bulk of the hazardous waste to be shipped offsite for commercial treatment and disposal is contaminated soil, and that there is a backlog of mixed waste that must be managed at DOE sites. Modifying current capacity to handle contaminated soil may be cost prohibitive.

Waste Types

The above four categories (mission, size and complexity, changing focus, and current capacity) contribute to the final reason to separate DOE remediation methodology from other program areas. Any one of them may not alter the demand for commercial hazardous waste treatment and disposal capacity. However, collectively, they contribute to the fifth reason to justify separating DOE from the other remediation program areas.

This project deals exclusively with hazardous waste as defined by the RCRA, and many of the DOE reservations currently generate or contain hazardous waste requiring remediation. For those sites with continuing operations, such as the three sites on the Oak Ridge Reservation, waste management activity—onsite and offsite—is an ongoing process (Tennessee Department of Environment and Conservation, 1993). In this way, DOE sites are not unlike private-sector RCRA corrective action sites. A hazardous contaminated soil from remediation at Oak Ridge might have the same hazardous constituents as contaminated soil from a chemical plant requiring corrective action.

It is not so much that the individual hazardous waste streams are different from other remediation programs. Rather, it is the combination of the above four factors that makes DOE unique from other remediation program areas. DOE generates many types of waste (*e.g.*, hazardous, mixed, radioactive) requiring remediation.

For example, the Inhalation Toxicology Research Institute in New Mexico—a research center that houses animals—generates solid, hazardous, low-level radioactive, transuranic, mixed, and biomedical wastes (DOE, 1993, p. II-10). The Kansas City Plant, which manufactures nonnuclear weapons components through machining, plastic fabrication, and electrical and mechanical assembly, generates hazardous and small quantities of low-level radioactive and low-level mixed wastes (DOE, 1993, p. II-15). Considering the operation of these two facilities and the various waste streams generated, it is not surprising that the DOE reservations producing nuclear weapons would similarly have multiple waste streams. Rocky Flats, for instance, has hazardous, TSCA, low-level radioactive, low-level radioactive mixed, transuranic (TRU), TRU-mixed, and mixed residues waste streams (DOE, 1993, p. II-199). Savannah River contains solid radioactive, low-level radioactive, intermediate level radioactive, hazardous, and mixed waste streams.

3.2.2 DOE Remediation Activities

Through its commitment to restoration and corrective action, DOE is addressing the cleanup of many of these waste streams. A policy decision on onsite versus offsite management of any of these wastes could lead to a department-wide policy on all waste streams, or it could introduce the option of commercial capacity (which is available for hazardous wastes) leaving onsite

management as the only option available for the treatment of radioactive waste generated at FUSRAP sites.⁶

Therefore, it is necessary to explore an alternative methodology for projecting commercial treatment and disposal demand, tailored to DOE's unique needs. Any attempt to equate DOE reservation needs with private sector cleanups could result in gross errors in calculating cleanup time schedules and amounts of waste, or in making decisions about onsite versus offsite management.

3.3 Department of Defense

Just as DOE remediation wastes need to be separated from other program areas, so too must DoD remediation wastes and activities be separated. The reasons for separating DoD, not surprisingly, parallel those already discussed about DOE in that its mission is unique to the federal government.

Mission and Length of Service

The mission of the military branches is not duplicated in the private sector. Warfare is strictly under the purview of the federal government and such activities are under the control of the U.S. Departments of Defense and Energy. Each military service and its main mission are listed in Appendix Table 3.3.

Most military installations have been in service for many years and under intense use during military buildups. For example, Plattsburgh Air Force Base, New York, has been used for military purposes since 1814 (Air Force Association, 1993). March Air Force Base and Dahlgren Naval Surface Warfare Center, as well as other military installations, were established in 1918 to support our involvement in World War I and U.S. military needs after the war. In addition, many military facilities were established in the 1930s and 1940s and were used by the U.S. military to meet the needs of World War II.

Size

Military installations vary greatly in size, geographic characteristics, and mission complexity. For instance, the Naval Industrial Reserve Ordnance Plant in Minnesota comprises only 83 acres. The northern portion of the facility is government-owned but operated by a private contractor, while the remainder of the facility is privately owned. This facility's sole mission is the design and manufacture of advanced weapons systems. On the other hand, Fort Wainwright, Alaska, covers approximately 918,000 acres and is home to the Army 6th Infantry Division. The facility is wholly government owned and operated, and consists of multiple functions which support the infantry's mission, equipment, training, operations, and personnel (*Defense Environmental Restoration Program Annual Report*, (DoD, DERP, 1992, pp. B-38 and B-65). The average military installation ranges in size from 1,000 to 50,000 acres: Anniston Army Depot (15,245 acres), Concord Naval Weapons Station (13,023 acres), and Ellsworth Air Force Base (4,858 acres) (DoD, DERP, 1993, Appendix C).

Military installations are located in every state and U.S. territory. They range from subtropical Florida and Puerto Rico to the near Arctic Circle in north central Alaska.

