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SYSTEM ANALYSIS OF ALTERNATIVES FOR FINAL DISPOSITION OF THE SINGLE-SHELL TANK SYSTEM ON THE HANFORD SITE

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ABSTRACT

A system analysis of the single-shell tank (SST) system at the U.S. Department of Energy's Hanford Site near Richland, Washington, was initiated as a key step in the planning process for final disposition and ultimate closure of that system. The analysis approach was systematic and structured, using systems engineering principles to provide for traceability and capability for iteration as the Hanford SST disposition program evolves. The disposition function of the system was divided into seven subfunctions that were used to 1) analyze various alternatives on how and how well the functions should be completed to satisfy a myriad of uncertain and conflicting regulatory guides and statutes and 2) establish a baseline for generating and updating planning documents.

A set of 541 candidate requirements was created from the analysis of interfacing needs of the seven subfunctions and from the regulations applicable to the Hanford SST system. The analysis was used to structure and prepare the Hanford Single-Shell Tank System Technical Support Program Plan and other planning documents for the system.

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DEFINITION OF TERMS

Systems engineering terminology is used frequently in this report. To aid the reader unfamiliar with this specialized language, some terms are defined below for quick reference.

- Hierarchy or Hierarchical - A vertical placement of interests, requirements, or authorities that have a stake in single-shell tank (SST) system performance. Looking up the hierarchical chain, the SST system is a subsystem of a larger system involving a broader social, political and technical scope. Looking down the hierarchical chain, the SST system is a synthesis of a set of subsystems with narrower technical scopes.

- Performers - The SST system is comprised of subfunctions that have requirements and methods for completing an action carried out by individuals, teams or organizations. These groups are performers of the function.

- Function - An action involving a transformation of an input to an output subject to certain controls. The transformation may involve information as well as materials. It is the principal means for dividing high level, broad actions into successively smaller-scoped specific actions (subfunctions) to simplify management of complex systems such as the single-shell tanks.

- Advocate - A person who develops a set of viewpoints, judgments or decisions from the focused interests of his assigned subfunction. The system analysis maintains these distinctions between subfunctions to resolve conflicts during the development and implementation phases of the SST system.

- Requirements - A set of measures that determine how well a function is to be performed. A requirement, to be capable of measurement, must consist of three elements: a name or attribute, a unit of measure, and a value or procedural description.

- Attributes - A list of identifiers that form one element of a requirement. Identification of attributes is the first step in defining a requirement.

- Unit of Measure - A scale or yardstick to measure performance of an attribute.

- Stringency Level - An attribute may be assigned a range of values depending on the performance desired. The system analysis identifies levels of stringency to show a range from "what is standard practice" to "what is plausible" along a scale defined by a unit of measure. The choice of a level of stringency depends on criteria that balance all interests up and down the hierarchical chain.

- <u>Constraint</u> - A requirement containing all its elements that has been specified and passed down the hierarchical chain. It is included in the requirements list but not considered as a variable in the impact analysis.

- <u>Assumptions</u> - A set of statements that defines the context in which a system is analyzed. Such statements are considered changeable but their impact on the decisions made is not evaluated.

- <u>Decision Criteria</u> - A basis for making selections from a range of alternative requirements and methods. The decision criteria are not to be confused with performance criteria and requirements.

- <u>Standards</u> - A set of requirements that has achieved a wide level of acceptance. In the context of SST system analysis, all requirements will eventually become standards as the program develops and matures. The requirements list herein is not a standards list as yet.

SUMMARY

This system analysis is a key step in the planning process for the disposition program of the U.S. Department of Energy's (DOE) single-shell tank (SST) system at Hanford. The disposition program calls for the ultimate closure of the SST system, and this system analysis provides a systematic and structured approach to meeting this objective, one that is traceable and capable of iteration so that alternatives considered and decisions made are revealed as the program evolves. The system analysis was conducted prior to preparation of the Hanford Single-Shell Tank Systems Technical Support Program Plan (SST-TSPP) (Klem et al. 1990), and the results were used to organize and help establish the baseline information for the SST-TSPP and future updates of this on-going effort. The system analysis was also conducted during the formulation of the Hanford Federal Facility Agreement and Consent Order (Tri-Party Agreement between the DOE, the EPA, and the Washington State Department of Ecology) (TPA 1989).

APPROACH AND STRUCTURE

Because of the uncertainties from conflicting regulations, lack of quantitative decision criteria, and the probable use of variances in the regulatory process, the structured approach described herein is needed to focus the development effort and to provide a bottom-up basis for a two-way dialogue between Tri-Party agency interests and the implementing organization. The output from the approach is a baseline for generating and updating the planning documents used in the program, such as the Hanford SST-TSPP (Klem et al. 1990).

The key steps in the Hanford SST system analysis were as follows:

1. Formulation of a mission statement defining why actions are needed to change the SST system from its present state.

2. A functional breakdown of what actions are to be performed to the level that permits exposition of requirements and methods for the system as a whole.

3. A requirements analysis of how well the actions are to be performed. A set of reference requirements is selected and is used in the planning.

4. A methods analysis of how the actions are to be performed. Also, a set of reference methods is selected and used in the planning.

Each of the above steps provides a building-block for a permanent structure that enables change control as new information becomes available. The term "reference" is used to indicate that at any instant in the program, there is a system requirements network that keeps the subsystems from working at cross-purposes.

FUNCTIONS

From the Mission Statement, the overall function--perform the final disposition of the Hanford SST system--was defined and then divided into seven subfunctions. Each of these subfunctions was assigned to a member of a team who acted as an advocate of the function. The advocacy views provide insights and viewpoints that generate the basis for selecting reference sets of system requirements and methods. Conflicting viewpoints are revealed to highlight the issues needing resolution in the planning process.

By performing the analysis in the sequence described above, a mechanism for understanding the basis for choosing a specific stringency level for a requirement and preferred methods for carrying out the functions is created. The seven functions are:

- characterize the SST system
- provide stabilization/isolation
- provide regulatory documents
- retrieve system components
- perform pretreatment of system components
- prepare final waste package
- provide long-term isolation of waste.

These functions represent a set of actions that are permanent over the development and implementing phases of the SST disposition program and are

unchanged by the choice of alternatives under consideration. This breakdown becomes the framework for planning as the program transitions from development to implementation.

Also, as the program matures, each of the seven functions can be divided into lower-level sets of actions revealing more detail. This analysis therefore initiates the functional breakdown sufficient to establish what requirements and methods are appropriate at the top level but does not complete it.

REQUIREMENTS AND METHODS

A set of candidate requirements was created from an analysis of interfacing information needs of each of the seven functions and from the regulations applicable to the SST system. The team identified 541 attributes as candidate requirements (called attributes) that may be used to set performance standards for the development and implementation of the SST final disposition. The identification of attributes is one element of the requirement-setting process. Each attribute has a range of values or procedures that denotes a degree of difficulty when compared with a defined unit of measure. The requirement is complete when a unit of measure and a particular value or procedure are selected from the range of choices. The system analysis performs the selection based on appropriate criteria for the selection process. This report presents the attributes for this selection process. Several temporary selection criteria were examined for completing the requirement-setting process but their application is being deferred until a more representative set of criteria (recommended in this report) has been evaluated.

Each functional advocate ranked the 541 attributes on a scale from 1 to 10 to reveal the importance of the attribute to performing the function satisfactorily. If several functions ranked an attribute high, then there is a potential for a conflict on the proper choice of the degree of difficulty (level of stringency), since not all functions may desire the same degree of difficulty. Rankings of 1 by the functional advocate denote that he is indifferent to the attribute's influence on his function and his involvement in the selection of a degree of difficulty is unnecessary. The rankings reported in

this document provide the basis for establishing allocation of resources for resolving conflicts and uncertainties between functions during the development phase of the SST program at Hanford.

Several alternative methods were examined by the functional advocate to help guide the requirements setting process. The methods proposed were unique to each of the seven functions. No sharing of a method between functions was evident so that the alternative methods could be selected after completion of the requirements setting using a separate set of selection criteria, if appropriate. Selection of a reference set of methods was deferred until the requirements setting was complete.

There are two paths for disposition of the SST system:

1. Leave the SST waste in place and perform the appropriate actions to satisfy regulatory requirements for long-term isolation of the in situ waste as a contained waste package.

2. Retrieve the SST waste and perform the appropriate actions to satisfy regulatory requirements for long-term isolation of the waste at suitable repository sites at Hanford or elsewhere.

The system analysis has assigned attributes for both options. There may need to be a separate set of requirements for each option, since they may be applied individually to the 149 tanks in the SST system at Hanford.

CONCLUSIONS AND RECOMMENDATIONS

The options of leaving or retrieving the SSTs have been addressed in the context of: if leaving the tanks is the choice, then how and how well is it to be performed and similarly for the retrieval option? The top-level disposition function can be divided into a subset of seven subfunctions that apply equally regardless of the leave or retrieve option chosen. The flow of information and material between the functions changes, however. Therefore, a separate set of attributes leading to two sets of reference requirements and methods for each option is necessary. The criteria for assigning the stringency level for an attribute have not been developed sufficiently for application to the SST system and must be formalized in discussions with TPA agencies. Furthermore, interfacing requirements for facilities to be shared with other waste systems undergoing environmental restoration at Hanford (such as

the double-shell tank disposition program) are needed to understand the capacity and potential interference points in the processing network.

Preliminary analysis of the alternatives to determine how well the retrieved waste should be treated by chemical processes before it is accepted for conversion to waste forms (and subsequently to waste packages) shows that potentially enormous cost increments are involved. Further work is recommended to establish credible cost estimates so that they may be factored in as one of the system performance measures in the selection of alternative courses of action.

Recommendations for the further activities that would improve the understanding of the Hanford SST system as a whole and aid in reaching the conclusions about future courses of action toward its disposition are presented as follows:

1. Provide and use a reference set of requirements as the basis for integration with current projects (HWVP, Grout, etc.) that will service the SST disposal project after some non-SST programs are completed.

2. Provide and use a simulation model of the waste process stream between the subfunctions of the SST system to allocate requirements (i.e., in-process storage capacity, availability, instantaneous processing rates) for integrated development.

3. Provide and use a set of performance measures (i.e., long-term health and risk, short-term risk, cost and schedule) that recognizes the interests of all parties involved in the approval process. These performance measures become the decision criteria for selecting alternative requirements and methods by the implementing organization.

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1.0 INTRODUCTION

1.1 PURPOSE

The U.S. Department of Energy (DOE) has entered into an agreement as part of the Record of Decision (DOE 1988) from its Environmental Impact Statement (DOE 1987) to evaluate the alternatives for the final disposition of the single-shell tank (SST) system at the Hanford Site. A 1989 Hanford Federal Facility Agreement and Consent Order between DOE, the Environmental Protection Agency (EPA) Region 10, and the Washington State Department of Ecology (Ecology), commonly known as the Tri-Party Agreement (TPA), has set a target date of 2018 to complete closure of the Hanford SST system (TPA 1989). Prior to final disposition (closure) of the system, a supplemental EIS will be approved after a period of evaluations and demonstrations of the appropriate technology for the closure process.

The Westinghouse Hanford Company (WHC) has been assigned by DOE as the operating contractor to perform the Hanford Site reclamation, which includes closure of the SST system. WHC requested that a system analysis be conducted of the Hanford SST complex as a first step toward organizing an extensive evaluation of the alternatives and to direct the development of technology for successfully closing down the single-shell tank system at Hanford. The Pacific Northwest Laboratory (PNL) coordinated the system analysis effort using a multidisciplined team, each member representing one of seven major functions required to complete the SST closure mission. The team consisted of WHC and PNL personnel.

The regulatory framework surrounding disposal of radioactive waste must be considered in establishing decision criteria for SST waste disposal alternatives. A review of the regulations (Keller et al. 1989) identified the performance, design, permit requirements, and criteria that should be considered. Conclusions from this review are that many regulatory issues need to be resolved and that many of the current statutes and regulations, such as the Resource Conservation and Recovery Act (RCRA), specify general requirements without providing sufficient quantitative criteria to assess performance of the disposition process.

The purpose of this system analysis is to provide a baseline for the technology planning effort. It provides the initial set of measurable requirements that satisfy the intent of the statutes that lack quantitative criteria. As the development matures and the regulatory dialogue continues, the system analysis provides the systematic and structured framework for traceability and iteration of requirements and methods to guide the decision-making process. It also balances the competing interactions between subfunctions to ensure a successful outcome of the system as a whole.

1.2 SCOPE

The analysis must consider all facets of the SST system at Hanford. It must also consider all reasonable alternatives consistent with the applicable statutes and regulations. Because of the uncertainty of these regulations and the absence of quantitative criteria, the technical aspects for design, development, and implementation must be conducted as the dialogue with public agencies is carried on. To foster a two-way dialogue in the hierarchical chain of interests, the system analysis must provide a mechanism for showing how and how well the various actions to be performed by the implementing organization (WHC) satisfy the higher order interests in the chain. As shown in Figure 1.1, the desires, intents, and constraints flowing down the hierarchical chain must be transformed into a set of measurable requirements using a systematic and structured system engineering process invoked at the SST system level. From analysis of the alternative requirements and methods, the consequences, risks, and impacts of various choices flow up the hierarchical chain. In this way, a balance between the social and political interests and the technical capabilities can be achieved.

The scope of the system analysis includes formulation of a system engineering process that provides traceability and that is capable of iteration as new information flows up and down the hierarchial chain. The system engineering process involves the following sequence of steps:

1. Formulation of a mission statement defining why actions are needed to change the Hanford SST system from its present state.

2. A functional breakdown of what actions are to be performed to the level that permits exposition of requirements and methods for the system as a whole.

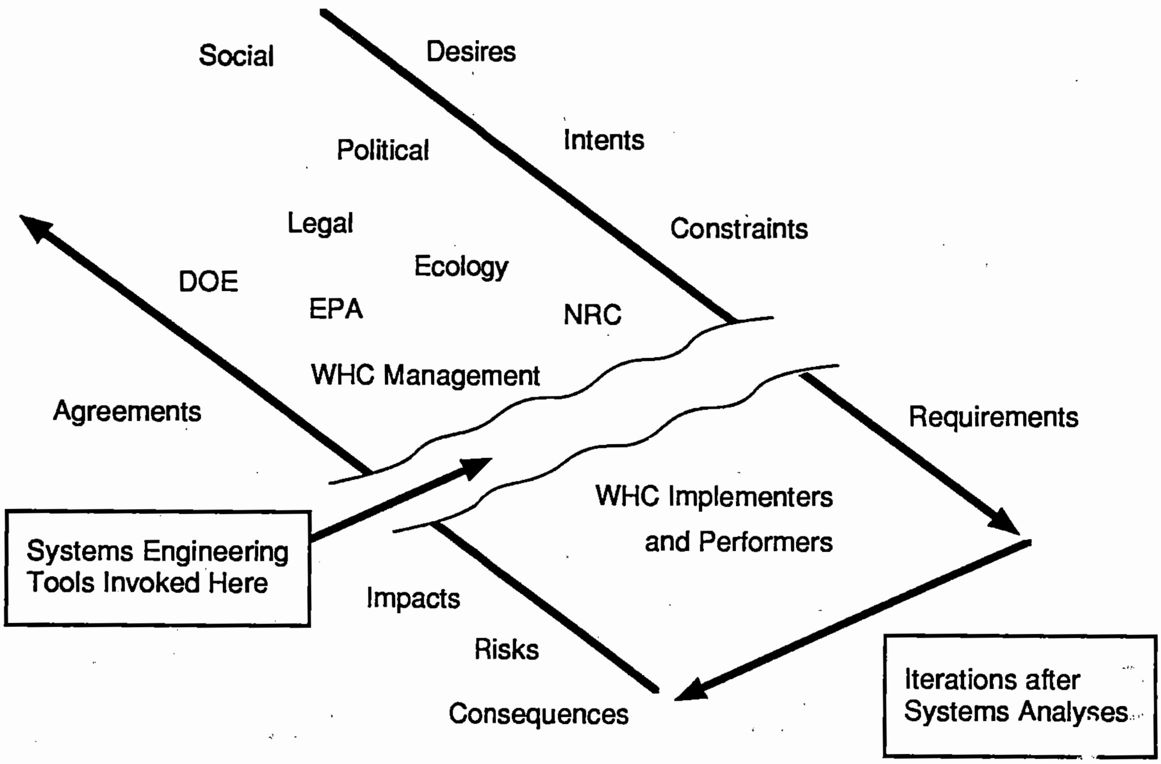

FIGURE 1.1. Hanford SST Hierarchical Chain of Interests

3. A requirements analysis of how well the actions are to be performed. A set of reference requirements is selected and used in the initial planning.

4. A methods analysis of how the actions are to be performed. Also, a set of reference methods is selected and used in the planning.

The system analysis provides the baseline at the system level for detailing of the design and development effort so that it is internally consistent among the functional segments of the SST system. This analysis provides the starting point for subsequent interactions and identifies major trade-off issues that need to be resolved early through exploratory development or through resolution by regulatory dialogue. The output from the analysis is to be incorporated into the various planning documents for the project, such as the Single-Shell Tank Systems Technical Support Program Plan (SST-TSPP) (Klem et al. 1990).

1.3 TECHNICAL APPROACH

The overall SST mission is divided into seven major functions and each member of the study team becomes an advocate of his assigned function. Each of the seven functions defines an action that must be performed by a group or organization and the advocate represents their interest in specifying the attributes that determine how and how well the function can be completed. All attributes are assessed by each advocate to identify potential conflicts as to how well a given performance attribute is to be achieved. Attributes passed down from regulations and statutes are included and are treated as constraints not subject to change if they meet the condition of being measurable. If not, then measurable attributes that do meet the intent are generated by the team. This process bridges the uncertainty gap in the "quantitativeness" of regulations raised by Keller et al. (1989) in their review, and surfaces conflicts in the interfaces between the seven major functions.

The attribute list, representing the collective performance of all functions and therefore the system as a whole, is analyzed from the view point of each function as to the importance of the attribute, to the degree of difficulty in achieving a desired level of stringency, and to the cost impact. These viewpoints form the database for making choices and for identifying key conflicting issues that need to be resolved. The database also can be used for a first-cut sensitivity analysis and to set the stage for more detailed trade studies.

