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**Mixed Waste Focus Area
Technical Baseline Report
Volume 1**

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Mixed Waste Focus Area Technical Baseline Report

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ABSTRACT

The Department of Energy (DOE) established the Mixed Waste Characterization, Treatment, and Disposal Focus Area (MWFA) to develop and facilitate implementation of technologies required to meet the Department's commitments for treatment of mixed low-level and transuranic wastes. The mission of the MWFA is to provide acceptable technologies, developed in partnership with end-users, stakeholders, tribal governments, and regulators, that enable implementation of mixed waste treatment systems. To accomplish this mission, a technical baseline was established in 1996 that forms the basis for determining which technology development activities will be supported by the MWFA. This technical baseline is revised on an annual basis to reflect changes in the DOE Mixed Waste Management strategies, changes in the MWFA technical baseline development process, and MWFA accomplishments. This report presents the first revision to the technical baseline and the resulting prioritized list of deficiencies that the MWFA will address. This report also reflects a higher level of stakeholder involvement in the prioritization of the deficiencies. This document summarizes the data and the assumptions upon which this work was based, as well as information concerning the DOE Office of Environmental Management (EM) mixed waste technology development needs.

SUMMARY

The Assistant Secretary for the Office of Environmental Management (EM) at the United States Department of Energy (DOE) initiated a new approach in August of 1993 to environmental research and technology development. The key feature of this new approach included establishment of five "focus areas" and three "crosscutting" technology programs, which address issues that are common to multiple focus areas. The six focus areas include the Subsurface Contaminants; Mixed Waste Characterization, Treatment, and Disposal; High-Level Waste Tank Remediation; Decontamination and Decommissioning; Plutonium; and Spent Fuels Focus Areas. The three crosscutting technologies programs include Characterization, Monitoring, and Sensor Technology; Efficient Separations and Processing; and Robotics Technology Development Programs. In addition, the Industrial Programs Group has been established to support all focus areas and crosscutting programs. The major thrust of the new approach is aggressive teaming with the customers within EM. This teaming approach is used to identify, develop, and implement needed technologies such that the major environmental management problems can be addressed, while cost-effectively expending the funding resources.

The Mixed Waste Characterization, Treatment, and Disposal Focus Area (MWFA) was formed to develop and facilitate implementation of technologies required to meet the Department's commitments for characterization, treatment, and disposal of mixed low-level and transuranic wastes. The MWFA is managed by the Department of Energy Idaho Operations Office (DOE-ID) and supported by Lockheed Martin Idaho Technologies Company (LMITCO).

The mission of the MWFA is to provide acceptable technologies that enable implementation of mixed waste treatment systems developed in partnership with end-users, stakeholders, tribal governments and regulators. These treatment systems include any necessary associated steps such as waste characterization, pretreatment, and disposal. To accomplish this mission, a technical baseline was established to form the basis for determining the specific technology development activities that will be supported by the MWFA. The technical baseline is the prioritized list of technology deficiencies and the resulting technology development activities to resolve these deficiencies the MWFA will pursue. A deficiency represents some roadblock related to a technical aspect of characterization, treatment, or handling of mixed waste. This report describes and documents the development and establishment of these deficiencies. The purpose of the technical baseline is to (a) provide strong technical justification for funded technology development, (b) tie technology development activities to customer needs, (c) systematically integrate technology development activities, and (d) develop technologies only when they are not commercially available.

The initial MWFA technical baseline was developed in 1995, established in 1996, and presented in Revision 0 of this report. The technical baseline is revised on an annual basis to reflect changes in DOE mixed waste management strategies, changes in the MWFA technical baseline development process, and DOE-EM and MWFA accomplishments. This report presents the first revision to the technical baseline and the resulting list of prioritized deficiencies.

The MWFA has categorized all mixed waste streams into five waste types. These five waste types, which are based upon waste characteristics that require similar treatment and waste management activities, are used as a basis to categorize the mixed waste technology development activities within the MWFA. The five MWFA waste types are (1) wastewaters, (2) combustible organics, (3) homogeneous solids and soils, (4) debris, and (5) unique wastes. To ensure that technology development activities are tied to customer needs, the MWFA recognized a need for strong customer input in the technical baseline

development and implementation process. The MWFA has addressed this need by a strong teaming arrangement with the EM customer organizations. The Waste Type Manager (WTM) positions, which are key to developing and implementing the entire MWFA strategy, have been filled with individuals that are members of the MWFA's customer organizations (Office of Waste Management, EM-30; Office of Environmental Restoration, EM-40; and Office of Nuclear Material and Facility Stabilization, EM-60). These WTMs were selected from experienced leaders, proposed by the sites in the DOE complex, through an open nomination process. The WTMs direct the development and demonstration of technologies that are responsive to customer needs and that achieve compliance with regulatory requirements for treating and disposing of the mixed waste within their respective waste type.

The technical baseline revision process documented in this report included the examination and prioritization of process flow diagrams, the examination/identification and prioritization of the associated process flow technology deficiencies, and the integration of these two prioritized lists. The revision process included a higher level of stakeholder, i.e., Community Leaders Network (CLN), involvement. Stakeholder input was solicited during the development of process flow and deficiencies prioritization criteria as shown in Figure ES-1. Subsequent MWFA activities will result in the selection of specific technology development activities that will resolve the deficiencies. The MWFA technology selection and deficiency resolution processes are described in the MWFA Program Management Plan, DOE/ID-10551, October, 1996.

A detailed systematic approach, shown in Figure ES-1, was used to develop the revised technical baseline. First, the current inventory of DOE mixed waste was analyzed and sorted into the five waste type categories and then further sorted by whether treatment for the waste existed or was planned (Category A, treatment exists on site; B, treatment exists offsite; C, no treatment currently exists; D, privatized treatment onsite; or E, privatized treatment off-site). Categories D and E were added during this revision to adequately reflect the impact of privatization on the Technical Baseline. Site needs based on the Ten-Year Plans (TYP) were obtained from Site Technology Coordination Groups (STCGs). Treatment systems identified during the creation of the initial technical baseline (this report Revision 0) were examined in light of revised waste stream data and the previous years accomplishments. These treatment systems include all of the steps necessary to treat the waste including characterization, pretreatment, treatment, off-gas treatment, and final waste form disposal. These treatment systems were developed at varying levels of detail and were based on the DOE sites Site Treatment Plans (STPs) and previous studies. The highest level treatment system, with the least detail, was provided in block flow diagrams. The next level of detail was provided in process flow diagrams. Additional detail was provided in treatment train diagrams. The block, process flow, and treatment train diagrams are shown in the appendices of this report.

Identification of DOE's mixed waste technology development needs is a key input to ensuring that the MWFA is addressing those needs. To define the needs of the EM customers, the MWFA analyzed TYP needs as received from STCGs. Using the needs identified from the DOE sites and the expertise of the WTMs and the Technical Resource Team (TRT), a team of technical experts from across the nation, mixed waste technology development deficiencies were identified within the various treatment system process flow diagrams. Separate prioritization criteria were prepared to prioritize the process flow diagrams and the individual deficiencies. Prioritization criteria used were those developed for revision 0 of the technical baseline revised to incorporate stakeholder concerns and issues. An analysis of the needs and prioritized deficiencies was performed as a check on the prioritization process. A crosswalk of site needs submitted by the STCGs and deficiencies is shown in the appendices to this report.

Figure ES-1. Technical baseline revision process

TECHNICAL RECOMMENDATIONS

Through the process described in this report, the MWFA has identified and prioritized the technical deficiencies that exist for mixed waste management. The technical recommendations, which include the prioritized list of technology deficiency areas that will be supported by the MWFA, are shown in Table ES-1.

Table ES-1. Prioritized integrated list of mixed waste technology deficiencies.

Technology Deficiency	Summary Description
1. Characterization	Nondestructive examination (NDE) and nondestructive assay (NDA) techniques and equipment are required to determine the nature of the waste matrix in any package, confirm the presence and concentration of RCRA regulated materials and radionuclides, and identify characteristics of concern for operational safety and process continuity.
2. Mercury Stabilization	Mercury at a contamination level less than 260 ppm requires stabilization to control mercury solubility to the Universal Treatment Standards (<0.2 ppm).
3. Salt Stabilization	Stabilization processes are required that increase salt waste loadings, improve durability and/or reduce the volume increase typical of today's standard practices.
4. Waste Form Performance	An objective, technically defensible evaluation of the value of advanced waste forms in disposal site performance assessments is being conducted. Data needs identified in the evaluation will be addressed as required.
5. Material Handling	Methods and equipment designs are required that will provide for handling of all types of DOE waste materials in all process steps without undue risk of exposure of operating personnel to radioactivity.
6. Sorting/Segregation	Efficient separation of mixed wastes from nonradioactive waste or waste that is radioactive only (i.e., non-mixed waste), in a manner that is safe, reliable, and minimizes exposure, is required.
7. Mercury Separation/Removal	New techniques must be developed to physically or chemically remove the mercury from waste matrices (including soil, all types of process residues or sludges and particulate materials, and debris) for separate stabilization.
8. Mercury Amalgamation	Methods and equipment designs are required for amalgamating bulk non-recyclable mercury to meet the Universal Treatment Standards (<0.2 ppm).
9. TRU Transportation	Improved methods would increase the amount of untreated waste shipped to WIPP or a treatment facility, thereby reducing risks and costs associated with repackaging and/or treatment. Improved methods would reduce gas generation potential, reduce flammable gas concentrations, or provide alternative approaches to demonstrating compliance with allowable gas generation rates.
10. Ash Stabilization	Ash stabilization processes are required that increase waste loadings,

Table ES-1. (continued).