Based on mission, length of service, and size, the types of wastes and their concentration remediated at DoD installations may be expected to differ greatly from wastes produced at a private-sector facility that has been in use for only 20 to 30 years. Some wastes are unique to the military, such as propellant packs, explosives' shells, explosives, and other types of weapons wastes. On the other hand, some military waste may be similar to private-sector waste. The type of underground storage tank wastes would probably be similar to those in the private sector. Other waste streams, such as wastes related to plane fuels and maintenance, may also be similar in volumes and contaminants to private sector wastes. Paints, petroleum products, and solvents are used in aircraft maintenance; electroplating acids and heavy metals are found at naval shipyards. However, it may be difficult, at this point, to determine whether the wastes associated with weapons and, in particular, missiles, are similar to those in the private sector.

Moreover, each branch of the military had a different mission. Therefore, broad generalizations and standardizations concerning wastes and treatment of wastes across all military facilities are inappropriate.

3.4 ENDNOTES

1. Of the 16 NPL sites, five are being cleaned up by DOE under FUSRAP or UMTRA (DOE, 1993, p. I-17). FUSRAP and UMTRA waste streams have radioactive contaminants and are thus beyond the scope of this project.
2. Many of the FUSRAP sites, although privately owned, supported the Manhattan Engineer District and the Atomic Energy Commission by developing, processing, and producing uranium and thorium. Again, the waste streams at these sites are radioactive and beyond the scope of this project.
3. However, Sandia's work also focuses on design and testing of nonnuclear components for nuclear weapons.
4. Obviously, not all of the DOE remediation sites are as large as the two highlighted. For instance, the Inhalation Toxicology Research Institute, which conducts health effect studies, occupies 200,000 square feet of laboratory space at an Air Force base. Similarly, the Lawrence Berkeley Laboratory is a 130-acre site. The point is that, in general, many of the DOE reservations are definitely larger than sites included in other remediation programs (RCRA corrective action, Superfund, UST, and state and private cleanups).
5. It is difficult to determine whether stored waste should be classified as "recurrent" or "nonrecurrent."

Although mixed wastes (radioactive and hazardous) are omitted from capacity assurance planning, there is the possibility that treatment of mixed wastes could result in increased demand for hazardous waste capacity. A process to separate the radioactive portion of the waste would, of course, leave the hazardous portion for treatment and disposal. Overall volumes of mixed wastes, at this point, have not been determined (see *Federal Register*, pp. 48142 and 48143).

6. This could oversimplify DOE's dilemma on how to manage all of its waste streams. The lack of available disposal for transuranic waste, due to the delay in opening the Waste Isolation Pilot Plant, has made onsite storage of that waste the only management option available to DOE at this point.

Appendix Table 3.1. DOE Facilities on the National Priorities List—Primary Mission

STATE	SITE NAME	PRIMARY MISSION
California	Lawrence Livermore National Laboratory-Main Site	research and development; originally a U.S. Navy airfield
	Lawrence Livermore National laboratory-Site 300	process, test, deactivate high-explosive materials
Colorado	Rocky Flats	production of nuclear weapons components fabricated from plutonium and metals
Idaho	Idaho National Engineering Laboratory	research and development
Missouri	Weldon Springs Quarry and Feed Materials Plant and Raffinate Pits	1940s Army ordnance works; 1950s and 1960s Atomic Energy Commission processed uranium and thorium
	St. Louis ¹	uranium developing, processing, and production
New Jersey	Maywood Site ¹	thorium development, processing, and production
	Wayne Site ¹	thorium development, processing, and production
New York	Brookhaven National Laboratory	research and development
Ohio	Fernald Environmental Management Project	production of uranium metals and compounds
	Mound Plant	manufactures nonnuclear and tritium-containing components for DOE weapons
South Carolina	Savannah River Plant	production of nuclear materials (tritium and plutonium)

Appendix Table 3.1. DOE Facilities on the National Priorities List—Primary Mission

STATE	SITE NAME	PRIMARY MISSION
Tennessee	Oak Ridge Reservation (a) K-25 Plant (b) Oak Ridge National Laboratory (c) Y-12 Plant	(a) production of enriched uranium hexafluoride for defense purposes (b) research and development (c) originally separation of uranium isotopes; later manufacturing and developmental engineering
Utah	Monticello Millsite ² Monticello Vicinity Properties ²	uranium mining uranium mining
Washington	Hanford	plutonium production

¹Environmental restoration activity conducted under the Formerly Utilized Sites Remedial Action Program (FUSRAP). Under the Atomic Energy Act of 1954 and the 1984 and 1985 Energy and Water Development Appropriations Acts, DOE is charged by Congress to remedy radiological conditions at sites used to support nuclear activities conducted for DOE and its predecessor agencies. Although many of these sites are privately or institutionally owned, the research activity during the 1940s and 1950s supported the Manhattan Engineer District and the Atomic Energy Commission. The programs involved research; development, processing, and production of uranium and thorium; and storage of processing residues. Wastes from these sites are radioactive and thus beyond the scope of the capacity assurance plan process, which deals solely with hazardous waste.

