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Program Management Plan for Development, Demonstration, Testing, and Evaluation Efforts Associated with the Oak Ridge Reservation's Land Disposal Restrictions Federal Facility Compliance Agreement

T. B. Conley

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Chemical Technology Division

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T. B. Conley

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NOTICE This document contains information of a preliminary nature. It is subject to revision or correction and therefore does not represent a final report.

Prepared by
OAK RIDGE NATIONAL LABORATORY
Oak Ridge, Tennessee 37831-6285
managed by
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EXECUTIVE SUMMARY

On June 12, 1992, the U.S. Department of Energy (DOE) Oak Ridge Operations Office and the U.S. Environmental Protection Agency (EPA)–Region IV signed a Federal Facility Compliance Agreement (FFCA) to regulate the treatment of wastes governed by the Land Disposal Restrictions (LDR) of the Resource Conservation and Recovery Act. Compliance Requirement 5 of the agreement states that ". . . DOE shall submit to EPA for review and approval a plan for the treatment of the LDR prohibited wastes identified in Appendices 1B, 2B, and 3B. This plan must identify the treatment strategy for such wastes to meet LDR treatment standards and must include a schedule, not to exceed two (2) years after the submittal of this plan (i.e., March 1995), for the evaluation and prioritization of treatment method options, treatability studies, if required, and technology development." The FFCA divided the mixed wastes currently stored on the Oak Ridge Reservation (ORR) into two categories. Appendix A listed those wastes for which existing treatment methods and facilities exist. Appendix B listed wastes for which no identified treatment methods or facilities exist on the ORR.

As part of the FFCA, DOE was required to submit to EPA a plan that documents the strategies that will be used to treat Appendix B wastes generated and/or stored on the ORR. These strategies considered the evaluation, selection, and prioritization of treatment technologies and the identification and performance of treatability studies and technology development activities necessary to comply with the applicable regulatory standards. The *Strategic Plan for the Treatment of Appendix B Wastes* was issued on February 12, 1993.

Development efforts will be coordinated with the FFCA programs at the Paducah Gaseous Diffusion Plant (PGDP) and the Portsmouth Gaseous Diffusion Plant (PORTS). The low-level mixed wastes currently stored at PGDP and PORTS are similar to those on the ORR. When waste types permit similar treatment, the PGDP and PORTS wastes will be integrated into the ORR process development efforts.

This program management plan covers the development, demonstration, testing, and evaluation efforts necessary to identify treatment methods for all the waste listed in Appendix B of the ORR's LDR/FFCA as well as any new wastes which meet Appendix B criteria. To successfully identify a treatment method, at least a proof-of-principle level of understanding must be obtained: that is, the candidate processes must be demonstrated as effective in treating the wastes to the LDR; however, an optimized process is not required. Where applicable and deemed necessary and where the budgets will support them, pilot-scale demonstrations will be pursued.

The overall strategy being adopted in this program will be composed of the following activities:

1. scoping of the study,
2. characterization,
3. development and screening of alternatives,
4. treatability investigations, and
5. detailed analysis of alternatives.

The strategic plan is the basis for the efforts described in this plan.

1. INTRODUCTION

On June 12, 1992, the U.S. Department of Energy Oak Ridge Operations Office (DOE-ORO) and the U.S. Environmental Protection Agency (EPA)–Region IV signed a Federal Facility Compliance Agreement (FFCA) to regulate the treatment of wastes governed by the Land Disposal Restrictions (LDR) of the Resource Conservation and Recovery Act (RCRA). Compliance Requirement 5 of the agreement states that ". . . DOE shall submit to EPA for review and approval a plan for the treatment of the LDR prohibited wastes identified in Appendices 1B, 2B, and 3B. This plan must identify the treatment strategy for such wastes to meet LDR treatment standards and must include a schedule, not to exceed two (2) years after the submittal of this plan (i.e., March 1995), for the evaluation and prioritization of treatment method options, treatability studies, if required, and technology development."[1] The FFCA divided the mixed wastes currently stored on the Oak Ridge Reservation (ORR) into two categories. Appendix A listed those wastes for which existing treatment methods and facilities exist. Appendix B listed wastes for which no identified treatment methods or facilities exist on the ORR.

As part of the FFCA, DOE was required to submit to EPA a plan that documents the strategies to determine which technologies will be used to treat Appendix B wastes generated and/or stored on the ORR. These strategies considered the evaluation, selection, and prioritization of treatment technologies and the identification and performance of treatability studies and technology development activities necessary to comply with the applicable regulatory standards. The *Strategic Plan for the Treatment of Appendix B Wastes* (TSP) was issued on February 12, 1993.[2]

Development efforts will be coordinated with the FFCA programs at the Paducah Gaseous Diffusion Plant (PGDP) and the Portsmouth Gaseous Diffusion Plant (PORTS). The low-level mixed wastes currently stored at PGDP and PORTS are similar to those on the ORR. When waste types permit similar treatment, the PGDP and PORTS wastes will be integrated into the ORR process development efforts.

The TSP arranged the Appendix B wastes into categories and subcategories defined by DOE's Mixed Waste Treatment Project (MWTP). These groupings consist of 9 major waste categories and 92 subcategories. Figure 1 represents the MWTP waste grouping hierarchy. The Appendix B wastes were grouped into seven of the nine major waste categories. Categories 8000 (Unknown) and 9000 (Treated Wastes) were not required. Waste data by site as well as summary data for the entire ORR can be found in Appendix A of this report.

The treatment strategies formulated in the TSP reflect DOE's preferred options for treating the Appendix B wastes. The TSP emphasizes four areas: pretreatment to allow either on-site or off-site treatment, development of technologies that are well defined or under development for similar waste types, integration of technologies under development at other DOE facilities to treat ORR wastes, and continued shipment of "No Radioactivity Added" wastes by modifying existing on-site facilities combined with establishment of procedures to ensure that potentially radioactively contaminated materials are not inadvertently released. Sixteen National Plan subcategories were combined to form 11 treatability groups. These treatability groups were distributed among 11 treatment technologies: 4 chemical processes, 5 thermal processes, and 2 immobilization processes.

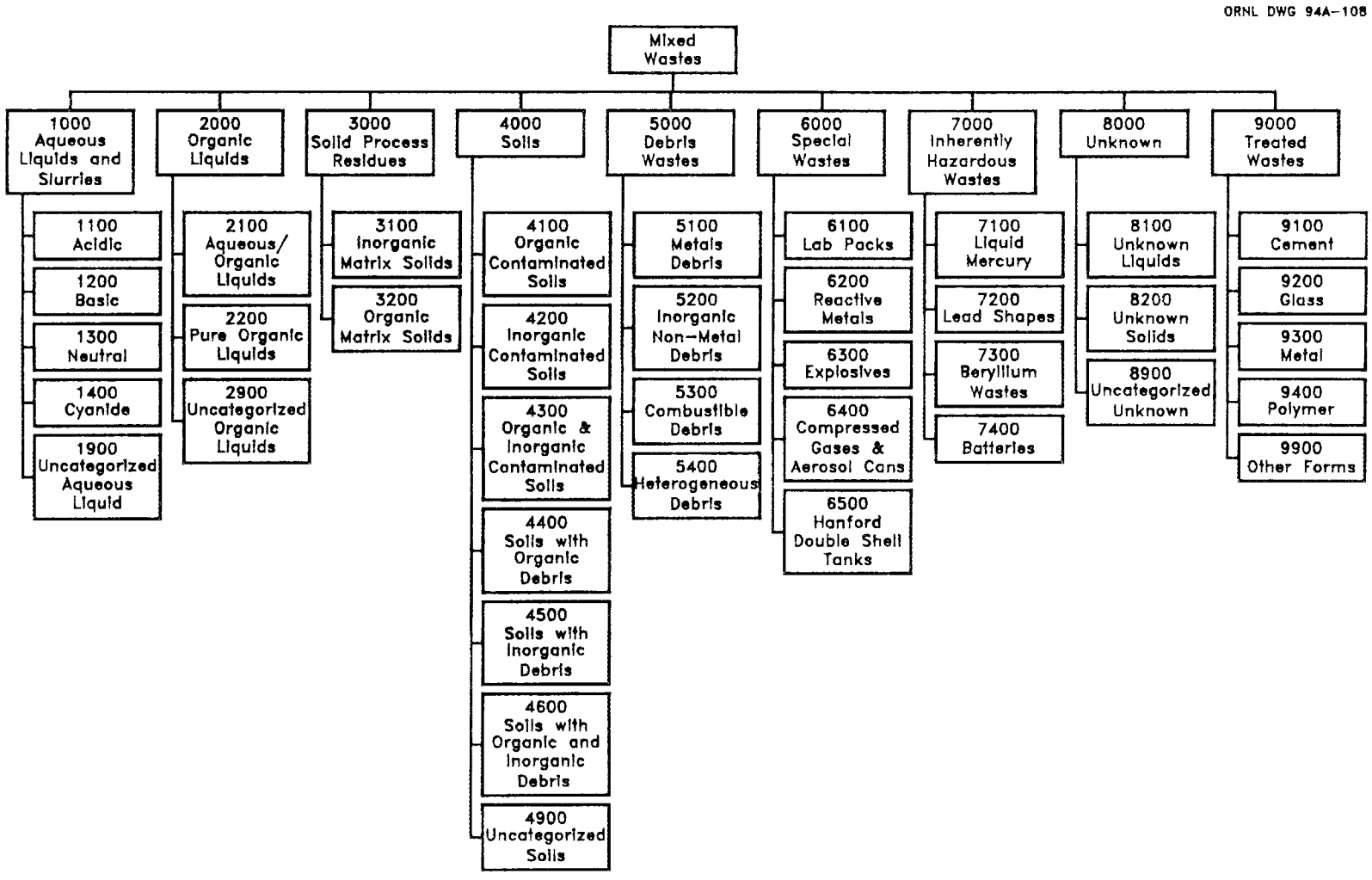

Fig. 1. DOE National Plan mixed waste classification system.

2. SCOPE

This program management plan covers the development, demonstration, testing, and evaluation (DDT&E) efforts necessary to confirm treatment methods identified in the strategic plan for the wastes. To successfully confirm a treatment method, at least a proof-of-principle level of understanding must be obtained: that is, the candidate processes must be shown to be effective in treating the wastes to the LDR; however, an optimized process is not required. As resources become available, pilot-scale demonstrations will be pursued.

At the present time, only one low-level mixed waste disposal option has a significant probability of being viable in the near future. That option is shipment to Envirocare. Envirocare, located near Clive, Utah, is the first and only commercial mixed waste disposal facility. The process is under way to establish Envirocare's availability for the disposal of DOE mixed waste. Envirocare's waste acceptance criteria (WAC) are to meet the LDR requirements and its own concentration limits on several radionuclides. Since all the treatment technologies already have the LDR requirements as their performance basis, no problems are anticipated meeting that portion of the WAC. Based on the current understanding of the radionuclide content of the ORR wastes, 90 to 95% of the wastes will meet the Envirocare WAC. For those wastes that do not, treatment processes must be developed when resources become available. Martin Marietta Energy Systems, Inc. (MMES), does not want to store the wastes indefinitely and, therefore, should keep disposal requirements in the plans.

The DDT&E efforts support the basic development needs of the Mixed Waste Treatment Facility (MWTF) but do not attempt to validate a specific design or process associated with this facility.

In addition, the efforts occurring on the ORR will be coordinated, as practicable, with the FFCA program at PGDP as well as at PORTS. The low-level mixed wastes at PGDP and PORTS are, in many ways, similar to those in Oak Ridge. When the similarities permit similar treatment, the PGDP and PORTS wastes will be accounted for in the ORR process development.

2.1 TREATMENT TECHNOLOGIES ADDRESSED

A wide range of possible candidate treatment technologies exists. These technologies are at various stages of development from conceptual design to commercial-scale facilities. Some of these technologies have been used to treat low-level mixed waste, but a majority have not. The strategic plan was developed by Energy Systems Waste Management Organization (ESWMO) to place the Appendix B wastes into categories as defined by the DOE low-level mixed waste project (funded by EM-30) and to identify all appropriate treatment technologies for each of those categories. A prioritization analysis was performed to match the categorized wastes with a preferred treatment technology or technologies. (see Table 1). The resulting matrix is the planning foundation for the DDT&E Program. Additional explanation of this table can be found in Section 5.1. Sixteen National Plan subcategories were combined to form 11 treatability groups. These treatability groups were distributed among 11 treatment technologies: 4 chemical processes, 5 thermal processes, and 2 immobilization processes. The two immobilization processes and two of the thermal processes (glass and microwave melting) are addressed as part of the Final Waste Forms (FWF) Project. Only one of the thermal processes, low-temperature thermal desorption, will be pursued vigorously on the ORR.

Table 1. Treatment technologies selected for treatability studies and monitoring

National Plan waste category[a]	2000	3100 5200	3200	4100	4200	5100	5300 5410 5420	6100 6400	6200	7100	7200 7400
Perform treatability studies and development											
Glass melting (vitrification)	x	x		x	x			x			
Microwave melting		x		x	x						
Low-temperature thermal desorption		x	x	x	x	x				x	
Cement solidification		x		x	x	x					x
Rotary kiln	x	x	x	x	x		x	x			
Integrate ORR requirements											
Supercritical fluid extraction		x	x	x	x	x	x				
Polymer solidification		x			x	x					x
Monitor technology development											
Acid digestion	x		x				x				
Biological treatment	x		x	x							
Chemical oxidation	x		x						x		
Plasma melting	x	x	x	x	x	x	x				

[a]See Fig. 1 for category names.

Thermal desorption is a mature, well-understood process which has the potential for treating the largest waste streams with a reasonably straightforward approach and thus will be emphasized in the DDT&E Program.

2.2 FINAL WASTE FORMS CONSIDERED

No single final waste form is applicable to all wastes due to either their matrix or their contaminants. The strategic plan identified four types of final waste forms that might be applicable to the Appendix B wastes: glass, ceramic, cementitious, and polymer encapsulation. The FWF Project will establish the framework by which each Appendix B waste can be matched to a waste form. The development work will consider several general criteria besides LDR considerations for final selection of a waste form. These other criteria are expediency (both schedule and cost) and how effectively the waste form meets the performance criteria [e.g., WAC, U.S. Nuclear Regulatory Commission (NRC) requirements]. The choices, by waste stream, will be based on a set of proof-of-principle studies that will be defined in the FWF Project plan.

The question of the "best" final waste form for low-level mixed wastes has consumed a great deal of time and effort throughout the DOE complex. The National Low-level Mixed Waste Program (NLLMWP) and its technical arm, the Mixed Waste Integrated Program (MWIP), which is funded by EM-50, are aggressively pursuing vitrification as their enhanced waste form of choice. There are several advantages to glass or ceramic waste forms, the primary one being volume reduction of the individual waste. Because significant resources will be required to develop these more advanced technologies and current mixed waste disposal options require only "stabilized" waste forms meeting Toxicity Characteristic Leaching Procedure (TCLP) standards, the early emphasis of the FWF Project will be to concentrate on conventional, cementitious waste forms. Other waste forms will be explored as alternatives to the grout-based approach.

3. OVERALL PLAN STRATEGY

The overall strategy being adopted in this program consists of the following activities:

1. scoping of the program,
2. characterization,
3. development and screening of alternatives,
4. treatability investigations, and
5. detailed analysis of alternatives.

Scoping is the initial planning phase, and most of the steps undertaken during scoping continue and are refined (and often revised) in the later phases. Typically, the first activity in the scoping is collection of existing data. Based on this information, the study boundaries are set, the objectives are identified, and the likely actions are defined. All of these activities have been performed and are documented in the strategic plan. Therefore, this plan will use that document for the scoping of the DDT&E Program.

An evaluation of existing Appendix B waste information will be conducted as the first step in the characterization effort. Each waste record will be reviewed to determine if sufficient compositional information is available to proceed with treatability studies. Waste generator interviews will also be conducted to gather additional information. Those wastes for which insufficient information can be obtained by this method will be submitted for characterization sampling and analysis.

Characterization is needed to establish the physical and chemical characteristics for those wastes that lack previous analytical data or sufficient process knowledge. This activity will occur in parallel with most of the waste stream identification effort. Characterization is normally scheduled so that the results of the initial sampling efforts can be used to refine the plans developed during scoping to better focus subsequent efforts.

The preliminary characterization of some ORR waste streams has been accomplished. However, waste stream characterization will be a integral part of this plan and will require considerable resources to accomplish. Section 6 of this plan outlines the evaluation of the existing data, while Section 7 discusses characterization. In all likelihood, a substantial portion of this work will have to be subcontracted to qualified vendors when MMES resources cannot support the schedule. These vendors will include both EPA Contract Laboratory Program (CLP) laboratories and personnel to actually take the samples in the field (for characterization) and experienced subcontractors to evaluate the available waste data.