Technology Deficiency	Summary Description
	improve durability, and/or reduce the volume increase typical of today's standard practices.
11. Mercury Monitor	Though mercury monitors are commercially available, it would be advantageous to develop real-time continuous emission monitors requiring minimal consumables and low maintenance, with operating ranges covering the emission limits typical of thermal treatment processes.
12. Alpha Monitor	Though alpha monitors are commercially available, it would be advantageous to develop real-time continuous emission monitors requiring minimal consumables and low maintenance, with operating ranges covering the emission limits typical of alpha material processing facilities.
13. Mercury Filter	A potential enhancement to traditional treatment design for selective mercury removal from offgas, which removes essentially all of the mercury from the offgas for separate treatment, is required.
14. Heavy Metal Monitor	It would be advantageous to develop real-time, multi-metal continuous emission monitors requiring minimal consumables and low maintenance, which can identify specific metals in operating ranges covering the emission limits typical of hazardous waste incinerators.
15. VOC/SVOC Monitor	It would be advantageous to develop real-time continuous emission monitors requiring minimal consumables and low maintenance, which can identify specific VOC and SVOC contaminants (particularly dioxins and furans) in operating ranges covering the emission limits typical of hazardous waste treatment facilities.
16. Alternative Organic Oxidation	Candidate technologies that are alternatives to incineration for oxidation of organics need to be demonstrated to verify whether any one or combination of technologies can reliably treat all of the organic constituents expected to be present in mixed waste, and be operated in a radioactive environment.
17. High Temperature Particulate Removal	Filters capable of operating at high temperatures, typical at the outlet of thermal treatment processes, and capable of removing a substantial fraction of the particulate prior to quenching or scrubbing are required.
18. Radionuclide Partitioning	More complete information on the partitioning of radionuclides between the final waste form, the offgas, and any secondary wastes in mixed waste treatment processes is needed to support equipment design and process permitting.
19. Trace Metal Removal	Techniques are needed to meet permit requirements in effluents (e.g., 0.001 mg/L cadmium, 0.003 mg/L lead, and 0.004 mg/L silver) while minimizing secondary waste generation.
20. Fission Product Removal	Methods are needed for removal or significant reduction of the concentrations of fission products from mixed waste, especially process residues, sludges and waste waters.

Table ES-1. (continued).

Technology Deficiency	Summary Description
21. Refractory Performance	Improved operating techniques better suited to the DOE-specific processing conditions are required for long-term processing success.
22. Nitrate Destruction	Methods are needed to destroy or remove residual nitrates from sludges and wastewaters.
23. Sludge Washing	Approaches are required to enhance the performance of candidate sludge washing technologies to demonstrate feed preparation and washing of process residues, sludges, and particulates to RCRA requirements.
24. Molten Product Decanting	Operating techniques and equipment design are required to facilitate decanting or transfer of molten materials from furnaces in an effective, reliable, and safe manner applicable to a radioactive environment.

Identification of specific technology development activities that will be supported by the MWFA to resolve the identified deficiencies will be selected based on the process defined in the MWFA Program Management Plan. These specific technology development activities, developed with public and tribal input, will comprise the integrated technical baseline.

During this process, several issues and activities were identified that must be addressed to ensure resolution of the deficiencies. These activities are described in Section 6, Issues and Assumptions, and Section 7, Path Forward, of this document. The technical baseline report is a living document and will continue to be updated periodically to contain the most complete and accurate technical basis for MWFA activities.

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ACRONYMS

AMWTP	Advance Mixed Waste Treatment Project
CCO	catalytic chemical oxidation
CFP	call for proposals
CIF	Consolidated Incineration Facility
CLN	Community Leaders' Network
CPC	Chemical Parameter Categories
DCO	direct chemical oxidation
DOE	U. S. Department of Energy
EM	Environmental Management
EPA	U. S. Environmental Protection Agency
FFCA	Federal Facility Compliance Act
FUSRAP	Formerly Utilized Sites Remedial Action Program
HEPA	high-efficiency particulate air
HLW	high-level waste
INEEL	Idaho National Engineering and Environmental Laboratory
IWPF	Idaho Waste Processing Facility
LANL	Los Alamos National Laboratory
LDR	Land Disposal Restriction
LLW	low-level waste
MLLW	mixed low-level waste
MPC	Matrix Parameter Categories
MTRU	mixed transuranic
MTU	mobile treatment unit
MWFA	Mixed Waste Focus Area
MWIR	Mixed Waste Inventory Report
NDA	nondestructive assay
NDE	nondestructive examination
NTS	Nevada Test Site
ORNL	Oak Ridge National Laboratory
OST	Office of Science and Technology
PCB	polychlorinated biphenyl
PEIS	Programmatic Environmental Impact Statement
PHP	Plasma Hearth Process
PI	principal investigator
PSTP	Proposed Site Treatment Plan
R&D	research and development
RCRA	Resource Conservation and Recovery Act
RFETS	Rocky Flats Environmental Technology Site
RPC	Radiological Parameter Categories
SCDE	supercritical carbon dioxide extraction
SNL-NM	Sandia National Laboratory-New Mexico
SPC	sulfur polymer cement
SRS	Savannah River Site
STCGs	Site Technology Coordination Groups
STP	Site Treatment Plan
TCLP	Toxic Characteristic Leach Procedure

TRT	Technical Resource Team
TRU	transuranic
TSCA	Toxic Substances Control Act
TSP	Technical Support Program
TST	Technical Support Team
TTP	Technical Task Plan
TVS	Transportable Vitrification System
TYP	Ten Year Plan
VOC	volatile organic compound
WAC	waste acceptance criteria
WIPP	Waste Isolation Pilot Plant
WTM	Waste Type Manager
WTT	Waste Type Team

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1. MIXED WASTE FOCUS AREA TECHNICAL OVERVIEW

The Assistant Secretary for the Office of Environmental Management (EM) at the United States Department of Energy (DOE) initiated a new approach in August of 1993 for environmental research and technology development. The key features of this new approach included establishment of five focus areas and three crosscutting technology programs which address issues common to multiple focus areas. The five focus areas include the Subsurface Contaminants; Mixed Waste Characterization, Treatment, and Disposal; High-Level Waste Tank Remediation; Decontamination and Decommissioning; Plutonium; and Spent Fuel Focus Areas. The three crosscutting technology programs include Characterization, Monitoring, and Sensor Technology; Efficient Separations and Processing; and Robotics Technology Development Programs. In addition, the Industrial Programs Group has been established to support all of the focus areas and crosscutting programs. The major characteristic of the new approach is aggressive teaming with the customers within EM. This teaming approach is used to identify, develop, and implement needed technologies such that the major environmental management problems can be addressed while cost-effectively expending the available resources.

The Mixed Waste Characterization, Treatment, and Disposal Focus Area (MWFA) was formed to develop and facilitate implementation of technologies required to meet the Department's commitments for treatment of mixed wastes, including mixed low-level waste (MLLW) and mixed transuranic (MTRU) waste under the Federal Facility Compliance Act (FFCA), and in accordance with the Land Disposal Restrictions (LDRs) of the Resource Conservation and Recovery Act (RCRA). The MWFA is managed by the Department of Energy Idaho Operations Office (DOE-ID) and supported by Lockheed Martin Idaho Technologies Company (LMITCO). To successfully implement the DOE's planned approach, the MWFA utilizes unique capabilities and expertise from across the DOE complex.

The mission of the MWFA is to provide acceptable technologies, developed in partnership with end-users, stakeholders, tribal governments, and regulators, that enable implementation of mixed waste treatment systems (including the associated steps from characterization through disposal). To accomplish this mission, a technical baseline is being established for determining which technology development activities will be supported by the MWFA. The technical baseline is the prioritized list of deficiencies that the MWFA will support, along with the associated technology development activities required to resolve those deficiencies. A deficiency represents a roadblock related to a technical aspect of characterization, treatment, or handling of mixed waste. The purpose of the technical baseline is to (a) provide strong technical justification for funded technology development, (b) tie technology development activities to customer needs, (c) systematically integrate technology development activities, and (d) develop technologies only when they are not commercially available. Resources available to the MWFA cannot support duplicative efforts at multiple sites, or repetitive demonstrations of essentially the same technology. The funding will be directed to provide the most progress overall in support of the requirements of the FFCA and the DOE-EM mission of responsible management and disposition of mixed wastes. The MWFA operating philosophy is to only fund tasks that have user endorsement.

To ensure that technology development activities are tied to customer needs, the MWFA recognized the necessity of strong customer input in the technical baseline development and implementation process.

The MWFA has addressed this need by a strong teaming arrangement with the EM customer organizations. The MWFA has categorized all mixed waste streams into five waste types. These five waste types are used to allocate the mixed waste technology development activities within the MWFA. The waste types are based on the treatability groups defined in the DOE Waste Treatability Guidance, DOE/LLW-217, which was generated as part of the FFCA process. The five MWFA waste types are (1) wastewaters, (2) combustible organics, (3) homogeneous solids and soils, (4) debris/solids, and (5) unique wastes.