²The Uranium Mill Tailings Radiation Control Act of 1978 directs DOE to provide for stabilization and control of uranium mill tailings from inactive sites. The act authorizes DOE to undertake remediation at 24 sites and approximately 5,048 vicinity properties. Like FUSRAP, these wastes are radioactive and beyond the scope of this project.

Sources: Compiled and adapted from U.S. Department of Energy. 1992. *Project Plan (Revision 3), Formerly Utilized Sites Remedial Action Program*, p. 1; U.S. Department of Energy. 1993. *Environmental Restoration and Waste Management Five-Year Plan, Fiscal Years 1994-1998*, Volumes I and II, pp. II-241, II-148, II-155, II-164, II-115, II-110, II-220, II-96, II-198, II-183, II-188, Glossary page 10; II-188, Appendix D1, 2, 3.

Appendix Table 3.2. Representative Cases of DOE Sites with Treatment Facilities

STATE	SITE NAME	TREATMENT FACILITY
Illinois	Argonne National Laboratory-East	RCRA permit for waste management activities/corrective action
New Mexico	Los Alamos National Laboratory	Controlled Air Incinerator for mixed waste; acreage reserved for future development of waste management functions
	Sandia National Laboratories-Albuquerque	RCRA permit for waste management activities/corrective action
New York	Brookhaven National Laboratory	Construction underway on hazardous waste management facility
South Carolina	Savannah River Plant	Incinerator under construction
Tennessee	K-25 Plant	TSCA incinerator for mixed waste
Texas	Pantex Plant	RCRA permit for waste management activities/corrective action

Source: Compiled from U.S. Department of Energy. 1993. *Environmental Restoration and Waste Management Five-Year Plan*, Fiscal Years 1994-1998, Installation Summaries, Volume II, pp. II-22, II-24, II-26, II-37, II-50, II-80, II-100, II-148, II-242.

Appendix Table 3.3. Department of Defense Branches and Missions

Department	Mission
Air Force	deploys personnel and equipment for air-based combat and inter-continental ballistic missiles
Army	provides troops and equipment for land-based combat along with air support equipment and personnel
Defense Logistics Agency	provides logistics, storage, and distribution support for the military branches
Navy	provides equipment and personnel for sea combat, initial strike, and aerial support

Appendix 3.2. Breakdown of Confidence Levels for DOE Data Base Sites

High confidence level sites

California sites:

Lawrence Berkeley Laboratory

1. Projected volume of waste is from RCRA closure.
2. Complete closure will occur in 1997.
3. All waste will be shipped offsite in one year (1997).
4. Communication with San Francisco Operations for offsite decision.

Santa Susana Field Laboratory

1. Projected volume of waste is from closure of Sodium Disposal Facility.
2. Complete closure will occur in 1993.
3. All waste will be shipped offsite in one year (1993).
4. Communication with San Francisco Operations for offsite decision.

Florida site:

Pinellas Plant

1. Projected volume of waste is from 4.5-acre closure.
2. Complete closure will occur in 1998.
3. All waste will be shipped offsite in one year (1998).
4. *Five-Year Plan* reports that wastes will be shipped offsite.

Missouri site:

Kansas City Plant

1. Projected volume of waste is part of the completion remediation schedule beginning in 1994 and ending in 1998.
2. Waste will be shipped offsite beginning in 1994 and ending in 1998.
3. Waste will be shipped offsite in equal increments (linear) between 1994 and 1998.
4. *Five-Year Plan* reports that waste will be shipped offsite.

New Mexico site:

Inhalation Toxicology Research Institute

1. Projected volume of waste is part of remediate sites schedule beginning in 1994.
2. Waste will be shipped offsite beginning in 1994 and ending in 1996.
3. Waste will be shipped offsite in equal increments (linear) between 1994 and 1996.
4. *Five-Year Plan* reports that waste will be shipped offsite.

Iowa site:

Ames Laboratory

1. Projected volume of waste is from chemical disposal site feasibility study (FS) report to be completed in 1994.
2. There will be a three-year period from FS report to ROD.
3. After signature of ROD, there will be a three-year period before remediation begins.
4. All waste will be shipped offsite in one year (2000).

Medium confidence level sites

Idaho site:

Idaho National Engineering Laboratory

1. Projected volume of waste is part of the eight RODs slated for completion in 1993.
2. After signature of ROD, there will be a three-year period before remediation begins.
3. Waste will be shipped offsite beginning in 1997.
4. Waste will be shipped offsite in equal increments (linear) between 1997 and 1999.
5. Communication with Idaho National Engineering Laboratory on offsite decision.

Ohio site:

Mound Plant

1. Projected volume of waste is part of cleanup of operating units 1 and 4 beginning in 1994.
2. Waste will be shipped offsite beginning in 1994 and ending in 1996.
3. Waste will be shipped offsite in equal increments (linear) between 1994 and 1996.
4. *Five-Year Plan* reports that waste will be shipped offsite.