The next phase of the program, which is development and screening of alternatives, requires the following:

1. identifying treatment objectives;
2. identifying potential treatment processes that will satisfy these objectives;
3. screening the technologies based on effectiveness, implementability, and cost; and
4. assembling technologies and their disposal requirements into alternatives.

The strategic plan contains the preliminary criteria and will form the basis for the screening of technologies described in this plan.

The treatability investigations and the detailed analysis of alternatives form the purpose and objective of this program plan. Treatability investigations or studies are conducted to provide sufficient data to allow treatment alternatives to be evaluated as well as to reduce performance uncertainties for those methods chosen to treat the waste or remediate the site. The decision process for treatability investigations consists of these steps:

1. determining the data needs;
2. reviewing the existing data and available literature on the technologies to determine if existing data are sufficient to evaluate alternatives;
3. performing treatability tests (bench and pilot scale), as appropriate, to determine performance, operating parameters, and relative costs of potential technologies;
4. evaluating the data to ensure that the data quality objectives (DQOs) are met; and
5. selecting technology for waste streams.

The data needs for the candidate technologies/processes will be provided by project teams focused on the major areas (see Section 5). This information will be vital to the evaluation activities outlined in Section 6. The number and kind of treatability studies will be an outgrowth of the efforts of the teams reviewing the technology areas and the waste data evaluation team.

As described in later sections of this plan, for numerous wastes streams, a determination must be made on how they will be treated. However, limited analytical data are available, and many of the proposed treatment technologies have had limited or no application in the treatment of mixed waste. The lack of characterization data and experience does not change the schedule that DOE and MMES must follow. Therefore, simply stated, this program will implement the detailed strategies outlined in the following sections only if sufficient resources are made available in a timely fashion.

4. PROGRAM MANAGEMENT

Effective program management is crucial to the successful implementation of this plan and thus to meeting the requirements placed on MMES by DOE. The DDT&E Program relies on the contributions of many organizational units within MMES for its success. These include ESWMO, MMES Engineering, the Chemical Technology Division, the Oak Ridge Y-12 Plant Development Division, the Waste Management divisions of all three plants, and Procurement (see Fig. 2 for organization chart). Not only is the organization large, but the schedule is tight and has a limited budget. Therefore, program management needs to be flexible and adaptable to meet the challenges put before it. The following sections briefly address the management tools to be utilized.

4.1 WORK BREAKDOWN STRUCTURE

A work breakdown structure (WBS) is being developed and will be utilized as the basis for the following:

1. uniform project planning and visibility,
2. assignment of responsibilities,
3. identification of end item objectives for monitoring and progress,
4. network scheduling and budgeting, and
5. ensuring interfaces among the various organizations.

4.2 RESPONSIBILITIES

As stated previously, one of the functions of the WBS is to assign responsibility for the discrete deliverables found in the lowest tier of each leg in the WBS. To accomplish this goal, a responsibility matrix will be generated. On one axis the deliverables will be listed, while the persons and organizations that are involved with the FFCA will be listed on the other axis. At each intersection of deliverable and responsible person or organization, a code will be placed. This code will designate what level or type of responsibility the designated person will have for the deliverable. If the block is left blank, no responsibility is conferred. To ensure that all interested parties are involved with the formulation of this matrix, blank copies will be circulated to those involved at DOE, ESWMO, Engineering, ORNL, the Y-12 Plant, the Oak Ridge K-25 Site, etc., to solicit each party's perspectives. The responses will be complied into a summary chart that will be used in working sessions to resolve any differences. The matrix will be published as a separate document since it may undergo several revisions before it can be considered final.

4.3 COORDINATION AND REPORTING

Due to the complexity of this program, coordination of all the individual efforts will be critical for it to succeed. To effect and maintain this coordination, regularly scheduled meetings will be held. This will include weekly meetings of the leaders of the major efforts

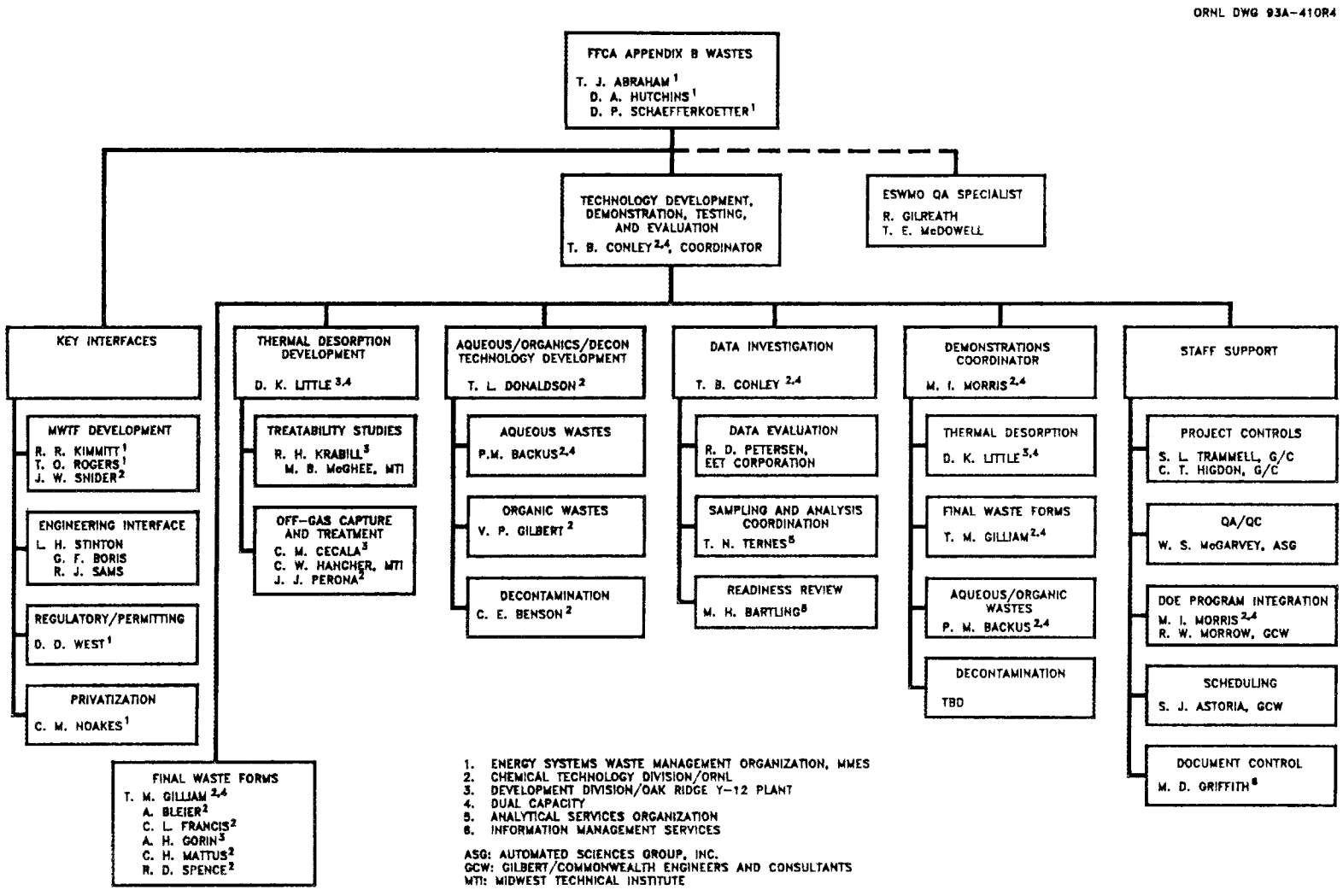

Fig. 2. Organization chart.

and biweekly meetings of the project teams. These meetings of the project teams are designed to maintain the exchange of information at the working level among the various groups. In addition, monthly reports will be issued (either by electronic mail or by hard copy) as well as quarterly reports. The monthly reports will be targeted to MMES personnel involved with or interested in the LDR/FFCA efforts. The quarterly reports will have DOE and EPA as their target audience.

4.4 CONFIGURATION CONTROL

With a program as large and complex as this one, many different documents will be generated to communicate the program's needs and progress. These documents will have several different authors and thus be published at several different locations. To maintain configuration control of the baseline program definition, the official record copy of each of the primary documents will be kept in a central location. This location will be the office of the DDT&E coordinator at ORNL.The documents that require configuration control include the following:

1. program management plan;
2. quality assurance plans (for the program and each of the major projects);
3. responsibility matrix;
4. project plans for Thermal Desorption, FWF; Radionuclide Removal, Surface Decontamination, and Liquids Treatment (aqueous and organic);
5. test plans; and
6. statements of work for vendors.

The MMES-established quality assurance (QA) requirements will be adhered to for document control and archiving.

5. DATA EVALUATION

The development of a successful treatment technology requires input and planning from many sources. At a minimum, the following information must be collected, compiled, or developed:

1. adequate information about the waste stream(s) to be treated,
2. a clear understanding of the capabilities or projected capabilities of the candidate technologies which are proposed for treating the wastes,
3. a list of information that is lacking from items 1 and 2 above that is required to perform treatability studies using the candidate treatment technologies,
4. a definitive set of performance criteria for the treated wastes, and
5. a detailed plan for closing the information gaps that prevent implementation of the chosen technologies.

Items 1 through 3 will be addressed in this section of the plan. The last two items in the preceding list will be addressed in Section 7 by general technology area.

The strategic plan requires that an evaluation of all LDR wastes be made. The goal of this effort is to establish the information to effectively conduct treatability studies and technology development for mixed waste treatment. The Evaluation of Waste Data project has the following four objectives:

- develop technology-based information standards that are required to adequately perform treatability studies on specific waste types;
- gather and evaluate waste information by reviewing existing waste databases and documentation and by conducting generator interviews, as necessary, to categorize wastes into National Plan categories (NPCs) and treatability study groups (TSGs);
- place wastes that share host matrix properties into treatability study populations; and
- establish pretreatment, primary treatment, and posttreatment requirements for all Appendix B waste.

The satisfactory accomplishment of these objectives will optimize the characterization efforts and minimize the number of treatability studies required to develop treatment technologies for Appendix B mixed wastes. In addition, this evaluation may identify potential deficiencies with previous RCRA characterizations. The data evaluation methodology is presented in Fig. 3.

5.1 DATA SOURCES

The primary sources of data concerning these wastes are the waste generators and those persons who have been tasked to store the wastes. The waste records were generated in an effort to comply with EPA and DOE requirements (mostly cataloging requirements). As such, they often do not provide sufficient information on which to base sound judgments as to the appropriate technology or technologies that could be applied to waste treatment. In addition to these waste records, several other data sources will be analyzed for possible use. These sources include, but are not limited to, project-specific databases, Material Safety Data Sheets,

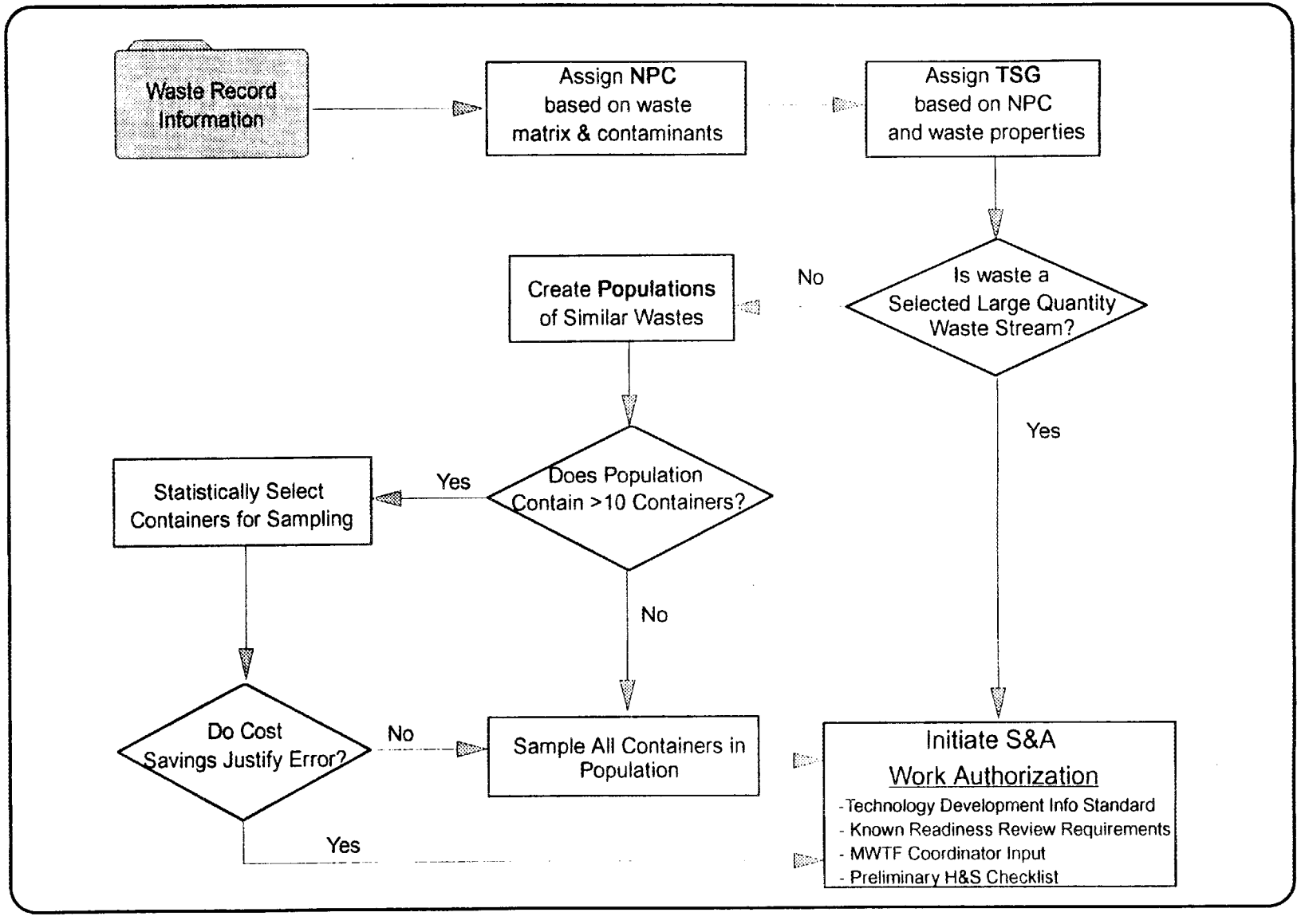

Fig. 3. Waste evaluation methodology. NPC = National Plan category; TSG = treatability study group; S&A = sampling and analysis; MWTF = Mixed Waste Treatment Facility; H&S = health and safety.

Request for Disposal (RFD) documentation, and process and/or building documentation. The evaluation of historical information has been completed or is currently being conducted at other DOE sites. The types of information being utilized in these efforts are presented in Table 2. The data quality of these miscellaneous sources will be closely scrutinized to ensure that the information is valid and meaningful.

If the preceding sources of data prove to be inadequate to meet our goal, the generators' process knowledge may be used to obtain the required information. Although process knowledge cannot guarantee what contaminants are in the wastes or the levels of these contaminants, it can provide a set of principles to use to reduce the scope of characterization required. For example, if process knowledge confirms that a particular waste has never been in a radiological area, then the characterization can focus on the RCRA aspects alone. Acquiring this process knowledge will prove invaluable in obtaining the information necessary to accelerate Oak Ridge's compliance efforts.

Process knowledge may not be necessary where actual and meaningful characterization has been performed. However, wastes with adequate characterization may be a small subset of the total inventory. An effort is in progress by the individual sites to augment the existing waste records with more complete data. The data evaluation group will work closely with those involved with the characterization through the program's sampling and analysis coordinator.

A further source of information is the studies that have been performed prior to this one. Researchers who have prepared studies evaluating alternatives and prioritizing waste streams and treatment technologies[3] have searched for available data to use in their deliberations. Such sources of information will be thoroughly sought out and utilized.

5.2 DATA COLLECTION

Unique databases containing a variety of waste information are maintained by each ORR facility. Each database contains several thousands of waste records, which are comprised of multiple data fields including, but not limited to, waste description, mass, EPA code, and container identification. Each waste record has been or will be assigned to an MWIP NPC according to the combination of its contaminant and matrix composition.

The primary sources of waste record information are the waste generators and facility personnel associated with ORR treatment and storage facilities. Waste records have been compiled over a period of several years to comply with EPA and DOE requirements. These records do not necessarily provide sufficient information to conduct treatment technology development. Other sources of waste information may include project-specific databases, Material Safety Data Sheets, RFDs, process documentation, and previously performed studies. The data quality of these sources will be closely scrutinized to ensure the information they provide is valid and meaningful.