Waste Type Managers (WTMs) were selected from across the DOE complex to direct the development and demonstration of technologies that are responsive to customer needs and achieve compliance with regulatory requirements for treating and disposing of the mixed waste within their respective waste type. The WTM positions have been filled with individuals that are members of the MWFA's customer organizations (EM-30, EM-40, and EM-60). These WTMs were selected from experienced leaders, proposed by the sites in the DOE complex, through an open nomination process. In May 1995 and November 1996, the MWFA solicited proposals from across the DOE complex for individuals to fill the five WTM positions. (Reference X, DOE Letter, Christine Bonzon to Distribution, "Development and Implementation of Mixed Waste Focus Area Program" [OPE-R&D-95-427], May 23, 1995; Reference X, DOE letter, Julie Conner to Distribution, "Mixed Waste Focus Area Debris/Solids/Soils Waste Type Manager" [OPE-MWFA-96-103], November 1, 1996). The criteria used to select the WTMs focused on strong EM-30 or EM-40 experience; an understanding of the technical, regulatory, and programmatic issues associated with that waste type; involvement in the FFCA process; and a tie to a DOE site with a large inventory in the particular waste type. As a result of this solicitation, the selected WTMs provide the customer link to ensure that the MWFA technology development activities support EM customer-identified needs.

The WTMs are listed in Table 1-1.

Table 1-1. Waste Type Managers.

Waste Type	Waste Type Manager
Wastewaters	Leon Borduin (Acting), Los Alamos National Laboratory (LANL)
Combustible Organics	Leon Borduin, Los Alamos National Laboratory (LANL) Dave Hutchins, DOE-Oak Ridge Operations Office
Inorganic Homogeneous Solids and Soils	Scott Anderson, Rocky Flats Environmental Technology Site (RFETS)
Debris	Cliff Thomas, Savannah River Site (SRS) Mike Martin, (INEEL)
Unique Wastes	Ron Nakaoka, LANL

To accomplish their activities, the WTMs are supported by Waste Type Teams (WTTs). The WTTs are composed of technical support, systems engineering, regulatory support, tribal and stakeholder interface personnel, EM customer interface and participation from the sites with significant waste volume in the particular waste type. A more detailed description of the WTT roles and responsibilities is provided in the MWFA Program Management Plan (DOE/ID-10551, October 1996) and the Waste Type Team Manual (INEL 95/0522).

The MWFA also recognizes the need for active involvement of tribes and stakeholders into our processes. The tribal and stakeholder interface personnel, which are members of the WTTs, act as a liaison between the activities ongoing within the WTTs and the various tribal and stakeholder groups.

The initial MWFA technical baseline was developed in 1995 and established in 1996 as presented in Revision 0 of this report. The technical baseline is revised on an annual basis to reflect changes in the DOE mixed waste management strategies, DOE-EM and MWFA accomplishments, and changes in the MWFA technical baseline development process. This report presents the first annual revision to the technical baseline and the resulting list of prioritized deficiencies. Identification of specific technology development activities that will be supported by the MWFA to resolve the identified deficiencies will be selected based on the process defined in the MWFA Program Management Plan. Technology development strategies and management of selected technology development activities to resolve deficiencies will be documented in Development Plans as described in the MWFA Program Management Plan.

The MWFA has used the term "quick wins" to address a certain set of activities that will be addressed outside the technical baseline process. These quick wins can generally be categorized as tasks that: (a) provide for more efficient utilization of existing equipment and capabilities within the DOE complex in treating mixed waste, including transfer of technologies between sites, (b) provide for expedited treatment of mixed wastes through RCRA treatability studies, or (c) resolve regulatory issues, thus allowing for expedited treatment of mixed waste. These activities were not addressed in the technical baseline development process because they are usually site specific and address small waste volume problems. However, they represent activities that could greatly benefit the DOE complex. A modified form of the evaluation process used by the MWFA in developing the technical baseline was used to prioritize the quick wins, separate from this technical baseline line process. A set funding level is established specifically for addressing quick wins. Many stakeholder and regulatory needs are driven by site- specific issues and are addressed on a site by site basis.

2. TECHNICAL BASELINE DEVELOPMENT PROCESS

A detailed systematic approach, shown in Figure 2-1, was used to develop the revised technical baseline. This figure is a graphical representation of the system of activities and interim products necessary to produce a defensible technical baseline. Each box in the diagram represents an activity and arrows represent products, data, or documents used as inputs into or the products out of the activity. The center row of boxes shows key activities of the WTM's, while the boxes on the top and bottom rows show inputs to these activities.

The first activity was to evaluate baseline treatment trains developed in support of the initial technical baseline development process. These treatment systems were originally developed at three levels: block flow diagrams, process flow diagrams, and treatment trains as shown in Figures 2-2, 2-3, and 2-4, respectively. The process flow diagram illustrates the sequence of technologies needed to provide the necessary characterization, processing, and final preparation to allow for disposal in compliance with applicable DOE, Environmental Protection Agency (EPA), and State requirements. Process flow diagrams and treatment trains for each waste type are included in Appendices B through F.

Process flow diagrams were evaluated (Box 1, Figure 2-1) in light of changes in Site Treatment Plans (Box 3, Figure 2-1), revised waste streams data sorts (Box 2, Figure 2-1) and technology development accomplishments since establishing the initial technical baseline. Award of waste clean-up privatization contracts at DOE sites required the development of two additional waste categories within the five major waste types (Box 2, Figure 2-1). The five categories (A, B, C, D and E) reflect whether wastes are destined for existing on-site treatment facilities (Category A), for existing off-site treatment facilities (Category B), for treatment facilities that do not yet exist (Category C), for privatized treatment facilities onsite (Category D), or for privatized treatment facilities offsite (Category E). Categories D and E were added during this revision to adequately reflect the impact of privatization on the Technical Baseline. Appendix A provides detailed information on these data sorts. Process flow diagram evaluation resulted in the elimination of one process flow diagram, unique waste-compressed gases, due to the resolution of all deficiencies in the process flow.

Identification of DOE's mixed waste treatment needs is a key input to ensuring that the MWFA is addressing those needs (Box 4, Figure 2-1). Site needs were collected during site visits in support of the initial technical baseline development process. However, Ten-Year Plan needs, as supplied by the Site Technology Coordination Group (STCG), were used in the development of the revised Technical Baseline documented in this report. A detailed listing of these STCG-supplied needs can be found in Appendix H.

Using the needs identified from the sites (Box 4, Figure 2-1) and a thorough evaluation of process flow diagrams (Box 1, Figure 2-1), a revised list of deficiencies was identified for each of the process flow diagrams (Box 5, Figure 2-1). These deficiencies represent significant barriers that must be overcome for DOE to treat mixed waste. Barriers that were determined to be strictly engineering adaptations of existing technologies and not technology deficiencies were generally not considered as technology development deficiencies in this process.

Process flow diagram and deficiency prioritization criteria used in the development of the initial technical baseline were revised to incorporate technical and stakeholder concerns (Box 6, Figure 2-1). Stakeholder issues and concerns were solicited and incorporated into the process flow diagram

Figure 2-1. Technical baseline development process. (Delete Phase I)

Debris Waste

Figure 2-2. Example of treatment systems block diagram.

Figure 2-3. Example of a treatment system process flow diagram.

PSTP Preferred Options

Category A	Category B	Category C	Category D	Category E
<ul style="list-style-type: none"> •TSCA Incinerator •FEMP Waste Water Treatment System •WERF 	<ul style="list-style-type: none"> •TSCA Incinerator •WROC •WERF •NSSI •CIF •CSRF 	<ul style="list-style-type: none"> •RTF •Ohio Option •RH Immobilization Facility 	<ul style="list-style-type: none"> •AMWTP 	<ul style="list-style-type: none"> •AMWTP

Debris, Thermal Process,
Incineration Treatment Train,
MWIR 5000

Figure 2-4. Example of a treatment train.

prioritization criteria through a series of meetings with members of the Community Leaders Network (CLN). The CLN members concerns with these criteria can be summarized as follows:

1. Criteria and associated weighting factors bias the program towards selection of technologies that are known at the risk of limiting improvement through innovation.
2. Criteria bias selection of technologies towards those systems that are mature and capable of treating more waste volume, resulting in a program that focuses on the major problems.
3. Criteria do not adequately incorporate the six tribal and stakeholder principles as developed by the Tribal and Stakeholder Working Group in support of the OST Mixed Low Level Waste Treatment Systems Studies.

Process flow diagram criteria used during development of the initial technical baseline were revised with CLN members input to address these and other stakeholder and technical concerns. This process resulted in the elimination of three criteria, addition of one new criterion, and changes to the criteria weighting. These changes did not eliminate all CLN members issues and concerns; however, it does represent a significant step forward in public involvement in the MWFA process.

The primary process flow diagram prioritization criteria include waste volume, number of customers, number of waste streams, waste hazard, and time to availability. The primary deficiency prioritization criteria include the impact that the technology deficiencies had on the treatment system (e.g., number of process flow diagrams that included that deficiency, number of other deficiencies within the same process flow diagram), consideration of whether the deficiency was a critical path issue, the maturity of on-going activities that could address the deficiency, detail available on functional requirements that the solution must satisfy, and compliance commitments. A detailed explanation of this process and the resulting criteria can be found in Appendix G.