Tennessee site:

Oak Ridge National Laboratory

1. Projected volume of waste is from waste area grouping (WAG) 6 interim ROD.
2. Interim ROD for WAG 6 will be finalized and signed in 1995.
3. After signature of ROD, there will be a three-year period before remediation activity begins.
4. Remediation activity will begin in 1998.
5. Waste will be shipped offsite beginning in 1998 and ending in 2000.
6. Waste will be shipped offsite in equal increments (linear) between 1998 and 2000.
7. Communication with Oak Ridge Operations on offsite decision.

Low confidence level sites

Kentucky site:

Paducah Gaseous Diffusion Plant

1. Projected volume of waste is from waste area grouping draft RFI reports planned for completion between 1994 and 1996.
2. Draft reports will be finalized in 1996.
3. Calendar on future activity begins in January 1997.
4. There will be a three-year period from draft RFI reports to final RFI reports.
5. There will be a three-year period for final RFI reports to RCRA permit modification.
6. After RCRA permit modification, there will be a three-year period before remediation begins.
7. Waste will be shipped offsite beginning in 2005.
8. Waste will be shipped offsite in equal increments (linear) between 2005 and 2008.
9. Communication with Oak Ridge Operations on offsite decision.

New Mexico site:

Los Alamos National Laboratory

1. Projected volume of waste is from waste identified in RFI workplan activity begun in 1991.
2. Waste will be shipped offsite beginning in 1997.
3. Waste will be shipped offsite in equal increments (linear) between 1997 and 2013.
4. Communications with Albuquerque Operations on offsite decision and shipment schedule.

New York site:

Brookhaven National Laboratory

1. Projected volume of waste is from ROD on operating unit 1 scheduled for completion in 1996.
2. After signature of ROD, there will be a three-year period before remediation activity begins.
3. Waste will be shipped offsite beginning in 1999.
4. Waste will be shipped offsite in equal increments (linear) between 1999 and 2002.
5. Communication with Brookhaven on offsite decision.

Ohio:

Portsmouth Gaseous Diffusion Plant

1. Projected volume of waste is part of the corrective measures study slated for final completion in 1994.
2. There will be a three-year period between completion of corrective measures study and signature of ROD.
3. After signature of the ROD, there will be a three-year period before remediation activity begins.
4. Remediation activity will begin in 2000.
5. Waste will be shipped offsite beginning in 2000 and ending in 2002.
6. Waste will be shipped offsite in equal increments (linear) between 2000 and 2002.
7. Communication with Oak Ridge Operations on offsite decision.

Tennessee sites:

Y-12 Plant

1. Projected volume of waste is from operating unit II.
2. ROD for operating unit II will be finalized and signed in 1998.
3. After signature of ROD, there will be a three-year period before remediation activity begins.
4. Remediation activity will begin in 2001.
5. Waste will be shipped offsite beginning in 2001 and ending in 2003.
6. Waste will be shipped offsite in equal increments (linear) between 2001 and 2003.
7. Communication with Oak Ridge Operations on offsite decision.

K-25 Site

1. Projected volume of waste is from K-1070 operating unit.
2. ROD for K-1070 operating unit will be signed in 1996.
3. After signature of ROD, there will be a three-year period before remediation activity begins.
4. Remediation activity will begin in 1999.
5. Waste will be shipped offsite beginning in 1999 and ending in 2001.
6. Waste will be shipped offsite in equal increments (linear) between 1999 and 2001.
7. Communication with Oak Ridge Operations on offsite decision.

Appendix 3.3. Army Installations Submitting Installation Action Plans

ARMY INSTALLATION	MAJOR COMMAND	STATE
Redstone Arsenal	AMC	Alabama
Riverbank Army Ammunition Plant	AMC	California
Savanna Army Depot	AMC	Illinois
Seneca Army Depot	AMC	New York
Tobyhanna Army Depot	AMC	Pennsylvania
Tooele Army Depot	AMC	Utah
Twin Cities Army Ammunition Plant	AMC	Minnesota
Volunteer Army Ammunition Plant	AMC	Tennessee
Fort Campbell	FORSCOM	Kentucky/Tennessee
Fort Drum	FORSCOM	New York
Fort Gillem	FORSCOM	Georgia
Fort Lewis	FORSCOM	Washington
Fort Riley	FORSCOM	Kansas
Sudbury Annex	FORSCOM	Massachusetts
Fort Richardson	USARPAC	Alaska
Fort Shafter	USARPAC	Hawaii
Fort Wainwright	USARPAC	Alaska
Schofield Barracks	USARPAC	Hawaii
Fort Dix	TRADOC	New Jersey
Fort Eustis	TRADOC	Virginia
Fort Lee	TRADOC	Virginia
Fort Jackson	TRADOC	South Carolina
Fort Story	TRADOC	Virginia
Cold Regions Research and Engineering Laboratory	CE	New Hampshire
Louisiana Army Ammunition Plant	AMC	Louisiana