A container survey is currently being conducted at the K-25 Site to verify drum contents and labeling. A similar survey has been conducted at ORNL. These results are currently being verified and refined. As each facility augments existing waste records, refined data will be incorporated into the waste evaluation process to ensure the use of the most current and reliable characterization data available.

Table 2. Typical DOE facility files

On-site files	Off-site files (unclassified only)
Classified files in vault storage	Personnel files for previous employees
Unclassified files	Health files (including x-ray records) for previous employees
Engineering project files	Engineering drawing files
Engineering drawing files	Engineering project files
Correspondence files	AEC/ERDA/DOE records (filed according to the AEC filing system)[a]
Waste management files	AEC/ERDA/DOE guidance and orders[a]
Weapons files	Air monitoring and sampling files
Waste shipment files	Dosimetry records
Analytical reports for both production and environmental activities	Special project files
Microfilmed files	Federal, state, and local standards
Legal files	Guidance and nationally recognized standards (such as National Bureau of Standards Handbook 52)
Incident and property loss files	Radiation contamination incident files
Radiation contamination incident files	Personal files from previous employees
Purchasing files	
Photography files	
Property utilization and disposal files	
Special project files	
Personal files from previous employees	

[a]AEC = U.S. Atomic Energy Commission; ERDA = U.S. Energy Research and Development Administration; DOE = U.S. Department of Energy.

Source: Barbara A. Swensen, Frank J. Blaha, and Ann K. Sieben, "Value of Historical Records and Corporate Memory in Environmental Restoration Work at DOE Facilities," presented at Waste Management '93: Technology and Programs for Radioactive Waste Management and Environmental Restoration, February 28–March 4, 1993.

5.3 DATA REVIEW

Existing electronic databases of stored wastes from each of the three ORR plants will be screened to establish a list of wastes without identified existing treatments. This screening may involve removal of all nonhazardous wastes and all wastes destined for existing treatment facilities on the ORR. Wastes without identified existing treatment which are stored on the ORR but are not recorded electronically will also be incorporated into the electronic database. Information such as container numbers, waste descriptions, EPA codes, mass, physical state, storage location, storage date, and radiological determinations will be available. Using these data, an NPC and a TSG will be assigned. Additional information required to assign NPCs and TSGs will be collected from document reviews and, if necessary, from generator interviews. After individual records are fully evaluated, information will be entered into an interim database and tracking system. The evaluated waste data can be interfaced with existing electronic files or future waste information systems.

After waste records have been assigned to a TSG, sorted, and subjected to document review, the database and tracking system will be updated to include this information. A methodology to evaluate this base information will be developed and may include further categorization of wastes within or across TSGs. Selecting waste groups for technology development and treatability study testing will include grouping wastes with like NPCs within a TSG. Further grouping as a treatability population will be made based on analytical or qualitative information concerning the waste matrix; a minimum waste quantity will be established to eliminate as candidates those wastes that cannot be sampled. Container numbers for each RFD within a population will be subjected to statistical analysis and samples from selected drums composited for treatability studies. Additional selection guidelines may be required, and a formal selection methodology will be prepared.

Performing treatability studies on representative samples from these groups rather than on individual wastes will minimize the amount of characterization and the number of treatability studies required, while providing the necessary engineering data to proceed with demonstration- and production-scale efforts. TSGs will combine wastes that have similar matrices and contaminants with respect to potential treatment. These groups will be representative of the range of host matrices and contaminants contained in an NPC. Criteria will be refined to ensure that wastes are combined in a way which will enhance the performance of the treatment options considered (e.g., assay blending).

Information standards are required as part of the characterization project. The information standard(s) will establish the analytes required to fully characterize the waste to effectively conduct treatability studies. The information needs depend on the specific technology selected for each waste type. Development of the information standards will include literature review, input from technology vendors, subject matter experts within and outside the DOE complex, MMES's technology development, and the MWTF personnel.

Even though it is recognized that most of the Appendix B wastes located on the ORR require technology development so that capable production treatment processes can be established, the resources to achieve this goal are limited. Prioritization of TSGs for technology development will be based primarily on waste quantity but will consider other factors as appropriate.

Table 3. Waste characterization sufficiency criteria

Characterization parameter	Organic liquid treatment	Aqueous liquid treatment[a]	Thermal desorption	Immobilization[b]	Surface decontamination[c]
Radioanalysis and screening[d]	X	X	X	X	X
Host matrix material composition	X	X	X	X	X
RCRA contaminant concentrations	X	X	X	X[e]	X
PCBs	X	X	X	X	X
Solution pH	X	X		X[f,g]	
Dissolved solids species and concentrations	X	X		X[g]	
Suspended solids concentration	X	X		X[g]	
Complexing and chelating agents present	X	X			
Moisture concentration	X		X	X	X
Halides and nitrate concentrations				X	
Sulfur and phosphorus compound concentrations				X	
Total organic carbon (TOC) concentration		X	X	X	
Oil and grease content		X	X	X	X
Bulk combustibles content	X[h]		X[h]	X[h]	X[h]
Particle size fractions	X			X	
Metal pieces content			X[h]	X[h]	X[h]
Bulk physical shape and size			X[h]	X[h,i]	X[h]
Surface characteristics (clean, painted, oily, cracked, etc.)				X[h,i]	X[h]

[a]Aqueous liquid treatment technologies include precipitation, ion exchange, chelation, filtration, carbon adsorption, and chemical extraction.
[b]Immobilization technologies include cementation, glass vitrification, polymer encapsulation, and microwave solidification.
[c]Surface decontamination technologies include thermal desorption, steam cleaning, electrochemical metal removal, and supercritical fluid extraction.
[d]As necessary to account for gross radiation levels.
[e]Toxicity Characteristic Leaching Procedure analysis also needed for the Resource Conservation and Recovery Act (RCRA) contaminants.
[f]Liquid phase pH.
[g]Needed only for liquids (<40% solids).
[h]Determined by inspection.
[i]Applicable only for macroencapsulation by cementation or polymer encapsulation.

5.4 TREATMENT OPTIONS

The strategic plan established a suite of candidate technologies for use in treating these wastes. The technologies described in the strategic plan will establish the framework for the treatment options assessments. As with the establishment of the TSGs, a set of performance objectives for assessing the viability of each treatment option against the proposed TSGs must be established. The performance objectives that must be taken into account include the following:

1. the treatment goals for each waste,
2. the composition of the TSG, and
3. the limitations of each of the technologies to be considered.

The end result will be a matrix of TSGs versus the possible treatment options to be considered.

6. CHARACTERIZATION PLANS

As discussed at length previously, insufficient data are associated with many waste streams on the ORR to enable investigators to formulate engineering judgments as to their treatment. To rectify this situation, these streams must be sampled in such a way to provide the investigators and process designers an understanding of the streams' matrices, constituents, and variability. The information obtained from these activities must be gathered and maintained so that all sites can utilize it and so that future investigations can access a definitive database.

The direction for the characterization efforts will be given based on the results of the data evaluation effort discussed in Section 5. Not only will the priority for the waste be delineated, but the chemical and physical analyses requirements will also be detailed.

6.1 PREPARATION OF SAMPLING AND ANALYSIS PLANS

Sampling and analysis plans (SAPs) will be written for each of the TSGs that have insufficient data to proceed with treatability studies. The SAPs will provide direction both to those taking the samples and to those analyzing them. Each site has personnel who are responsible for the preparation of SAPs, and full advantage will be taken of this resource. When the resources at the sites are deemed inadequate to meet the schedule requirements, subcontractors with experience in this field will be hired to provide the needed manpower. Since there are several sites with numerous different waste streams, various authors will generate these plans. A uniform approach will be critical to ensuring the long-term utility of the results. A set of DQOs will be formulated that clearly specifies the kinds of data required, the techniques to be used in the analyses, and the format for the results. These objectives will be developed as a group effort among the affected sites and users (current and projected). Also, close contact will be maintained with the efforts of the NLLMWP in this area.

As the SAPs are developed, careful consideration will be given to the formulation of reference batches of wastes. These reference batches will provide continuity for the data generated during treatability studies at different locations through the pilot-scale demonstrations to the actual treatment of the waste stream. The project plans for each technology area will provide the information necessary to establish these reference materials.

6.2 DATA ANALYSIS

The analytical laboratories located on the ORR will be the primary resource for waste analysis. However, MMES has CLPs already under subcontract. When the local laboratories cannot handle the volume of samples, these other facilities will be utilized.

6.3 STANDARDS FOR QUALITY ASSURANCE/QUALITY CONTROL

The applicable quality assurance/quality control (QA/QC) standards will be applied to the development and implementation of these plans. At a minimum, the requirements

stipulated under RCRA and the Toxic Substances Control Act (TSCA) regulations as well as DOE Order 5700.6C will be included in the plans.

7. DEVELOPMENT OF TREATMENT TECHNOLOGIES

Once the wastes to be treated are known, the development of a successful treatment technology requires a definitive set of performance criteria for the treated wastes and a detailed plan for the closing the information gaps that prevent implementation of the chosen technologies. This section will address these requirements by general technology area.

7.1 TECHNOLOGY DEVELOPMENT ELEMENTS

The decision process for the development of technologies (outlined in Section 3) consists basically of formulating data needs (for the technology or process); analyzing the available data to determine whether or not they meet those needs; and, if they do not, performing the studies necessary to obtain the required information. Rather than incumber the program plan with the requisite level of detail to adequately cover the technologies, separate project plans will be written for each of the major technical areas.

The format of the individual project plans for each of the technology areas will be similar; however, their technical content will vary according to the state of readiness of the technologies to treat the wastes. Each plan will address the following areas at a minimum:

1. the purpose of the plan and its overall approach to the task;
2. project management, including the organization, deliverables, documentation, safety, regulatory issues, and integration with the other projects and Engineering;
3. description of the technologies;
4. data requirements for proper selection of candidate waste streams and the rationale, justification, or source for these data;
5. performance criteria and the assumptions made to arrive at these criteria;
6. testing requirements, including test goals, data needs, proposed facilities (at least type of facilities required), and evaluation criteria (especially for down-selection of candidates for pilot demonstration);
7. vendor (internal or external to MMES) requirements and capabilities;
8. pilot demonstration goals and data (output) requirements; and
9. costs and schedules.

The DQOs of the treatability studies as well as the pilot demonstrations are to be addressed in these plans as well. Finally, each of these projects will have a project quality assurance plan (PQAP) that will provide the detailed QA initiatives to be undertaken for each project. Each PQAP will address those items called out in the quality assurance program plan (QAPP) (see Section 11).

The coordination of these project plans and the elements that comprise them is critical to the DDT&E efforts since they are interrelated. For example, the key waste characteristics that must or should be known before a meaningful assessment can be made will also be delineated in the project plans. This will establish the basis for the data evaluation efforts (Section 5) to identify gaps in the existing characterization data. When gaps are discovered, the missing information becomes part of the scope of work for the characterization studies. Since these technologies will eventually form a treatment train, the inputs and outputs of each

technology for each waste stream affect the performance of both the successor and the predecessor.

The strategic plan designated 11 technologies for which the DDT&E Program is to (1) formulate treatability studies, (2) integrate the ORR requirements in other sites' treatability studies, or (3) monitor technology development (see Table 1). Treatability studies have already been discussed in general terms. This program will scope the required treatability studies, characterization, and pilot-scale demonstrations necessary to permit the development of a treatment methods plan as required under the FFCA. In the following sections, further detail is offered on thermal desorption and final waste forms (cement solidification, glass melting, and microwave melting). The rotary-kiln incinerator will not be addressed in this DDT&E Program because an existing system is in place at the K-25 Site (the TSCA incinerator) and the technology is well established.

Integration of the ORR requirements in Table 1 refers to the cooperative efforts of the DDT&E Program with such national initiatives as the MWIP and the Decontamination and Decommissioning Integrated Demonstration (D&DID). Section 12 of this plan further addresses this activity.

The four technologies listed under "monitor technology development" will simply be the subjects of literature reviews because they are not considered applicable to the ORR, PGDP, and PORTS problems at this time.

MMES and DOE-ORO are currently scoping the construction of a central treatment facility known as the MWTF. The MWTF is a collection of interdependent line-item projects that, once constructed, could provide the treatment capability and capacity for the majority (by volume) of wastes listed in the tables in Appendix B of the FFCA. The stated mission of the MWTF is to provide the capability to treat low-level radioactive mixed wastes. This treatment could involve (1) removing the hazardous constituents, (2) removing the radioactive constituents, and/or (3) removing both the hazardous and radioactive constituents.[4] All residues from these treatments would be processed into acceptable final forms for ultimate disposal. Those streams that have been scheduled for treatment in the MWTF are listed in Appendix B of this report. Support of this proposed multi-line-item facility will require the efforts of many different organizations on several different tasks and thus will require a substantial budget. The efforts outlined below will support the basic development required to determine the technical suitability of the proposed MWTF processes. The MWTF processes planned for inclusion in this program plan are thermal desorption and stabilization/fixation. There are several waste streams listed in Appendix B that are not currently scheduled for treatment in the MWTF (listed in Table 4). It is hoped that many of these streams can actually be treated in existing facilities (on-site and off-site) or can be accommodated in the MWTF. Whether these streams can be treated in existing facilities or in the MWTF, a viable treatment method will be determined for each waste stream. The final waste product will meet, at a minimum, the LDR requirements.

7.2 MATRIX OF WASTE STREAMS VERSUS TECHNOLOGIES

Table 6.1 in the strategic plan[1] is entitled "Preferred treatment technologies" and appears in this plan as Table 1. This table, which displays the waste category/subcategory versus the preferred treatment technology, is the basis for the technology evaluations described in the pages to follow and therefore for several of the data evaluation criteria in Section 5.

Table 4. Wastes not currently scheduled for treatment in the MWTF

Waste group	ORNL Annual generation (kg)	ORNL Storage (kg)	Y-12 Annual generation (kg)	Y-12 Storage (kg)	K-25 Annual generation (kg)	K-25 Storage (kg)
1000	24,464	5,379	17,885	15,813	33,071	170,704
2000	3,828	11,696	62,704	177,790	18,706	84,652
3200	0	5,107	82,668	69,742	29,160	113,144
5300	0	224	1,184	36,367	18,614	20,432
5400	0	75	6,908	27,070	60,486	124,266
6000	9,685	26,664	396	12,314	9,003	4,687
7000	0	2,335	17,474	4,435	1,234	2,769
Total	**37,977**	**51,480**	**189,219**	**343,531**	**170,274**	**520,654**

The previous treatability studies performed on ORR wastes are summarized in Appendix C of this report. Included in this summary with thermal desorption and FWF technology is radionuclide removal. Radionuclide removal is a major process in the MWTF but is not necessary to meet the LDR; therefore, it is not a part of the DDT&E Program.

7.3 THERMAL DESORPTION

The removal of volatile RCRA and TSCA constituents, in particular mercury, polychlorinated biphenyls (PCBs), and chlorinated solvents, is essential to the development of a treatment method for many of the Appendix B wastes because of the widespread nature of these contaminants in ORR wastes.[5] The broad class of processes known as thermal desorption has been chosen to accomplish the removal of these volatile hazards. Thermal desorption is an ex situ means to physically separate volatile and semivolatile contaminants from soil, sediments, sludges, and filter cakes.[6] A project plan for thermal desorption will be developed that provides the data required to design an optimized processing facility (or facilities in the case of transportable units). This optimized process will include not only the parameters of the desorption unit itself but also the off-gas and front-end handling systems. The data will be acquired through bench-scale and pilot-scale experiments either on-site (the ORR) or off-site (at other DOE facilities or at a commercial vendor).

7.4 FINAL WASTE FORMS

The FFCA TSP identified four immobilization technologies for treatment of the Appendix B wastes: cementation, glass melting, microwave solidification, and polymer encapsulation. The FWF Project is chartered with providing the necessary data and process information to support development of these technologies. This section describes the activities comprising the FWF Project. This project will support the identification and selection of the TSP stabilization processes and, as funding permits, the design and operation of a stabilization facility.

The FWF Project has four fundamental goals:

- develop stabilization methods for specific FFCA Appendix B wastes,
- provide the technical information necessary to facilitate selection of the stabilization technology,
- provide technical assistance for the design of the MWTF, and
- provide the capability to evaluate future modifications to the MWTF and treatment options for miscellaneous small-quantity waste streams.

To accomplish these goals, four key activities are planned: Development of Stabilization Technologies, Development of Final Waste Form Performance Criteria, Development of a Waste Matrix Baseline, and Establishment of Potential Vendor Requirements. The stabilization technology development effort involves coordinating final waste form development activities with activities of other DDT&E projects as well as with the MWIP. Consequently, the FWF Project may be modified to reflect developmental and process knowledge gained from these projects.