The prioritization criteria were then applied to the identified process flow diagrams and to the revised list of technology deficiencies (Box 7, Figure 2-1). Detailed results of the prioritization process are included in Appendix G. Objective criteria, such as volume of waste assigned to a particular process flow diagram, are evaluated based upon available information such as that described in Appendix A. Subjective criteria, such as time to availability, were evaluated using the experience and judgment of the WTM's, with assistance from Waste Type Team members. Upon completion of the prioritization of the process flow diagrams and the individual technology deficiencies, the two prioritized lists were integrated as described in Section 3. The resulting list of prioritized deficiencies was reviewed (Box 8, Figure 2-1) for consistency with the STCG needs. Results of this review are located in Appendix H. This resulting list of prioritized technology deficiencies forms the basis of the revised Technical Baseline. The MWFA process for resolving these deficiencies is presented in Section 7.

3. TECHNICAL BASELINE RESULTS

The end deliverable from the technical baseline development process described in Section 2 is the prioritized, integrated list of technology deficiencies. Three additional interim deliverables led to this final prioritized list of deficiencies. These deliverables are summarized below.

3.1 Process Flow Diagram Prioritization

The first step in the prioritization process was the process flow diagram prioritization. Table 3-1 shows the summary of the prioritization effort. As described in Section 2, and in detail in Appendix G, a number of criteria were considered when ranking the process flow diagrams. Weighting factors were assigned to each criterion and a scale of merit for each criterion was defined. A numerical value was assigned for each criterion and the results totaled for each process flow. Table 3.1 lists the process flow diagrams (in descending order of priority), the criteria, and the numeric values assigned to each process flow diagram.

Table 3-1. Process flow prioritization results.

Weighting Factor		0.17		0.11		0.12		0.3		0.3		1.00
Flowsheet Name		Waste Volume		Number of Customers		Number of Streams		Waste Hazard		Time to Available		Total
1	Sludge, Stabilization	5	0.85	5	0.55	5	0.60	2	0.60	5	1.50	4.10
2	Debris, Stabilization	2	0.34	5	0.55	4	0.48	3	0.90	5	1.50	3.77
3	Debris, Non-Thermal Treatment	3	0.51	5	0.55	4	0.48	3	0.90	4	1.20	3.64
4	Elemental Mercury	1	0.17	4	0.44	2	0.24	4	1.20	5	1.50	3.55
5	Debris, Thermal Treatment	4	0.68	4	0.44	4	0.48	3	0.90	3	0.90	3.40
6	Combustible Organic, Thermal	1	0.17	5	0.55	2	0.24	3	0.90	5	1.50	3.36
7	Alternative Organic Destruction	1	0.17	4	0.44	2	0.24	3	0.90	4	1.20	2.95
8	Debris Thermal Desorption	2	0.34	4	0.44	2	0.24	3	0.90	3	0.90	2.82
9	Wastewater, Direct Stabilization	2	0.34	2	0.22	1	0.12	2	0.60	5	1.50	2.78
10	Lab Packs, Chemical Oxidation	1	0.17	2	0.22	2	0.24	3	0.90	4	1.20	2.73
11	Wastewater, Thermal	1	0.17	3	0.33	2	0.24	2	0.60	4	1.20	2.54
12	Sludge, Thermal Desorption	1	0.17	2	0.22	1	0.12	2	0.60	4	1.20	2.31
13	Sludge, Thermal Treatment	1	0.17	3	0.33	2	0.24	2	0.60	3	0.90	2.24
14	Wastewater, Non-thermal	1	0.17	5	0.55	2	0.24	2	0.60	2	0.60	2.16
15	Lab Packs, Stabilization	1	0.17	3	0.33	1	0.12	1	0.30	4	1.20	2.12
16	Sludge, Extract/Oxidation	1	0.17	1	0.11	1	0.12	2	0.60	2	0.60	1.60

3.2 Technology Deficiency Prioritization

The second step in the prioritization process was to prioritize the individual technology deficiencies that had been identified. Table 3-2 shows the summary of the individual technology prioritization efforts. A technology deficiency represents some roadblock related to a technical aspect of characterization, treatment, handling, or disposal of mixed waste. As described in detail in Appendix G, a number of criteria were considered when prioritizing the individual deficiencies. Weighting factors were assigned to each criterion and a scale of merit for each criterion was defined. A numerical value was assigned for each criterion and the results totaled for each technology deficiency. Table 3-2 lists the individual deficiencies (in descending order of priority), along with the criteria and the numeric values assigned to each deficiency.

Table 3-2. Technology deficiency prioritization results.

Weighting Factor	0.2	0.1	0.15	0.15	0.15	0.1	0.15	1.00							
	Number of F.S.		Number of Gaps in F.S.		E. S. & H.		Critical Path	Develop. Maturity	Function. Reqmt.	Compliance Commit.	Total				
1 Characterization	5	1.00	4	0.40	5	0.75	4	0.60	4	0.60	3	0.30	5	0.75	4.40
2 Mercury Amalgamation	4	0.80	2	0.20	4	0.60	5	0.75	4	0.60	5	0.50	5	0.75	4.20
3 Mercury Stabilization	5	1.00	2	0.20	4	0.60	1	0.15	4	0.60	5	0.50	5	0.75	3.80
4 Ash Stabilization	4	0.80	1	0.10	3	0.45	3	0.45	5	0.75	5	0.50	5	0.75	3.80
5 Salt Stabilization	5	1.00	4	0.40	4	0.60	1	0.15	3	0.45	5	0.50	5	0.75	3.85
6 Material Handling	5	1.00	1	0.10	5	0.75	3	0.45	4	0.60	3	0.30	3	0.45	3.65
7 Mercury Separation	4	0.80	2	0.20	4	0.60	1	0.15	3	0.45	5	0.50	5	0.75	3.45
8 TRU Transportation	4	0.80	2	0.20	4	0.60	5	0.75	3	0.45	3	0.30	3	0.45	3.55
9 Sorting/Segregating	5	1.00	2	0.20	3	0.45	2	0.30	4	0.60	3	0.30	3	0.45	3.30
10 Mercury Monitor	4	0.80	2	0.20	3	0.45	1	0.15	5	0.75	3	0.30	5	0.75	3.40
11 Waste Form Performance	5	1.00	4	0.40	5	0.75	1	0.15	3	0.45	1	0.10	2	0.30	3.15
12 High Temp Part Removal	3	0.60	3	0.30	3	0.45	3	0.45	5	0.75	3	0.30	1	0.15	3.00
13 Fission Product Removal	2	0.40	3	0.30	4	0.60	1	0.15	4	0.60	3	0.30	3	0.45	2.80
14 Heavy Metal Monitor	4	0.80	1	0.10	3	0.45	1	0.15	3	0.45	3	0.30	5	0.75	3.00
15 Mercury Filter	4	0.80	2	0.20	4	0.60	1	0.15	4	0.60	3	0.30	2	0.30	2.95
16 Alpha Monitor	4	0.80	1	0.10	3	0.45	1	0.15	4	0.60	3	0.30	2	0.30	2.70
17 Alternative Organic Oxidation	2	0.40	1	0.10	3	0.45	1	0.15	4	0.60	3	0.30	5	0.75	2.75
18 Radionuclide Partitioning	2	0.40	1	0.10	4	0.60	1	0.15	4	0.60	3	0.30	1	0.15	2.30

3.3 Needs Matrix

Upon completion of the FY 1997 prioritization for both the process flowsheet diagrams and the technology deficiencies, the two resulting prioritized lists were combined into one final set of prioritized, integrated deficiencies. This was necessary so that those deficiencies that affected the higher priority process flowsheet diagrams rate higher than those deficiencies affecting lower priority process flowsheet diagrams. Table 3-3 shows this needs matrix, which integrates the prioritized process flowsheet diagrams and the prioritized technology deficiencies. The 16 process flowsheet diagrams are listed across the top of the matrix, starting with the highest priority process flowsheet diagram (sludge stabilization) at the left. Other process flowsheet diagrams follow from left to right in descending order of their priority score. The 24 deficiencies are listed on the left side of Table 3-3, with the highest priority deficiency (characterization) at the top of the column and others following in descending order. A "1" on the matrix indicates which process flowsheet diagrams are associated with each particular technology deficiency. This matrix was then used to develop the final deliverable, which is the FY 1997 prioritized, integrated list of technology deficiencies.