ARMY INSTALLATION	MAJOR COMMAND	STATE
Aberdeen Proving Ground	AMC	Maryland
Anniston Army Depot	AMC	Alabama
Badger Army Ammunition Plant	AMC	Wisconsin
Lexington-Bluegrass Army Depot (Bluegrass Facility)	AMC	Kentucky
Cornhusker Army Ammunition Plant	AMC	Nebraska
Iowa Army Ammunition Plant	AMC	Iowa
Joliet Army Ammunition Plant	AMC	Illinois
Lake City Army Ammunition Plant	AMC	Missouri
Letterkenny Army Depot	AMC	Pennsylvania
Lone Star Army Ammunition Plant	AMC	Texas
Longhorn Army Ammunition Plant	AMC	Texas
Picatinny Arsenal (ARCDEC)	AMC	New Jersey
Milan Army Ammunition Plant	AMC	Tennessee
Natick Research, Development, and Engineering Center	AMC	Massachusetts
Newport Army Ammunition Plant	AMC	Indiana

AMC = Army Materiel Command
 FORSCOM = Forces Command
 TRADOC = Training and Doctrine Command
 CE = U.S. Army Corps of Engineers
 USARPAC = U.S. Army of the Pacific

Appendix 3.4. Number of DoD Installations per State

STATE	ARMY	NAVY	AIR FORCE	DEFENSE LOGISTICS AGENCY
Alabama	37	0	7	0
Alaska	4	6	41	3
Arizona	7	3	9	0
Arkansas	28	0	3	0
California	46	70	29	6
Colorado	14	1	7	0
Connecticut	23	4	2	0
Delaware	4	1	2	0
District of Columbia	2	4	1	0
Florida	32	18	15	2
Georgia	23	4	5	0
Hawaii	10	20	11	0
Idaho	5	0	3	0
Illinois	47	4	5	0
Indiana	21	3		1
Iowa	25	0	2	0
Kansas	35	0	3	1
Kentucky	26	1		0
Louisiana	22	2	6	1
Maine	5		4	2
Maryland	25	22	2	1
Massachusetts	21	5	9	0
Michigan	23	0	8	1
Minnesota	24	3	5	0

STATE	ARMY	NAVY	AIR FORCE	DEFENSE LOGISTICS AGENCY
Mississippi	19	2	5	0
Missouri	29	1	5	0
Montana	9	0	4	0
Nebraska	17	2	2	0
Nevada	2	1	4	0
New Hampshire	5	0	2	1
New Jersey	19	3	4	1
New Mexico	9	0	4	0
New York	64	9	14	2
North Carolina	29	3	5	0
North Dakota	4	0	5	1
Ohio	38	1	12	3
Oklahoma	30	0	6	0
Oregon	12	0	6	0
Pennsylvania	94	7	7	2
Rhode Island	9	5	3	1
South Carolina	18	7	5	1
South Dakota	2	0	2	0
Tennessee	13	3	5	1
Texas	65	7	16	0
Utah	13	1	4	1
Vermont	5	0	1	0
Virginia	41	25	2	1
Washington	28	12	10	1

STATE	ARMY	NAVY	AIR FORCE	DEFENSE LOGISTICS AGENCY
West Virginia	23	2	2	0
Wisconsin	34	0	5	0
Wyoming	2	0	2	0
TOTALS	1142	267	325	34

Source: U.S. Department of Defense. 1993. *Defense Environmental Restoration Program, Annual Report to Congress*, Appendix C.

Appendix 3.5. Flow Diagrams

Appendix 3.5.1.
Treatment of Contaminated Soils
by Incineration-Organics Only-Scenario 1

VRF = Volume reduction factor

- Projected waste volume
- Projected waste mass
- Projected waste mass to landfill

Appendix 3.5.2.
Treatment of Contaminated Soils
by Incineration-Organics Only-Scenario 2

VRF = Volume reduction factor

- Projected waste volume
- Projected waste mass
- Projected waste mass to landfill

Appendix 3.5.3.

Treatment of Solid Waste by Incineration-Organics and Metals

159

VRF = Volume reduction factor

LRF = Landfill residual factor

- Projected waste volume
- Projected waste mass
- Projected waste mass for stabilization
- Projected waste mass to landfill

Appendix 3.5.4. Treatment of Solid Waste by Stabilization-Metals

LRF = Landfill residual factor

Projected waste volume

Projected waste mass for stabilization

Projected waste mass to landfill

Appendix 3.5.5.