An aggressive schedule is planned for both the FFCA and the MWTF final waste form development projects. Therefore, stabilization development activities must be conducted in parallel with waste evaluation and characterization efforts. Therefore, the design effort for the MWTF must be flexible to adapt as new waste stream information becomes available. To meet the design data needs of the MWTF Conceptual Design Report (CDR), a CDR development testing plan will be developed by the MMES Engineering Division. The resulting test plan will be integrated into the FWF Project plan. During the design phase of the MWTF, a variety of engineering information will be required. The preliminary data needs will also be addressed through the development activities described in the project plan and the CDR development testing plan. As the design of the stabilization processes proceeds, the evaluation of specific hardware configurations will be necessary. Although many of the hardware issues may be evaluated on a small scale, some issues can be adequately addressed only at the pilot- demonstration scale.

7.4.1 Development of Stabilization Technologies

Immobilization technologies encompass a broad range of treatment methods. The TSP selected two solidification and two stabilization methods for consideration as immobilization treatment alternatives. Solidification is any physical treatment of waste to form a monolith. The principal method of protecting the environment is physical encapsulation of the waste. The solidification medium forms a barrier to impede contaminant leaching by an external water source. Stabilization may produce a monolithic final form but also chemically binds the waste matrix and contaminants to the stabilization medium. These treatments produce waste

forms that are potentially less leachable and more environmentally benign. EPA treatment standards favor stabilization over solidification.

7.4.1.1 Cementation

Cementation processes comprise a large number of solidification media including portland cements, pozzolans, and sulfur-polymer. A brief description of the more common cementation processes follows. Various waste types might use variations of these solidification processes in order to effectively treat a specific waste stream.

The most common cementation method uses portland cement as the solidification medium. The process involves combining portland cement, water, and the solid or liquid waste to form a grout which can be cast into a variety of containers. Some solidification processes allow for the mixture of constituents directly in the drum used for final waste disposal. Treatability tests must be performed prior to production-scale waste treatment to establish the ratio of cement, water, and waste which will create the best waste form for specific waste types and contaminants. The adequacy of the waste form varies according to the physicochemical composition of the waste and the manner in which it is processed. Various admixture components may be used to affect various physical or chemical properties of the final waste form. Portland cement solidification is an easily implemented process, but it significantly increases the weight and volume of the final form. Portland cement solidification has been widely used to treat soils, sludges, ashes, and other materials contaminated with both hazardous and radioactive contaminants.

A modification to portland cementation incorporates pozzolanic material as an additive. This method uses the finely divided, noncrystalline silica in pozzolanic materials and the calcium present in the portland cement to produce a grout composed of calcium silicate and aluminohydrates. Another approach is to use thermoplastic sulfur cements for encapsulation of a variety of low level and mixed wastes. The sulfur mixture is heated above its melting point, combined with dry waste to form a homogeneous mixture, and cooled to form a monolithic solid. This process has been used to treat sodium sulfate salts, boric acid salts, incinerator bottom ash, and incinerator fly ash.

7.4.1.2 Glass Melting

Glass melters are used for processing wastes by incorporating the waste matrix and metal contaminants into the glass. Solid wastes are mixed with glass formers and fluxes and introduced into the glass melter cavity. The mixture is heated to its melting point using a variety of energy sources including natural gas, resistance heating, or joule heating. Molten glass is drawn from the bottom of the melter and either pelletized or poured directly into heated drums. The drums are slowly cooled to alleviate thermal stress fracturing and to prevent undesirable crystallization. Fluxing agents may be added to effect favorable changes to chemical characteristics of the glass. A major drawback may be the need to add large amounts of silica to specific waste matrices in order to produce an amorphous waste form. Glass melting has the potential of reducing the total waste volume while creating a leach-resistant final waste form.

7.4.1.3 Microwave Solidification

Microwave solidification processes use microwave energy to heat waste materials to their melting points directly in the shipping container. Microwave melters have been reported to reduce the volume of certain wastes by up to 80% (compared with cementation processes) while forming a synthetic mineral. Synthetic minerals incorporate the metal contaminants directly into the crystal structure; however, mineral morphology needs to be determined for specific waste matrices. The interaction of the energy and waste during processing is conducive to crystal formation. Additives to the waste, to aid in melting and subsequent mineral formation, are minimal. The drum serves as the resonant cavity for the application of the microwave energy.

7.4.2 Waste Form Performance Criteria

To assess the effectiveness of specific waste forms, performance criteria need to be established and the rationale for their selection developed. These criteria will also aid in establishment of process down-selection criteria by forming the basis for waste form comparisons. The definitive performance criteria will take into account process, transportation, NRC and other regulations, and disposal site WAC. Development of the performance criteria will be integrated with similar efforts at other DOE facilities including the FWF TSG in support of the MWIP. However, the schedule for the MWIP efforts is not as aggressive at that presented in this plan.

Initial performance criteria will be based on 40 CFR 268, LDR Prohibitions, Subpart D, Treatment Standards. Analysis of the extract from the TCLP will be used as the initial performance test. The performance standards will be the Constituent Concentrations in Waste Extract, Table CCWE, 40 CFR 268.41, for specific LDR contaminants. Other criteria will be identified through document searches and interaction with Facilities Engineering.

Ultimately performance testing will be conducted that will correlate the waste form characteristics to long-term durability. This relationship would allow waste disposal facility performance assessment evaluations to take responsibility for the final waste forms and hence reduce overall disposal costs. The validity of currently known test methods related to durability will be assessed and evaluated with respect to development needs.

7.4.3 Waste Matrix Baseline

Due to time, budget, and manpower constraints, each Appendix B waste stream and secondary waste destined for treatment through stabilization cannot be fully characterized and evaluated to meet the FFCA and MWTF design deadlines. Therefore, the development efforts concentrate on waste streams having sufficient processing history with respect to suitability with a given grout, glass, or mineral morphology.

Reports and other documents will be reviewed to determine if final waste forms for specific waste types have previously been tested. This will facilitate identification of Appendix B waste streams that have the appropriate waste form specified by regulation. Recognized experts in grout, glass, and mineral formulation will also be identified and subcontracts established with appropriate scopes of work. In addition, a list of problem contaminants will be established.

7.4.4 Vendor Requirements

Each development project will establish the requirements necessary for selection of vendors to perform appropriate development or consulting services. These requirements may include permits currently held at the vendor's laboratory, quality assurance plans, waste managements plans, testing and safety procedures, and training documentation. These requirements will be compiled and defined in a document for vendor evaluation.

Using these requirements, a list of qualified vendors will be developed in consultation with the Procurement Division. The selected vendors will be subjected to a formal audit to ensure compliance with all applicable MMES and DOE requirements. This audit will be performed in conjunction with properly trained MMES QA auditors.

7.5 TREATMENT PROCESSES FOR AQUEOUS/ORGANICS/DECONTAMINATION

The technologies discussed so far will cover the treatment of 80 to 90% (by volume) of the mixed wastes on the ORR. The remaining 10 to 20% must also have viable treatment options for inclusion in the treatment methods plan due to the EPA in March 1995. These wastes can be categorized into three classes: aqueous liquids, organic liquids, and debris. Treatment technologies listed for debris in Table 1 for which treatability studies will be performed are glass melting, microwave melting, thermal desorption, solidification, and rotary-kiln incineration. The aqueous and organics wastes must be either treated for discharge or pretreated prior to primary treatment in an existing waste treatment process or at the MWTF (when it is operational). The TSP indicates that the pretreatment approach is to be pursued for the aqueous and organics wastes. The problematic characteristics for the treatment or pretreatment processes may be physical, such as particulate size distribution (micron-size particulates may blind filters in an off-gas treatment system) or chemical, such as the presence of chlorides, nitrates, and organics (creating problems for the final waste forms). The characteristics of concern, whether chemical or physical, must be delineated by the applicable regulations (e.g., Clean Water Act and National Emission Standards for Hazardous Air Pollutants); the other projects within this DDT&E Program; and/or the WAC of the existing treatment facility that would further process the wastes. The separation or elimination of these characteristics or the species that create them will be the focus of this project within the DDT&E Program. A listing of many of the chemical/physical separations technologies available can be found in Table 5.

7.5.1 Aqueous Liquids

Aqueous liquids contain <1% organic content and are pumpable. This category includes corrosive acids, corrosive bases, reactive cyanides, and toxic metals. Contaminants include mercury, lead, and trace amounts of other toxic metals and hazardous organics. The other treatment processes generate streams that must be treated as well. These include decontamination solutions, scrubber solutions containing metal chlorides, and condensate that does not meet disposal criteria. The primary function of these processes is to separate or destroy organic contaminants as well as suspended and dissolved solids from the aqueous matrix[7] to produce water that is suitable for either recycle or discharge in compliance with the appropriate regulations. One of the more challenging wastes in this area will be those contaminated with mercury.

Table 5. Chemical/physical separation technologies

Solid/liquid separation technologies	
• Chemical techniques	
· Neutralization	· Surfactants
· Coagulation/Flocculation	· Oxidation/Reduction
· Pyrochemical processing	· Precipitation
• Biological processing	
• Media beds	
· Activated carbon adsorption	· Chromatography
· Noncarbon adsorption	· Ion-exchange beds
· Affinity chromatography	· Biosorption
• Membranes	
· Reverse osmosis	· Electrodialysis
· Ultrafiltration	· Supported liquid membranes
· Microfiltration	
• Electrolysis	
• Electrokinetic techniques	
• Thermal	
· Conventional evaporation	
· Thin-Film evaporation	
· Drying	
• Filtration	
• Solvent extraction	
• Nitrate destruction	
· Salt splitting	· Nitrate to ammonia and ceramic conversion
· Electrodialysis ion exchange	· Biodenitrification
· Electrochemical ion exchange	· Steam reforming
• Mechanical separation	
· Sedimentation	· Hydrocyclones
· Centrifugation	· Flotation

Table 5 (continued)

Liquid/liquid separation technologies	
• Media beds · Granular activated carbon · Powdered activated carbon · Biosorption	
• Distillation	
• Steam stripping	
• Air stripping	
• Mechanical techniques · Centrifugation · Plate settlers	· Flotation · Gravity settlers
• Membranes · Pervaporation · Ultrafiltration	· Microfiltration · Supported liquid membranes
Solid/solid separation technologies	
• Mechanical techniques · Air classifiers · Density tables · Friction slides	· Trommel screens · Dense media separation
• Electromagnetic techniques · High field gradient magnetic · Conventional magnetic · Eddy current	· Electrostatic · Magnetic fluid

Source: C. H. Brown, Jr., and W. E. Schwinkendorf, *Technical Area Status Report for Chemical/Physical Treatment, Volume 1*, DOE/MWIP-8, Martin Marietta Energy Systems, Inc., August 1993.

7.5.2 Organic Liquids

Organic liquids include >1% organic content, and most, but not all, streams are pumpable. This category includes nonhalogenated organics, halogenated organics, and scintillation cocktails. Other contaminants include mercury and trace amounts of other toxic

metals. Liquids generated by other treatment processes will include solvents used in decontamination or hazardous species leached from dry wastes.

These wastes are expected to contain suspended and dissolved solids and up to 99 wt % water. The primary waste input includes organic liquids, spent solvents, scintillation vials, PCBs, heavy oils, and organic sludges and slurries. The form of the waste will be varied, consisting of vials of liquid, laboratory packs containing liquid containers, and barrels of liquid, as well as oils and sludges containing solids in the form of grit, rags, gloves, and small equipment items.

In addition, organic liquids will come from the phase separation processes used to treat aqueous waste. Organic solvents used in decontamination processes will also be sent to this treatment line. One of the greatest challenges to be met by this group of processes is the condensate from the thermal desorption of soils or sludges contaminated with mercury, PCBs, and volatile organic compounds (VOCs). The PCBs and VOCs must be separated from the mercury and water prior to shipment to the TSCA incinerator.

7.5.3 Debris

Debris is characterized as construction or remediation wastes having physical dimensions over 60 mm. These wastes will be excluded as RCRA hazardous if they are contaminated only with listed hazards. Characteristically hazardous debris will have to be treated as any other characteristically hazardous waste. Part of the strategy for debris will be to include physical pretreatments that reduce the volume of debris requiring treatment.

7.6 TREATABILITY STUDIES APPROACH

A majority of the DDT&E efforts will focus on the development and performance of treatability studies. The treatability studies span the gap between the understanding of the waste characteristics and the pilot-scale demonstrations. These bench-scale or laboratory-scale studies look at comparatively small volumes of waste to test for the individual parameters of a treatment technology. The general purpose of these studies is to determine whether or not the technology concept is feasible for or applicable to the wastes tested. Due to the small volumes and relatively inexpensive equipment used, the bench-scale studies are utilized to test relatively large numbers of both performance and waste-composition variables.

In a few cases, the characterization data will be sufficient for treatability studies to proceed immediately. However, in most cases, a series of preliminary activities will be initiated first and the treatability studies begun after sufficient information exists to make them worthwhile. One of these preliminary activities will be a literature search. Included in this literature search will be these questions:

1. On what wastes has the technology already been used?
2. How successful was it?
3. What are the problematic constituents for the process?
4. Are there vendors with the capability to run treatability studies and/or pilot-scale demonstrations?

Item #3, concerning problematic constituents, is critical to the efficient implementation of the data evaluation and characterization efforts (Sections 5 and 6).

With the inputs from the literature search, the data evaluation, and the characterization efforts, the treatability studies can proceed. However, individual studies will proceed when the knowledge base on the waste/technology pairing meets the criteria set in the project plan. Each project will assess the capabilities available on the ORR and at other DOE sites as well as those available through commercial vendors. With the known capabilities scoped, the best mix of locations can be derived for the treatability studies. Even in the event that the majority (if not all) of the studies are done by outside vendors on a particular technology, confirmatory studies will be performed locally, if possible, to provide assurance of the quality of the data from the vendors. In addition, the studies will be set up among several vendors (with some degree of overlap). This overlap will serve the same function as the internal confirmatory studies (reality check) with the added benefit of providing a means to compare the results of different technologies on different waste streams.

8. PILOT-SCALE DEMONSTRATION FACILITIES

Despite the amount of knowledge and insight that will be gained through the treatability studies and the characterization efforts, insufficient information will exist in most cases to properly design a treatment facility. Both treatability studies and waste stream characterization are static inquiries; only a small portion of the waste stream, which does not include all the variability of an entire process, is treated. Therefore, those dynamic attributes associated with the streams are still unknown. Additionally, the full impact of physical and chemical kinetics can be addressed only on a theoretical level at the treatability-study level. Also, a systems approach must be taken at an intermediate scale to assess the process from start to finish (which normally is not done at the treatability-study level). Until the effects of scaling up the process and the issue of looking at the whole process are addressed, too much uncertainty regarding the process effectiveness will exist for large treatment facilities. The best way to learn how a process will work with particular waste streams is to scale up from the bench or laboratory scale to the pilot scale. Pilot-scale demonstrations can and will provide the developers and designers with information that only these larger-scale studies can provide.

8.1 RATIONALE

To support the design of potential treatment options for the Appendix B wastes, pilot-scale demonstrations are planned for each of the technology areas described in Section 7 (thermal desorption, final waste forms, plus aqueous, organics, and decon). The selection of the process or processes within each of technologies as well as the waste streams to test in those processes will depend on results from the treatability studies. Even at this point, however, several general comments can be made.

First, because of the limited time and resources to apply to treatment development, waste streams for application to the pilot demonstration in each technology area will be chosen to provide the best possible spread of matrices and contaminant levels. This list of wastes may change as the characterization work progresses; however, a set or sets will be chosen, and the rationale for those selections will be documented.

Second, because of the variety of waste matrices and contaminants, more than one pilot per technology area is likely. Consider the case of thermal desorption. The divergent feeds (different soil types plus sludges) make it unlikely that a single process will emerge from the treatability studies for all applications.

Thirdly, given the schedule constraints placed on the DDT&E Program, failure of a single technology cannot be permitted to bring the program to a halt.

Finally, no pilot-scale demonstrations are currently planned for radionuclide removal. Several reasons exist for not pursuing this technology area beyond treatability studies, primary of which is the fact that it is not an LDR requirement and does not open truly viable options. The LDR on which Oak Ridge's FFCA is based does not require any action on the radioactive components in the mixed waste. Therefore, the program cannot justify a large expenditure of its limited resources to address the issue. This is especially true because treating the mixed waste to remove radionuclides so that the uranium activity is 35 pCi/g or less does not ensure MMES/DOE that a disposal option then becomes available.

The state of Tennessee has established the 32 or 35 pCi/g as an acceptable level for industrial wastes disposed of on-site. This level is based on two letters from DOE-ORO personnel.[9,10] The licensing of an on-site landfill is many years in the future at best. Since there are no hazardous waste landfills operating in the state, the possibility of off-site disposal is a long-term hope at best.