This general description of the technical approach is shown schematically in Figure 1.2 in more detail. Three columns of boxes represent activities that focus on generating options, actions/outputs and criteria.

The options and criteria activities are inputs to an analysis box that generates an output in the center column to the next box below. The arrows show the flow of inputs and outputs between the activity boxes.

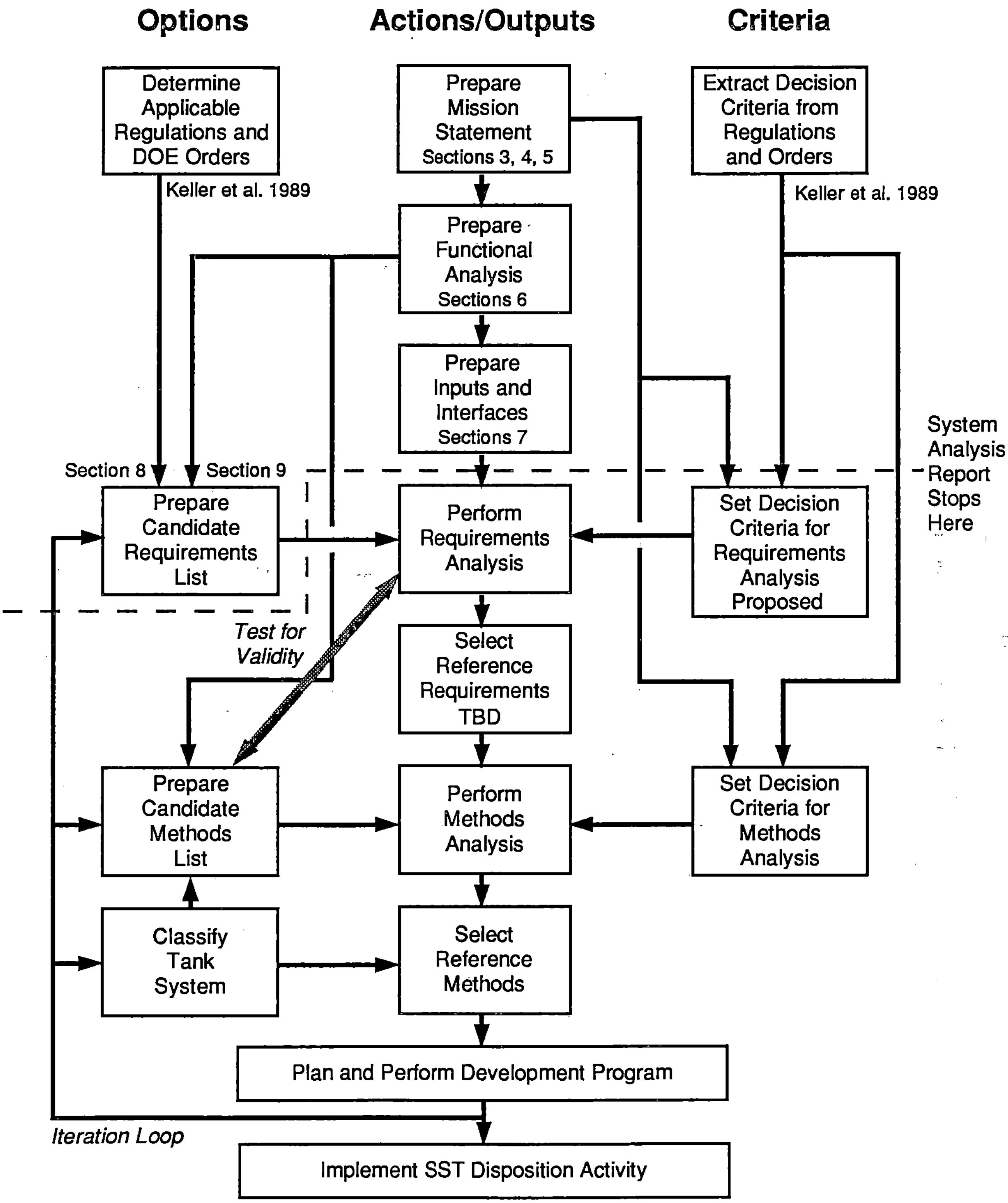

FIGURE 1.2. Hanford SST Systems Engineering Approach

The order of activity is to prepare the mission statement, functional analysis and interfaces first. The mission statement (Section 3.0) generates the top-level function as input to the functional analysis and may also generate appropriate decision criteria. The functional analysis divides the top-level function into lower-level functions to enable an analysis of interfaces and inputs between functions at the same level. Each of the functions also provides the options for requirements and methods to determine how and how well the function should be completed. The intents and constraints from the applicable regulations and DOE orders are combined with the inputs from the functions to prepare a candidate requirements list.

Similarly, the decision criteria from the regulations and DOE orders are combined with inputs from the mission statement to establish a set of decision criteria for the requirements analysis. The same logic path is used for the methods analysis except that applicable regulations may be involved to a lesser degree.

System engineering principles require determination of reference requirements before determination of reference methods. However, there must be at least one valid and plausible method for a given set of requirements (illustrated in the Figure 1.2 by the broader arrow labeled a test for validity).

The dashed line shows the extent to which this report has completed the technical approach. The boxes above the dashed line identify the applicable sections of this report where the activity is described. The boxes below the dashed line are subsequent activities under way. Because of the long-term development and implementation, it is recognized that several iterations are expected and such is represented in the figure by the arrows to the left returning back to requirements, methods, and tank classification boxes for reanalysis based on new information. The tank classification activity box assigns the appropriate "leave" or "retrieve" option to each of the 149 tanks in the SST system and is included in the figure for future use.

The technical approach provides the visible basis for decisions, the traceability of the evolution of the technology, and the capability for iterations to accommodate and control changes for the very complex SST disposition.

2.0 CONCLUSIONS AND RECOMMENDATIONS

The options of leaving or retrieving the Hanford single-shell tanks (SSTs) have been addressed in the context of: if leaving the tanks is the choice, then how and how well is it to be performed? Similarly, if closing the system (i.e., final disposal of the contained wastes and of the SST system components) is the choice, then how well is that option to be performed? The top-level disposition function can be divided into a subset of seven subfunctions that apply equally regardless of the option chosen. The flow of information and material between the functions changes, however; therefore, a separate set of attributes leading to two sets of reference requirements and methods for each option is necessary. The criteria for assigning the stringency level for an attribute have not been developed sufficiently for application to the SST system and must be formalized in discussions with Tri-Party Agreement (TPA) agencies. Furthermore, interfacing requirements for facilities to be shared with other waste systems undergoing environmental restoration (such as the double-shell tank system at Hanford) are needed to understand the capacity and potential interference points in the processing network.

Preliminary analysis of the alternatives to determine how well the retrieved waste should be treated by chemical processes before it is accepted for conversion to waste forms (and subsequently to waste packages) shows that potentially enormous cost increments are involved. It is concluded, therefore, that cost must be included as one of the system decision criteria, although a subordinate one, in the selection of alternative requirements and methods. With the milestone from the TPA of 2018 as the completion date for closure of the Hanford SST system, time to accomplish complex closure tasks must also be a decision criterion. From the Resources Conservation and Recovery Act (RCRA) and other applicable statutes, decision criteria also must be focused on the long-term health and safety risks to the public. DOE orders and other statutes also require near-term exposure to the public and employees from operations performing the closure of the SST system as a consideration for decision criteria.

Recommendations for further activities to improve the selection of requirements and methods for the Hanford SST system as a whole and to aid in reaching conclusions about future courses of action toward its disposition are presented below.

1. **Provide and use a reference set of requirements as the basis for integration with current projects (HWVP, Grout, etc.) that will service the Hanford SST system after some non-SST systems are completed.**

   In the anticipation that the double-shell tank (DST) and other waste streams will receive priority for recovery, it is imperative that the needs of the SST system be overlayed with other Hanford Site dispositions where a commonality of facilities and technologies are used. Pretreatment and waste packaging of glass and grout wastes are particularly important. Since SST waste uniquely contains an excess of sodium nitrate, aluminum and silicon compounds, the process system must accommodate this burden. Alternatively the grout and glass waste packages must be reformulated to contain higher concentrations of these relatively low hazard but abundant waste constituents without destroying their long-term waste package performance in the disposal environment.

   This step will require strong involvement of SST concerns in the project definition stages of other pretreatment and waste packaging design and construction projects at the Hanford Site. The candidate requirements generated in this report provide the initial instrument for this action.

2. **Provide and use a simulation model of the waste process stream between the sub-functions of the SST system to allocate requirements (i.e., in-process storage capacity, availability, instantaneous processing rates) for integrated development.**

   The large and diverse quantities of waste accumulated in the Hanford SST system require an analysis of the flow streams if retrieval is attempted. Blending and interim storage of sludge and supernatant liquids will need to be managed if stringent control of certain hazardous chemical constituents is applied. Some constituents cannot be extracted from the waste streams and are subject to large swings in concentration from one tank to the next. The retrieval, pretreatment and waste packaging schedules must be closely matched to achieve an efficient disposition process. Before commitments of major pretreatment and waste packaging projects to DST and other waste recovery plans are finalized, the surge capacity and its strategic placement for SST needs must be recognized.

   The simulation study can be readily accomplished early in the program and provides a high leverage in cost savings by minimizing the number of waste packages. The simulation model should be structured using the SST functional breakdown to allocate requirements to each function. The model should be simply applied initially and grow in

complexity and sophistication as the SST characterization activity defines the SST waste sources more accurately.

3. **Provide and use a set of performance measures that recognizes the interests of all parties involved in the approval process. These measures become the basis for selecting alternative requirements and methods by the implementing organizations.**

   One of the key purposes of a performance assessment is to satisfy (through technical arguments) the interests of all parties involved in the approval process--that is, the TPA agencies. Because of the complexity of the problem, and the multiple performance considerations stipulated by the statutes and the governing agencies as described above, four types of SST performance measures are recommended to establish decision criteria:

   a. Long-Term Health Effects/Risk

   b. Short-Term Health Effects/Risk

   c. Time-to-Complete

   d. Cost-to-Complete

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3.0 MISSION STATEMENT

Radioactive wastes have been generated since 1944 on the U.S. Department of Energy's (DOE) Hanford Site in Washington State as part of the program required to support national defense activities at Hanford. Liquid radioactive and chemical wastes from the nuclear materials production and research activities were transferred to underground, reinforced concrete, steel-lined tanks, commonly referred to as single-shell tanks (SSTs), for storage. The SSTs were used to store several types of liquid wastes before 1971.

A total of 149 SSTs, with capacities ranging from 55,000 to 1 million gallons each, were constructed on the 200 Area plateau of the Hanford Site. Waste from several of the SSTs was retrieved in the 1950s for extraction of uranium and in the 1960s and 1970s for extraction of cesium and strontium fission products. During the 1970s, the volume of liquid wastes stored in these tanks was reduced by evaporation of the liquids, leaving moist sludge and saltcake in the SSTs. The evaporation effort also served to reduce the environmental impacts of potential releases from the tanks by minimizing the volume of drainable liquids available to contaminate the soil around the tanks. The SSTs now contain about 37 million gallons of saltcake, sludge, and interstitial and nonpumpable supernatant liquids. The wastes contain radionuclides and potentially hazardous nonradioactive chemicals.

Production operations at the Hanford Site have produced approximately 1150 waste management units, as addressed in the Hanford Federal Facility Agreement and Consent Order, more commonly known as the Tri-Party Agreement (TPA 1989). These waste units have been grouped into 78 operable units (excluding four groundwater units) to assist in the management of final disposal activities. The six SST operable units include treatment, storage and disposal (TSD) units and past practices units. The SST TSD units comprise the tanks, currently associated piping and soils contaminated by leaks from 66 SSTs. The Resource Conservation and Recovery Act (RCRA) past practice (RPP) units include diversion boxes, a crib, a french drain, and several septic tanks. The cribs and trenches that received discharges from cascade SST operations are included in the other operable units and are not covered by

this system analysis. Separate remedial investigation and feasibility study work plans are being developed for these waste units.

Interim management activities for the Hanford SST operable units will be continued until a decision is made on the actions required for final closure and waste disposal. These interim activities include characterization of tank wastes, soil, groundwater and ancillary equipment; stabilization to reduce the volume of liquids contained in the waste solids; surveillance to detect leaks, liquid intrusions and changes in the radiological status of the contaminated solids; heat management to prevent excessive tank temperatures; and tank isolation (i.e., sealing the tank piping and openings) to deter liquid intrusion and monitoring of the groundwater for radionuclides and chemicals.

Final disposal of SST structures and contaminated wastes was addressed in the Final Environmental Impact Statement for the Disposal of Hanford Defense High-Level, Transuranic and Tanks Wastes (DOE 1987). The final HDW-EIS presented five alternatives with respect to the SSTs:

1. Geologic Disposal Alternative--Retrieve, separate, process, package and transport to dispose of most of the SST waste in a geologic repository.

2. In-Place Stabilization and Disposal Alternative--Dispose of SST waste in-place, including dome filling and using a protective barrier and marker system. Waste processing will be limited to liquid removal and some SSTs will require interim heat removal equipment.

3. Reference Alternative--The reference alternative is identical to the In-Place Stabilization and Disposal Alternative for the SSTs.

4. Preferred Alternative--Defer decisions on disposal of waste in the SSTs until additional developnent and evaluation are complete. In the interim, DOE will continue storage and maintenance of the SST wastes. This alternative was developed as a response to agency and public review.

5. No-Disposal-Action Alternative--Continue storage of the wastes in the existing tanks. The SSTs will be monitored and maintained. Ongoing activities, such as reduction of liquids in the SSTs, will continue. This case was analyzed in accordance with the requirements of the Council on Environmental Quality-National Environmental Policy Act (NEPA).

As stated in the final HDW-EIS Record of Decision (DOE 1988). DOE has decided to select the preferred alternative and conduct additional development

and evaluation before making a final decision on disposal of the SST wastes. This additional development and evaluation will include 1) characterizing radioactive waste and hazardous waste (HW) constituents, 2) demonstrating barrier performance by both instrumented field tests, natural analog studies, and modeling, 3) determining the need and methods for improving the stability of the waste form, 4) determining the need and methods for destroying and stabilizing hazardous waste constituents, and 5) developing and evaluating methods for retrieving, processing and disposing of the wastes. The final HDW-EIS ROD commits to the preparation of a supplemental EIS for the single-shell tank waste at Hanford.

Additional development and evaluation will be integrated with regulatory requirements for permitting and closing hazardous waste (HW) sites. In May 1987, DOE issued a final rule stating that the HW components of DOE radioactive waste that are defined as HW under the RCRA are subject to the RCRA regulations. In November 1987, the U.S. Environmental Protection Agency (EPA) authorized the Washington State Department of Ecology (Ecology) to regulate mixed wastes (MW) within the state. Consequently, the SST wastes are jointly regulated by DOE (radioactive constituents) and the EPA and Ecology (hazardous chemical constituents).

The Draft Single-Shell Tank Closure/Corrective Action Work Plan presents a work plan for activities associated with final disposal of the SST operable units. This plan serves as the primary basis for more detailed documentation such as the Hanford Single-Shell Tank Systems Technical Support Program Plan (SST-TSPP) (Klem et al. 1990). As part of the SST-TSPP preparation, a system analysis activity was initiated as described in this report.

The SST disposal program mission can be stated as follows:

> The overall mission of the SST disposal program is to develop, evaluate and implement methods for ultimate disposal of the SST operable units, in compliance with applicable regulations, standards and permit requirements. The disposal methods must prevent significant adverse impact to the biosphere and must protect the long-term health and safety of the general public and maintain worker exposure to as low as reasonably achievable (ALARA).

For purposes of the system analysis, the primary functional action derived from the mission statement is to <u>perform final disposition of the</u>

Hanford single-shell tank system. This function is accomplished through many subordinate functions that can be constructed from a functional analysis using the approach described in Section 1.0.

4.0 MISSION ASSUMPTIONS

The major assumptions used to guide the analysis of the Hanford single-shell tank (SST) system are provided in this section. These assumptions were generated during the analysis to clarify situations raised by the team where there was no guidance from existing planning documents. These assumptions are considered temporary and may be modified in the future. However, because of the serious impacts that may be involved, such modification to the assumptions must be accompanied by a reanalysis to ensure that any resulting changes are properly identified.

- All SST barriers as originally designed will fail eventually and cannot be used for performance credit in the new concept.
- All tanks will transition from their present state to a stabilization/isolation state before remedial and final disposition actions are performed. This situation provides a uniform reference point for analysis of the interface requirements between the stabilization/isolation function and the other functions.
- A tank farm will have all tanks in the farm stabilized and isolated prior to final disposition. This situation provides a similar uniform reference point for analysis of the sequencing strategies for the leave or retrieve options.
- Offsite repositories will be available to accept the SST waste entities as they are generated. The system analysis does not consider the impacts of interim storage because of delays or upsets outside the SST system.
- Some SST-treated wastes will be disposed of in LLW grout vaults onsite.
- The double-shell tank (DST) system will be available for cross-blending and conditioning of SST waste on demand. Final disposal of the DST waste will precede the SST disposition. As a point of reference, cost impacts of pretreatment alternatives will assume that DST technology and capital expenditures are previously incurred costs and will not be allocated to the SST system cost if used by follow-on SST disposition. SST derived technology and provisions for additional DST processing capacity and storage will be included in the analysis of SST system costs.

- For the purpose of performing the requirements analysis, surveillance and monitoring of SST waste will be performed within the boundary of the SST system. It is realized, however, that compliance is a site issue and potential overlaps in these activities may occur with other non-SST operable units and allocation of certain requirements may be necessary.

5.0 SYSTEM DEFINITION

The system definition includes the contents of the six SST operable units (OUs) defined in the Tri-Party Agreement (TPA 1989). The inventory of the contents is listed for each OU in the Hanford Single-Shell Tank Systems Technical Support Program Plan (SST-TSPP) (Klem et al. 1990). For purposes of the system analysis the types of treatment, storage, and disposal (TSD) units are: tank waste, tank structure, associated piping, pumps, ventilation equipment, and contaminated soils from some of the 149 SSTs. Also within the six OUs are Resource Conservation and Recovery Act Past Practice (RPP) units that include: diversion boxes, spills from diversion boxes, a crib, a french drain, and several septic tanks. The contents of the RPP units and the associated piping, pumps, and the ventilation equipment in the TSD units were combined in this report into one category and named "ancillary equipment." The cribs and trenches that received discharges from cascade SST operations are included in the other OUs and are outside the SST system definition. Also, operational service lines outside the first diversion box in a tank array are not covered as part of the system analysis.