Treatment of Sludges by Stabilization

LRF = Landfill residual factor

Projected waste volume

Projected waste mass for stabilization

Projected waste mass to landfill

Appendix 3.5.6. Treatment of Contaminated Soils by Incineration-Organics and Metals-Scenario 1

162

COMMENTS:

1. Incineration scrubber water will also be a hazardous waste unless treated to meet LDR treatment standards
2. Assumes 20% of treated soil exceeds LDR treatment standards for metals and requires further treatment

VRF = Volume reduction factor

LRF = Landfill residual factor

LDR = Landfill disposal restrictions

Projected waste volume

Projected waste mass

Projected waste mass for stabilization

Projected waste mass to landfill

Appendix 3.5.7. **Treatment of Contaminated Soils** **by Incineration-Organics and Metals-Scenario 2**

163

COMMENTS:

1. Incineration scrubber water will also be a hazardous waste unless treated to meet LDR treatment standards
2. Assumes 20% of treated soil exceeds LDR treatment standards for metals and requires further treatment

VRF = Volume reduction factor

LRF = Landfill residual factor

LDR = Landfill disposal restrictions

Projected waste volume

Projected waste mass

Projected waste mass for stabilization

Projected waste mass to landfill

Appendix 3.5.8. Treatment of Hazardous Waste Solids by Metals Recovery

Appendix 3.6. Army Installation Action Plans
and Air Force Management Action Plans List

Army Management Action Plans

Installation Action Plan—Aberdeen Proving Ground, Maryland. (31 July 1992).

Installation Action Plan—Anniston Army Depot, Alabama.

Installation Action Plan—Badger Army Ammunition Plant, Baraboo, Wisconsin. (August 1992).

Installation Action Plan—Cold Regions Research and Engineering Laboratory.

Installation Action Plan—Combined Arms Support Command and Fort Lee, Virginia.

Installation Action Plan—Cornhusker Army Ammunition Plant, Nebraska. (July 92).

Installation Action Plan—Fort Campbell, Kentucky and Tennessee.

Installation Action Plan—Fort Dix, New Jersey. (June 1992).

Installation Action Plan—Fort Drum, New York. (August 1992).

Installation Action Plan—Fort Eustis, Newport News, Virginia.

Installation Action Plan—Fort Gillem, Georgia. (August 1992).

Installation Action Plan—Fort Lewis, Washington. (15 July 1992).

Installation Action Plan—Fort Richardson, Alaska.

Installation Action Plan—Fort Riley, Kansas.

Installation Action Plan—Fort Shafter, Oahu, Hawaii.

Installation Action Plan—Fort Story, Virginia Beach, Virginia.

Installation Action Plan—Fort Wainwright, Alaska.

Installation Action Plan—Iowa Army Ammunition Plant, Middletown, Iowa. (June 1992).

Installation Action Plan—Joliet Army Ammunition Plant, Illinois.

Installation Action Plan—Lake City Army Ammunition Plant, Independence, Missouri. (15 July 1992).

Installation Action Plan—Letterkenny Army Depot, Pennsylvania. (June 1992).

Installation Action Plan—Lexington-Blue Grass Army Depot and Bluegrass Facility, Kentucky.

Installation Action Plan—Lone Star Army Ammunition Plant, Texas.

Installation Action Plan—Longhorn Army Ammunition Plant, Texas.

Installation Action Plan—Louisiana Army Ammunition Plant, Louisiana. (May 1992).

Installation Action Plan—Milan Army Ammunition Plant, Tennessee.

Installation Action Plan—Natick Research Development and Engineering Center, Massachusetts.

Installation Action Plan—Newport Army Ammunition Plant, Indiana. (June 1992).

Installation Action Plan—Picatinny Arsenal, New Jersey.

Installation Action Plan—Redstone Arsenal, Alabama. (September 1992).

Installation Action Plan—Riverbank Army Ammunition Plant, California. (15 July 1992).

Installation Action Plan—Savanna Army Depot Activity, Illinois. (July 1992).

Installation Action Plan—Schofield Barracks, Oahu, Hawaii.

Installation Action Plan—Seneca Army Depot, New York. (28 August 1992).

Installation Action Plan—Sudbury Annex, Massachusetts.

Installation Action Plan—Tobyhanna Army Depot.

Installation Action Plan—Tooele Army Depot-North Area, Utah. (9 July 1992).

Installation Action Plan—Tooele Army Depot-South Area, Utah. (9 July 1992).

Installation Action Plan—Twin Cities Army Ammunition Plant, Minnesota. (July 1992).

Installation Action Plan—Volunteer Army Ammunition Plant, Tennessee. (June 1992).

Air Force Management Action Plans

Management Action Plan and Appendix A Budget and Schedule Confirmation for Andrews Air Force Base, Camp Springs, Maryland. (4 December 1992).

Management Action Plan—Altus Air Force Base, Altus, Oklahoma (DCN 92-269-069-17-16; RCN 269-069-17-02). (1 December 1992).

Management Action Plan—Barksdale Air Force Base. (30 September 1992).

Management Action Plan—Beale Air Force Base. (30 September 1992).

Management Action Plan—Cannon Air Force Base. (23 September 1992).

Management Action Plan—Charleston Air Force Base, Charleston, South Carolina. (December 1992).

Management Action Plan—Davis-Monthan Air Force Base. (30 September 1992).

Management Action Plan—Dover Air Force Base, Dover, Delaware. (10 December 1992).

Management Action Plan—Dyess Air Force Base, Abilene, Texas. (30 September 1992).

Management Action Plan—Ellsworth Air Force Base. (29 September 1992).

Management Action Plan—F. E. Warren Air Force Base. (September 1992).

Management Action Plan—Fairchild Air Force Base. (30 September 1992).