3.4 Prioritized List of Technology Deficiencies

With the relative importance of process flowsheet diagrams and technology deficiencies depicted in the needs matrix of Table 3-3, a final prioritized, integrated list of technology deficiencies was developed and is provided in attached Table 3-4. This final prioritization was determined by multiplying the deficiency score by the sum of the scores for those flowsheets to which the deficiencies apply. For example, the mercury amalgamation deficiency score of 4.20 is multiplied by the sum of the six applicable flowsheet scores ($3.55+3.40+3.36+2.82+2.54+2.24=14.55$) indicated for that particular deficiency to provide a final deficiency score of $4.20 \times 14.55 = 75.2$. This method of integrating the two prioritization processes is best represented by the mathematical formula:

$$\text{FDS (Final Deficiency Score)} = \text{ODS (Original Deficiency Score)} \times \Sigma \text{FS (Flowsheet Score)}.$$

Based on the results of these product sums, the 24 deficiencies were reprioritized based on their new score. Table 3-4 provides this final reprioritization along with its original ranking and deficiency score. Even though this final prioritization method is subject to the sensitivities of the original numerical values of both the deficiency and flowsheet scores, it does ensure that the high priority deficiencies that address the high priority flowsheets reach the top of the reprioritized list. The final prioritized, FY 1997 integrated list of technology deficiencies, with a brief explanation of each technology deficiency, is shown again in Table 3-5. Details of the technology deficiencies, and the requirements that must be met to resolve the deficiencies, can be found in the Technology Development Requirements Documents.

Table 3-3. Needs matrix.

Deficiency Score	Flowsheet Score	INTEGRATED FLOWSHEET DEFICIENCY PRIORITIZATION MATRIX	4.10	3.77	3.64	3.55	3.40	3.36	2.95	2.82	2.78	2.73	2.54	2.31	2.24	2.16	2.12	1.60	Sum of Products
4.40	Characterization		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	154
4.20	Mercury Amalgamation					1	1	1	1	1			1		1				75
3.80	Mercury Stabilization		1		1	1	1	1	1	1			1		1	1		1	123
3.80	Ash Stabilization		1				1	1	1	1			1		1				70
3.85	Salt Stabilization		1				1	1	1	1	1	1	1		1	1	1		120
3.65	Material Handling		1	1	1	1	1	1	1	1		1			1			1	112
3.45	Mercury Separation				1	1	1	1	1	1					1			1	81
3.55	TRU Transportation		1	1	1	1	1								1				71
3.30	Sorting/Segregating		1	1	1	1	1	1	1	1		1		1	1			1	109
3.40	Mercury Monitor					1	1	1	1	1		1	1	1	1				69
3.15	Waste Form Performance		1	1	1	1	1	1	1	1	1	1		1	1		1	1	149
3.00	High Temp Part Removal					1	1	1			1				1				27
2.80	Fission Product Removal						1	1								1			14
3.00	Heavy Metal Monitor					1	1	1		1		1	1		1				43
2.95	Mercury Filter				1	1	1	1		1			1		1				53
2.70	Alpha Monitor				1	1	1	1		1			1	1	1				55
2.75	Alternative Organic Oxidation				1				1			1				1			32
2.30	Radionuclide Partitioning						1			1				1					20
2.25	VOC/SVOC Monitor						1	1	1	1			1		1				39
2.20	Nitrate Destruction										1					1			11
2.30	Refractory Performance						1								1				13
1.75	Molten Product Decant						1												6
1.85	Sludge Washing															1		1	7
1.95	Trace Metal Removal															1			17

Table 3-4. Prioritized Deficiencies for 1997 Technical Baseline

Deficiency ranking	Prioritized deficiency ranking	Deficiency score	Integrated flowsheet deficiency prioritization matrix	Sum of products
1	1	4.40	Characterization	154
3	2	3.80	Mercury Stabilization	123
5	3	3.85	Salt Stabilization	120
11	4	3.15	Waste Form Performance	119
6	5	3.65	Material Handling	112
9	6	3.30	Sorting/Segregating	109
7	7	3.45	Mercury Separation	81
2	8	4.20	Mercury Amalgamation	75
8	9	3.55	TRU Transportation	71
4	10	3.80	Ash Stabilization	70
10	11	3.40	Mercury Monitor	69
16	12	2.70	Alpha Monitor	55
15	13	2.95	Mercury Filter	53
14	14	3.00	Heavy Metal Monitor	43
19	15	2.25	VOC/SVOC Monitor	39
17	16	2.75	Alternative Organic Oxidation	32
12	17	3.00	High Temp Part Removal	27
18	18	2.30	Radionuclide Partitioning	20
24	19	1.95	Trace Metal Removal	17
13	20	2.80	Fission Product Removal	14
21	21	2.30	Refractory Performance	13
20	22	2.20	Nitrate Destruction	11
23	23	1.85	Sludge Washing	7
22	24	1.75	Molten Product Decant	6

Table 3-5. Prioritized integrated list of mixed waste technology deficiencies

Technology Deficiency	Description
1. Characterization	Nondestructive examination (NDE) and nondestructive assay (NDA) techniques and equipment are required for the initial characterization of many hazardous wastes and all other (tramp) materials in waste drums and boxes. Obtaining representative samples of these heterogeneous wastes and materials is made much more difficult in a radioactive environment, which escalates costs dramatically. It is necessary to determine the nature of the waste matrix in any package, confirm the presence and concentration of RCRA regulated materials and radionuclides, and identify characteristics of concern for operational safety and process continuity. This is to be accomplished noninvasively or with minimal penetration.
2. Mercury Stabilization	Toxic metal contaminants regulated under the Resource Conservation and Recovery Act (RCRA) contained in mixed wastes require removal or stabilization to control solubility under the conditions of the Toxic Characteristic Leach Procedure (TCLP) before the wastes can be disposed. Under RCRA, mercury at contamination levels less than 260 ppm (>260 ppm requires retorting) require stabilization to control mercury solubility to the Universal Treatment Standards (<0.2 ppm). Verification of treatment, i.e. penetrating the entire matrix and stabilizing essentially all of the mercury in the system, is required.
3. Salt Stabilization	Some existing mixed wastes, and various types of waste residues that will be produced in the treatment of other mixed wastes, will be high in salt content, typically chlorides, nitrates, and hydroxide sludges. These salts can be very difficult and expensive to stabilize in glass or standard Portland cement-based grouts. Polymeric compounds may contain higher concentrations of some salts in the near term, but do not chemically bind the contaminants, and an organic matrix may be undesirable for some disposal scenarios. Stabilization processes are required that increase waste loadings, improve durability and/or reduce the volume increase typical of today's standard practices. Significantly improved matrices such as new grouts based on innovative chemistries, polymers, etc. will be required.
4. Waste Form Performance	The performance criteria for regulated hazardous constituents are generally established in State and EPA regulations, such as TCLP requirements. No such requirements have been finalized for radionuclides, so the increased durability of vitrified, slagged, or encapsulated waste forms has not been incorporated into disposal facility permitting or performance assessments. An objective, technically defensible evaluation of the value of advanced waste forms in disposal site performance assessments is being conducted. Data needs identified in the evaluation will be addressed as required.

Table 3-5. (continued).

Technology Deficiency	Description
5. Material Handling	Handling of DOE mixed waste must be accomplished safely in a radioactive environment, including containment for alpha contamination. Containment of radioactive material, limits access to the waste containers, and creates difficulties for opening of containers, removal of wastes, conditioning (feed preparation), and size reduction prior to treatment. Many common industrial practices involving manual sorting, shredding, and conveying of materials into and out of a process may not be possible, because of the radioactive contamination of these wastes. Methods and equipment designs are required that will provide for handling of all types of DOE waste materials in all process steps without undue risk of exposure of operating personnel to radioactivity.
6. Sorting/Segregation	Mixed waste packages contain waste materials with many different matrices. It will often be necessary to sort or segregate materials such as debris from sludges, or different types of debris matrices, before the waste can be assigned to appropriate treatment. Efficient separation of non-radioactive, (no RCRA regulated constituents) materials from mixed wastes could produce substantial savings. Because these wastes are radioactive and may contain volatile hazardous materials, the sorting and segregation must be done with adequate containment to control potential releases.
7. Mercury Separation/Removal	The presence of mercury complicates the design of offgas systems, stabilization of residuals, and monitoring of all effluents. It may be advantageous to remove the mercury as a pretreatment to simplify downstream operations. New techniques must be developed to physically or chemically remove the mercury for separate stabilization. Waste matrices from which mercury separation may be required include soil, all types of process residues or sludges and particulate materials, and debris. Processing methods must ensure adequate removal, and include measuring and monitoring methods to control and verify the process.
8. Mercury Amalgamation	Elemental mercury may be derived as a product of retorting high mercury (>260 ppm) wastes, or recovered from the offgas of a thermal treatment unit, in addition to the elemental mercury streams in the DOE mixed waste inventory. Radioactive mercury can probably not be completely purified and verified for recycle. Disposal of the mercury will require amalgamation to form a stable, insoluble product for disposal. Methods and equipment designs are required for amalgamating bulk non-recyclable mercury.

Table 3-5. (continued).