8.2 DEMONSTRATION MANAGEMENT

The current organization chart shows a demonstrations coordinator matrixed to the DDT&E coordinator. These personnel will have the responsibility for ensuring that the needed demonstrations are performed by the appropriate vendors, that the data/process requirements are clearly communicated, and that the work is performed within specified budgets. Each pilot will have a written statement of work to serve as the primary documentation of the study's requirements. A key technical contact will be appointed to each of the demonstration pilots. This will be the technical resource that monitors the performance of the vendors to provide reasonable assurance that MMES instructions are carried out. For these activities to occur, regular meetings will be held between the development personnel and those dealing directly with the pilots. Where possible, these will in fact be one and the same. Periodic reports from the vendor will be made to the demonstration coordinator and the DDT&E coordinator for inclusion in the program's quarterly reports. Letter reports will be written as required to distribute key information in "real time."

For more information on the proper conducting of demonstrations, please refer to ORNL/TM-11848, *Guidance Manual for Conducting Technology Demonstration Activities.*[8]

9. PROCESS ANALYSES

To fully assess a treatment process, the total system must be analyzed. This analysis on several different treatment trains will be a substantial task that is essential to provide the decision makers the full picture of the alternatives. The alternatives will be analyzed using the FLOW software developed by personnel in the Chemical Technology Division of the Oak Ridge National Laboratory. FLOW (which is available to all DOE installations) is similar to ASPEN and CHEMCAD in that it contains user-friendly interfaces and a library of process unit operations. These operations can be linked and their operating parameters varied to analyze and compare systems. With these data the effectiveness, risks, and life-cycle costs can be better estimated. FLOW provides rough-order-of-magnitude mass and energy balances. If more sophisticated analyses are required, FLOW can communicate with the more powerful ASPEN-PLUS program. The aim of the process analyses is not only to provide direct comparisons of different technologies but also to eliminate personal bias as the primary decision-making criteria.

As data from the treatability studies become available, they will be fed to the process analysis group. The data will assist this group in setting up and verifying its unit operations. At the same time, the work this group is performing for the national program (FLOW and ASPEN-PLUS) can be used to refine our models and to bring to light possible problems with or contradictions between the two efforts. When the pilot data are available, these too will be entered and the technologies assessed.

10. PERMITS

The DDT&E Program has more challenges than just technical ones. Regulatory limits on the quantity of waste that can be involved in treatment studies reduce the resources that MMES can potentially utilize to address the problems. Therefore, a strategy needs to evolve that can maximize our effectiveness without violating the regulations.

10.1 COORDINATION AMONG ACTIVITIES AND WITHIN THE SITES

Each site has a Treatability Study Exemption (TSE) from the state of Tennessee. The TSE permits the storage of 1000 kg of waste at each site at any one time and the processing of 250 kg/day at each site. To ensure compliance with the TSEs, each site has personnel who constantly monitor these activities and set restrictions on the studies. Thus, this program does not have to formulate or implement plans in this regard. However, the different projects will have to work together when these limits are reached at one or more of the sites. This will be accomplished on a case-by-case basis. The criteria used to evaluate these conflicts, when or if they arise, will include waste stream priority, complexity of study, and schedule impacts.

10.2 OVERALL PERMITTING STRATEGY

At this point, the need for an overall ORR permitting strategy is not clear. After the individual project plans are written and the schedule details are established, a more distinct picture will develop, and the need for an overall strategy can be examined. If more than the TSEs are required for the sites and it is not appropriate for an outside vendor to perform the work, three possible courses of action can be pursued: apply for a research, design, and development permit; apply for a Part B permit; or negotiate a new interpretation of "facility" under the TSE. Only the new interpretation of "facility" has the potential to be implemented in time to affect this program.

The TSE limitations require that no more than 1000 kg of waste be involved in treatability studies at any facility at a time and that no more than 250 kg be studied each day. If the Tennessee Department of Environment and Conservation (TDEC) could be convinced to change the interpretation of facility from each of the ORR sites to, for example, the project level of this program (e.g., thermal desorption), then each project would be limited to 1000 kg of waste, 250 kg/day. This request has never been made to TDEC; therefore, only estimates can be given of the time required to obtain concurrence and permission. Four to six months would be a reasonable guess for a routine negotiation. It is hoped, however, that the state would be amenable to expediting the process in the interest of seeing waste streams treated rather than just stored. If the new interpretation is granted, then this program and the sites would be responsible for developing a system to monitor the studies for compliance.

10.3 ASSESSMENT OF OFF-SITE FACILITIES' PERMITS

The assessment of the off-site facilities' permits will be an integral part of the readiness review that each potential vendor must undergo prior to the initiation of a subcontract for its services. Not only will their RCRA, TSCA, and RAD permits be examined, but the QA/QC and safety procedures will be reviewed for compliance with MMES, DOE, and EPA standards.

11. QUALITY ASSURANCE/QUALITY CONTROL

The DDT&E efforts associated with the Oak Ridge LDR FFCA depend on the quality of the work performed by many different groups of professionals both inside MMES and outside (other DOE sites and commercial vendors). To help ensure that the activities performed by these diverse groups are conducted in a planned and controlled manner as well as meet the standards necessary to satisfy MMES, DOE, and EPA requirements, this program shall write a QAPP. Performing quality work and implementing a QA program can only be achieved through a cooperative effort and a commitment to quality by all program personnel.

The QAPP will set forth the upper-level QA requirements for the major projects (thermal desorption, final waste forms, radionuclide removal, and data evaluation/characterization) making up this program. The QAPP will address many different QA aspects, including the following:

1. project category evaluation (to determine the theorized consequences of a lack of quality and thus to establish the level of QA required),
2. customer needs and requirements,
3. DQOs,
4. experimental work plans and procedures,
5. design and process control,
6. test control,
7. document control and configuration management, and
8. reporting.

Those involved in each of these major projects will write a PQAP for their specific areas. Since these areas cover a fairly wide range of subactivities, the QA requirements for these projects will vary. However, these variations will be permitted only after each project has assessed its required QA level against the standards set in the QAPP.

Special efforts will be made to ensure that the QAPP and the PQAPs do not contradict the QA plans of the divisions represented in the organization chart. These groups include ESWMO, Y-12 Development, Chemical Technology, and Engineering.

12. INTERACTIONS WITH THE NATIONAL LOW-LEVEL MIXED WASTE PROGRAM

Mixed waste is a problem throughout the DOE complex. The NLLMWP has been tasked to formulate a comprehensive and consistent approach to technology development. The NLLMWP has taken a two-pronged approach: the MWTP and the MWIP. The MWTP has developed a baseline for the treatment of mixed wastes based on commercially available technologies for generic DOE wastes. The MWIP has identified areas of need for this baseline and will plan and manage the national research, development, testing, and evaluation (RDDT&E) for DOE's Office of Waste Management. The technologies listed in Table 1 for possible integration of ORR's requirements into the MWIP include polymer encapsulation (in the FWF Project plan), as well as supercritical fluid extraction and steam cleaning (in Aqueous/Organics and Decontamination Project plan).

The MWIP has several other initiatives that should be followed as part of this effort. Three prime examples of these initiatives where synergism could be achieved are (1) "vitrify-to-delist-to-dispose," (2) characterization of "representative" DOE wastes, and (3) mercury removal. A brief description of each follows.

One of the major concerns of any treatment scheme is whether or not the treated material can be disposed of rather than stored in perpetuity. For RCRA wastes considered to be characteristic, testing can be performed to verify that the characteristic hazard has been treated successfully. For listed wastes, the process of delisting (certifying that the contaminants of concern are no longer of concern or are in a form that is no longer a concern) must occur. DOE has never delisted a waste stream; therefore, no precedence exists after which to pattern a successful delisting effort. To break the necessary ground to delist a waste stream and eventually a process, several waste streams from throughout the DOE complex have been screened and chosen as candidate waste streams for direct vitrification. The plan is to characterize these wastes, run them through a well-thought-out set of vitrification runs, collect the requisite data on the glass, and submit the results to EPA for delisting. One of the waste streams chosen for this effort is the West End Treatment Sludge from the Y-12 Plant. Close communication and cooperation will be maintained to reap the maximum benefit from this effort.

The national program has as one of its objectives the construction of a series of prototype mixed waste treatment plants throughout the complex. To accomplish this objective, treatability and pilot-scale studies need to be performed. The problems associated with using prototype treatments to treat more than one waste type are compounded in that the wastes streams at the different sites are variable not only within themselves but from site to site even if they carry the same designation. To ensure that the processes they test are comparable, the MWIP has chosen 16 categories from among its waste categories to have surrogates developed. These surrogates will be used to test all technologies associated with the designated waste categories. Personnel at the K-25 Site will be leading the surrogate efforts. An understanding of the surrogate formulations will aid us in assessing the results of the national program's testing efforts. The categories that K-25 Site personnel have selected are shown in Fig. 4.

ORNL personnel are leading an MWIP initiative to assess the state of the art for mercury removal from solids, liquids, and gases. This type of literature search is an important starting point for efforts associated with the FFCA, especially for thermal desorption. Mercury will have to be removed from soils and sludges and then treated in the off-gas systems (either

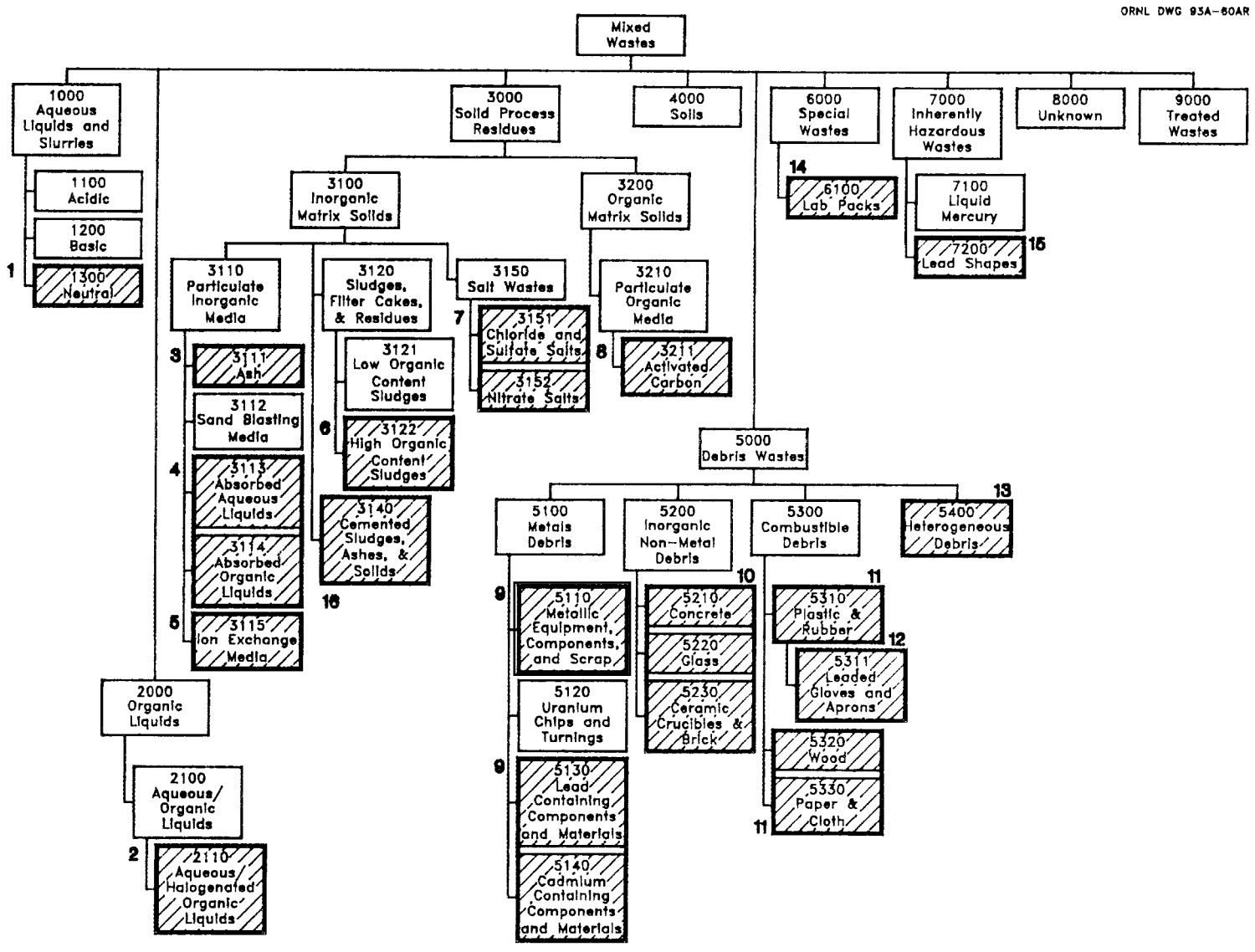

Fig. 4. Surrogate waste streams for MWIP.

in liquid or gaseous effluents). The leader of this task is a key team member in the thermal desorption project for the FFCA.

As other NLLMWP efforts come to light or if ways emerge in which the Oak Ridge work can advance the national program, these data will be exchanged. If warranted and if resources permit, someone will be assigned full-time to ensure that the synergisms occur.

The D&DID is another DOE-funded program with national scope with which the DDT&E Program will establish a working relationship. Although the exact areas of cooperation are not known at this point, this relationship should prove beneficial to both programs. The D&DID does not currently have any regulatory drivers, only economic ones. By seeking to fill technology gaps identified by the DDT&E Program, the D&DID obtains the regulatory driver of support for the ORR FFCA. Obviously, the DDT&E Program will benefit through access to the integrated demonstration's expertise and testing facilities.

13. SCHEDULES AND COSTS

In March 1995, DOE must submit to EPA the treatment plan for the wastes listed in Appendix B. To accomplish this task, the necessary data must have been obtained and analyzed so that informed, defendable decisions can be made. More directly stated, the characterization, treatability studies, and the pilot-scale demonstrations should be sufficiently advanced by the end of the first quarter of FY 1995 to begin the drafting of the treatment plan. These needs (striving to meet these needs) are the basis for the schedules and the costs shown (see Table 6 and Fig. 5). The DDT&E efforts will continue for several years beyond the first quarter of FY 1995 (into FY 1998) to improve our understanding of the waste streams and the treatment technologies for MWTF as well as to develop technologies for the non-MWTF waste streams.

In the following sections, the rationale and other assumptions that were used to generate the projected costs and schedules are delineated. The budgeted amounts are based on guidance from ESWMO rather than on those amounts deemed necessary to propose the best treatment options available.

13.1 THERMAL DESORPTION ASSUMPTIONS

Since the data evaluation effort is not complete, the full picture of how many waste streams are candidates for thermal desorption is not clear. However, based on the data available, 46 waste streams that are contaminated by mercury, PCB, or both have been identified for treatment in the MWTF. Added to this list are 14 non-MWTF waste streams. These 60 wastes will be sampled to varying degrees of thoroughness. Full characterization (as determined by the requirements in the project plans for Thermal Desorption and FWF) of four of these wastes will probably be necessary to scope the anticipated capability required of the process. To fully characterize a large waste stream, it has been assumed that 30 samples will be required and that the analysis for each sample will cost $5K. The number of samples and the projected cost per sample are based on discussions with the former K-25 Waste Management Division during its preparations to sample the Central Neutralization Facility (CNF) sludges in April 1993.

Six other wastes would be "fingerprinted" starting in FY 1994. This would involve a lesser number of samples with full analysis on each or the same number of samples with fewer analyses conducted. It was further assumed that the treatability studies and the pilots had the costs for analyzing the treated wastes and other effluents in their estimates. The rationale for the limited characterization of the remaining wastes is twofold: (1) budgets are limited, and (2) the waste streams chosen for full characterization will have the largest impact on the processes due to their volume and/or the concentrations of contaminants.