Management Action Plan—Grand Forks Air Force Base, North Dakota. (September 1992).

Management Action Plan—Griffiss Air Force Base. (28 September 1992).

Management Action Plan—Grissom Air Force Base, Peru, Indiana. (21 May 1993).

Management Action Plan—Holloman Air Force Base. (30 September 1992).

Management Action Plan—Homestead Air Force Base. (30 September 1992).

Management Action Plan—K.I. Sawyer Air Force Base. (September 1992).

Management Action Plan—Langley Air Force Base. (30 September 1992).

Management Action Plan—Little Rock Air Force Base, Jacksonville, Arkansas. (November 1992).

Management Action Plan—Luke Air Force Base. (30 September 1992).

Management Action Plan—Malmstrom Air Force Base, Great Falls, Montana (DCN 92-269-069-12-45; RCN 269-069-12-30). (30 October 1992).

Management Action Plan—March Air Force Base, Moreno Valley, California. (September 1992).

Management Action Plan—Maxwell Air Force Base and Gunter Annex, Montgomery, Alabama. (March 1993).

Management Action Plan—McChord Air Force Base, Washington (DCN 92-269-069-17-08; RCN 269-069-17-08). (December 1992).

Management Action Plan—McConnell Air Force Base. (21 September 1992).

Management Action Plan—McGuire Air Force Base, Wrightstown, New Jersey. (December 1992).

Management Action Plan—Minot Air Force Base. (September 1992).

Management Action Plan—Moody Air Force Base, Georgia. (29 September 1992).

Management Action Plan—Mountain Home Air Force Base, Idaho. (30 September 1992).

Management Action Plan—Nellis Air Force Base. (30 September 1992).

Management Action Plan—Norton Air Force Base, San Bernardino, California. (26 May 1993).

Management Action Plan—Offutt Air Force Base. (30 September 1992).

Management Action Plan—Plattsburgh Air Force Base, Plattsburgh, New York. (September 1992).

Management Action Plan—Pope Air Force Base. (23 September 1992).

Management Action Plan—Scott Air Force Base, Belleville, Illinois (DCN 92-269-069-17-13; RCN 269-069-17-10). (December 1992).

Management Action Plan—Seymour-Johnson Air Force Base. (25 September 1992).

Management Action Plan—Shaw Air Force Base. (18 September 1992).

Management Action Plan—Travis Air Force Base, Fairfield, California. (December 1992).

Management Action Plan—Tyndall Air Force Base. (30 September 1992).

Management Action Plan—Whiteman Air Force Base. (30 September 1992).

APPENDIX 4
UNDERGROUND STORAGE TANKS

Appendix 4.1. Aging Algorithm Parameters*

*Source: Donna S. Bueckman, Sunita Kumar and Milton Russell. Underground Storage Tanks: Resource Requirements for Corrective Action. Knoxville, Tennessee: The University of Tennessee, 1991, Appendix A.

The following are the percentages used in the estimation of the first and second variables for the base case and the alternative cases. The base case percentages for the protected USTs are used for all cases. The percentages for the protected USTs are given first, followed by the unprotected percentages. The latter differ between the first two and the second two scenarios.

Period 1 = 1990-1994

Period 2 = 1995-1999

Period 3 = 2000-2004

Period 4 = 2005-2009

Period 5 = 2010-2014

Open: Active or inactive, registered status is *open*.

Close: Formal closure procedure, services of the UST are not replaced.

Replace: Services of an UST that was closed are reopened with a new tank system—on the same site or elsewhere.

Add Prot: An unprotected UST may be upgraded/retrofitted to obtain a protected status.

Base Case and Alternatives Protected USTs, Period 1			
AGE	Open	Close	Replace
0-5 years	0.97	0.015	0.015
6-10 years	0.97	0.015	0.015
11-15 years	0.95	0.025	0.025
16-20 years	0.95	0.025	0.025
> 20 or unknown	0.00	0.25	0.75

Base Case and Alternatives Protected USTs, Period 2			
AGE	Open	Close	Replace
0-5 years	0.97	0.015	0.015
6-10 years	0.97	0.015	0.015
11-15 years	0.95	0.025	0.025
16-20 years	0.95	0.025	0.025
> 20 or unknown	0.00	0.10	0.90

Base Case and Alternatives Protected USTs, Periods 3, 4, and 5			
AGE	Open	Close	Replace
0-5 years	0.97	0.015	0.015
6-10 years	0.97	0.015	0.015
11-15 years	0.95	0.025	0.025
16-20 years	0.95	0.025	0.025
> 20 or unknown	0.00	0.00	1.00

Base Case and Alternative 1 Unprotected USTs, Period 1				
AGE	Open	Close	Replace	Add Prot
0-5 years	0.60	0.075	0.025	0.30
6-10 years	0.60	0.075	0.025	0.30
11-15 years	0.60	0.10	0.15	0.15
16-20 years	0.60	0.10	0.25	0.05
> 20 or unknown	0.00	0.40	0.60	0.00