The system definition must include also the facilities (temporary and permanent) that are needed to conduct the closure process. Depending on the alternatives for disposition, the facilities may be located at the SST sites, at designated burial sites at Hanford for LLW disposal, or at a central location for processing and in-process storage of SST waste. The system definition does not include offsite facilities for final disposition of the transported waste that may require further processing and packaging. These facilities are assumed to be available for receipt of waste according to defined acceptance criteria and their services are included in the system analysis as a unit cost based on the number of units transported.

The system definition also includes equipment used during the disposition. Depending on the type of method for disposition, various major equipment items should be identified at the system level, such as in situ vitrification assemblies, retrieval assemblies, and transportation casks. However, most of the equipment may be identified later at lower levels in the system

analysis. The principal concern is that equipment life, decontamination, and disposal may influence the decision about alternative methods and should be recognized early in the system analysis.

Materials consumed or used in the formulation of waste entities for final disposition are also part of the system definition. The SST waste may be divided into several waste forms. The waste form is created by combining the raw waste with host materials in a controlled process that limits release after the containment period has been exceeded. Containment is achieved by incorporating the waste form in a waste package. The waste package consists of one or more material combinations that isolate the waste form from intrusion of destructive elements and from dispersal of its contents during a designated containment period. In the SST system, there are several alternative situations where regulations require containment, including during transport. Therefore, a wide variety of packages are envisaged with their own set of requirements. The system analysis has used the terms "waste form" and "waste package" generally as described here to unify the perspective for examining alternative requirements and methods. The combination of the waste form and the waste package is one class of enclosure. Transportation casks, facility isolation barriers, and intrusion barriers are additional classes of enclosures involved in the SST system definition. All these classes are categorized as engineered enclosures in the system definition.

Figure 5.1a,b shows the SST system relative to other waste management systems at Hanford, and a schematic representation of Hanford tank farm facilities is shown in Figure 5.2. Figure 5.3 provides a cross-sectional view of the four types of underground single-shell tanks at Hanford. These figures are from DOE (1987).

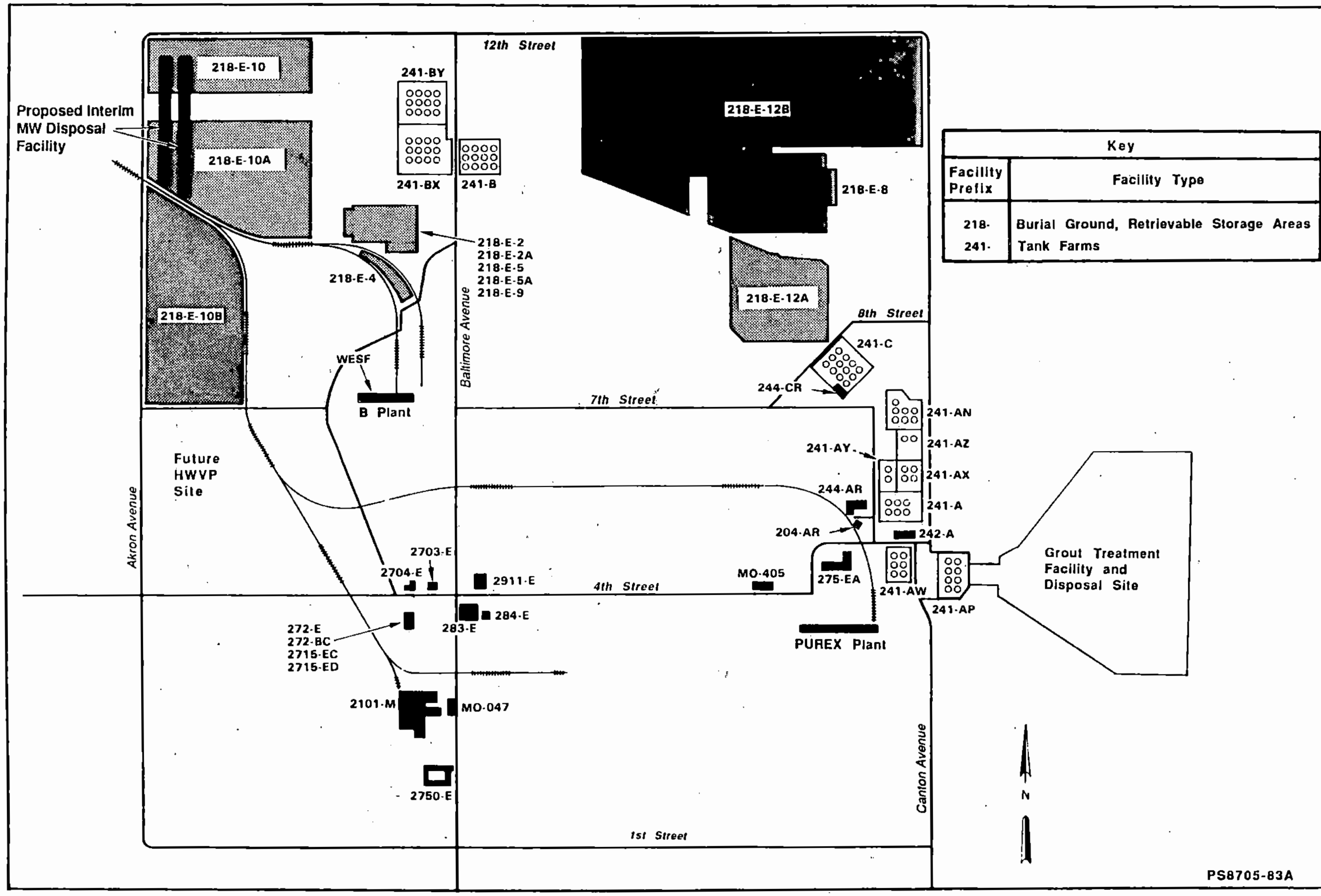

FIGURE 5.1a. Hanford Site 200 East Area

9 1 1 1 8 9 0 1 8 3 9

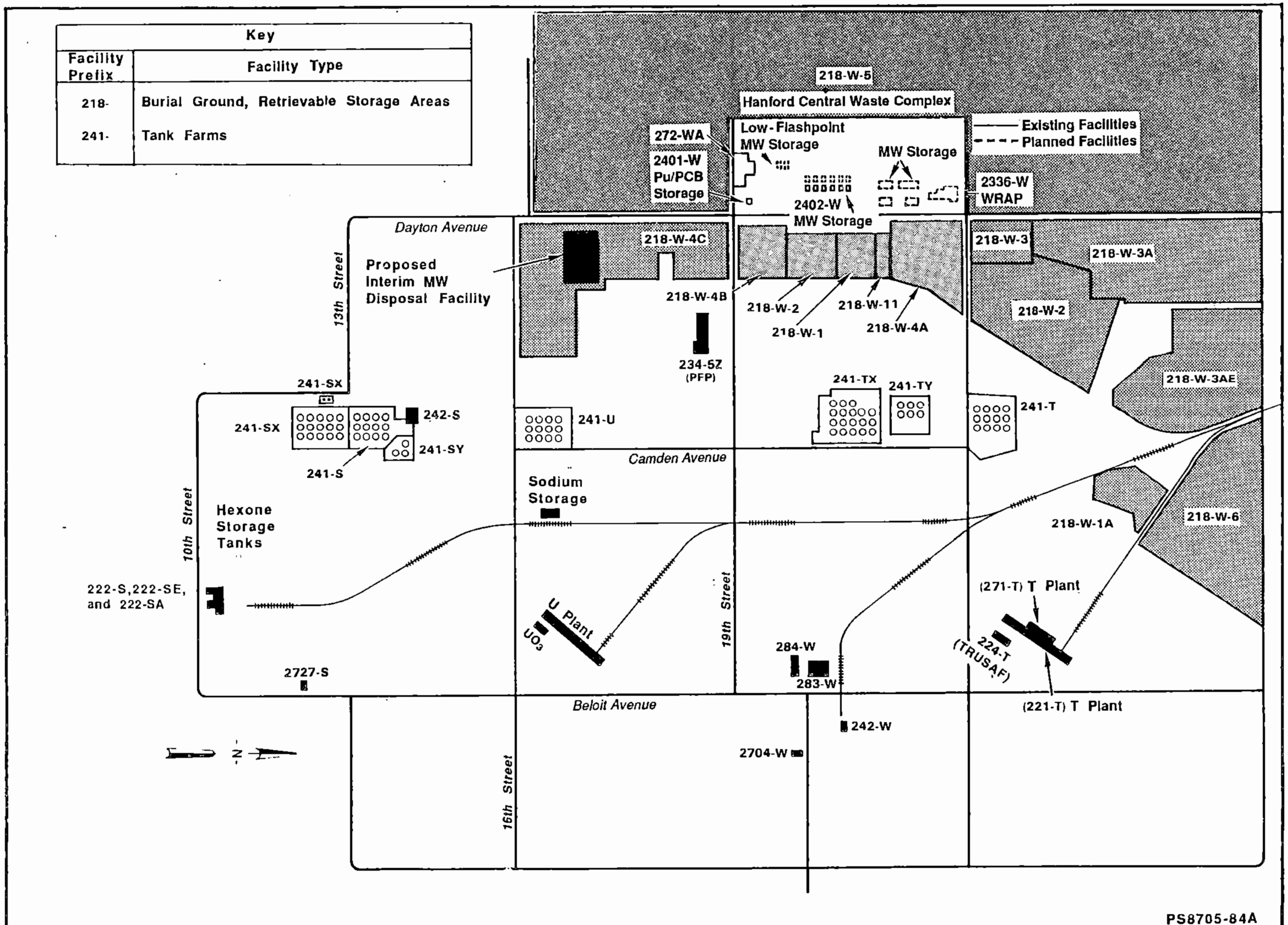

FIGURE 5.1b. Hanford Site 200 West Area

Existing Underground Waste Tank Farms

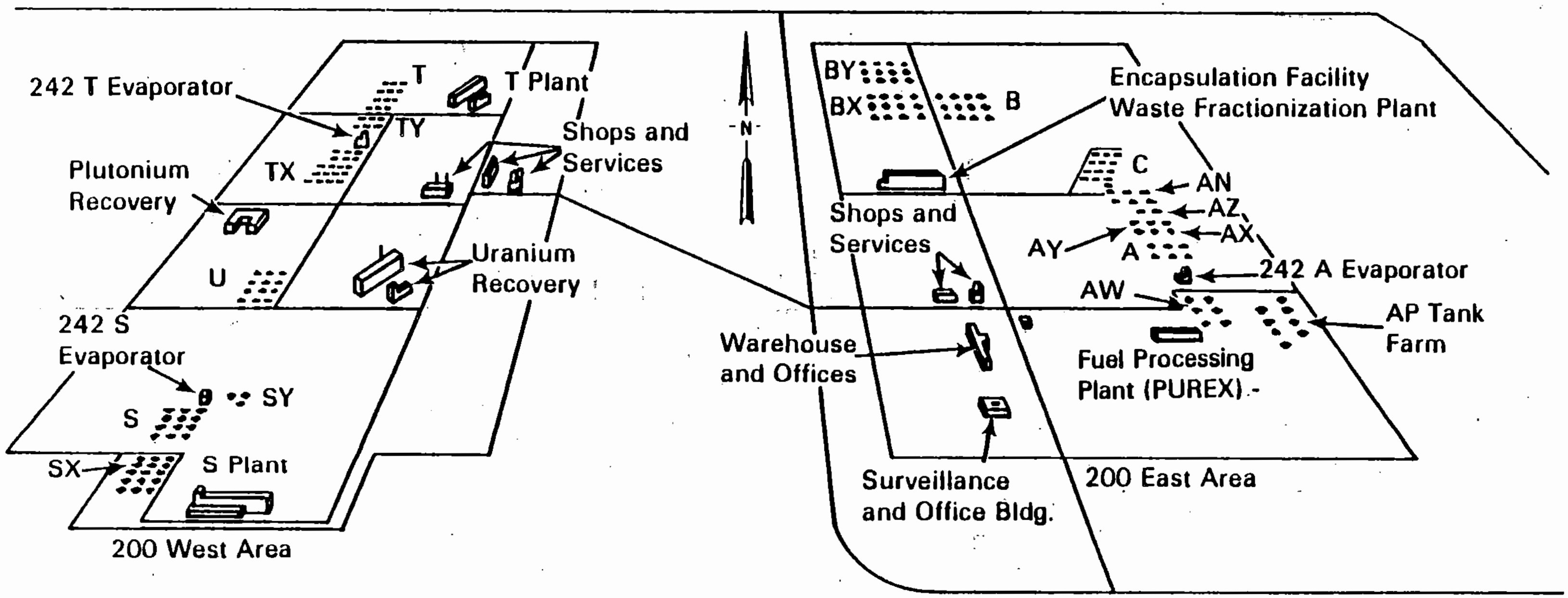

FIGURE 5.2. Schematic Representation of Hanford Tank Farm Facilities (Not to scale. Farms in 200 East and 200 West Areas are about 10 km apart.)

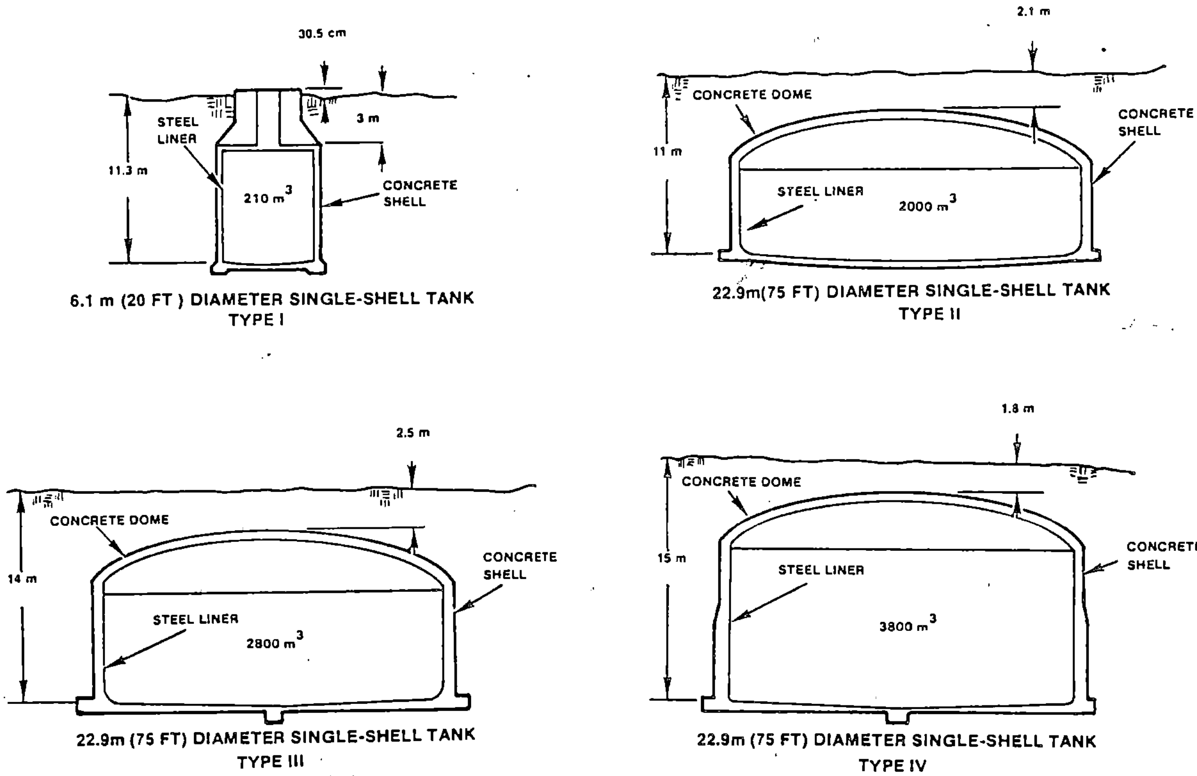

FIGURE 5.3. Underground Single-Shell Tanks at Hanford

6.0 FUNCTIONAL ANALYSIS

The results of a functional analysis of the Hanford single-shell tank (SST) system are presented in this section. The functional analysis starts at the primary (zero) function level and continues to the third-level functions. Details of the functional analysis are provided in Appendix A.

In the Mission Statement, the primary function was described as: Perform Final Disposition of the Hanford Single-Shell Tank System. This descriptor reveals little detail but is the starting point for a functional analysis that systematically unfolds the multiplicity of functional actions to be performed. The purpose of this functional analysis is to delineate a layer of subfunctions so that when they are successfully completed, the parent function is also successfully completed. The revelation of functional detail may proceed through many levels. A representative example, extracted from the detailed breakdown in Appendix A, is shown in Figure 6.1. The box diagram at the bottom of the figure illustrates the "parent-child" relationship.

At the initial stage of a system analysis it is sufficient to develop a functional breakdown only to the first level, in order to identify major segments that would influence the setting of system requirements and methods. However, it is beneficial to identify provisionally two more levels, in order to organize and justify the requirements and methods from a bottom-up perspective.

One approach to segmenting the primary function is to determine which actions if not performed would render the primary function incomplete. Examination of the regulatory statutes and the DOE orders prescribes a characterization activity to inform the public of the present state of a potential waste source. This provides a data base for judging the hazard level and making decisions for follow-on actions. The regulatory statutes also prescribe a reporting action to justify, through a permitting process, the course of action to be followed toward closure and to monitor performance during the implementation of final closure. Therefore, characterization and reporting are two functions that are essential to achieve final closure.