Treatability studies would begin in FY 1994 for the four waste streams that will have full characterization. The cost of a treatability study was assumed to be $150K. Additionally, for FY 1994, six other wastes would go through studies that do not entail the rigor of a treatability study. In FY 1995 through 1998, four or five streams each would be involved in treatability studies. Because these wastes will be smaller in volume, the scope of the studies will be smaller, and cost per study will be lower. Please note that a smaller number of wastes will go through treatability studies than will be characterized. With the limited budgets anticipated, the strategy is to bound the processes required using the largest volumes and the

Table 6. DDT&E budget requirements

	DDT&E budget requirements ($K) by fiscal year						
Item	**1993[a]**	**1994**	**1995**	**1996**	**1997**	**1998**	**Total**
Thermal desorption							
Characterization	0	786	750	500	400	400	2,836
Treatability studies	136	700	750	750	600	600	3,536
Fast-track pilot	370	112	0	0	0	0	482
Follow-on pilots[b]	0	0	600	700	700	400	2,400
Subtotal	506	1,598	2,100	1,950	1,700	1,400	**9,254**
Final waste forms							
Characterization	0	815	750	750	750	750	3,815
Treatability studies	879	2,780	1,000	800	800	550	809
Capital equipment	264	0	0	0	0	0	264
Pilot demos[b]	0	0	1,750	1,500	1,000	1,000	5,250
Subtotal	1,143	3,595	3,500	3,050	2,550	2,300	**16,138**
Aqueous/Organics/Decontamination technology development							
Characterization	0	87	500	700	500	500	2,287
Treatability studies	31	500	1,000	750	500	500	3,281
Pilot demos	0	0	0	750	850	900	2,500
Subtotal	31	587	1,500	2,200	1,850	1,900	**8,068**
Data investigation							
Evaluate waste data	725	886	50	50	50	50	1,811
Characterization support	50	470	500	400	400	300	2,120
Subtotal	775	1,356	550	450	450	350	**3,934**
Program management	500	800	800	800	600	500	**4,000**
National program interface	50	50	50	50	50	50	**300**
Total	**3,005**	**7,986**	**8,500**	**8,500**	**7,200**	**6,500**	**41,691**

[a]Amounts shown for FY 1993 include projected expenditures as well as those monies contractually committed.

[b]Capital and expense dollars.

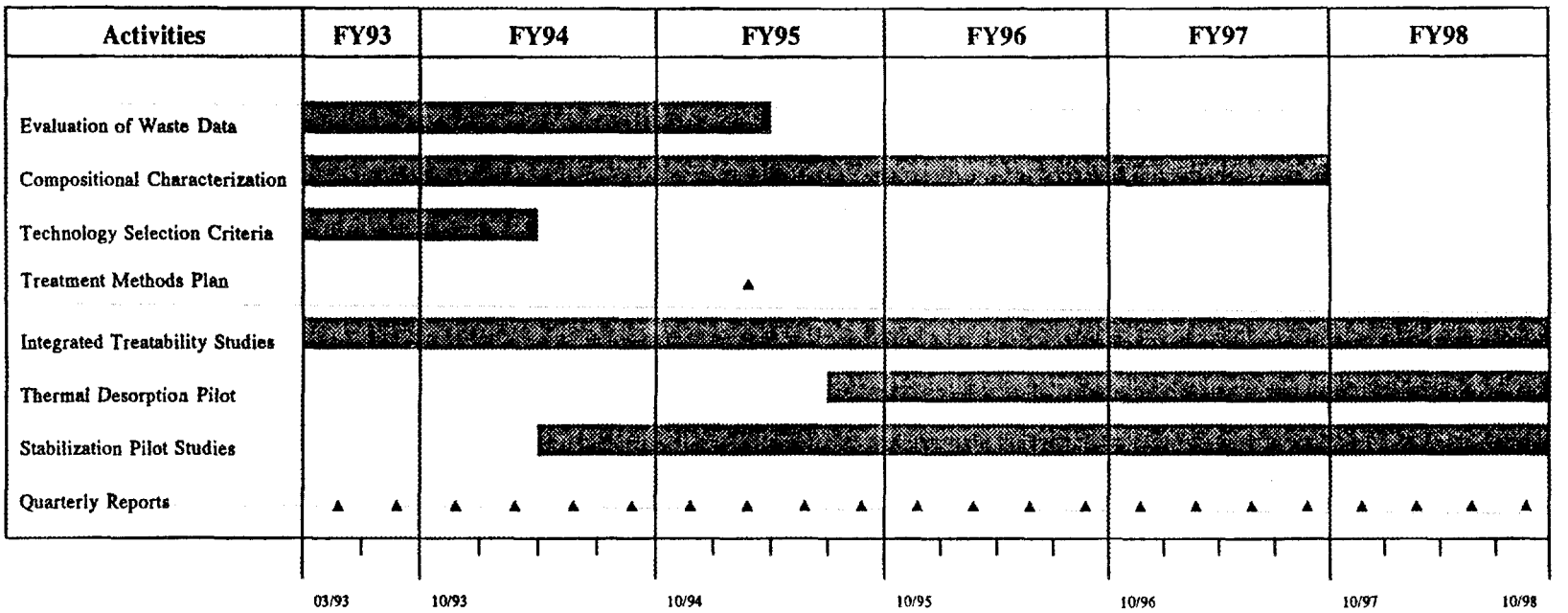

Fig. 5. FFCA treatability study/technology development schedule.

most-contaminated wastes. The characterization efforts will attempt to ensure that the heterogeneity of the wastes is accounted for prior to treatment.

The fast-track pilot began its efforts in FY 1993 and will continue into FY 1995. This would be the largest and most ambitious of the pilots for the Thermal Desorption Project. Several different vendors would be involved with treatability studies initially. These studies would require 6 months to complete. A subset of those that performed treatability studies will satisfy the acceptance criteria to be considered for actual pilot operations. Some characterization would be done by the vendors to confirm the data supplied to them in the statement of work and to determine whether the treated wastes meet the performance criteria. It was assumed that four vendors would perform the treatability studies and that the studies would cost MMES $50K per month per vendor. The final assumption made for this pilot was that only two vendors would move on to the pilot scale and would cost 100K per month per vendor for 9 months.

A series of three follow-on pilots would commence in FY 1995 and continue through FY 1997 (one each in FY 1995, FY 1996, and FY 1997). These pilots would examine those wastes that might require a sufficiently different set of parameters (handling and operating) to justify the costs as well as to examine the off-gas and effluents treatments at a larger scale.

13.2 FINAL WASTE FORMS ASSUMPTIONS

To account for the wastes that are candidates for direct stabilization/solidification and the secondary wastes from the MWTF that will require treatment prior to disposal, the assumption was made that 75 wastes must be characterized. Of these 75, only 4 would receive full characterization in FY 1994 and 10 would be fingerprinted, because of funding restrictions. The same cost assumptions used in the preceding thermal desorption section were applied here.

Treatability studies would start in FY 1994 and continue through FY 1998. The initial work in FY 1994 would consist of performing literature studies, formulating experimental matrices, preparing MMES laboratory space (total of $500K), and getting subcontractors on board (200K). The subcontractors would perform the initial treatability studies, while MMES could prepare its facilities and would provide expertise in handling organics, for example. The capability to support the FFCA and those processes put in place to do the actual treatment in the future are the driver for the MMES laboratory facilities. The vendor treatability studies would be completed in FY 1995, and in-house treatability would commence in mid–FY 1994.

Pilot work would not begin until FY 1995. Each pilot has an assumed cost of approximately 1000K. This is based on discussions with Catholic University/Duratek, which currently have a contract with MMES to do the first vitrification treatability studies. It was estimated that a total of five pilot-scale demonstrations will be required to cover the range of treatment options and the scope of the wastes to be treated. Some of these pilots will cost much less than the $1000K estimated, while some could cost up to $2000K. Thus the estimate used will be an average for the five pilots. Capital equipment purchases will be minimized due to the limited funding in FY 1995 through FY 1998. This may severely hamper MMES' ability to find subcontractors to perform these pilots, particularly in the area of ceramics and vitrification. If this is so, the program will be forced to utilize grout, with its increased life-cycle costs, for almost all applications.

13.3 AQUEOUS/ORGANICS/DECONTAMINATION TECHNOLOGY DEVELOPMENT ASSUMPTIONS

These are the technologies required to treat aqueous and organics wastes as well as debris (surface decontamination). From a characterization standpoint, these waste streams may be the least understood. Despite this shortcoming, the current budgets will not permit characterization to begin until FY 1994. The characterization that will be performed will be used to support the treatability studies with limited data (5 wastes in FY 1994, 25 to 28 in FY 1995, 40 in FY 1996, with 25 each in FY 1997 and FY 1998). These limited data will permit the treatability studies to establish a foundation for a development program to be referenced in the treatment plan. The treatability studies needed will be formulated in skeletal form in FY 1994 after the data evaluation effort has provided sufficient information. The pilot demonstrations for the treatment processes to be designated in the treatment plan will start in FY 1996 on a reduced scale.

13.4 DATA INVESTIGATION ASSUMPTIONS

Since the data evaluation is the critical path for this program, during the last 6 months of FY 1993 and the first 7 months of FY 1995, seven persons would be dedicated to the effort. A majority of the work will be performed by subcontractors. After the initial effort, the database would require upkeep, which should be a quarter of a full-time equivalent (FTE).

The item "characterization support" from Table 6 includes an FTE to coordinate all the characterization efforts for the DDT&E Program and the costs of sampling the wastes.

13.5 OTHER ASSUMPTIONS

The management of the DDT&E Program will require that the DDT&E coordinator be assigned to this function full-time. In addition, the program management estimates include the services of a QA specialist(s) to administer the QAPP.

The ongoing efforts associated with the NLLMWP will be monitored as practicable within the budgets available to attempt to ensure that duplication of work is minimized and that key data are communicated in both directions. This would require someone working these issues full-time under optimal circumstances. However, funding for only one quarter of an FTE is available.

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APPENDIX A. DATA SUMMARY

APPENDIX A. DATA SUMMARY

The tables that follow contain summaries by site and summary data for the entire ORR for the Land Disposal Restricted mixed wastes that appeared in Appendix B of the FFCA. The amounts shown here will change as more detailed information is acquired in the Data Evaluation Project.

Table A.1. Summary of K-25 Site Land Disposal Restricted mixed waste without identified treatment technologies

Waste handling	Waste group	Annual generation (kg)	Storage (kg)	EPA code
1000 Aqueous liquids	1100	28,315	142,639	D001, 2, 7, 8, 9
	1200	4,389	27,085	D002
	1900	159	150	D001, 2, 3, 5, 6
	1900 (Hg)	208	830	D002, 7, 9; F006
2000 Organic liquids	2100	18,475	76,928	D0MX; F001, 2, 3
	2200	28	7,691	D001
	2900	203	33	D0MX; U160
3000 Solid process residues	3111	50,678	116,561	D008; F001, 2, 3
	3120	48,541	36,515,639	D006, 7, 8; F001, 2, 3, 6
	3120 (PCB)	41,885	181,106	F001, 2, 3, 6
	3160	54	68	D001
	3190	19,779	127,301	D0MX; F0MX; P0MX; U0MX
	3190 (Hg)	0	31,857	D001, 2, 3, 4, 5, 6, 7, 8, 9, 11
	3211	156	25,284	D0MX; F001, 2, 3; MX; U0MX
	3230 (Hg)	10,015	55,291	D001, 7, 8, 9
	3240	11,827	1,281	D001; F001, 2, 3, 5
	3290	7,162	31,288	D001, 18-43; F001, 2, 3, 4, 5; P0MX; U0MX
4000 Soils	4200 (Hg)	388	250,103	D009; U151

Table A.1 (continued)

Waste handling	Waste group	Annual generation (kg)	Storage (kg)	EPA code
5000 Debris wastes	5110	0	0	D008, 9
	5130	6,953	112,524	D008
	5140	47	140	D006
	5190	0	2,455	D007, 8, 9
	5220	0	0	D006, 9
	5290	0	0	D0MX; F0MX; P0MX; U0MX
	5330	18,614	20,432	D001, 2, 4, 6, 7, 8, 9, 10, 18; F001, 6
	5420 (PCB)	37,550	94,675	F001, 2, 3
	5490	12,489	19,144	D001, 6, 7, 9; MX; F001, 2, 3, 5, 6, 7
	5490 (PCB)	10,447	10,447	F001, 2, 3
6000 Special wastes	6110	5,123	3,000	D001, 3, 8, 18-43; F003; MX; U223, 228; MX; P0MX
	6120	2,153	864	D001, 3; MX; U134
	6130	618	221	D001, 2, 3, 6, 8; MX; P0MX; U0MX
	6200	11	1	D001, 2, 3
	6300	1	0	D003
	6400	1,097	601	D001, 2, 3, 18; U043, 115
7000 Inherently hazardous wastes	7200	742	2,318	D009; U151
	7430	492	451	D002, 3, 6, 7, 8, 9
Total		338,599	37,858,408	

Table A.2. Summary of Y-12 Plant Land Disposal Restricted mixed waste without identified treatment technologies

Waste handling	Waste group	Annual generation (kg)	Storage (kg)	EPA code
1000 Aqueous liquids	1100	7,170	3,315	D001, 2, 6, 7
	1200	3,671	207	D002, 3
	1900	6,544	7,570	D001, 6, 7, 8, 9, 18; F002; P050, 051; U060, 080
	1900 (PCB)	0	4,721	D002
	1900 (Hg)	500	0	D008, 9
2000 Organic liquids	2100	3,510	0	D008, 17, 18, 35; F003
	2100 (PCB)	3,100	0	D035
	2200	10,519	168,582	D001, 18, 35
	2300	36,627	0	U226, 236
	2300 (PCB)	6,550	0	F001, 2
	2900	2,010	414	D001, 35; F001, 2, 3; U236
	2900 (PCB)	388	8,681	D004, 6, 7, 8, 35; F001, 2, 3
	2900 (PCB/Hg)	0	113	D009
3000 Solid process residues	3111	1,433	0	D002; F002
	3113	1,877	651,462	D018, 35; F001, 2
	3113 (PCB)	0	10,626	D001, 18, 35, 39, 40; F001, 2; U226
	3113 (Hg)	0	207	D009
	3120	562,137	7,672,773	D002, 8; F001, 2, 6
	3120 (Hg)	501	0	D008, 9
	3190	2,756	26,482	D002, 3; F006
	3190 (PCB)	100	0	F006
	3190 (Hg)	0	1,035	D008, 9; F002
	3190 (PCB/Hg)	5,502	3,985	D004, 5, 9; F002
	3210	69,974	0	F006
	3212	0	32,164	
	3240	10,114	0	D018, 35, 43; F001, 6
	3240 (PCB)	100	0	F001

Table A.2 (continued)

Waste handling	Waste group	Annual generation (kg)	Storage (kg)	EPA code
3000 Solid process residues (continued)	3290	2,380	18,723	D001; F002, 3, 6
	3290 (PCB)	100	18,400	D001, 2, 4, 6, 7, 8, 11, 18, 27; F001, 5, 6
	3290 (PCB/Hg)	0	455	D009
4000 Soils	4100	50	1,036	F001
	4100 (PCB)	0	6,892,360	F001
	4200	4,220	1,277,400	D006, 8; F006
	4200 (Hg)	350	1,386,589	D009
	4300	2,500	622	D006, 7, 39
	4300 (Hg)	0	622	D009
	4500 (PCB/Hg)	0	1,217	D006, 9
	4600	0	5,411	D008; F001
	4700	0	6,838	F001
5000 Debris wastes	5110	0	113	D008
	5110 (PCB)	0	705	D018, 35
	5130	0	254,411	D008
	5140	0	1,781	D004, 6, 8
	5190	18	1,976	D004, 6, 8
	5190 (PCB/Hg)	0	114	D009
	5190 (Hg)	270	207	D009
	5210	0	277,886	D006
	5220	0	1,035	D008; U188
	5220 (PCB)	0	114	D018
	5220 (Hg)	0	19,368	D009
	5220 (PCB/Hg)	0	457	D009
	5290	0	1,336	D005, 8
	5290 (Hg)	0	10	D009
	5310	350	1,916	D008, 18
	5320	0	4,014	D008; F001

Table A.2 (continued)

Waste handling	Waste group	Annual generation (kg)	Storage (kg)	EPA code
5000 Debris wastes (continued)	5330	834	13,636	D009
	5330 (PCB)	0	10,315	D001, 7, 35, 37, 39; F001, 2, 3
	5330 (Hg)	0	200	D007, 9; F001
	5330 (PCB/Hg)	0	768	D009
	5390	0	4,327	D018; F001, 2, 6
	5390 (PCB)	0	723	F002
	5390 (Hg)	0	300	D009
	5390 (PCB/Hg)	0	168	D009
	5410	550	8,915	D007; F001, 6
	5410 (PCB)	70	787	D018, 43; F001, 2, 3
	5420	2,688	300	D001, 2, 7, 8, 35; F001, 2
	5420 (PCB)	1,350	0	D035; F001, 2
	5490	2,250	13,849	F001
	5490 (Hg)	0	3,219	D008, 9; F001
6000 Special wastes	6110	0	414	U158
	6130	0.33	0	D008
	6190	145	11,799	D011; F001; U0MX
	6190 (Hg)	0	100	D008, 9
	6200	251	0	D003
	6200 (PCB)	0	1	D003
7000 Inherently hazardous wastes	7200	16,924	0	D008
	7210	0	2,365	D008
	7410	500	207	D008
	7420	0	1,242	D006
	7430 (Hg)	50	621	D002, 9
Total		770,933	18,841,709	