Base Case and Alternative 1 Unprotected USTs, Period 2				
AGE	Open	Close	Replace	Add Prot
0-5 years	0.00	0.00	0.00	0.00
6-10 years	0.00	0.10	0.20	0.70
11-15 years	0.00	0.20	0.50	0.30
16-20 years	0.00	0.25	0.70	0.05
> 20 or unknown	0.00	0.30	0.70	0.00

APPENDIX B : PROTECTED AND UNPROTECTED HAZARDOUS TANKS BY AGE COHORT
NOTE : HP = HAZARDOUS PROTECTED TANKS ; HU = HAZARDOUS UNPROTECTED TANKS

10:41 Tues

OBS	STNAME	HP0	HP6	HP11	HP16	HP20	HU0	HU6	HU11	HU16	HU20
1	ALABAMA	12	30	17	24	8	2	7	6	10	5
2	ALASKA	1	1	0	0	1	4	19	3	0	9
3	AMERICAN SAMOA	0	0	0	0	0	0	0	0	0	0
4	ARIZONA	17	4	1	3	1	28	21	8	20	8
5	ARKANSAS	11	3	6	2	0	10	8	19	5	0
6	CALIFORNIA	167	225	215	161	1330	263	368	353	260	7430
7	COLORADO	12	5	6	3	2	15	28	48	22	10
8	CONNECTICUT	56	71	67	59	201	7	25	30	23	155
9	DELAWARE	0	0	0	0	1	1	1	1	0	6
10	DISTRICT OF COLUMBIA	4	0	1	0	1	6	3	3	0	9
11	FLORIDA	0	0	0	0	0	0	0	0	0	0
12	GEORGIA	39	39	141	4	7	10	13	65	2	5
13	GUAM	0	0	0	0	0	0	0	0	0	0
14	HAWAII	1	2	1	0	0	1	9	5	0	4
15	IDAHO	14	0	7	1	15	13	0	19	3	56
16	ILLINOIS	67	73	67	55	59	49	179	263	296	489
17	INDIANA	34	50	40	47	258	38	54	55	66	436
18	IOWA	12	18	11	13	13	4	34	32	33	31
19	KANSAS	3	0	2	0	5	3	0	10	0	57
20	KENTUCKY	13	0	0	0	11	16	2	2	5	77
21	LOUISIANA	0	0	0	0	6	0	0	0	0	21
22	MAINE	4	15	28	6	41	0	0	0	0	2
23	MARIANAS	0	0	0	0	0	0	0	0	0	0
24	MARYLAND	28	7	4	8	15	62	64	39	76	169
25	MASSACHUSETTS	82	15	16	16	14	87	78	112	163	207
26	MICHIGAN	68	29	28	32	41	82	170	233	269	442
27	MINNESOTA	47	151	103	45	217	12	64	66	31	264
28	MISSISSIPPI	40	16	11	7	3	14	37	53	23	14
29	MISSOURI	24	26	12	9	21	23	60	36	29	75
30	MONTANA	8	2	1	2	6	19	23	11	15	39
31	NEBRASKA	10	3	1	2	4	3	7	3	12	24
32	NEVADA	5	0	1	0	1	8	0	6	0	9
33	NEW HAMPSHIRE	10	4	2	1	1	10	33	27	18	13
34	NEW JERSEY	70	51	42	37	62	65	119	124	111	229
35	NEW MEXICO	2	1	0	0	0	4	4	4	3	2
36	NEW YORK	51	31	18	21	40	103	238	240	315	497
37	NORTH CAROLINA	128	230	321	133	200	33	74	133	66	171
38	NORTH DAKOTA	9	2	0	0	1	12	12	2	0	2
39	OHIO	67	71	68	57	54	64	57	108	106	236
40	OKLAHOMA	7	5	3	2	3	13	34	26	18	27
41	OREGON	2	14	6	5	7	2	60	43	37	68
42	PENNSYLVANIA	64	24	22	12	22	140	167	278	193	376
43	PUERTO RICO	19	7	17	3	1	18	16	48	10	2
44	RHODE ISLAND	8	7	6	4	5	11	17	20	16	40
45	SOUTH CAROLINA	61	104	24	25	49	24	103	25	31	70
46	SOUTH DAKOTA	1	0	1	0	1	1	8	15	3	3
47	TENNESSEE	24	3	4	4	10	30	30	42	47	113
48	TEXAS	19	53	49	18	43	18	123	144	55	157
49	UTAH	10	5	1	0	3	8	20	2	2	35
50	VERMONT	3	6	0	8	0	0	3	0	4	1
51	VIRGIN ISLANDS	0	0	0	0	0	0	0	0	0	0
52	VIRGINIA	58	15	13	8	14	108	165	164	90	234
53	WASHINGTON	15	13	27	13	46	14	30	81	38	170
54	WEST VIRGINIA	5	2	2	2	9	10	14	12	18	44
55	WISCONSIN	38	39	37	51	45	36	90	110	157	165
56	WYOMING	11	2	0	0	0	15	10	0	7	3

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