Technology Deficiency	Description
9. TRU Transportation	<p>Contact-handled transuranic (CH TRU) waste is intended for disposal at the Waste Isolation Pilot Plant (WIPP). Limits are imposed on shipping container (TRUPACT-II) contents for hydrogen, methane, and potentially flammable VOCs. The quantity of TRU that can be shipped in a TRUPACT-II based on both fissile gram equivalents and thermal power is also limited. There is a problem associated with TRUPACT-II arising from the gas generation potential of the waste and the subsequent requirements imposed to ensure that a potentially flammable/explosive package is not being transported. A large percentage of the TRU drums exceed the wattage limits in the TRUPACT-II Safety Analysis Report (SAR) and cannot be shipped using the current certification methodologies. Currently, the only options available for solving this problem are to pierce the inner containment bags and/or repackage the wastes into additional drums. This can create thousands of additional waste drums requiring shipment to WIPP. Improved methods are needed to increase the number of drums that can be certified and shipped to the WIPP. Improved methods would reduce gas generation potential, reduce flammable gas concentrations, or provide alternative approaches to demonstrating compliance with allowable gas generation rates. Improved methods would increase the amount of untreated waste shipped to WIPP or a treatment facility, thereby reducing risks and costs associated with repackaging and/or treatment.</p>
10. Ash Stabilization	<p>Ash is routinely produced at DOE facilities incinerating mixed wastes. The Universal Treatment Standards have made leach resistance requirements more stringent for some heavy metals. Stabilization processes are required for this ash that increase waste loadings, improve durability and/or reduce the volume increase typical of today's standard practices. Significantly improved matrices such as new grouts based on innovative chemistries, polymers, etc. will be required.</p>
11. Mercury Monitor	<p>Mercury is present in a wide variety of mixed waste matrices and at widely varying concentrations. Monitoring methods for mercury vapors are required to ensure that mercury is not being released, particularly from processes operating at elevated temperatures. Though mercury monitors are commercially available, it would be advantageous to develop real-time monitors requiring minimal consumables and low maintenance, with operating ranges covering the emission limits typical of incinerators.</p>

Table 3-5. (continued).

Technology Deficiency	Description
12. Alpha Monitor	<p>Processing of mixed wastes will require monitoring of wastes at all stages of handling to ensure that radioactivity, especially alpha radionuclides, are not being released, particularly with processes operating at elevated temperatures. Though alpha monitors are commercially available, it would be advantageous to develop real-time monitors requiring minimal consumables and low maintenance, with operating ranges covering the emission limits typical of alpha material processing facilities.</p>
13. Mercury Filter	<p>Mercury is present in a wide variety of mixed waste matrices and at widely varying concentrations. Mercury will be present in some wastes for which mercury treatment will not be indicated. At elevated temperatures in many waste treatment processes mercury will vaporize. Therefore the off-gas system for most, if not all, mixed waste treatment systems will require a step for mercury removal. Typically this step is a water quench, which condenses most volatiles, but creates a mixture in the blowdown stream that is difficult to treat. A potential enhancement to this traditional design would be a selective mercury removal step, which removes essentially all of the mercury from the off-gas stream for separate treatment. Candidate processes exist, but have not been demonstrated on mixed waste off-gas streams.</p>
14. Heavy Metal Monitor	<p>RCRA regulated heavy metals are present in many mixed wastes. In high temperature processes some of these metals can be volatilized. Though most of these metals are readily captured, some may be carried through the offgas system as fine particles, or potentially as vapors as described above for mercury. It would be advantageous to develop real-time monitors requiring minimal consumables and low maintenance, which can identify specific metals in operating ranges covering the emission limits typical of hazardous waste incinerators.</p>
15. VOC/SVOC Monitor	<p>RCRA regulated volatile and semivolatile organic compounds (VOCs/SVOCs) are present in many mixed wastes. Because these contaminants are volatile, they are highly mobile, and will be released from newly opened packages and at any stage in processing that involves elevated temperatures. Monitoring of VOCs in the treatment facility effluent is necessary to ensure the facility is operating in accordance with environmental protection requirements. It would be advantageous to develop real-time monitors requiring minimal consumables and low maintenance, which can identify specific contaminants in operating ranges covering the emission limits typical of hazardous waste treatment facilities.</p>

Table 3-5. (continued).

Technology Deficiency	Description
16. Alternative Organic Oxidation	<p>Successful destruction of regulated organic constituents in mixed waste is necessary to produce a suitable final waste form. As an alternative to thermal treatment, it is desired to destroy organic constituents in an aqueous chemical treatment process. Organic contaminated wastes may contain dissolved and suspended solids along with any of a wide variety of organics. Of particular concern are halogenated and high molecular weight compounds. Several candidate technologies exist, but it remains to be demonstrated that any one or a combination can reliably treat all of the organic constituents expected to be present in mixed waste, and be operated in a radioactive environment.</p>
17. High Temperature Particulate Removal	<p>Particulate in offgas from thermal treatment systems has several detrimental impacts, one of which is to provide active sites for formation of dioxins. Conventional particulate filtration requires offgas to be cooled, generally by water quenching or scrubbing, which results in a waste sludge that must then be treated. Filters capable of operating at high temperatures and offgas conditions typical at the outlet of thermal treatment processes, and capable of removing a substantial fraction of the particulate prior to quenching or scrubbing are required.</p>
18. Radionuclide Partitioning	<p>During mixed waste treatment processes, particularly thermal systems, the distribution and migration of radionuclides throughout the processing system must be understood to ensure adequate control. Only limited data exist to predict the fractional distribution of radionuclides between the offgas, the final waste form, and any secondary waste streams. More complete information on the radionuclide distribution in high temperature mixed waste treatment processes is needed to support equipment design and process permitting.</p>
19. Trace Metal Removal	<p>Some wastewater treatment facilities in the DOE complex are subject to new permitting requirements that mandate extremely low levels for some metals in effluents (e.g., 0.001 mg/L cadmium, 0.003 mg/L lead, and 0.004 mg/L silver). Standard water polishing ion-exchange resins are not sufficiently specific to avoid depletion by other ions in the wastes. Other techniques are needed to meet permit requirements while minimizing secondary waste generation.</p>
20. Fission Product Removal	<p>Some mixed wastes contain elevated levels of radionuclides requiring special handling and treatment. Techniques for selective removal of nuclides such as cesium, strontium, and tritium would simplify processing of the balance of the matrix. Methods are needed for removal or significant reduction of the concentrations of fission products from mixed waste, especially process residues and sludges.</p>

Table 3-5. (continued).

Technology Deficiency	Description
21. Refractory Performance	<p>Refractory lifetime is a limiting factor for operation of incinerators and most other thermal treatment processes. Refractories are degraded by acid and caustic conditions and thermal cycling, and sorb metals and radionuclides during operation. Replacement of refractories decreases operating time, adds to operating costs and personnel exposure, and generates a secondary mixed waste stream. Improved refractories, or operating techniques better suited to the DOE- specific processing conditions, are required for long-term processing success.</p>
22. Nitrate Destruction	<p>Most DOE chemical operations are conducted in nitrate based systems because of process simplicity and material compatibility.</p> <p>As a result, many of DOE mixed wastes contain nitrates. Nitrates are reactive oxidizers, which can cause complications in treatment processes and additional difficulties in waste stabilization processes. Methods are needed to destroy or remove residual nitrates from sludges and wastewaters.</p>
23. Sludge Washing	<p>Sludge washing may be a key step in non-thermal treatment processes. This treatment is also potentially applicable to small quantities of waste. Organic removal requirements in RCRA regulations are generally well beyond that which has been demonstrated for any of the candidate processes. Alternative approaches are required, or methods are needed to enhance the performance of the candidate sludge washing technologies, to demonstrate feed preparation and washing of process residues, sludges, and particulates to RCRA requirements.</p>
24. Molten Product Decanting	<p>Many treatment processes being developed for mixed wastes will operate with molten material. These processes require the transfer of a molten product from the furnace to another vessel for final handling/disposal. Usually separation of the molten material from untreated waste and perhaps a slag or metal phase is required. Operating techniques and equipment design are required to accomplish this decanting or transfer of molten phases in an effective, reliable, and safe manner applicable to a radioactive environment.</p>

4. ASSESSMENT OF DOE TECHNOLOGY NEEDS AND DEFICIENCIES

Revision 0 of the technical baseline reflected the site needs through evaluation of the Preliminary Site Treatment Plans (PSTP) and other documents, analysis of the 1995 Mixed Waste Inventory Report (MWIR) database, and direct data collection through site visits. Since that time, the site mixed waste inventory data has been revised, and the PSTPs have been updated. Additionally, the STCGs at all major DOE sites have been involved in a directed effort to identify technology needs and deficiencies as part of the Ten-Year Plan development.

To support this technical baseline update, the MWFA targeted two primary areas. First, the updated STPs were reviewed to identify mixed waste stream and DOE targeted treatment process revisions. Second, the STCG needs and opportunities were collected and evaluated.

4.1 Mixed Waste Focus Area Database Update

The MWFA created a database in the summer of 1995 that merged and updated two existing databases. The 1995 MWIR database was combined with the STP database to form the most comprehensive listing available of the DOE mixed waste streams. This database catalogued detailed information about each waste stream including waste stream identification number, DOE site, radiological contaminants, hazardous contaminants, waste matrix, mass, 5-yr generation projection, and a point of contact.

Most DOE sites that store mixed waste were required by Section 3021(b) of the Resource Conservation and Recovery Act (RCRA), as amended by the Federal Facility Compliance Act (FFCAct), to prepare STPs. These STPs resulted in Consent Orders with the host States. Based on agreements with the States, these plans are periodically updated. STP documents provide an update to basic waste stream information. In addition, STPs describe the planned treatment technologies for each mixed waste stream.

The MWFA routinely collects the Updated STPs and incorporates the information available into the MWFA database. Each waste stream in the database is assigned to a MWFA defined process flow. Tables identifying waste stream to process flow assignments are included in Appendix B-F of Volume II. A more detailed explanation of the database is included in Appendix G of Volume II.