Table A.3. Summary of ORNL Land Disposal Restricted mixed waste without identified treatment technologies

Waste handling	Waste group	Annual generation (kg)	Storage (kg)	EPA code
1000 Aqueous liquids	1100	0	3,455	D001-11; F003; U134
	1200	0	155	D001, 2, 3
	1900	24,464	1,125	D001-11
	1900 (Hg)	0	644	D001, 4, 6, 7, 8, 10, 11
2000 Organic liquids	2100	0	2,755	D001, 2, 3, 9, 21; F002, 3, 5
	2190	0	377	D007
	2200	0	26	F001, 2; D007, 10, 19, 39
	2200 (Hg)	0	247	F001, 2; D001
	2300	0	4,927	D001, 2, 3, 6, 10, 11, 18, 19; F002, 3, 5, 27; U151
	2330	0	1	F003, 5
	2900	3,828	740	F001-5; D001-10, 17-43; U080
	2900 (Hg)	0	2,623	D001, 4, 5, 6, 7, 8, 10; F002, 3, 5
3000 Solid process residues	3120	0	7,132	D004, 5, 6, 7, 8, 10, 11, 18, 21, 27, 29, 40
	3120 (Hg)	0	152	D008, 10
	3120 (TRU)	110,600	2,612,200	D0MX
	3130	0	151	D008, 10
	3160	0	43	D001, 2, 3, 7, 8, 11
	3190	3,828	3,195	D001, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11; F003
	3190 (PCB)	0	18	D039
	3190 (Hg)	0	1,909	D006, 7, 8, 10
	3210	0	208	D001
	3211	0	621	D006; F003
	3212	0	6	F003
	3219	0	7	D001
	3230	0	414	F001
	3230 (Hg)	0	207	F001
	3240	0	2,434	D001, 7, 11, 18, 22; F003, 5; U002

Table A.3 (continued)

Waste handling	Waste group	Annual generation (kg)	Storage (kg)	EPA code
3000 Solid process residues (continued)	3290	0	1,001	D001, 3, 39, 43; F001, 3; U022, 80, 165
	3290 (Hg)	0	209	D006, 40; F001
4000 Soils	4100	0	4	F002, 3
	4200	0	115	D005, 7, 8, 9
	4200 (Hg)	0	0.3	D006
	4300	0	320	D004, 5, 6, 7, 8, 10
5000 Debris wastes	5110	0	210	D005, 7, 9
	5130	0	2,694	D004, 5, 6, 7, 8, 9, 10, 11
	5130 (Hg)	0	769	D006, 7, 8
	5140	0	459	D006
	5190	0	191,812	D004, 7, 8, 11
	5220	0	7	D005, 7, 9
	5310	0	38	D005, 7
	5330	0	50	D001, 39; F003
	5350	0	136	D008
	5440	0	75	D001; F002
6000 Special wastes	6110	0	4,042	D001, 2, 18-39; F002-5, 27; P014; U0MX
	6110 (Hg)	0	36	D006, 7, 8; U107
	6120	0	24	D001, 2, 11; P014; U004, 12, 134, 154
	6130	0	670	D002; F003; P028, 29, 98, 106; U002, 12, 44, 50, 64, 80, 154, 165, 197
	6140	0	21,888	D001, 2, 8, 9; F001, 2, 3, 5; U002, 154, 220, 239
	6190	9,685	2	P029, 98, 106; U004, 80
	6200	0	2	D001, 2, 3
7000 Inherently hazardous wastes	7100	0	2,127	D001, 2, 5, 7, 8, 9, 11, 18, 31; U151
	7300	0	0.2	D001; P015
	7410	0	208	D008
Total		152,405	2,374,470	

Table A.4. Summary of ORR Land Disposal Restricted mixed waste without identified treatment technologies

Waste group	ORNL		Y-12 Plant		K-25 Site	
	Annual generation (kg)	Storage (kg)	Annual generation (kg)	Storage (kg)	Annual generation (kg)	Storage (kg)
1000	24,464	5,379	17,885	15,813	33,071	170,704
2000	3,828	11,696	62,704	177,790	18,706	84,652
3000	114,428	2,131,707	656,974	8,436,312	190,097	37,085,676
4000	0	439	7,120	9,579,215	388	250,103
5000	0	196,250	8,380	622,950	86,100	259,817
6000	9,685	26,664	396	12,314	9,003	4,687
7000	0	2,335	17,474	4,435	1,234	2,769
Total	**152,405**	**2,374,470**	**770,933**	**18,848,829**	**338,599**	**37,858,408**

APPENDIX B. MIXED WASTE FEED STREAM DATA FOR MWTF

Table B.1. Mixed waste feed stream data for MWTF

Waste Description	Waste Type	Location	Current Inventory (cu ft)	Annual Generation (cu ft)	Major Contaminant	Form
WM @ Y-12						
West Tank Farm Sludge	Mixed	F7,F8,F9	241,000	16,710	U, Cr, Ni, Pb, Zn	Drums
CPCF Metal Sludge	Mixed	K-25	14,781		U, Cr, Ni, Pb, Zn	Drums
Oil Pond Soil	Mixed	9720-60	81,000	NA*	U, Cr, Pb, PCB	Bulk
Oil Land Farm Soil	Mixed	Tent Covers	16,200	NA	U, Be, PCB, Solvents	Bulk
Oil seep sediments	Mixed	Tent Covers	5,400	NA	U, PCB, Organics	Bulk
Storm Sewer Mixed Sediment	Mixed	ST-5 @ Y-12	6,750	NA	U, Hg, PCB	B-25
E.Chestnut Ridge Waste Pile	Mixed	Y-12	58,210	NA	U, Hg, Pb, Cd	Bulk
Civic Center Soils	Non-RCRA	Y-12	135,000	NA	Hg	Bulk
Demolition Waste	Hg cont.	Y-12	2,000	NA	Hg	Bulk/Drums
SEG, Inc., Ash	LLW	Y-12	472	1,416	U	Drum
Noncomb. LLW	LLW	Y-12	3,584	10,740	U	B-25/ Bulk
Y-12 WM Sub-Total			564,397	28,866		
ER @ Y-12 PLANT						
Wastes processed through Central Plant						
Beta-4 Security Pits	Mixed	Y-12	1,300,990		U, Organics, Acids	
Building 9418-3 Uranium Vault	Mixed	Y-12	24,868		U oxide, Solvents	
Z-OIL Contaminated Area	Mixed	Y-12	536,233		U, PCB, Mineral oil, Hg	
Salvage Yard/Scrap Metal Stor and Drum DEH	Mixed	Y-12	305,909		U, Oils, Solvents	
BLD. 9201-2 Transformer and Capacitor Storage	Mixed	Y-12	235,566		U, PCB, Oils, Hg	
TANK 2063-U	Mixed	Y-12	45,250		U, Oils, Solvents	
TANK 2064-U	Mixed	Y-12	4,246		Be, WW	
TANK 2104-U	Mixed	Y-12	14,146		U, Hg, Metal hydroxide brine	
TANK 2116-U	Mixed	Y-12	4,352		U, Th, HNO3, Solvents	
TANK 5 OF 9720-22	Mixed	Y-12	8,886		U, Oils, Solvents	
TANK (BLD. 9202)	Mixed	Y-12	2,708		U, Be, Organics	
Laundary Sump	Mixed	Y-12	11,110		U, Solvents	
9202 East Pad	Mixed	Y-12	7,508		U, Misc. RCRA	
Bldg 9995 UST 2077-U,2079-U,2	Mixed	Y-12	7,758	NA	U, Organics	Bulk
Nitric Acid Pipeline	Mixed	Y-12	30,092	NA	U, Organics, Metals, HNO3	Bulk
MISC.	Mixed	Y-12	14,878	NA		Bulk
Y-12 Process Waste Sub-Total			2,554,500			Bulk
Field Operations						
Soil	Mixed	Y-12	7,255,146		U	
PPE/Trash	Mixed	Y-12	13,521			
Y-12 Field Operations Sub-Total			7,268,667			
W M @ OAK RIDGE K-25 SITE						
CNF Sludge	Mixed	K-25	25,240	8,542	U, Cr	Drum
TSCA Incinerator Ash	Mixed	K-25		883	U	Drum
TSCA Scrubber Blowdown	Mixed	K-25	7,350	3,676	U, PCB, Metals	Drum
Lab/Paint Sludge	Mixed	K-25	1,626	294	U, Solvents	Drum
Metal Shavings With Lead	Mixed	K-25	820	204	U, Pb	Drum
Laundry Sludge	Mixed	K-25	1,035	40	U	Drum
Fernald Treatment Waste	Mixed	K-25	483	166	U	Drum
Misc. Mixed Solids	Mixed	K-25	8,623	37	U	
Old Quarry	Mixed	K-25	6,476	NA	U, metals	Bulk

Table B.1 (continued)

Waste Description	Waste Type	Location	Current Inventory (cu ft)	Annual Generation (cu ft)	Major Contaminants	Form
K-25 WM Sub-Total			51,653	13,842		
E R @ K-25 SITE						
Waste processed through Cental Plant						
K-25/K-1007-P1 Holding Pond	Mixed	K-25	3,103	NA	U, Solvents, Acids, Bases	Bulk
K-25/K-1004 Area Lab drain	Mixed	K-25	3,843	NA	U, Solvents, Acids, Bases	Bulk
K-25/K-1420 Process Lines	Mixed	K-25	4,609	NA	U,PCB,Organics,Oils,Metals	Bulk
K-25/K-1413 Process Lines	Mixed	K-25	32,597	NA	U, Metals, Organics	Bulk
K-25/K-1413 Treatment Tank	Mixed	K-25	3,597	NA	U, Classified Waste	Bulk
K-25/SFO (Site Facility Opera	Mixed	K-25	66,020	NA		Bulk
MISC.	Mixed	K-25	22,481	NA		Bulk
K-25 Process Waste Sub-Total			136,250			
Field Operations						
Soil	Mixed	K-25	13,701			
Sludge	Mixed	K-25	923			
PCB Equipment	Mixed	K-25	7,696			
Metal	Mixed	K-25	2,100			
PPE/Trash	Mixed	K-25	7,443			
MISC.	Mixed	K-25	45,205			
K-25 Field Operations Sub-Total			77,068			
W M @ ORNL						
Misc. Operational Metals	Mixed	ORNL	700	100	U, metals, solvents	Drum
E R @ ORNL						
Wastes processed through Central Plant						
MISC.	Mixed	ORNL	827	NA	U, metals, solvents	Bulk
WAG 1/RA Early Action (2009-2	Mixed	ORNL	126,360		Misc. Rad, Hg	
ORNL Process Wastes Sub-Total		ORNL	127,187			
Field Operations						
Soil	Mixed	ORNL	228,634			
Sludge	Mixed	ORNL	102,060			
PPE/Trash	Mixed	ORNL	1,245			
ORNL Field Operations Sub-Total			331,939			
W M @ PORSTSMOUTH						
Spill Cleanup	Mixed	PORTS	2,019	577	U, metals	Bulk
Chromic Acid Closure Sludge	Mixed	PORTS	tbd	tbd	U, metals	
Metal Microfiltration Sludge	Mixed	PORTS	4,845	1,384	U, metals	Drum
Filter Table Solids	Mixed	PORTS	180	72	U	Drum
Floor Sweepings	Mixed	PORTS	1,254	242	U, metals	
Waste Decon. Solids	Mixed	PORTS	4,884	1,396	U, metals, solvents	
Fluorine Gen. Scrap & Debris	Mixed	PORTS	121	35	U, metals	
Chromic Acid Spill (soil)	Mixed	PORTS	2,004	58	U, metals	
Fluorine Gen. Sludge	Mixed	PORTS	125	36	U, metals	
GW T & S Tank Closure	RCRA	PORTS	TBD	TBD	Solvents	
Cleaning & Neut.Tank Sludges	Mixed	PORTS	172	49	U, solvents	

Table B.1 (continued)

Waste Description	Waste Type	Location	Current Inventory (cu ft)	Annual Generation (cu ft)	Major Contaminants	Form
Glass Beads	Mixed	PORTS	25		U, metals	
X-705A Incinerator Ash	Mixed	PORTS	>1	0	U, metals, solvents	
Silver Solder Slag	RCRA	PORTS	2	2	Metals	
Vapor Degreaser Sludge	Mixed	PORTS	59	17	U, solvents	
Metal Shavings & Scrap	Mixed	PORTS	644	185	U, metals	
Haz. Waste Unit Closure Waste	Mixed	PORTS	TBD	TBD	U, metals, solvents	
Rags, gloves, wipes, etc.	Mixed	PORTS	200	114	U, metals, solvents	
PPE & related debris from RFI	Mixed	PORTS	809	TBD	U, solvents	
RFI Related Soils	Mixed	PORTS	15,862	TBD	U, solvents	
Lead Dust/Debris, filters	RCRA	PORTS	146	33	Metals	
Bag Filters	Mixed	PORTS	TBD	TBD	U, organics	
Paint Solids & Sludges	RCRA	PORTS	355	102	Metals, organics	
Spent HEPA Filters	Mixed	PORTS	11	2	U, metals	
Cement Dust	Mixed	PORTS	207	110	U, metals	
X-701B Closure Solids	Mixed	PORTS	16,984	TBD	U, solvents	
Silver Solids	RCRA	PORTS	TBD	TBD	Metals	
Lead Solids	Mixed	PORTS	TBD	TBD	U, metals	
Chromium Cont. Solids	Mixed	PORTS	2,005	43	U, metals	
Filter Cloth & PPE	Mixed	PORTS	TBD	TBD	U, metals	
Cooling Tower Curtains	Mixed	PORTS	144	NA	U, metals	
Solvent Cont. Solids	Mixed	PORTS	423	259	U, solvents	
Waste Metal Turnings	Mixed	PORTS	287	4	U, metals	
Solid and Liquid Cleanup	Mixed	PORTS	TBD	NA	U, metals, solvents	
Ash (ASH-1)	Mixed	PORTS	TBD	TBD	TBD	
Solid & Liq. Cleanup(X-7725-2	Mixed	PORTS	280	NA	Multiple	
Mixed WAste Sludge (X-710)	Mixed	PORTS	172	TBD	U, solvents, metals	
Chromium Sludge Cont. Wastes	Mixed	PORTS	203	175	U, metals	
Mixed Waste Sludge	Mixed	PORTS	59	30	U, metals, solvents	
Mixed Soils (Raffinate Spill)	Mixed	PORTS	292	TBD	U, metals	
Arsenic Contaminated PPE	Mixed	PORTS	15	8	U, metals	
Contaminated Waste Metals	Mixed	PORTS	359	17	U, metals	
Spent Printing Solids	Mixed	PORTS	6	2	U, solvents	
Fuel Contaminated Solids	Mixed	PORTS	440	188	U, metals	
Lead Contaminated Soils	Mixed	PORTS	251	TBD	U, metals	
Solvent Cont. Soils (X-744Y)	Mixed	PORTS	14,859	TBD	U, solvents	
Well Cuttings (soil)	Mixed	PORTS	2,420	1,976	U, solvents	
PPE and Misc.	Mixed	PORTS	518	422	U, solvents	
Machine Grinding Sludge	Mixed	PORTS	18	5	U	
Absorbent Cloth	Mixed	PORTS	52,000	19,000	U, PCB	
701B Soils	Mixed	PORTS	10,800	TBD	U, PCB, solvents	
Sludge (X-6619)	Mixed	PORTS	5,900	800	U, PCB	
Floor Sweepings	Mixed	PORTS	4,000	0	U, PCB, metals	Drum
Floor Sweepings	Mixed	PORTS	600	0	U, PCB	
PORTS WM Sub-Total			146,959	22,391		
ER @ PORTSMOUTH						
Wastes processed through Central Plant						
X-710 Laboratory Facility	Mixed	PORTS	70,852		U, Ni, PCB, Met, Org, Cyanide	
X-744Y Rad Waste Storage Faci	Mixed	PORTS	20,732		Misc. Rad	
X-701B North Half Area	Mixed	PORTS	50,110			
X-230J5 W. Hold. Pond & Oil S	Mixed	PORTS	160,245		U, PCB, Oils, Hypochlorite	
X-326 Process Building	Mixed	PORTS	31,636		U,Tc,Cr+6,PCB,Oils,Solvents	
X-330 Process Building	Mixed	PORTS	32,125		U,Tc,Cr+6,PCB,Oils,Solvents	

Table B.1 (continued)