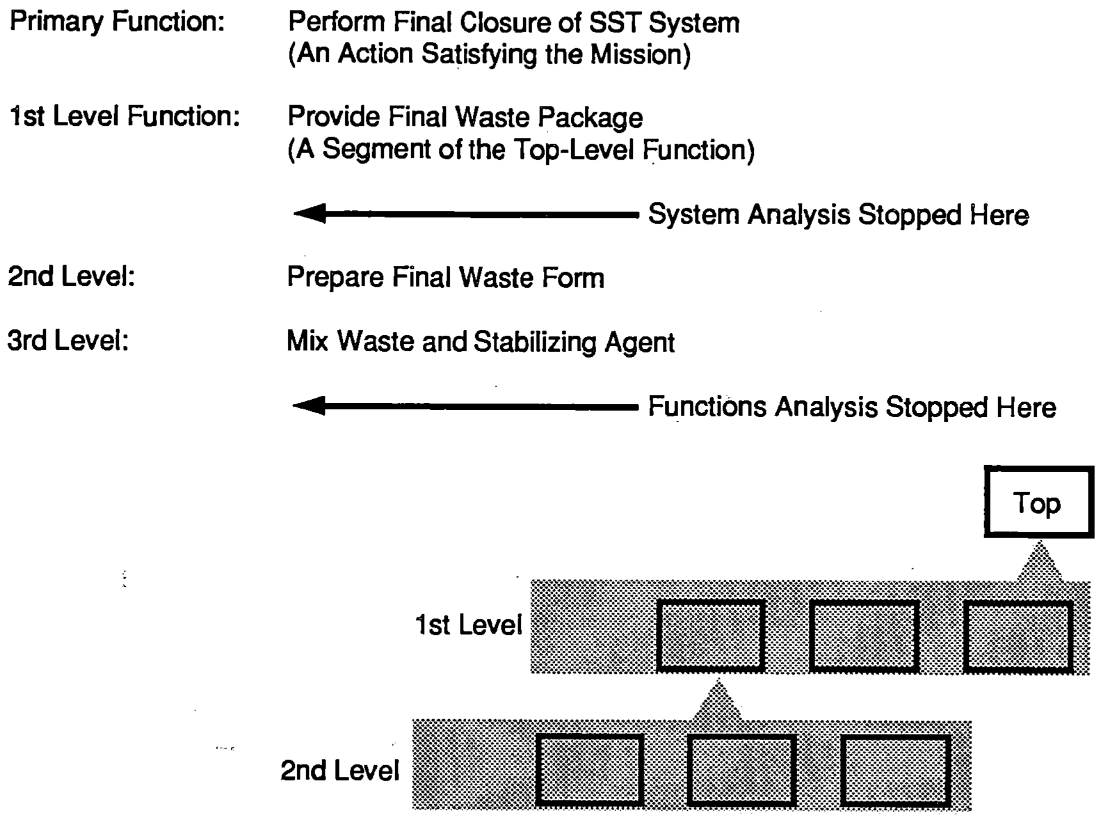

FIGURE 6.1. Hanford SST Functional Analysis, Illustration of Functions and Subfunctions

Because of the complexity of the SST system, there will be a significant period of development before closure is initiated. DOE has committed to a stabilization and isolation action performed on all waste tanks during this interim period. Since the stabilization/isolation of the SSTs may influence other closure actions, it must be included as a function at the first level.

Examination of the known contents and the physical state of the SST waste indicates that up to four distinct types of physical actions are required to complete the final closure process regardless of the choice of disposal option. Each type requires different mechanisms and disciplines, an appropriate condition to designate them as separate functions. These functions are 1) to retrieve SST waste and/or its ancilliary components, 2) to partition the waste materials by chemical pretreatment into specific waste feed streams to optimize the cost within the constraints of regulations, 3) to prepare waste

packages from the feed streams as a containment vehicle for isolation, and 4) to provide a long-term isolation function to monitor containment and to prevent intrusion of ecological elements that would destroy resistance to dispersal of the waste in the public domain. Elimination of any of these four actions would curtail the opportunity to utilize a number of "leave" or "retrieve" options to perform the mission safely and efficiently.

In all, seven first-level functions are needed to satisfy the mission and its primary function. These include the four physical actions as well as other required actions, e.g., development of regulatory documentation. It is expected that all these functions will be applied to some part of the SST system during implementation of the final closure phase. During the development and assessment phases these functions provide the infrastructure for conducting supporting R&D. Each of the seven functions are described in more detail below. For purposes of indexing, each function is assigned a four-digit number. For the primary function, the number is 1000. For the seven first-level functions, the numbers are 1100 to 1700. Lower-level functions are indexed by the third and fourth digit.

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6.1 FUNCTION 1100 - CHARACTERIZE THE SST SYSTEM

This function provides the knowledge of the system state before any closure processing is initiated. Measurements are performed to include all data needed to do assessments for regulatory documentation. Sampling is performed on tank contents and on contaminated soil to determine the hazard level. Sampling may be performed also on uncontaminated soil and groundwater to establish baseline compositions and properties for performance assessments of transport rates. Property determinations of the waste and other components are carried out to provide basic data for handling and transporting the waste. Finally, all measuring techniques are qualified for use in performance assessment and risk analysis evaluations. The output of this function is directed as input to other first-level functions which need the data. The function has been implemented as part of the closure planning process.

6.2 FUNCTION 1200 - PROVIDE STABILIZATION/ISOLATION

As described in the Mission Statement this function has been implemented as part of the interim management activity until a decision is made on the actions for final closure. It is assumed all SST tanks will be pumped to a stabilized condition and isolated before final disposition of the tank begins. It is expected that interim management can be performed without any inputs from the other functions, except possibly the characterization function. However, other first-level functions may be dependent on how well this function is performed, in particular the amount of liquid remaining in the tanks after pumping. For subsequent retrieval, pretreatment or conversion to a suitable waste form, conditioning of the tank waste to reduce the remaining free liquids to a lower level may be a necessary action for this function.

6.3 FUNCTION 1300 - PROVIDE REGULATORY DOCUMENTS

The outcome of this action is to obtain the necessary permits and approvals prior to final disposition. Because the regulatory path is complex and unpredictable, it is appropriate to view this step as a primary first-level function. This enables the system analysis to evaluate judgments from the regulatory viewpoint on an equal basis with engineering and operational viewpoints, thereby creating an opportunity for safe but lower cost remediation options. The perspective of regulators is essential in the system analysis, since their actions enable many of the other functions to be performed within the interpretation of the regulations. All performance assessments needed for preparing documents to satisfy the "permitting" process are subfunctions of this function.

6.4 FUNCTION 1400 - RETRIEVE SYSTEM COMPONENTS

Even if in situ entombment is selected, it is necessary to remove, disengage or modify some components in the SST system. This "opening" of the system presents special challenges and represents a unique set of actions that may influence the overall performance of the final disposition such as increasing the risk of short-term health and safety effects for the performers. Retrieval is a field action that must reflect productivity as well as

operational safety concerns. Containment during operations, transport from the field to a processing facility, storage of in-process waste, and the repeated dismantling and reassembly of the retrieval system are some of the activities involved with this function.

6.5 FUNCTION 1500 - PERFORM PRETREATMENT OF SYSTEM COMPONENTS

This function includes all treatments that generate one or more waste streams when applied to the system components, in situ or after retrieval. There is a multiplicity of processes involved, including conditioning of the sludge, salt cake and possibly contaminated soil before chemical processing; partitioning the feed streams for selective control of the disposal paths for various constituents; chemical extraction; and conditioning of the output feedstreams before consolidation in the appropriate engineered enclosure. For retrieved components, the pretreatment may involve a centrally located facility to service all the SSTs. For in situ treatments, field processes would be necessary. An example of an in situ treatment would be conversion of the nitrate species to elemental nitrogen, thereby reducing its toxicity. An example of treatment of the retrieved waste would be to partition the more abundant sodium, aluminum, phosphorous and silicon compounds to the LLW-type engineered enclosure and the less abundant but toxic elements such as chromium, Sr-90, Cs-137 and the transuranics to a HLW-type engineered enclosure.

6.6 FUNCTION 1600 - PREPARE FINAL WASTE PACKAGE

All hazardous system components must be packaged within an engineered enclosure appropriate for their disposal path. Several disposal paths are possible according to the classification of the waste form. This function receives the waste after conditioning by stabilization, retrieval or pretreatment and converts it to a waste form. Pretreatment may enable a change in classification to reduce the hazard potential and/or reduce the cost of disposal. Preparation of the waste form includes consolidation, sequestering in an isolation media such as glass or grout, or possibly as recycled waste for reuse. Containment of the waste form by one or more engineered enclosures is also part of this function. For HLW or other types of waste forms to be

shipped offsite, this function provides only that portion of the enclosure required to be performed onsite prior to shipment. For LLW waste forms and for in-place waste forms to be buried onsite, this function performs all the enclosures needed to ensure containment after burial. An example of an in-place waste packaging would be 1) preparation of a waste form by dome-filling and then, if necessary, subsequent sequestering by in situ vitrification or in situ grouting and 2) preparation of an engineered enclosure to provide the appropriate containment. The waste packaging term is used here as a broad description of the functional action and not as a specific design description for a particular class of regulations.

6.7 FUNCTION 1700 - PROVIDE LONG-TERM ISOLATION

This function is limited to onsite disposal paths only, of which there are three types:

1. In situ isolation using the existing SST system where this function must provide its own qualification and controls for management of the environmental protection system.

2. Isolation of wastes in grout using an onsite facility where the function must provide its own qualification and controls.

3. Other isolation paths using existing or planned burial grounds serving other disposal sources as well where there is no functional responsibility for management and control.

This function includes providing isolation barriers, markers, and monitoring of the site after final disposition is completed. The term "isolation barrier" is aimed primarily at preventing intrusion of water and other ecological phenomena from destroying control of containment and dispersal rates of the waste packaging system developed under Function 1600. Onsite isolation includes selection and preparation of the sites for waste package receipts, off-loading, and emplacement. Offsite isolation functions managed outside the SST system are included in Functions 1500 or 1600 as a cost of service and are not included in this function.

In summary, these seven first-level functions each represent a particular viewpoint for input to the SST system analysis. Each segment is dependent on the other functions in regards to inputs/outputs, to shared requirements, and

to the methods used by each segment. The primary purpose of the first-level functional segmentation is to evaluate these interdependencies at the system level before further segmentation to lower levels of functional actions.

Appendix A provides a provisional list of second- and third-level functions for each of the first-level functions. In a few cases, a fourth level was added. This breakdown conveys a perceived set of actions that would successfully complete the parent function. Later, when requirements may need to be allocated, this breakdown of the second and lower levels may be reconsidered and updated.

In general, most second-level functions are segmented by components of the SST system and then the third level reveals a set of sequential actions to be performed on each component. The system components are tank waste, tank shell, ancillary equipment, and contaminated soil. Summary highlights of the functional breakdown are as follows:

- 1100 - Characterization is segmented by system components and the third level is segmented by a sequence of steps to gather and evaluate integrity of the components or to obtain and evaluate compositions of components. Evaluation of the compositions is aimed at providing source term data used by other functions.

- 1200 - Stabilization/Isolation is a series of sequential actions followed by a surveillance action and defines the second-level functions. Third-level actions are also sequential. The stabilization segment, however, has two facets, depending on the use of a jet pump or non-jet pump capability.

- 1300 - Preparing Regulatory Documents is segmented at the second level by the responsive actions to satisfying three major statutes: NEPA, RCRA, and CERCLA. In addition, there are actions needed to respond to several auxiliary documents. All these documents require performance assessments that are also included at the second level. Each second-level function is segmented to a sequence of actions appropriate for each document.

- 1400 - Retrieval is segmented by system component and each component is segmented at the third level by a sequential set of actions.

- <u>1500 - Pretreatment</u> has to consider two environments for processing: in-place or at a processing facility. Each of these segments has the same set of sequential actions. These sequences are very general since the specific methods for the many chemical constituents are varied and complex.

- <u>1600 - Providing the Final Waste Package</u> involves a sequence of actions assembling the waste package from its components: waste form, container, mass transport barriers, etc. Each of these sequential steps in turn involves a more detailed set of sequences at the third level.

- <u>1700 - Providing Long-Term Isolation</u> involves three steps: prepare the site, provide an intrusion barrier, and monitoring. Each of these second-level actions has further controlling or monitoring actions to satisfy several constraints for long-term isolation.

7.0 FUNCTIONAL INTERFACES

This section provides an overview of the functional interfaces of the single-shell tank (SST) system at Hanford. These interfaces show the degree of interdependence between the functions and indicate the information needs to complete the overall task. To conduct the interface analysis, advocates for each of the functions defined in the previous section identified key materials and data needed from each other's functions. Flow diagrams were then used to illustrate the linkage patterns, and specific data requests were bundled into an arrow representing a summary statement of the kind of information needed. The specific details were used to generate a list of attributes as candidate requirements described in the next section.

The principal waste flow streams between the functions are shown in Figure 7.1. All waste streams are input to a function from the left, transformed by the function, and output to the right. As shown in the figure, **AND/OR** branching is extensive due to the many options being considered in this system analysis. The tank system comprised of its components is the initial input which branches to the Characterization function and Stabilization/Isolation function. The Characterization function extracts waste samples to obtain information and outputs a sample waste stream to an entity outside the system. The Stabilization/Isolation function transforms the tank system to an interim state. The tank system is output that may be directed to one of three **OR** branches: Retrieval, Pretreatment, or Prepare Waste Package. This branching is not exclusive as all components and tanks in the system may not each follow the same path. For example, one of the "leave" options is the branch going directly from the Provide Stabilization function to the Prepare Waste Package function. The Prepare Waste Package function transforms the components of the waste received from one of the three sources and distributes the segregated waste to offsite disposal (i.e., HLW, LLW, WIPP) and to onsite facilities such as grout vaults or in-place burial. The onsite waste packages are assigned to the control of the Long-Term Isolation function everafter. The function, Prepare Regulatory Documents, has no material flow interfaces to and from the other function. Its actions are informational.

The information flows between the functions are shown in Figures 7.2a through 7.2g. A diagram is shown for interfaces involving each one of the seven functions separately. Information inputs from the left on the figures represent data needed by the function to complete its set of actions. Information outputs to the right are used by other functions. In the figures, there are two kinds of linkages. Outputs may be linked to another function's input like the material stream. The other kind of linkage is information which is a control on another function's actions, shown by arrows entering from the top of the box. The control is a gate or regulator of the transformation of material or information. In a process system, the controls relate to procedures affecting safety, quality, productivity, etc. One of the functions providing many controls on all other functions is Prepare Regulatory Documents. Based on regulatory requirements, the specifications for design and development are passed to each function. During the development phase, the performance assessments provide for further refinement of the specifications. During the implementation phase, the conditions allowed in the license or permit become outputs to control other functions' actions in the form of procedures. Acceptance criteria is another output/control feedback linkage, particularly when the functional flow is sequential as in the functions: Retrieve, Pretreatment, and Waste Package Preparation.

The illustrations provide a basis for defining what information is needed and how well the information and materials should be detailed to satisfy the needs of all the functions. This foundation is provided to carry out the next step, developing system requirements that are meaningful to the lower-level functions in the functional flow network. When the same information is desired by several functions, its importance can be determined by a ranking that is described in the next Section 9.0.

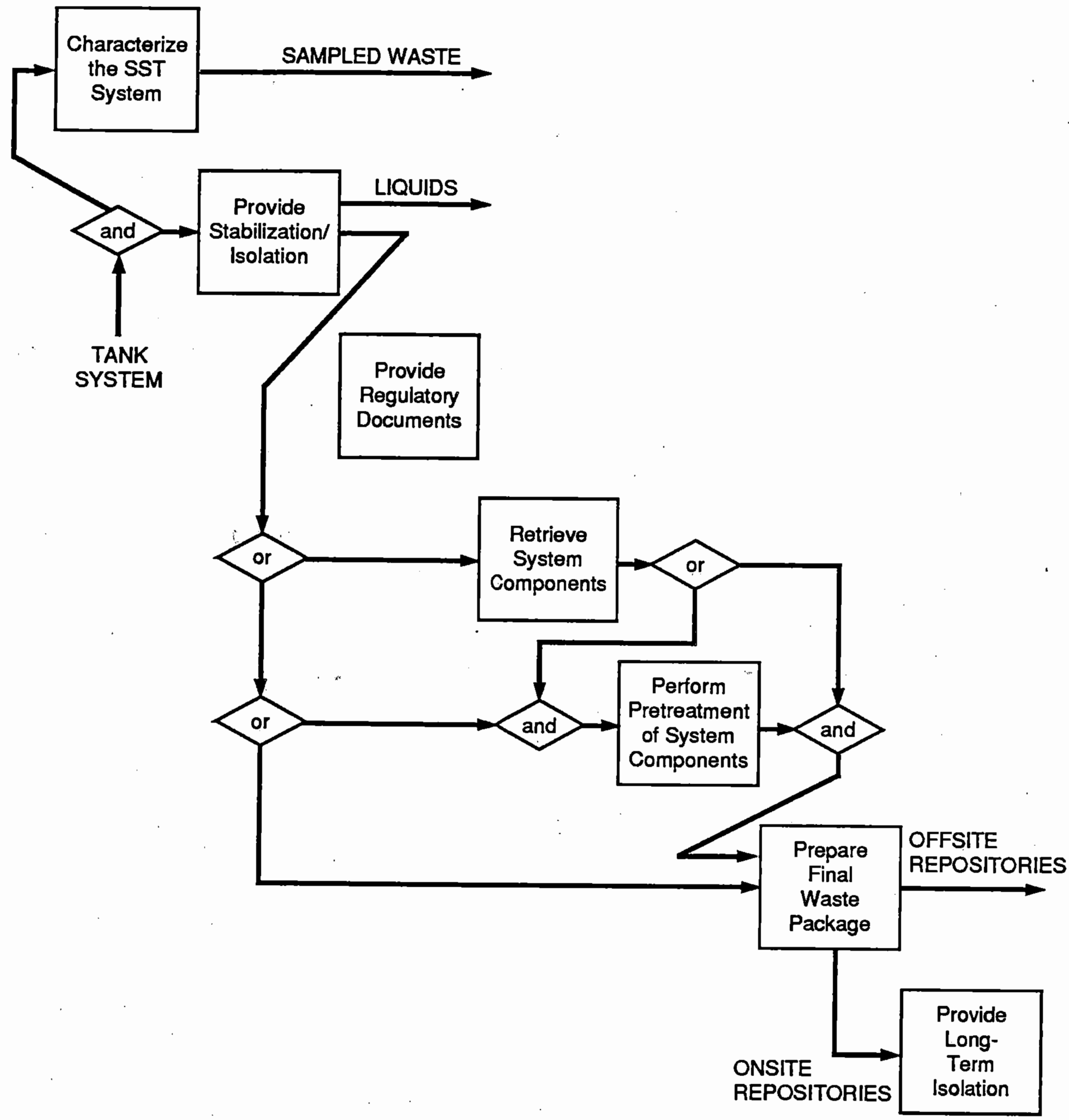

FIGURE 7.1. SST Functional Interfaces Material Flow (During Implementation)