The targeted treatment options listed in the STPs were reviewed by the MWFA to identify potential technology deficiencies.

4.2 Review of Site Technology Coordination Group Needs

Each DOE Operations Office designated a STCG in support of the Ten-Year Plan process. The STCGs are responsible for coordinating and transmitting site needs to the various OST focus areas and cross-cut programs. The MWFA received technology needs and opportunities from the STCGs in many forms, and at various levels of detail. This data was reviewed and evaluated by the MWFA to determine which of these needs and opportunities were consistent with the defined scope for the MWFA. In many cases, this required directly contacting site personnel to get further definition and clarification of the needs. The MWFA identified 108 of the needs and opportunities provided by the STCGs that fell within the MWFA purview. These 108 needs were categorized into 15 technology areas, that generally reflect the

MWFA technical baseline. Table 4.1 provides an overview of this categorization. A letter documenting the disposition of each STCG need and opportunity was transmitted to all sites during February 1997 (reference 1, W. A. Owca letter to distribution (OPE/MWFA-97-014), dated 2/6/97, "Response to Site Technology Coordination Group Needs).

Table 4.1 Summary of needs supplied by STCGs.

Need	AL	BN	FM	IN	NT	OK	OR	RF	RL	SR
Air Pollution Control Systems			X	X						
Continuous Emission Monitor			X	X			X			X
Drum Pressure							X			
HEPA Filter Improvements				X						
Mercury	X	X					X			X
NDE/NDA				X		X	X	X	X	X
Unspecified Non-Thermal Technologies			X					X		
Aqueous Organic Removal	X						X			
Sorting/Segregation	X		X	X	X			X	X	X
Stabilization				X			X			X
Thermal Desorption		X								
TRU Issues			X	X				X		X
Unspecified Thermal Technologies				X					X	X
Unspecified Treatment Technologies				X						X
Waste Form Issues				X	X		X	X		X

(Note: For Table 4.1 and 4.2, the following abbreviations apply: AL = Albuquerque Sites, BN = Brookhaven National Laboratory, FM = Fernald Site, IN = Idaho National Engineering and Environmental Laboratory, NT = Nevada Test Site, OK = Oakland Sites, OR = Oak Ridge Reservation, RF = Rocky Flats Environmental Test Site, RL = Richland Site (Hanford), and SR = Savannah River Site.)

In general, the MWFA response to a STCG identified need or opportunity was grouped into one of three categories: 1) the need is being or has been addressed; through MWFA work related to a technology deficiency; previously funded activities; or other MWFA supported efforts (i.e. a quick win project); 2) the identified need, as understood by the MWFA, is not related to technology development and is, therefore, not within the MWFA scope; or 3) the MWFA is aware of the general need, and studies are being conducted to identify specific technology development requirements.

4.3 Needs Derived from the Updated Site Treatment Plans

A comprehensive listing of all the STCG needs reviewed by the MWFA, with their disposition relative to the MWFA Technical Baseline Prioritization Process, has been included in Appendix H.

Table 4.2 lists the prioritized deficiencies that constitute the MWFA FY1997 technical baseline, and identifies site-specific STCG needs being addressed by each deficiency.

4.4 Incorporation of Needs

With the revised technical baseline in place, the MWFA began comparing the identified 108 STCG needs to the existing defined deficiencies. This resulted in removal of some of the previously defined needs. This was due to various reasons, including: 1) the need had been addressed and resolved; or 2) the deficiency, as understood by the MWFA, was determined, upon further investigation, to not actually be a deficiency. Table 4-2 lists the prioritized deficiencies that constitute the MWFA FY1997 technical baseline, and identifies site-specific STCG needs being addressed by each deficiency.

A comprehensive listing of all the STCG needs reviewed by the MWFA, with their disposition relative to the MWFA Technical Baseline Prioritization Process, has been included in Appendix H.

Table 4.2. Site needs cross-walked to the MWFA FY1997 deficiencies.

Prioritized Deficiency	Deficiency Title	AL	BN	FM	IN	NT	OK	OR	RF	RL	SR
1	Characterization	X			X		X	X	X	X	X
2	Mercury Stabilization	X						X			
3	Salt Stabilization			X	X			X			X
4	Waste Form Performance				X	X		X			X
5	Material Handling	X		X					X	X	
6	Sorting/Segregating	X				X				X	
7	Mercury Separation	X						X			
8	Mercury Amalgamation	X						X			X
9	TRU Transportation				X				X		X
10	Ash Stabilization			X	X			X			X
11	Mercury Monitor				X			X			X
12	Alpha Monitor			X	X						X
13	Mercury Filter	X						X			
14	Heavy Metal Monitor				X						X
15	VOC/SVOC Monitor				X						X
16	Alternative Org. Oxidation	X						X			
17	High Temp Part Removal										•
18	Radionuclide Partitioning										•
19	Trace Metal Removal		X					X			

Table 4.2. (continued).

Prioritized Deficiency	Deficiency Title	AL	BN	FM	IN	NT	OK	OR	RF	RL	SR
20	Fission Product Removal		X					X			
21	Refractory Performance				X						
22	Nitrate Destruction							X			
23	Sludge Washing										*
24	Molten Product Decant										*

*Work to be completed in FY 97.

5. THE MIXED WASTE FOCUS AREA QUICK WIN PROGRAM

The MWFA initiated the Quick Win Program in FY1996. The purpose of this program is to expedite implementation of mixed waste treatment technologies, through treatability studies and demonstrations, while addressing site-specific needs relative to small volume waste streams. In addition, the quick win projects often result in quantifiable cost savings. The FY1997 Quick Win Program will lead to a projected overall cost reduction of almost \$40M over the next five years, based on information provided by the sites that submitted the proposals.

Generally, quick win projects are relatively low cost, completed within one year, and result in near term reduction of the DOE mixed waste inventory. Additionally, the Quick Win Program provides a method for addressing the site-specific needs that are not included in the MWFA Technical Baseline.

5.1 Quick Win Categories And Criteria

Five categories of projects have been identified for the Quick Win Program. These are defined as follows:

- 1) Projects that provide for expedited treatment of actual mixed wastes through Resource Conservation and Recovery Act (RCRA) treatability studies or other acceptable means, preferably eliminating the target waste stream at the treatment site and/or providing a capability for treatment of small volume waste streams from other sites.
- 2) Projects that provide opportunities to rapidly transfer technologies between sites, resulting in expedited treatment schedules and/or reduced costs.
- 3) Projects that bridge a customer-identified gap between technology development and DOE Environmental Management (EM) operations.
- 4) Projects that provide for more efficient utilization of existing equipment and capabilities within the DOE complex for expedited treatment of mixed waste.
- 5) Projects that resolve regulatory issues associated with the implementation of existing treatment systems, thus expediting treatment of mixed waste.

In addition, all quick win projects have other over-riding requirements that must be met. These include the following:

- 1) All projects must demonstrate a technology that is subsequently implemented; or must actually implement a technology that will be used for further treatment of mixed waste following the initial quick win effort.
- 2) All projects must provide data that can be used by EM customers to support waste management decision-making processes.
- 3) Projects must NOT simply accomplish waste treatment or other processes and functions normally performed by EM operations. (This is a requirement that was not an established

criterion for the FY1996 Quick Win Program, but was strictly adhered to for the FY1997 Quick Win Program.)

- 4) All projects must be supported by the appropriate DOE EM customer, including Waste Management (EM-30), Environmental Restoration (EM-40), and Facility Transition and Management (EM-60). This support will generally be demonstrated through documented intent to deploy a technology, intent to use data developed to assist deployment decisions, or provide cofunding to demonstrate the technology. This criterion is included in the detailed requirements for each quick win category.

5.2 Quick Win Proposal Review Process

The MWFA Quick Win Program was initiated in late FY 1996. Due to the late start, many of the

FY 1996 quick win projects are ongoing and will be completed during the first and second quarters of FY 1997.

The primary difference between the FY1996 and FY 1997 Quick Win Programs is the emphasis on testing and demonstrating treatment technologies that are subsequently implemented by the EM customer. The following sections describe the review processes for the FY 1996 and FY 1997 Quick Win Programs, which include screening, evaluation, and selection of projects.

5.2.1 FY 1996 Quick Win Review Process

The MWFA issued a Call for Proposals (CFP) to the DOE complex for the FY 1996 Quick Win Program on March 7, 1996. The MWFA received 50 proposals, totaling over \$13.5M, in response to this original CFP. However, not all the proposals met the established quick win criteria, as defined above, nor did the budget allow funding of all acceptable proposals. Accordingly, the responses were prescreened, evaluated, and ranked for funding consideration.

Evaluation and ranking of acceptable proposals was performed by an established Quick Win Review Team. This team consisted of waste-type managers, technical resource team members, technical support team members, and DOE-ID participants.

The review team evaluated the 23 proposals that passed the screening based on the prioritized criteria described above. The 15 projects recommended for funding are documented in Appendix I.

5.2.2 FY 1997 Quick Win Review Process

The FY 1997 Quick Win Program CFP was issued on August 21, 1996. The MWFA received 57 proposals, totaling over \$13.7M, in response to the FY 1997 Quick Win Program CFP. After the initial pre-screening, 27 proposals were reviewed for funding consideration. The 12 projects recommended for funding are documented in Appendix I.