Waste Description	Waste Type	Location	Current Inventory (cu ft)	Annual Generation (cu ft)	Major Contaminants	Form
X-615 Abandoned Sanitary Sewa	Mixed	PORTS	42,252		U, PCB, Sylvex Herbicides	
Treatment Fac.	Mixed	PORTS				
X-230J6 N.E. Holding Pond and	Mixed	PORTS	35,823		U,Oils,PCB, Cr, Anhydrous F	
Secondary Oil C.	Mixed	PORTS				
X-622 Groundwater Treatment U	Mixed	PORTS	10,079			
X-623 Groundwater Treatment U	Mixed	PORTS	10,080	NA		
X-624 Groundwater Treatment U	Mixed	PORTS	10,080	NA		
MISC.	Mixed	PORTS	72,389	NA		
PORTS Process Sub-Total			546,403			
Field Operations						
Soil	Mixed	PORTS	10,791			
Debris	Mixed	PORTS	160			
Metal	Mixed	PORTS	44			
PPE/Trash	Mixed	PORTS	4,598			
PORTS Field Operations Sub-Total			15,593			
W M @ PADUCAH						
Nickel Stripper Sludge	Mixed	PAD	185	26	U, metals	Bulk
Misc. Mercury Bearing Wastes	Mixed	PAD	11	6	U, Hg	Bulk
Misc. Lead Bearing Wastes	Mixed	PAD	203	40	U, Lead	Bulk
Misc. Chromium Bearing Wastes	Mixed	PAD	248	40	U, Cr	
Misc. Solids with Heavy Metal	Mixed	PAD	513	11	U, meatls	
Dirt - LLW	Rad	PAD	87,675	2,000	U	
PCB Trash (metal, PPE, glass)	Mixed	PAD	23,036	6	U, PCB, metals	
PCB Debris (concrete, soils)	Mixed	PAD	47,937	5,900	U, PCB	
Misc. Metal Waste	Mixed	PAD	686	14	U, metals	
Paducah WM Sub-Total			160,494	8,043		
E R @ PADUCAH						
Wastes processed through Central Plant						
C-400 Technetium Storage Tank	Mixed	PAD	456		Tc, Cr	
C-746-T Inert Landfill	Mixed	PAD	2,253			
C-340 Hydraulic Systems	Mixed	PAD	3,218		U, Oils, PCB, Petroleum products	
C-7460 Classified Scrap Yard	Mixed	PAD	4,294			
Kellog Bld.	Mixed	PAD				
C-410-B, HF Neutralization Sl	Mixed	PAD	430		Lead, HF, Flyash	
North/South Div. Ditch, Outsi	Mixed	PAD	10,650		U, Tc, Solvents, PCB, Metals	
North/South Diversion Ditch,	Mixed	PAD	7,440		U, Tc, Solvents, PCB, Metals	
Security Fence	Mixed	PAD				
C-375-E5 Effluent Ditch	Mixed	PAD	3,064		U, PCB, Hydrocarbons, TCE, Cr+6	
Little Bayou Creek	Mixed	PAD	94,964		U, Tc, PCB, Solvents, Cr+6	
C-375-E3 Effluent Ditch	Mixed	PAD	7,973		U,PCB,Solvents,Cr+6,Hydrocarbon fuels	
C-340 PCB Spill Site	Mixed	PAD	656		U, Tc, Oils, PCB	
C-540-A PCB Spill Site	Mixed	PAD	3,809		U, Tc, Oils, PCB	
C-531 Switchyard	Mixed	PAD	57,819		s,PCB,Chlorinated solvents	
C-533 Switchyard	Mixed	PAD	92,717		U, Tc, PCB, Solvents	
C-633 Pumphouse & Cooling Tow	Mixed	PAD	415		U, Cr	
C-635 Pumphouse & Cooling Tow	Mixed	PAD	63,774		As,Cr+6,Zn,Pentachlorophenol	
C-747 Oil Landfarm	Mixed	PAD	1,370		U, PCB, Oils, Solvents	

Table B.1 (continued)

Waste Description	Waste Type	Location	Current Inventory (cu ft)	Annual Generation (cu ft)	Major Contaminants	Form
C-375-W7 Oil Skimmer Ditch	Mixed	PAD	10,041		U, PCB, No. 2 Fuel Oil	
Big Bayou CreekK	Mixed	PAD	126,025		U, PCB, Oils, Cr	
C-375-W9 Effluent Ditch	Mixed	PAD	4,090		Cr+6, No. 2 Fuel Oil	
C-728 Motor Cleaning Facility	Mixed	PAD	1,146		U,Oil,Mineral spirits,Grease,NaOH	
C-375-E2 Effluent Ditch	Mixed	PAD	7,959		U,PCB,Cr+6,Hydrocarbon Fuels,Solvents	
C-337A Vaporizer	Mixed	PAD	15,152		PCB, UF6	
C-535 Switchyard	Mixed	PAD	638		U, PCB, Solvents	
C-537 Switchyard	Mixed	PAD	1,001		U, PCB, Solvents	
C-637 Pumphouse & Cooling Tow	Mixed	PAD	126,857		U, As, Zn, Cr+6, Pentachlorophenol	
C-746-A Haz and Mixed Storage	Mixed	PAD	30,973			
C-616-E Sludge Lagoon	Mixed	PAD	820		U, Cr+3	
C-616-F Full Flow Lagoon	Mixed	PAD	1,221		U, Cr+3, Flyash	
C-746 TRU Storage Area	Mixed	PAD	186		U, Tc	
C-746-B PCB Waste Storage Are	Mixed	PAD	696		U, PCB	
C-616 Chromate Reduction Faci	Mixed	PAD	5,413		Cr, Acid, FeSO4,Ca(OH)2	
Concrete Rubble	Mixed	PAD	8,654		U, Tc, PCB, Solvents	
Plant Storm Sewer	Mixed	PAD	406,541		U, PCB, Solvents	
C-400 TO C-404 Undergrnd Tran	Mixed	PAD	8,156		U	
C-404 LL Radioactive Waste Bu	Mixed	PAD	650		U, Solvents	
MISC.	Mixed	PAD	6,322			
Paducah Process Waste Sub-Total			1,117,842			
Field Operations						
Soil	Mixed	PAD	7,325,407			
Debris	Mixed	PAD	461,093			
Sludge	Mixed	PAD	2,285,528			
PPE/Trash	Mixed	PAD	46,101			
MISC.	Mixed	PAD	11,514			
Paducah Field Operations Sub-Total			10,133,643			
Waste Management Total			924,203	73,242		
ER Process Wastes (ER to Plant) Total			4,482,182			
ER Field Operations Total			17,826,910			

APPENDIX C. SUMMARY OF PREVIOUS TREATABILITY STUDIES

APPENDIX C. SUMMARY OF PREVIOUS TREATABILITY STUDIES

Previous Thermal Desorption Studies on ORR Wastes

Pilot-scale technology demonstrations were performed to test the effectiveness of soil washing and thermal desorption on the removal of mercury and PCBs from Type I and Type II soils. The soil-washing process used sodium hypochlorite solutions in the presence of an ultrasonic vibrator to enhance mercury and PCB removal. The thermal desorption process heated contaminated soil to temperatures ranging from 200 to 430°C in a heated rotary dryer through which nitrogen carrier gas was passed. Treatment goals of 12 ppm mercury and 2 ppm PCBs in the treated soil were established.

Using thermal treatment, mercury levels were reduced to 23 ppm and therefore did not meet the 12-ppm treatment goal. PCB levels were reduced to <1 ppm in both soil types using thermal desorption. Soil washing resulted in ~80% removal of mercury and 70% removal of PCBs from contaminated soils but did not meet the treatment goals for either contaminant.

Previous Final Waste Forms Studies on ORR Wastes

The area of final forms is the latest addition to the RDDT&E efforts within the DOE complex as well as on the ORR. Therefore, no studies had been commissioned by MMES prior to the writing of this plan. In the future, the subject will receive a great deal of scrutiny and will enjoy much more emphasis.

RADIONUCLIDE REMOVAL AND SOIL WASHING

Many dry or semidry solids as thermal desorption residues or as direct feed will require radionuclide removal to meet the process treatment objective of <35 pCi/g of uranium source material per gram of waste so that the disposal option of either a sanitary (if RCRA constituents are destroyed or delisted) or a RCRA landfill is preserved. In addition, since it is known that there are other radionuclides in these waste categories, each technology's removal capability for these miscellaneous constituent shall be assessed, and performance objectives for the removal of radionuclides other than uranium shall be established.

Two different sets of drivers are involved when discussing radionuclide removal: waste management (WM) drivers and environmental restoration (ER) drivers. Those WM streams that will be processed in the MWTF central facility (as opposed to a transportable unit) will not be returned to their origins but will be prepared for ultimate disposal. On the other hand, ER soils will be returned to the ground since the plan for their treatment is through the use of transportable units that do not leave the area of contamination. What this means is that the technologies for the central facility and for the transportable units may or may not be the same. The technologies utilized in the transportable units must not destroy the beneficial characteristics of the soil. The central facility does not have such a consideration and in fact must consider other things such as the effects of the treatment on the final waste form.

Despite the fact that the goals of the central facility and the transportable units are not exactly the same, they will more than likely rely on the same types of technologies to accomplish their tasks: selective leaching and selective extraction. Selective leaching is a process or combination of processes in which specific species of concern are selectively

removed by chemical means. This is often referred to as soil washing. The selective nature of the process is achieved by adjusting the aqueous solution conditions and chemistry such that only the species of interest are made to enter solution as a stable complex in preparation for removal by various hydrometallurgical unit operations. Solution chemistry is closely controlled so that other unwanted components do not enter the solution. Selective extraction is a process or a series of processes which are used to preconcentrate or to completely remove species of interest from matrix materials such as soils or sludges. The applicability of such processes is a strong function of the species' properties such as density, chemical form, and distribution within the matrix, as well as (in some cases) its magnetic properties.

One overall assumption has been made by the architect-engineer that covers both of these waste stream types: that is, that any stream destined for radionuclide removal that has volatiles such as mercury and/or PCBs will be thermally desorbed first. Thermal desorption prior to radionuclide removal may have a deleterious effect on the leaching process. This assumption will be tested.

Previous Radionuclide Removal Studies on ORR Wastes

Treatability studies were performed on three of the subject mixed waste streams. These wastes included sludges, oil-solvent mixtures, and soils. Treatability studies were performed by multiple vendors for each waste type. Treatment objectives focused on removing either hazardous or radioactive constituents from the waste to allow for disposal. Treatment objectives established for each treatability study targeted uranium, beryllium, mercury, and PCBs for removal. Table C.1 summarizes the treatability studies, along with their performance date, scale, objective, and success.

Sludges

Treatability studies were performed on two basic sludge types for uranium removal. Type I sludges are primarily metal hydroxides, which contain uranium, oil, grease, and other organics from the physicochemical treatment of metal-bearing wastewater. Type II sludges are primarily calcium carbonates from the West End Treatment Facility clarification and biodenitrification process, which contain metal hydroxides (e.g., uranium) with only minimal quantities of oil, grease, and other organic constituents. Both sludge types contain ~40% solids. Treatability studies performed on these sludges using acid digestion and carbonate extraction are discussed in the following sections.

Acid Digestion

Bench-scale and pilot-plant testing was performed using an acid digestion process to remove uranium from Y-12 Plant sludges contaminated with both uranium and RCRA heavy metals. Effective segregation of the uranium and heavy metals would allow separate disposal of the respective hazardous and radioactive components.

The acid digestion process solubilizes uranium through the addition of hydrochloric acid and sodium hypochlorite at 80°C. Undissolved material is then filtered from the acid brine. Uranium is selectively removed from the acid brine using ion exchange, while other metals are precipitated from solution via lime and polymer addition. The process is conducted in batch mode to accommodate changes in waste stream characteristics.

Table C.1. Summary of completed treatability studies

Waste form	Treatability study	Treatment objective	Treatment results (pass/fail)	Scale	Date
Oil-solvent mixtures	Filtration	U—32 pCi/g (89 ppm) Be—0.5 ppm	P P	Pilot	03/92
	Acid extraction with phase separation	U—32 pCi/g (96 ppm) Be—0.5 ppm	P P	Bench	09/91
Soil	Soil washing with density separation	U—32 pCi/g (96 ppm) Hg—12 ppm PCB—2 ppm	P F P	Pilot	01/90
	Soil washing	Hg—12 ppm PCB—2 ppm	F F	Pilot	12/89
	Thermal desorption	Hg—12 ppm PCB—2 ppm	F P	Pilot	12/89
Sludge	Acid digestion	U—32 pCi/g (96 ppm)	F	Pilot	03/92
	Carbonate extraction	U—32 pCi/g (96 ppm)	F	Pilot	03/92

The treatment objective of 32 pCi/g (96 ppm) was not reached using this approach, although the treatment process did reach over 93% of the uranium from the feed sludge. Only Type II sludge was investigated at the pilot-scale level using the process.

Carbonate Extraction

Bench-scale and pilot-scale carbonate extraction treatability tests were performed to remove uranium from inorganic sludges contaminated with both uranium and RCRA heavy metals. A treatment goal of 32 pCi/g (96 ppm) uranium in the treated sludge was established.

This process included several unit processes conducted in the following order. Feed sludges were ground to reduce particle size and increase surface area. Leaching was then performed using carbonate/bicarbonate solutions and potassium permanganate. Solids and liquids were separated; then the solids were repulsed, and the leaching process was repeated. The leaching process was repeated three times before the solids were considered ready for disposal.

The treatment objective of 32 pCi/g (96 ppm) was not reached, although the treatment process did remove over 97% of the uranium from the Type I feed sludge and 82% of uranium from the Type II feed sludge.

Oil-Solvent Mixtures

Oil-solvent mixtures containing enriched uranium and beryllium in excess of the TSCA incinerator acceptance criteria levels were processed using a filtration technique and an acid-extraction phase-separation technique. Treatment goals of 32 pCi/g uranium and 0.5 ppm beryllium in the waste oil were established for both techniques. These processes are discussed in the following sections.

Filtration

Bench-scale and pilot-scale treatability tests were performed to remove uranium and beryllium from oil-solvent mixtures using two filtration alternatives. The first alternative involved the addition of methanol to reduce feed viscosity, followed by rough screening using a 100-mesh screen, filtration using a 270-mesh screen and a 10-micron cartridge filter, and, finally, effluent polishing using a 0.2-micron cartridge filter. The second alternative was conducted in a similar manner, except a plate-frame, fabric pressure filter with diatomaceous earth was used instead of the 270-mesh screen and cartridge filter.

Alternative 2 produced the best uranium and beryllium removal results. However, the treatment standard of 32 pCi/g (89 ppm) uranium was achieved for only one waste sample. The beryllium treatment standard of <0.5 ppm was reached for three of four samples, although the maximum initial beryllium concentration for any sample was 0.8 ppm.

Acid Extraction with Phase Separation

Bench-scale treatability tests were performed to measure the effectiveness of removing uranium and beryllium from oil-solvent mixtures using a combination of unit processes, including acid extraction, solvent extraction, and filtration.

Acid extraction was accomplished by solubilizing and separating the uranium and beryllium from the oil-solvent mixture using 6 *N* hydrochloric acid. Soltrol-100 was added to

the acid mixture to facilitate phase separation. The oil and acid phases were backwashed and recycled to minimize waste stream volume. Undissolved solids were filtered from the oil and acid phases using a microfilter. The process was repeated until the desired results were achieved.

Treated waste oil concentrations contained ~3 ppm uranium and 0.1 ppm beryllium. These concentrations were well below the established treatment goals of 89 ppm uranium and 0.5 ppm beryllium. However, for each pound of oil treated, 0.56 to 0.66 pounds of waste acid and waste solids were produced that would require further treatment.

Soils

Treatability studies have been performed on two soil types. Type I consisted of storm sewer sediments contaminated with uranium, mercury, and PCBs. Type II consisted of oil landfarm soil contaminated with uranium and PCBs.

Soil washing with density separation

Pilot-scale technology demonstrations were performed to test the effectiveness of soil washing and density separation to remove uranium, mercury, and PCBs from Type I and Type II soils. The soil-washing process tested was an enhanced chemical extraction process which uses compounds such as sodium hypochlorite, acetic acid, and surfactants in an attrition scrubbing environment to promote contact between the extractant and soil by creating significant particle-to- particle interactions. Soils were sieved and contaminants separated according to their differences in density. Treatment goals of 32 pCi/g (96 ppm) uranium, 12 ppm mercury, and 2 ppm PCBs in the treated soil were established.

Uranium levels were reduced to 32 ppm in Type I soils and to 63 ppm in Type II soils, both below the 96-ppm treatment goal. PCB levels were reduced to below the 2-ppm treatment goal for both soil types. Mercury content in the mercury sediments was reduced from 840 ppm to 100 ppm, which did not meet the treatment goal of 12 ppm mercury.

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