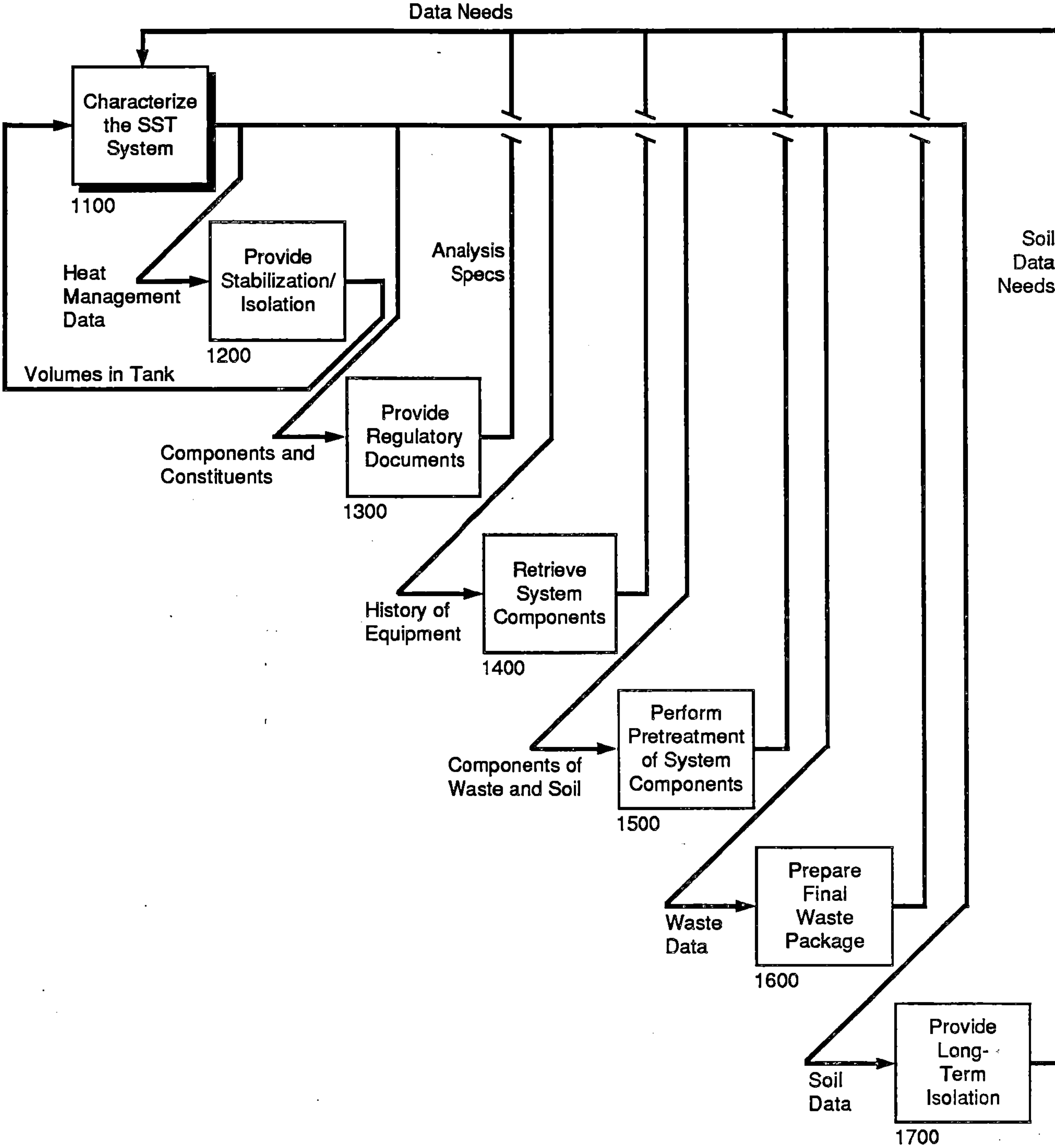

FIGURE 7.2a. SST Functional Interfaces Information Flow To/From 1100

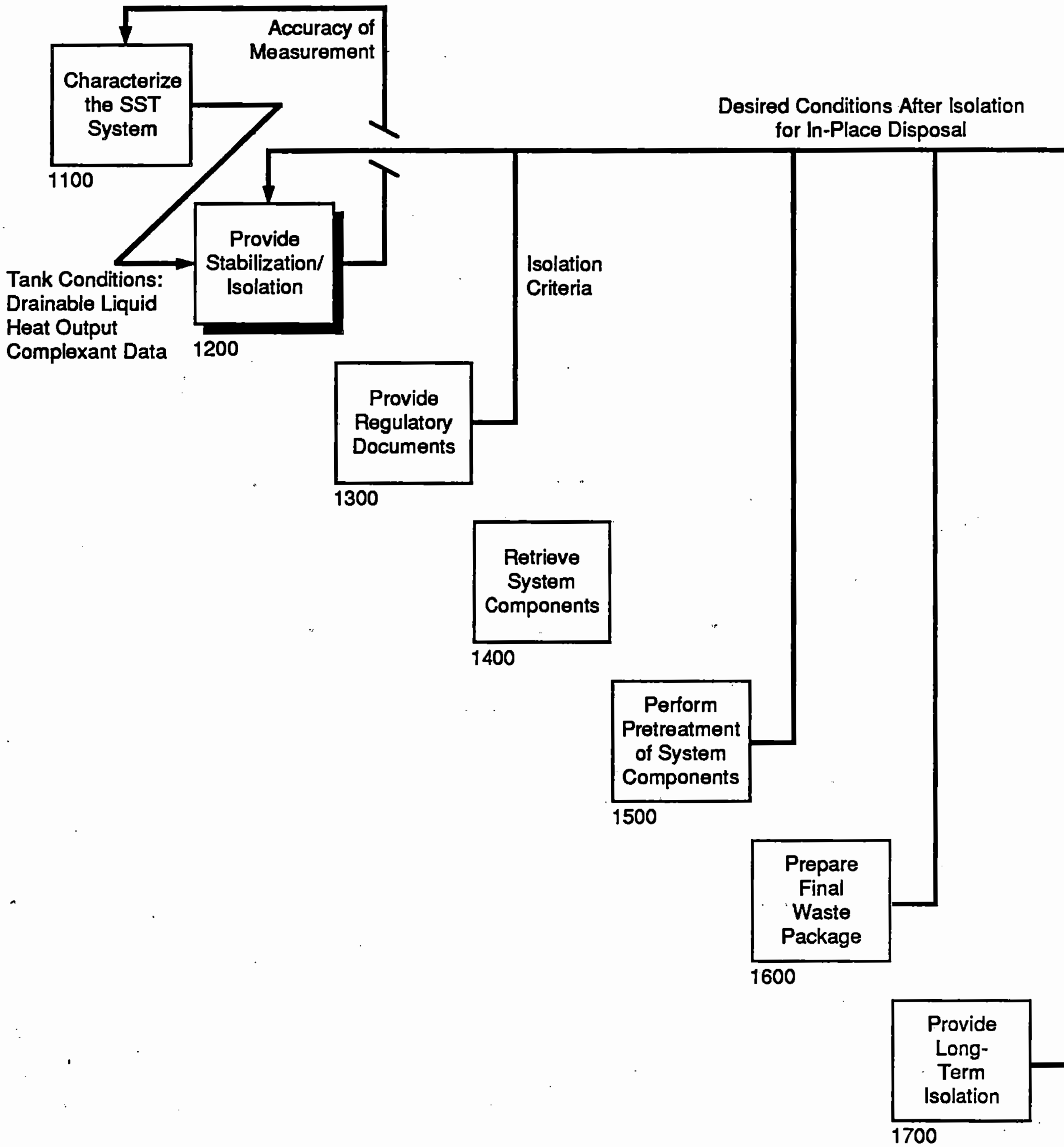

FIGURE 7.2b. SST Functional Interfaces Information Flow To/From 1200

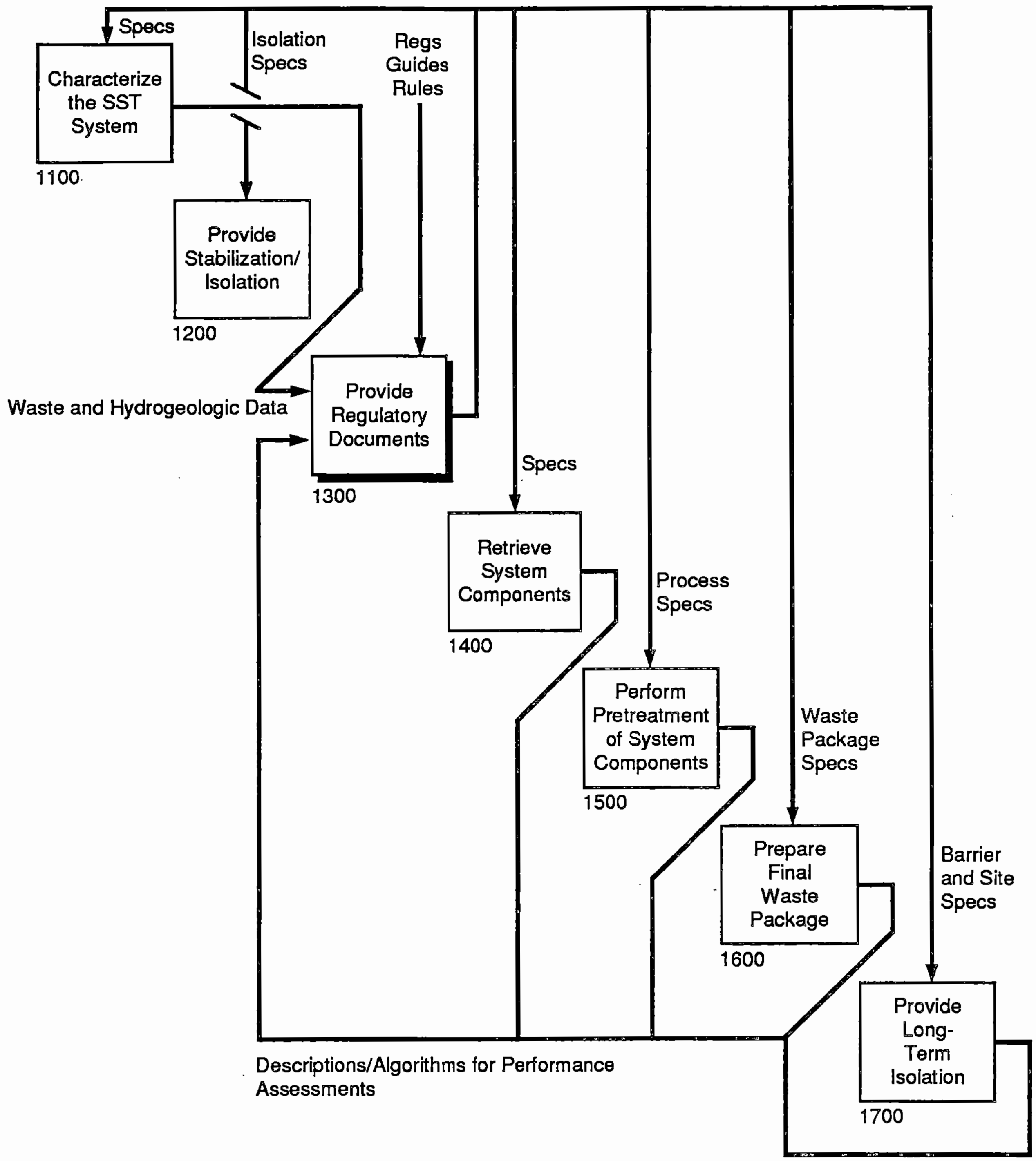

FIGURE 7.2c. SST Functional Interfaces Information Flow To/From 1300

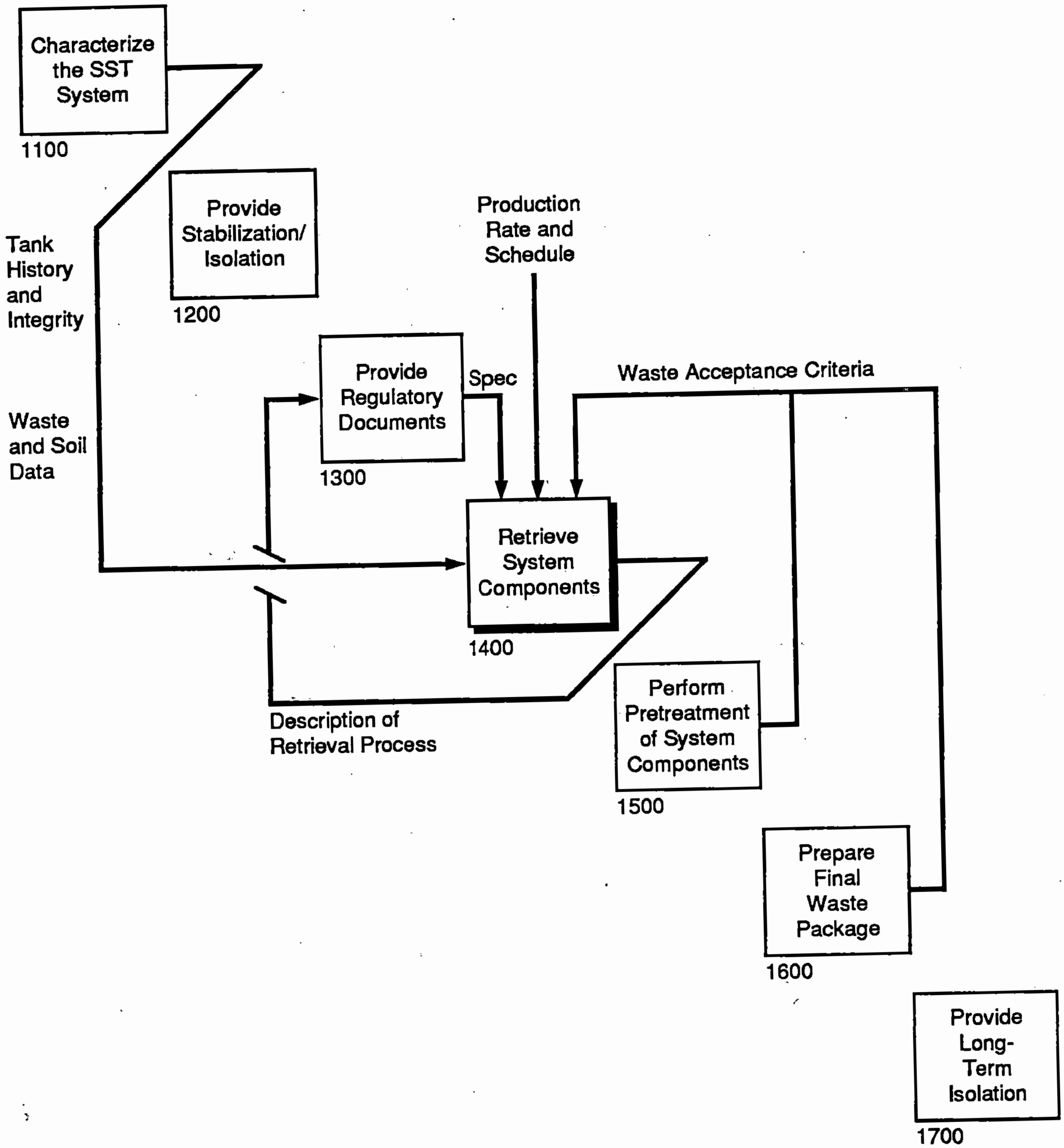

FIGURE 7.2d. SST Functional Interfaces Information Flow To/From 1400

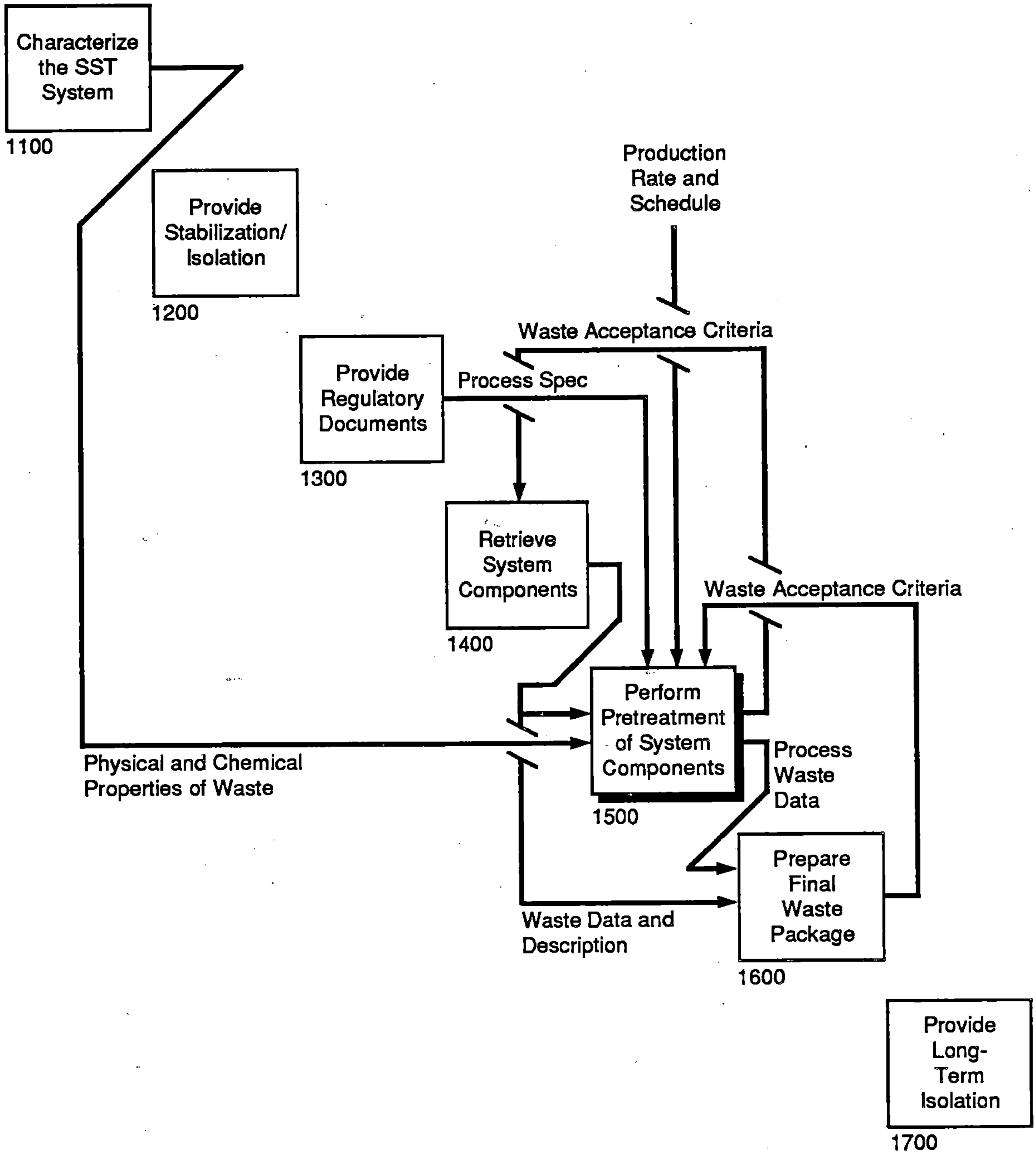

FIGURE 7.2e. SST Functional Interfaces Information Flow To/From 1500

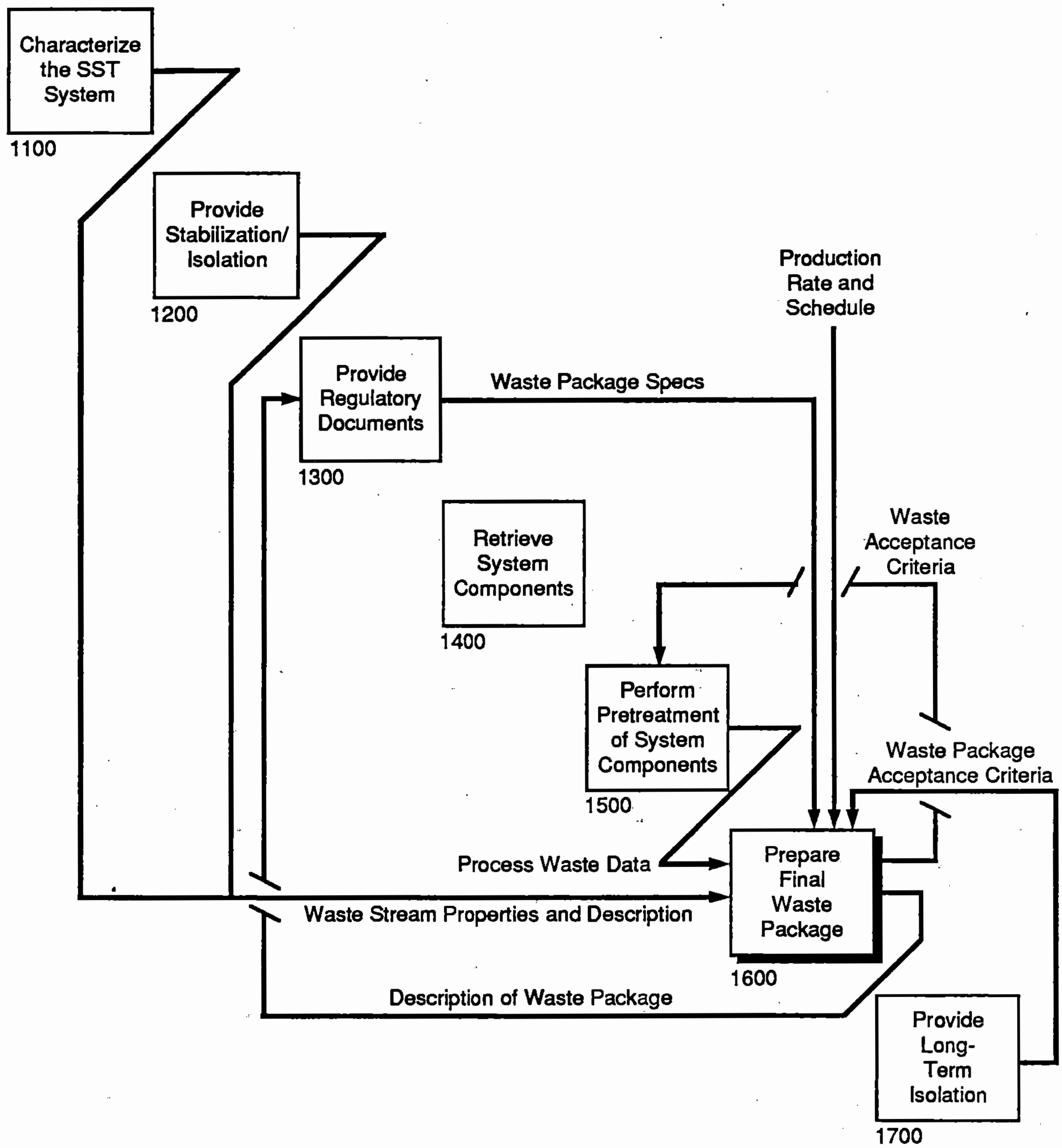

FIGURE 7.2f. SST Functional Interfaces Information Flow To/From 1600

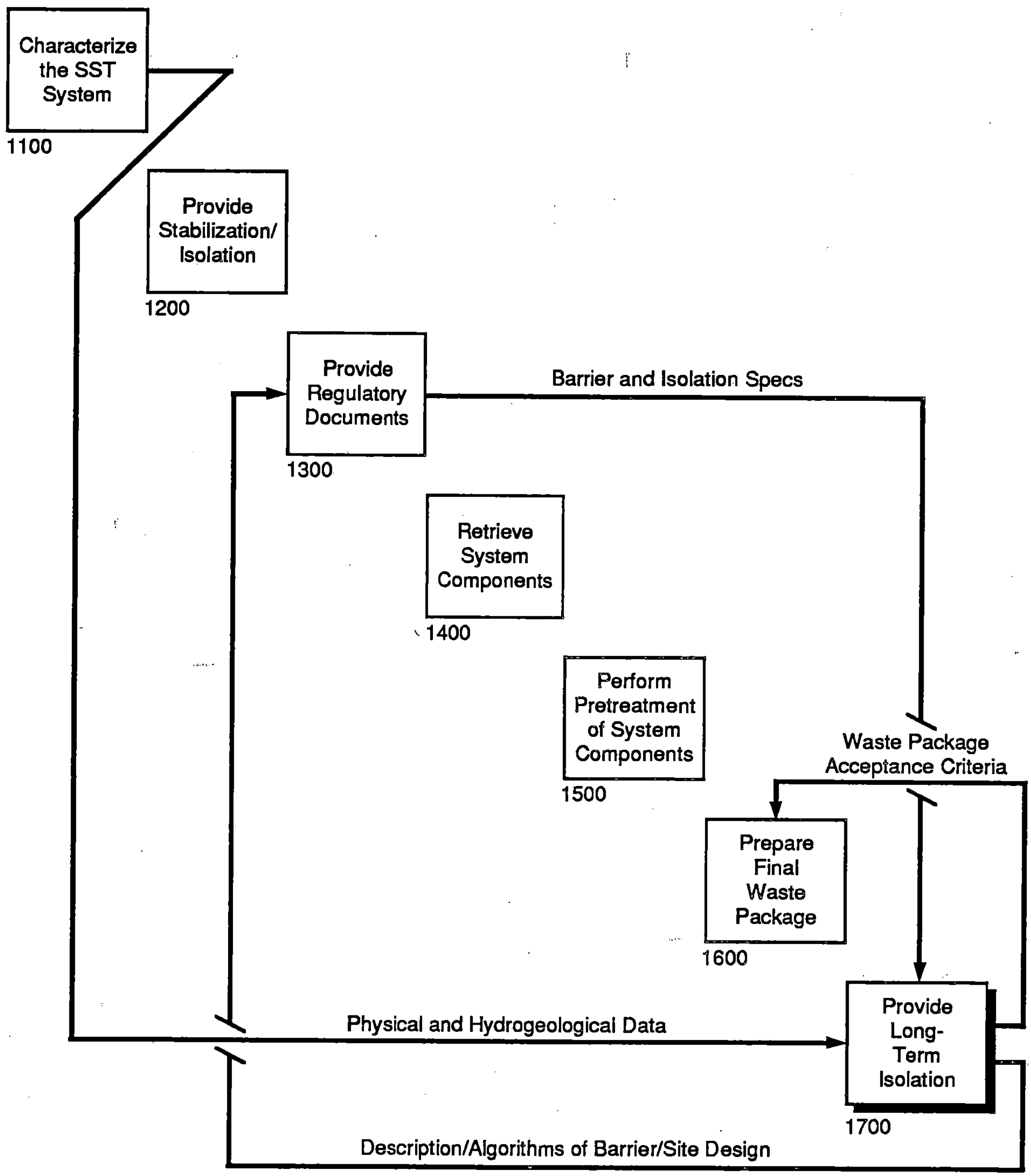

FIGURE 7.2q. SST Functional Interfaces Information Flow To/From 1700

8.0 HIERARCHICAL SOURCE ANALYSIS

Waste disposal decisions regarding the single-shell tank (SST) waste at Hanford must be made by taking into consideration the regulatory requirements that may impose constraints on implementation of the final disposition of the waste. At present, waste disposal regulations specific to radioactive mixed wastes have not been promulgated. In the absence of such specific guidance, the wastes may come under the purview of a wide range of statutes and regulations related to radioactive waste disposal, hazardous waste disposal, and water and air protection--collectively referred to in this analysis as the "hierarchy" or "hierarchical chain" of regulatory requirements. A comprehensive review of the environmental pollution control and radiation protection statutes and regulations that are relevant to Hanford SST waste characterization and management was completed by PNL (Keller et al. 1989) for DOE. The review identifies the performance, design, and permit requirements and criteria that should be considered in 1) evaluating SST waste disposal options and 2) designing an efficient waste characterization scheme that provides the information necessary to make this evaluation.

The system analysis performed herein used Keller et al. (1989) as the starting point for developing candidate requirements from these hierarchical sources. Specific statements that identified a significant control or concern about actions taken in the SST disposition were extracted from all sources reviewed. Each extracted statement was assigned to one or more of 14 categories, as shown in Table B.1 of Appendix B. Each category represented a specialized activity used by the functions for disposing of the SST waste. About 120 statements were extracted and assigned to the following categories:

- CO Constraints from the hierarchical source
- AIR Atmospheric release
- CA Corrective actions
- DC Design and construction
- ES Employee safety and health
- H20 Water release

- L Landfill
- MA Maintenance and surveillance
- MC Monitoring and Characterization
- OP Operations
- PS Public safety and health
- RE Reporting
- RAC Remedial actions after closure
- RBC Remedial actions before closure

These categories enabled a cross-comparison of the statements generated from the many statutes and regulations issued. In some cases, the extracted statements were identical from several sources. However, they were mostly statements of performance objectives and intents rather than specific requirement values capable of measurement. Nevertheless, the exercise revealed the complexity of satisfying all regulating bodies. Those statements that prohibited certain actions or contained measureable performance requirements were categorized as constraints and were treated as unalterable during the system analysis. The constraints were incorporated into the attribute list generated in Section 9.0, "Requirements Analysis." The remaining statements were used in the system analysis by the functional advocates as "guiding statements" in developing attributes that would satisfy their intent. After completion of the attribute list, each attribute was assigned to one or more of the 14 categories described above. The attributes that are applicable to the regulatory statements can be examined through these 14 categories. This approach allows the statements that are presented in legal documents to be transformed to measurable requirements that can be acted on by technically performing groups.

8.1 CONSTRAINTS

The primary constraint applicable to the Hanford SST system is the stipulation in 40 CFR 264.314 and WAC 173-303-665(9) that placement of bulk liquids in landfills is prohibited. For all future actions for SST disposition, only limited amounts of bulk liquids are to be added to the existing tanks.

The primary source of liquids would come from decontamination of retrieved components or from process water used in retrieving and in pretreatment of waste to selectively remove certain constituents. In addition, there will be some interstitial liquid remaining, because the interim stabilization efforts stop when pumping rates reach 0.05 gal/min. Also, it may be necessary to leave some moisture in the tank waste in order to maintain stability with respect to the tanks containing ferrocyanide (FeCN). Inasmuch as some residual liquid in the single-shell tanks exists already, it remains to be determined under the intent of the statutes if it is a bulk liquid. This aspect of the regulation cannot be treated as a constraint since liquid is already in the tank. Therefore, the system analysis must examine the levels of stringency that might be representative of the "no bulk liquid" stipulation. Three possible technical interpretations are:

- No "bulk liquid" is present when it cannot be pumped at a flow rate >.05 gal/min. (present practice for tank stabilization)
- No "bulk liquid" is present when the analyses of a set of samples is below 10 vol% of the residual solids. (i.e., below slurry flow condition)
- No "bulk liquid" is present when the sample releases less than 1 vol% of the solid as water vapor upon heating from 70°F to 300°F. (partial dehydration).