The review process was modified by the MWFA for the FY 1997 Quick Win Program. A more thorough evaluation methodology was developed and implemented. The criteria description, criteria weighting, and scales of merit for each criterion are listed in Appendix I.

5.3 Conclusion

By the end of FY97, the MWFA Quick Win Program will have resulted in elimination of 665 m³ of waste, including 53 waste streams, and addressed many site-specific needs. Additionally, many technologies will be demonstrated and subsequently implemented by the EM customer throughout the DOE complex. Complete cost estimates have not been compiled yet, but the quick wins are expected to result in savings of tens of millions of dollars. The Quick Win Program is expected to continue throughout the life of the MWFA.

6. ISSUES AND ASSUMPTIONS

The following issues and assumptions associated with the development of the technical baseline were identified.

6.1 Issues

- 6.1.1** Existing mixed waste treatment facilities cannot accept transuranic (TRU) contaminated waste. The Consolidated Incineration Facility (CIF) waste acceptance criteria (WAC) allows up to 58 nCi/g alpha-contamination; however, the technical ability to detect alpha-contamination at this level hinders CIF acceptance of alpha-contaminated waste.
- 6.1.2** Waste stream data is suspect. The following problems have been identified in the data:
- Sites do not use uniform criteria to designate remote handled waste.
 - Sites have identified waste treatment option that are inconsistent with the Chemical Parameter Categories and/or Radiological Parameter Categories (CPC/RPC) codes.
- 6.1.3** Since the planned disposal facilities have not finalized their WACs, waste form performance requirements cannot be established and access to DOE disposal facilities is not available. This issue is being addressed under the waste form initiative.
- 6.1.4** Although significant progress has been made in the area of EM privatization with the placement of the Advanced Mixed Waste Treatment Facility contract at the INEEL and the Commercial Thermal Treatment Facility contract at Hanford, the impact of privatization on MWFA technology development activities continues to evolve. The waste targeted to privatization units, where the contract has been let, has been removed from MWFA consideration in the technology deficiency prioritization process.
- 6.1.5** While there has been increased public and tribal involvement in the technical baseline development, the MWFA will continue to incorporate public and tribal criteria.

6.2 Assumptions

- 6.2.1** The waste stream data set was based on the 1995 Mixed Waste Inventory Report (MWIR) as revised by Updated Site Treatment Plans (STP). Dates for each STP varied based on specific State Consent Agreements.
- 6.2.2** Preferred treatment options are based on the Updated STPs and are assumed to be correct.
- 6.2.3** Contaminant Parameter Codes (CPC), Radiological Parameter Codes (RPC), Matrix Parameter Codes (MPC) are based on the MWIR as updated to reflect STP revisions.
- 6.2.4** Based on the targeted treatment option, each stream was assigned to a category A, B, C, D, or E. Streams assigned to category A represent those wastes scheduled to be treated on-site at an existing facility via an existing process. Category B streams represent those streams targeted to be treated

off-site at an existing facility via an existing process. Category C streams represent all streams not represented by another category. Category D streams represent streams targeted to be treated on-site by a facility that will be built and operated by a commercial vendor for which a contract has been signed. INEEL waste targeted to the Advanced Mixed Waste Treatment Project (AWMTP) and Richland waste targeted to the Commercial Thermal Treatment Facility are included in category D. Category E streams represent streams targeted to be treated offsite by a facility that will be built and operated by a commercial vendor for which a contract has been signed.

- 6.2.5** The technical baseline prioritization criteria includes waste streams, volumes, and targeted treatment options for category C streams only.
- 6.2.6** Waste identified in the database as "requiring further characterization" are included in category C.
- 6.2.7** Mixed low-level waste with alpha contamination greater than 10 nCi/g were grouped with MTRU waste in a category of 'Alpha' for the process flow diagram evaluation.
- 6.2.8** INEEL streams identified in the INEEL STP were subdivided based on site input to account for the requirement in the Spent Nuclear Fuel Agreement. The agreement indicates 15,000 drum equivalents (3100 m³) of untreated waste will be shipped to WIPP by the end of calendar year 2002.
- 6.2.9** Technology needs associated with treatment facilities to be built and operated by a commercial vendor for which a contract has been signed, will be addressed by that commercial vendor.
- 6.2.10** Soils have been incorporated into the inorganic homogeneous solids/soils waste type analysis.
- 6.2.11** PEIS treatability groups form the basis for the technical baseline process flow diagram development.
- 6.2.12** The primary focus of the technical baseline is to support EM-30, 40, and 60 in meeting waste treatment commitments as made in STPs, RODs, and Consent Orders.
- 6.2.13** Changes to the STP preferred options based on political, equity, technical, and economic issues were not considered. Issues on shipment and WAC acceptability were not considered.
- 6.2.14** Technology needs submitted by the Site Technology Coordination Groups (STCG) were used to revise the technology deficiency list.
- 6.2.15** Impacts due to the Ten-Year Plan process were not available at the time of the Technical Baseline revision. It is assumed sites will continue to support options identified in their STPs.
- 6.2.16** The technical baseline development process focused primarily on treatment technology deficiencies (i.e., true technology development needs) as opposed to facility engineering issues/equipment adaptation.
- 6.2.17** WIPP will open in November 1997.
- 6.2.18** "Non-thermal" refers to reactions which are driven by other than elevated temperatures.

7. PATH FORWARD

The path forward from here is to complete the process of resolving the prioritized technology deficiencies. The steps in developing the needed technologies and providing them to the end-users in time to meet their schedules are described below.

7.1 MWFA Product System

In FY-96, the MWFA developed and implemented a formalized, systematic approach for moving from identifying end-user needs to demonstrating and delivering technology to meet those needs. This systematic process is schematically depicted in Figure 7.1, the MWFA Product System. The first step in system, end-user needs identification, was completed in order to define the technology deficiencies and to help in the prioritization process. The second step, prioritizing the deficiencies and establishing the MWFA Technical Baseline, is the subject of this report.

7.2 Technology Development Requirements Document

The next step after preparation Technical Baseline is to carefully specify performance requirements for technologies which would resolve the deficiencies. Technology Development Requirements Documents (TDRDs) are prepared to document those requirements which the technology developers must meet so that end-user can implement the technology. Each TDRD contains set of technical, regulatory, stakeholder, and end-user performance requirements. These requirements serve as set of clear, concise and verifiable statements of how the technology must perform at the end of the development project in order for it to meet end user needs when implemented. The TDRD also includes the requirements of other aspects of the program which would enhance the eventual implementability of the technology.

7.3 Integrated Master Schedule (IMS)

The IMS is a list of treatment systems identified in the site treatment plans and consent orders, with identified technology needs and associated schedules. In Figure 7.1, it is referenced as End User Schedules. The schedules, the technology development activities, and the treatment system status are verified by the end-users. The IMS matches technology development efforts to the needs and schedules of the end-user, and provides a basis to determine when "sufficient" technologies have been developed.

7.4 Development Plans

Development Plans (DPs) will be prepared covering all the of deficiencies in the Technical Baseline. Deficiencies are grouped in DPs by broad technical subjects in so a generalized, multi-year strategy can be formulated. The Development Plan documents technology development strategies, life-cycle planning and management of technology development activities, and commercialization aspects of technology development projects for the resolution of selected deficiencies. A specific technology may only require the involvement of one or two organizations, or it may involve many different organizations. Integration into an end-user's or private sector participant's facility may be simple or complex. For complex arrangements involving many organizations, many facilities, or complex funding and timing arrangements, development shall proceed under a documented Development Plan (DP). Simpler development efforts may proceed without a DP. The WTM will determine the need for a DP.

7.5 Technology Development Transition Guidance

This guidance is patterned after the Paladino Technology Gate model. This document establishes criteria used to move a technology along its development path and negotiate the transfer of responsibility for development to an end-user, or a commercial partner.

7.6 Technical Task Plans

Proposals to conduct development and demonstration activities are prepared by qualified Principal Investigators (PIs) in the form of a Technical Task Plan (TTP). These proposals are prepared in accordance with the MWFA TTP guidance which identifies the applicable TDRD(s) and specifies that PI must prepare a Test Plan early in the performance period.

7.7 Test Plans

All development and demonstration activities are conducted under an approved test plan. The test plan provides the details of the technology development and demonstration including experimental design, experimental setup, analytical methods, data to be collected, and intended precision and accuracy. A formal test plan format and content guidance document will be prepared and issued by the MWFA Program.

7.8 Reviews

Project performance reviews are conducted twice each year at a minimum. At these reviews, the PI's progress against the requirements of the TDRD and the Gates criteria of the Transition Plan are assessed. When all of the requirements have been met, the TD project is complete and results of the entire, integrated effort are documented in order that the end users can decide how to implement the technology into their treatment facilities.

7.9 Technology Performance Report

The MWFA's specific product in these technology development projects is the Technology Performance Report (TPR). A completed TPR will provide the end-user adequate information to enable them (either DOE or the private sector) to design, construct, and operate treatment systems that incorporate these new and/or improved technologies. Portions of each TPR provide a detailed record of the involvement of the end-user, tribal and public entities and regulators in the technology development process from its beginning, thereby assuring that the product is integrated and the technology is implementable.

Figure 7-1. Technical baseline development process.