A second primary constraint is the allowed contaminants in discharges to sources of drinking water that have been defined consistently by several regulatory agencies. The maximum concentration levels (MCLs) defined in WAC-173-303-645 were used as constraints for the system analysis. The list of chemical species was incorporated in the attribute list generated in Section 9.0.

Additional constraints from the governing statutes have been incorporated in the attribute list and designated as such in Section 9.0. Additional constraints have been included to cover acceptance criteria such as for HLW repositories receiving glass containers. These constraints are passed indirectly to the SST system to satisfy licensing requirements for the HLW repository.

8.2 MEASURABLE PERFORMANCE REQUIREMENTS

The statutes and DOE orders list several requirements that can be measured. These are:

- Exposure to public (at the site boundary) shall not exceed 25 mrem/yr to the whole body and no more than 75 mrem/yr to any organ from atmospheric release.
- High-grade Class II groundwater consumed by an individual cannot result in an increase of 4 mrem/yr on a 2 liter/day consumption rate.
- Exposure to radiation by SST personnel shall be maintained within 10 CFR 20 and EPA limits through final disposition and closure.
- Any single waste package for final disposition as LLW or MW shall have a TRU content <100 nanocuries/gm.
- The criticality state of all credible water-moderated process environments shall be below a k(eff) of 0.95.

These measurable requirements have well-established precedence and are applied routinely and should be assigned as constraints. However, the principle of ALARA has been incorporated in these statutes and orders and this requires that operations be conducted such that a lowering of the total dose to a work force must be constantly applied. As a result, the system analysis must view measurable dosage requirements for personnel as a maximum allowed (constraint), but the real requirement influencing the choice of alternatives for performing the final dispostion should be a target reduction value to be determined by the system analysis. Retrieval and pretreatment of waste material has an increased exposure potential and must be monitored in ALARA terms throughout the task of disposing of 149 single-shell tanks.

8.3 DESIGN, QUALIFICATION AND TEST REQUIREMENTS

There are several categories where the statutes emphasize design, qualification, and test requirements. Characterization, monitoring, surveillance, and analytical procedures are listed without specific rules or measurable targets. The system analysis of the Hanford SST system develops many attributes that respond to the intent of the statutes and are measurable.

Specific design requirements are: no ignitable, reactive, and incompatible wastes be used in land burial. The guidance is to reduce the waste volume through processes such as destruction, separation, etc., as much as possible.

There are reporting requirements for unplanned releases and for recovery plans for remedial action. The system analysis develops specific sets of measurable attributes that are responsive to this class of requirements.

8.4 PERFORMANCE CRITERIA

Most of the statements in the statutes contain criteria for performance and areas to be considered rather than specific requirements. The goals of maximizing safety to the public and maintaining a quality of performance preserving the environment are dominant themes in the statutes. The challenge is to translate these goals into measurable requirements that define successful outcomes for the SST disposition. The system analysis provides a backfill of requirements that can satisfy the goals stated in the statutes. This aspect is developed in the Requirements Analysis section.

8.5 DECISION CRITERIA FOR SELECTION OF ALTERNATIVES

Many of the statutes regulating the disposition of the Hanford SST system acknowledge that performance goals and cost benefits should be considered in selecting various alternatives. For the SST system analysis there are alternative requirements and alternative methods. A requirement may be assigned different levels of stringency depending on what is reasonable when all hierarchical interests are considered. Unfortunately, the mechanism for establishing a quantitative set of criteria for deciding on the alternatives is undefined. Inspection of the statutes and DOE orders shows four general performance goals applicable to the SST system: safety, quality, productivity, and cost. There is a need to maximize the first three elements and minimize the fourth. A given alternative probably will not satisfy all four goals simultaneously; therefore, a weighting must be established.

Examination of the regulations reveals concerns about the ability to complete an intended action at a margin of safety declared adequate at the outset

of the SST disposition. In addition, quality of the activity is highlighted by the need to report and verify that an intended action was carried out. Safety and quality should probably receive a preferred weighting in selecting alternatives over productivity and cost. Cost is the only one of the four which can be scaled easily for quantitative evaluation of alternatives. The SST system analysis considered preliminary evaluations using these four decision criteria elements, but the activity was deferred until there was further dialogue with the Tri-party agencies.

Decision criteria based on validated computational models may be considered also for quantitative evaluation of alternatives. Four models have been proposed to cover the hierarchical interests and are recommended for further development in this report. These models are discussed in turn below.

To meet the primary concerns for public safety and health risks, a quantitative model to calculate long-term health and safety risks for the surrounding population after closure is recommended. This type of modeling evaluates the potential hazard for contaminating the ecological systems. Some elements of this activity are under way now at the Hanford Site.

A second primary concern is the short-term health and safety risks during the final disposition. This involves models that calculate risk assessments of potential exposures to personnel performing the task as well as the public as a result of performing alternative methods.

Because of the TPA milestone to complete the final disposition (closure) by the year 2018, a third calculational model is recommended that evaluates the impact of various alternative requirements and methods on the Time-To-Complete the final disposition.

Similarly, because the funds must be supplied through one of the TPA agencies, a fourth model that evaluates the impact of alternatives on the Cost-to-Complete the final disposition is recommended.

Taken together, these models can provide the basis for making quantitative decisions on the alternatives.

9.0 REQUIREMENTS ANALYSIS

This section initiates the development of system-level requirements by identifying attributes that describe how well the single-shell tank (SST) closure function at Hanford should be performed.

The section is organized as follows: Section 9.1 describes the creation of 541 attributes and groups them into six main categories. Section 9.2 shows how the attributes are linked to the statements extracted from the applicable statutes discussed in Section 8.0. In Section 9.3, a format for evaluating the attributes is described. In Section 9.4, the attributes are ranked by each of the first-level functions as a measure of importance to the function. The basis for selecting a level of stringency for each attribute has been deferred until the criteria for the selection are established.

9.1 IDENTIFICATION OF ATTRIBUTES

A requirement, to be useful, must be definable as a measurable attribute. Therefore, identifying the attributes is the first step in establishing SST system requirements. Each attribute must have a defined unit of measure or scale on which to assign a level of performance. The second step is to assign a value somewhere on the scale for each attribute. The location of a value on the scale may be fixed by constraints from the statutes or there may be several choices based on a desired level of stringency. Before assigning values, the purpose of this section is to collect all the attributes considered appropriate from the analysis of statutes and orders (Section 8.0) and from the advocates representing each of the first-level functions described in Sections 6.0 and 7.0. In Section 7.0, the interfaces between the first-level functions identified the types of data and information needed by each function from each other. These needs are also a principal source for defining the appropriate attributes.

This approach identified 541 attributes as being potentially significant to the successful performance of one or more of the first-level functions and may be considered as candidates for inclusion as system requirements for the overall SST closure function. Each advocate drew upon other disciplines

involved in completion of his function as additional sources for identifying appropriate attributes. Sources performing analytical chemistry, developing performance assessment models, conducting chemical processing operations at the Hanford Site, and performing design and testing studies provided key information. The attribute list is shown in the second column of Table C.1 of Appendix C. Each attribute has been assigned a number for reference purposes and this number is shown in the first column. The list was organized such that the attributes could be grouped under six major headings with subgroupings as appropriate. The corresponding units of measure for each attribute are shown in the third column of Table C.1. Values will be assigned later after the criteria for selecting the appropriate level of stringency are established. The six categories are discussed below. The applicable attribute numbers in each of the categories are identified in the parenthesis in the subheading.

9.1.1 Chemical Attributes (1 to 110)

The SST waste contains many constituents accumulated from a variety of processes and support functions used before 1970 at Hanford in the reprocessing of fuel. New regulations require characterization of the waste before initiating an implementation program. This category collects all properties related to the quality of chemical measurements, such as detection, accuracy, and sampling. Chemical properties defining the concentration limits or thresholds for performance of waste enclosures or waste processing streams have been placed in other categories.

The chemical attributes category includes the detection level required for all the perceived constituents in the SST waste. These detection levels have been subdivided further into radioisotopes compounds and/or ionic species. The method of detection depends on these two subdivisions and also on the degree of interference by one constituent upon another. Samples submitted for detection will include core drillings as part of the SST waste characterization function, control of pretreatment waste streams, qualification (leaching tests) of waste forms prior to placement in engineered enclosures, and surveillance of SST groundwater monitoring wells. There are about

80 elements and radionuclides of interest to the SST system. This list of species subject to characterization and surveillance arises from the need to demonstrate that all possible constituents are known based on confirmatory evidence or past records. Many of the non-radioactive constituents appear as a result of fuel reprocessing chemistry; however, other constituents were included as laboratory discards and are only a very minor constituent. Because of the inhomogeneous nature of the tank waste, identifying minor constituents will be a major challenge. The organic content of the tank waste should be very low since most of the sensitive hazardous contaminants like organic chlorides and hydrocarbons would have evaporated before discharge as waste. The principal organic species are the complexants that are water soluble. The complexants have not been listed individually but are considered as a group: "Total Organic Carbon" (TOC). The general groundrule adopted for the system analysis is that if TOC exceeds a certain stringency level, then an organic compound identification (TOC Identification) attribute would be triggered with its own stringency level for qualitative detection of the TOC species to the specified percentage.

The radioactive species listed may be divided into two parts:

1. Species that are dominant due to their abundance as fission products and their short-term activity content. A high level of stringency for these species may require special treatment to satisfy low-level waste burial criteria. A low level of stringency may require higher certainty in the performance assessment if the engineered barriers were to become ineffective prematurely.

2. Species that are less abundant but longer-lived. These species can be expected to be the radioactive source after engineered barriers have exceeded their design life. Characterizing these isotopes in a background of higher activity is a major challenge.

The desired detection level depends on the source of the samples and the combination of chemical and radionuclides in the sample. Samples from groundwater monitoring wells will require the most stringent level of detection and as a minimum must satisfy the maximum concentration levels (MCLs) listed in the Washington State Water Quality Standards cited in Section 8.0 (see also attributes 380-396 in Table C.1). Since groundwater samples are expected to be relatively abundant, detection levels can be made very sensitive by

evaporation to concentrate the samples sufficiently to achieve the appropriate level of chemical mass or radionuclide activity to register on the appropriate instruments with confidence. On the other hand, samples containing high concentrations of ionic species or radionuclides can mask other species such that extraction and/or concentration is necessary before detection by an instrument. As a general rule, if any of the constituents exceed 1000 ppm (parts per million), it is difficult to detect any other constituent much below the 1000 ppm level. Conversely, if pristine water is analyzed, subppm detection levels of many elements are readily achieved. A similar situation occurs in the detection of radionuclides. A given counting instrument can detect very low levels of radioactive species (~25 picocuries). However, the ability to detect specific isotopes depends on interference from more abundant species such as uranium and on difficult decay characteristics. Chemical separation to extract the species preferentially may be used; however, higher personnel exposures are often encountered as a result.

The accuracy of some of the chemical constituents of key subsystem components was included as part of the chemical attributes category. By choosing high levels of stringency, these attributes reduce uncertainties and in turn improve the quality of the performance assessments that use the data. Reducing the uncertainty, however, may tax the available resources to achieve this level of stringency, raising the probability that the task might not be successful. Attributes related to accuracy of the chemical measurements, listed under subcategory 1.2, were considered important for establishing the interface requirements between some of the functions.

Detection and accuracy attributes, however, may be of little system value if variances due to sampling are not controlled also. Samples to be characterized range from retrieved waste (moist sludge and salt cake), pretreatment process streams, contaminated soil, and pristine groundwater. Because many waste components are highly inhomogeneous mixtures, sampling density and frequency are important attributes that may determine the uncertainty of the SST

tank waste, leaks or spills. Each of these attributes have been further subdivided to delineate a particular stage in the waste processing sequence where a level of accuracy is needed.

9.1.2 Physical Attributes (111 to 182)

This category identifies the physical attributes of various components of the SST system. Subcategories of the physical attributes are spatial properties, physical properties, and decontamination factors. Every component requires physical definitions that determine its effectiveness to be handled, modified, or characterized in the overall system. Spatial properties define dimensions and shapes important for fitting components into standardized casks or for manipulation by machinery. Most of the dimensions relate to retrieved packages of disassembled SST components such as tank wastes, contaminated soils, the tanks themselves, and ancillary equipment. One level of stringency may use dimensions that are compatible with a large specialized container while another level may be based on a standard 55-gallon drum size. The range of spatial properties for SST retrieval packages should determine the performance and cost sensitivity between using casks common to other environmental restoration tasks at the Hanford Site versus specialized casks for the SST system only. Similarly, the sensitivity between casks common to all SST components versus special configurations for each SST component should be determined. The purpose of the spatial attributes listed here is to evaluate configuration options and handling strategies at the system level. Precise detailing of dimensions and tolerances would be done later at subfunction levels of the SST system.

There are three kinds of containers to be considered for disposal of retrieved SST waste: two of them are for offsite disposition, the other is for onsite disposition as a grout waste package. The attributes of the HLW glass waste container have been fixed by existing guides and regulations for compatibility with commercial HLW waste packages; therefore, the HLW container spatial dimensions are assigned as constraints, as noted by the letter "C" placed next to the attribute number in Table C.1 of Appendix C. Similarly, containerized TRU wastes for offsite disposal at WIPP have a set of spatial attributes, defined by DOE orders, which have been designated as constraints.

Because there are two types of TRU wastes: contact-handled (CH) and remote-handled (RH), each type has a separate set of dimensions. For onsite disposal of the grout container (vault), there are no dimensional limits pertinent to the SST system analysis except the maximum free volume inside the grout container. The free volume may be an important performance consideration for the integrity of the grout disposal system.

Many physical properties of the SST system are required for characterization and performance assessments. Physical attributes that can not be controlled but require a precision on the measurement of the property of the tank waste are identified under category 2.2 of the attribute list. These precision attributes are important to know the margins for safely managing the heat and the flowability of the tank waste during the closure process. They apply to the retrieval option where the tank waste is moved by sluicing and pumping as a slurry.

In category 2.3, the physical properties of SST components that should be controlled during the closure function are listed. These properties include temperature limits and heat generation rates for HLW and grout waste forms. Properties for other engineered materials used in the disposal process to confine the waste are listed also. Strength, load compliance parameters, and temperatures are some of the design attributes for the waste containers, soils/clays, and concrete when used as a structure/barrier. Permeability is also an important attribute for design of non-metallic containment materials such as soils and cements. The physical properties were included in the attribute list for the requirements analysis only if they could be preset and controlled within established limits during design and operation of the SST closure function. Other properties may be measured and used as input data to performance assessments and process control decisions but they cannot be assigned a level of stringency for evaluation by a system analysis.

The final category of physical attributes is the contamination levels acceptable for completion of a task within a function. These acceptance levels determine release criteria to the next function. Higher stringency levels will require greater attention and care in the design and procedures, particularly for retrieval tasks and would affect the productivity. Most

attributes related to smears on packages should have stringency levels at or below DOT standards for shipment in the public domain.

The residues in the tank and in the ancillary equipment are key attributes for the system as all functions are impacted by the choice of stringency level. There is a large uncertainty how well the residues in the tank can be retrieved, and specialized development activities will be needed if the tank system is to be cleared of activity sufficient to dismantle the liner as some regulations would indicate.

9.1.3 Engineered Enclosures (183 to 443)

This category identifies the attributes for the broad class of engineered enclosures used during and after closure of the SST system. Six types of engineered enclosures have been identified. An engineered enclosure consists of one or more sets of diverse and redundant mechanisms for preventing spread of hazardous material at unsafe levels to the environment. In some cases the enclosure consists of a waste form to limit the rate of dispersal after a containment vessel has reached its design lifetime. The combination of a waste form and a containment vessel along with additional barriers (i.e., special soils) to sequester the hazardous constituents or slow the dispersal rates is defined here as a waste package. A waste package applies to disposition of any of the SST waste components, including in-place disposition. In addition to waste packages, additional engineered enclosures necessary for the conduct of the SST closure function are enclosures to prevent intrusion of water to the vicinity of the waste package, enclosures to prevent dispersal when the waste is being processed (i.e., HWVP or B plant facilities) and enclosures to prevent dispersal when the waste is being transported.

For purposes of dividing almost half of the 541 attributes listed for defining how well these types of enclosures should perform, six subcategories are defined as follows.

1. Transport containers for retrieval of waste components and movement to a facility for processing.

2. Waste packages for burial of the HLW in glass at a commercial repository or in the Waste Isolation Pilot Plant (WIPP).

3. Vaults for permanent placement of the grouted LLW waste form.

4. In-place waste packages for the single-shell tank.

5. Earthen barriers to prevent intrusion of surface water to any of the onsite buried waste packages.

6. Site facilities for retrieving, transporting, or processing waste.

Attributes for the transport containers (item 1) are grouped as category 3.1; all waste packages (items 2, 3, 4) are grouped as category 3.2. The intrusion barrier and site facilities are grouped as categories 3.3 and 3.4 respectively. Each category may be subdivided further into a set of performance attributes and a set of design or process attributes. Performance attributes define how well the enclosures (waste form, waste package, intrusion barrier, etc.) must resist damage or degradation due to all external influences (i.e., physical, chemical, and environmental). Design and/or process attributes define how well input data for design and control during processing and packaging of the waste form must be stated to ensure that the performance attributes can be achieved.

The six subcategories for the engineered enclosure attributes are discussed below.

Transport Containers (183 to 184)

Only two performance attributes were identified, relevant primarily to the retrieval function, since most of the physical attributes for the containers were described in Subsection 9.1.2 (category 2). It is often required to qualify a container by performing a drop test and evaluating its integrity afterwards. The level of stringency for its integrity may range from a simple retention of its containment function to a more complex rigidity specification. The second performance attribute defines the longevity of the container, which may range from a one-time-use to several thousand times similar to a cask.

Waste Packages - Glass, Grout, In-Place (185 to 369)

The performance attributes for the three types of waste package disposal units are listed in category 3.2.1 and include lifetime of containment,

release rate after loss of containment, and a closure specification such as a leak test or equivalent. These attributes are intended to meet the performance goals listed by many of the applicable statutes described in Section 8.0. The design attributes for the waste package units are listed in category 3.2.2 and include the limiting feed stream concentrations of various ionic and radioactive species after pretreatment but before transformation to waste forms and waste packages. The feed streams concentrations are not expected to be specified by statutes, but the ability to meet the performance requires control of the waste concentrations as they are transformed to a waste form. There are many chemical species involved in the SST system; however, some species will have more relevance to meeting performance goals of the statutes than others. The attributes for these species will require a higher level of stringency.

The attributes defining the lifetime of the various types of enclosures to provide isolation and/or containment of the waste were obtained from performance goals in the applicable statutes. The minimum desired lifetimes range from 300 to 10,000 years depending on the regulation. HLW, LLW, Grouted Vaults and In-Place waste packages each require a containment design life.

Release Rates from Glass Waste Package. A second set of performance attributes is needed to define the allowed rates of release of a number of potential species from the HLW, Grouted Vault and the In-Place waste forms. The list of over 50 radioactive and potentially hazardous species was obtained from all closure subfunctions involved in meeting the performance goals. No attempt was made to limit the number of species of concern at this stage of the system analysis.

Explicit release rates specified as a mass dissolution rate (micrograms of the waste form/cm^2/day) have been defined in regulations applicable to defense waste for burial in commercial HLW repositories for glass compositions containing Cs, U, Si, B and Na. These constituents are expected to be dissolved in a molten mixture of solids from the pretreated waste stream slurry and from the sodium borosilicate frit used as a solvent. The release rates for these constituents were treated as constraints. A major SST constituent, sulfate, has been added to the list and further analysis has indicated that

phosphate and chromium may need to be added as well since they may be present in high concentrations in the slurry waste stream and could affect the overall release rate. The mass fraction of the waste form due to solids in the feed stream has been included as an attribute also as part of the recipe established in regulations for an acceptable HLW glass waste form and has been included on the attribute list.

Release Rates from Grout Waste Package (Vault). The key performance attributes for the grouted waste form are the release rates represented by a leachability index per ANSI 16.1 for each species under evaluation. A large number of hazardous chemicals and radionuclides have been included in the attribute list to cover the range of concerns about both short- and long-term isolation. There have been no specific statements in the regulations about release rates from grout; however, these leachability attributes are necessary to satisfy performance goals and to test the validity of performance assessment models. A detailed approach for using the leachability index for SST grouted waste has been developed as part of the SST program. The leachability indices may be selected from observations on selected constituents in the Hanford grouts, estimates of solubilities or mobilities in groundwater, and an NRC requirement that the leachability index should be ≥ 6 for all radioactive species listed. The leachability index has the units of log of the effective diffusion coefficient specified in cm^2/sec. This term is determined experimentally using the formulations stated in ANSI 16.1.

Some additional attributes for the grouted waste package have been included to cover possible degradation mechanisms that could increase mobility of hazardous material. These are the Total Organic Content (TOC), Residual free water content, Gel strength after 10-minute setting periods, critical flow rate, and ASTM test for withstanding 30 thermal cycles and biodegradation.

Release Rates from In-Place Waste Package. Performance attributes for the in-place tank waste package, in principle, should be based on criteria similar to that set for the grouted vault waste package. This waste form however cannot be pretreated and isolated as with glass or grout. There are few

choices for selectively partitioning or recovering some of the waste constituents. The performance attributes for controlling the release rate from an In-Place waste package should include all the identifiable hazardous constituents in the SST system. The initial step for establishing performance for these constituents in this analysis was to specify minimum concentration levels (in units of g/m^3 or ci/m^3) below which the hazard is acceptable. The levels for acceptance could be based on the dispersal rate defined by appropriate methods for sequestering the SST waste in situ. Eventually, as the methods are qualified, the sequestered system could be evaluated as a waste package similar to the grouted waste package described previously.

Similar to the grouted waste package, the In-Place waste package should have performance attributes for the residual free water (volume % water released up to 300°F heat) and for the TOC. An additional attribute for the In-Place waste package is the pH after pretreatment as this could influence the degradation of any sequestering mechanisms used.

Containment Attributes for Waste Packages. Most waste packages are expected to have some form of containment that prevents spread of hazardous material for a specified period. Attributes that define the closure property depend on the method used. For glass waste forms sealed in metal containers, an ANSI standard for a leak rate has been used as the attribute. For grout or In-Place waste packages, a sealed containment does not appear feasible and some other attribute is needed. But, as yet, the appropriate unit of measure has not been found and must be reconsidered later.

Process Attributes for Glass and Grout Waste Streams. To support the performance goals and attributes cited above, a set of design or process attributes must be defined for the waste feed stream concentrations prior to conversion to the their respective waste forms. A set of attributes is listed for the grout feed stream and the glass feed stream. There is no feed stream for the in-place waste package. The feed stream concentrations are important interfaces between the pretreatment function (1500) and the waste package (1600) function. To meet the desired performance goals for some of the hazardous SST constituents, either the feed streams must be pretreated and adjusted to concentrations acceptable to conversion to the waste form or the

waste form and/or enclosures must be upgraded and qualified to accommodate higher concentrations of certain SST hazardous constituents. Either approach is a challenge.

The acceptance level for concentrations of certain hazardous constituents in the grout feed stream and the glass feed stream highlights the opposing positions of the pretreatment and the waste package functions. Acceptance of a high concentration level would place the greatest burden on the waste package function to assure that the total waste package will be protective and may need additional engineered enclosures or modifications of the waste form to contain larger concentrations to meet the waste package release rates. Acceptance of a low concentration level would place the greatest burden on the pretreatment function to develop a qualified extraction or partition process to meet the desired performance without any alteration in the enclosure design. If no such process is feasible, then dilution, producing a larger number of waste packages, is the only alternative. Preliminary analysis indicates that the greatest variability in SST system cost is associated with this set of attributes. Careful analysis and evaluation of the levels of stringency should be carried out with a well-established set of criteria before making a selection.

The key constituents for HLW glass waste feed stream are listed under category 3.2.2.a. These attributes are specified as the weight percent of the constituent as a dry solid after removal of the aqueous portion of the slurry. This unit of measure is convenient for the formulation of the glass waste form which will be constrained by qualifying tests on glass samples prior to production in a glass melter. The constituents were selected based on their potential ability to influence glass degradation and dissolution rates after loss of containment. Most constituents must be maintained below a maximum weight percentage set by the qualification tests. However, Fe_2O_3 and Na_2O should be maintained within a specified concentration band to provide control of the melting process. The particle size of the solids in the slurry must also be controlled to ensure that the solids will be dissolved in the glass

melter before pouring. The total organic carbon (TOC) also is included as an attribute due to its potential for generating carbonaceous off-gasses that may upset the melting process.

The SST waste may contain constituents in excess of concentrations evaluated for other defense wastes qualified for disposal as a glass waste form in commercial repositories and may require reformulation and requalification of a new glass waste form. High concentrations of phosphates, sodium, aluminum, and silicon may be present as a complex compound requiring a new formulation. Cyanide exists as a complex anion with iron but its characteristics in the glass melt should be similar to other carbon compounds and is included in the TOC determination. Other constituents listed may influence the melting process or the properties of the glass waste form.

Process attributes which define the feed stream concentrations for grouted waste forms are listed under category 3.2.2.b. This waste stream has a large number of attributes since both hazardous chemical and radiochemical constituents are involved. The convenient units of measure are g/m^3 or ci/m^3. The cyanide is identified as the free ion concentration because of its potential high toxicity and mobility. In contrast to the glass waste form, TOC is identified separately from the cyanide because of differences in chemical behavior in grout. Some constituents listed for the grout waste stream may have no toxicity standards established as yet and may be dropped later. High concentrations of the sodium and nitrate species could have a large effect on the stability of the grout system and also on the amount of grout needed. The pH and the volume percent of solids in the grout stream need to be specified also for control of the grout solidification process.

Additional design attributes were identified for the in-place tank waste package, which consists primarily of the as-found stabilized waste form, carbon steel liner, and a reinforced concrete enclosure. The liner and concrete enclosure would be subject to deformation if certain operations were carried out without controls. Attributes which ensure against damage are excessive hydrostatic loads, heat generation, and pressure differences relative to the

ambient and are listed as constraints since the single-shell tanks already have specified as-built design conditions.

Intrusion Barriers (370 to 433)

Another major enclosure is the barrier to prevent intrusion of surface water to the buried waste package. Several performance and design attributes, involving mainly soil and environmental parameters, have been identified (see category 3.3). In addition, attributes identifying data uncertainty levels for some key environmental parameters have been listed to provide reliability of the performance assessments needed.

The performance attributes identified for the barrier include lifetime, drainage rate, storage capacity of fine soil, fine content in the soil, permeability of the soil, and allowed subsidence and thickness changes from erosion/deposition. Washington State regulations for control of the state's water usage also list constraints for specific constituents (i.e., As, Cd, Cr, Pb, Hg and chlorinated hydrocarbons) in the groundwater and constraints on the monitoring frequencies of the groundwater or vadose zone. The maximum concentration levels (MCL) which have been designated in the regulation could be applied to the SST operable units (OUs) only or to all Hanford waste OUs collectively. In the latter case, the allowed MCL values may be partitioned among the OUs. The Washington State regulations also include a provision to add chemicals to the list for specific permits. Specific details cannot be determined as yet; however, it is anticipated that three attributes that define MCLs for the activity emanating from TRU elements and certain radionuclides and MCLs for the concentration of a justified chemical such as the nitrate ion will be included after the performance assessments are completed.

Twenty-one design attributes were identified for intrusion barriers. Several attributes define the physical characteristics of the composite of soils and markers that are part of the barrier design. Each of the attributes have units of measure that are appropriate for the design basis calculations of performance. Attributes for animal intrusion, plant growth intensity, and rain and wind intensity have been included.

Thirteen attributes were identified which specify uncertainty limits for key environment parameters for climatology, hazards probability, and void size in the barrier that could influence the accuracy of the performance assessment of the barrier system. Many of these attributes have been discussed in prior planning documents for barrier development. The units of measure have been difficult to define for some of the attributes and after further analysis they may be deleted.

Site Facility Enclosures (434 to 443)

Many site facilities are engineered enclosures which protect the public and employees from exposure to hazardous materials during processing of the SST waste. Typical examples are the structures and environmental control system for the HWVP or the mobile structure and control system surrounding retrieval operations at a SST OU. The principal performance attributes for this type of enclosure are to control gaseous oxides of nitrogen (NOX) and of sulfur (SOX) and particulate effluents released to the atmosphere. At present, emission constraints have been established with the local tri-county emissions control organization. Attributes for the amount and the form of the liquids discharged from the site facility may have very tight limits such that all liquid side-streams would be transformed to solid or gaseous substances before discharge.

There are a large number of attributes for design of facilities that are defined by standard building codes; however, for purposes of the system analysis, only five were considered appropriate for identification at this stage of the analysis. The design basis for seismic events should be specified for permanent and temporary structures used during SST closure. Facility operating life, post-closure life, and maximum wind speed for operating permanent or temporary facilities may need to be specified also.

9.1.4 Operating Attributes (444 to 500)

This category identifies attributes important for the continuity of the flow of material between various processes involved in the SST system at Hanford. These attributes include system level process rates, personnel qualifications, and design standards and practices for operating systems. The

attribute for overall processing rate of the SST system determines the capacities and availabilities of subfunctions for SST closure. The TPA (1989) has set the target for completion of closure for the year 2018. If all 149 tanks were involved, the mean rate would be about 10 tanks per year after start of implementation. However, the system analysis must evaluate a range of processing rates to understand the cost/risk benefits of delays and interruptions in the closure process.

For the retrieval option, if the SST closure process sequence is to operate efficiently, then in-process storage may be required. Some statutes have performance objectives of minimizing this storage period. The range of in-process storage times could be from 90 days to no limit. Statutes also have set objectives to minimize the amount of process water associated with recovery of waste. Three attributes have been identified to satisfy this objective, one for each of the three main processing functions involved in SST closure. Each function may independently set its own water utilization target based on a unit of measure in terms of a ratio of the liquid water in the output stream relative to the amount of water in the input stream.

In Section 9.1.3, attributes were identified for the maximum concentrations of various constituents in the grout and glass feed streams. If no pretreatment process was available to meet these limits, then dilution of the feed streams would be the only option. In this category, a set of process design attributes is identified to determine how well a given constituent should be extracted when one or more pretreatment methods are available. There are three potential pretreatment situations: removal of constituents from the glass feed stream, removal of constituents from the grout feed stream, and removal of constituents in situ. The goal is to minimize the waste volume so that dilution becomes unnecessary. The unit of measure is the ratio of concentration of the output after treatment to the concentration of the input before treatment. A low stringency level would be a value of one, i.e., no reduction of the output relative to the input. A high level of stringency would be as low a fraction as is practical for large-scale processing systems. Species identified for control in the glass stream are: Na, Fe, Al, Si and U (and possibly Bi and Phosphate) to minimize the quantity of

waste. Also, total organic carbon (TOC), which includes the cyanide in the sludge, is controlled to prevent unfavorable reactions in the glass melter. Species identified for control in the grout stream are: TRU, Sr-90, Tc-99 and Cs-137 to improve the quality of the grout vaults for burial of the low-level and hazardous waste.

Pretreatment of the waste in the tank was considered in the early stages of this system analysis. Stringency levels for meeting concentration limits for in-place tank waste packages require very large reduction of many key species, especially the TRU elements. These attributes would be an enormous challenge. Several potential processes were considered, such as in situ nitrate destruction, but all had shortcomings of potential uncontrolled reactions or required excessive heat applications in a system not designed for such. The species listed for in-place pretreatment, however, were retained on the attribute list for future reexamination, but there is little prospect for a feasible, safe, and efficient method for in-place pretreatment.

The final set of attributes in this category identifies personnel practices and public protection practices that enable an operating system to function in a safe manner. The degree of training is an important attribute in this regard also. Higher levels of training impact the efficiency of implementation and lead to higher qualification costs. Mockup testing of field operations is a feature that may be appropriate for qualification of equipment and personnel. Exposure limits for personnel are constraints set by statutes. However, under the principle of ALARA, it is appropriate to set stringency levels below those allowed for safe operation. Because of the hazardous nature of retrieving waste from buried tanks not designed for retrieval, the exposure potential is high. A high stringency level could be a target percentage reduction of 10% in the overall exposure to the working teams for every thirty tanks processed. This would reduce the team exposure by one-half between the first tank processed and the last tank if all 149 tanks were retrieved.

9.1.5 Site-Selection Attributes (501 to 525)

As part of the SST closure function, sites for grout burial must be established. The performance measures and design attributes for defining how

well this activity may be carried out are listed in this category. Many of these attributes apply to qualifying the in-place burial of tank waste as well. Several design attributes are constraints from existing statutes. Accuracies for key data important to the performance assessment associated with the site selection have been listed in this category as well. Three principal attributes are the accuracies of measurements for the groundwater depth, the groundwater or vadose travel time, and the groundwater mass flow.

9.1.6 Records and Reporting Attributes (526 to 541)

Inspection of several statutes shows a high frequency for reporting requirements such as notification of unplanned events and for documentation to initiate the final disposition and to initiate remedial actions. This category was created to list attributes which would respond to the reporting requests raised in the statutes. The attributes may be assigned a range of stringency levels to evaluate the potential impact. The impact may involve more issues than just administrative detail since the operating system may not be able to synchronize its response to some time constraints and suffer a major loss of productivity. The method and contents of the reporting have been identified as constraints by the Resource Conservation and Recovery Act (RCRA). Also, annual reports on the volume of solids and total volume of water in the SST system are constraints from DOE orders.

Also included in this category are attributes defining how well a performance assessment is performed relative to the quality of input data and the quality of algorithms used in the calculation of margins for overall public and employee safety or risk. The origin of the algorithm may have a different margin if it is based on first principles of science instead of an empirical relationship. In general, a high level of stringency for these attributes would require large margins in the outcome of the assessment to offset reliance on less accurate or low quality inputs. Attributes with specific margins for temperature calculations, escape rate from the waste forms, and transport rate in the surrounding soil (carrier system) have been identified for acceptability requirements of the performance assessment itself.

9.2 ALLOCATION OF ATTRIBUTES TO HIERARCHICAL OBJECTIVES

In Section 8.0, "Hierarchical Source Analysis," the applicable statutes were reviewed for statements that revealed performance objectives, goals, or constraints. As described, 120 statements were extracted and grouped in one or more of 14 categories useful for technical application. To provide a connection between these statements and the attributes identified in this section, one or more of the 14 categories was assigned to each of the 541 attributes. In this way, the statements may be reviewed directly with the attributes in the same category.

The results of this exercise are shown in Appendix B. The categories assigned to the attribute are listed in the last column of Table C.1 of Appendix C. As described in Section 8.0, Table B.1 of Appendix B shows the list of statements and the assigned categories. Table B.2 lists all the attributes by their assigned number under each category. Those attributes which are constraints as defined and discussed in Section 8.0 are identified by the letter "C" in the status column of Table C.1 of Appendix C.

The major purpose is to show how the responses from the viewpoints of the first-level functions as to "how well" they should perform are linked to the performance objectives and constraints from the hierarchical interests. This transformation from general intents to specific requirements can be used for further dialogue in regulatory interactions.

9.3 FORMAT FOR EVALUATION OF ATTRIBUTES

A system requirement is not complete until an appropriate value is assigned to the attribute. This value should be assigned in a systematic manner to provide traceability and justification. Some attributes can be assigned a range of possible values on the scale and selection of the appropriate value (level of stringency), but this requires inputs on the sensitivity of a value on each of the seven first-level functions. Some functions may have little or no sensitivity to the choice of the stringency level, others may have conflicting or opposing sensitivities. Completion of the requirements analysis (i.e., selecting a specific value within a range of plausible values) has been deferred until there is a set of selection criteria

which can be applied systematically to each of the 541 attributes. In preparation for the selection, the following tasks were performed on the attribute list.

1. Each attribute was examined for its application to the "In-Place" or the "Retrieve" option. Some attributes apply to only one of the two options and others apply to both. The fourth and fifth columns of Table C.1 in Appendix C indicate a YES or NO label for these options. This enables one to narrow the scope of the requirements analysis depending on the choice of the closure option. 100 attributes are singularly identified with the "In-Place" option, 260 are singularly identified with the "Retrieve" option, and 181 are identified with both options.

2. Each attribute was ranked as to its importance to each of the first-level functions. The ranking is scaled between 1 and 10 where 10 represents the highest importance and 1 represents complete indifference by the function. Each function must have a 10 for at least one attribute, and no zero rankings are allowed. The rankings for the seven functions are shown in Table C.2 of Appendix C. This task identifies which functions have a high stake in the selection of the stringency level and which do not. Those that do not should not be involved in the selection process. Functions having an intermediate ranking should have a proportionate weighting as to their influence in the selection process. Analysis of the rankings is provided in Section 9.4.

9.4 ATTRIBUTE RANKING BY FUNCTION

Examination of the ranking of the attributes by each function shown in Table C.2 of Appendix C reveals an overall balance of interest in the attributes. The character of the rankings may be analyzed from the viewpoints of the average ranking by each function and of the number of ones chosen for each attribute by the functions.

The average of the 541 rankings (top row of Table C.2) shows the overall level of importance by each function. The highest average levels of importance were from the Provide Regulatory Documents (1300) and Provide Waste Packages (1600) functions. These two functions provide the confidence in the performance assessment (Function 1300) and the quality of the waste package containment (Function 1600) for a large number of the chemical and radioactive constituents listed as attributes and therefore would show a high level of importance. Conversely, Functions 1200 (Stabilization) and 1400 (Retrieval)

show the lowest average rankings because of their lesser scope of interest in the chemical content of the tank waste in performing those functions. Pretreatment (Function 1500) has the next lowest average ranking, primarily because only a limited number of constituents is involved in the process control of preparing feed streams to the various waste forms used. Characterization (Function 1100) and Long-Term Isolation (Function 1700) have the second highest average in the rankings.

The overall order of average ranking among the functions is:

$$1300 = 1600 > 1700 = 1100 > 1500 > 1400 > 1200.$$

The number of ones shown in the last column of Table C.2 reveals the breadth of interest in an attribute among the functions. If there is a large number of ones for an attribute, then the breadth of interest is narrow and the choice of stringency level for that attribute involves only a few functions. If there are no ones or a few ones, then the breadth of interest is extensive and the choice of stringency level for the attribute may require a consensus of views among the functions. The distribution of the number of ones is as follows:

Number of Ones	Frequency	Percent
0	14	2.6
1	57	10.6
2	97	18.0
3	79	14.7
4	196	36.4
5	57	10.6
6	39	7.2

The distribution is slightly asymmetrical. The broadest range of interest (0) is less than the narrowest range (6) by about 5% (2.6% versus 7.2% of the attributes). The median for the breadth of interest is about 3.3. This distribution indicates that potential conflicts in choice of stringency level may require a consensus of judgments involving four or more functions for about 46% (247) of the attributes. Some of these attributes, however, may be constraints (52) where the level of stringency is already selected by the

statute or orders, or the choice of stringency level may be unanimous by the functions involved, reducing the number requiring a consensus.

Finally, the purpose of this analysis is to identify pathways for iteration of requirements as the SST closure function evolves from the development stage to the implementation stage. Research and development of the methods of performing SST closure functions and dialogues with the regulatory and sponsoring agencies may require changes in the SST system requirements. The rankings enable the SST project managers to know where the changes should be applied in the subfunctions of the SST closure process.

10.0 REFERENCES

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APPENDIX A

LISTING OF FUNCTIONAL ACTIONS TO BE PERFORMED ON THE HANFORD SST SYSTEM

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APPENDIX A

LISTING OF FUNCTIONAL ACTIONS TO BE PERFORMED ON THE HANFORD SST SYSTEM

This appendix lists (in Table A.1) the descriptions of the functional actions to be performed on the single-shell tank system at Hanford. A numerical code is used to identify each function at the appropriate level. Subsystem functions comprise a complete set which reveals the functional content of the parent or higher-level function. This analysis does not detail the functional contents below the third level except in a few instances where a fourth level has been used. The numerical code is as follows:

1000	Zero Level
1X00	First Level
1XX0	Second Level
1XXX	Third Level
1XXX.X	Fourth Level

"X" represents a serial digit from 1 to 7.

See Section 6.0 of the main report for a brief summary of these descriptions.

TABLE A.1. Functional Breakdown - Final Closure of the SST System

1000 PERFORM FINAL CLOSURE OF THE SST SYSTEM
- 1100 CHARACTERIZE SST SYSTEM
  - 1110 DETERMINE INTEGRITY OF TANK SUBSYSTEM
    - 1111 EVALUATE WASTE ACCUMULATION HISTORY
    - 1112 EVALUATE FAILURE HISTORY
    - 1113 EVALUATE RELEVANT SURVEILLANCE DATA
    - 1114 DETERMINE PROJECTED LIFE OF TANK SUBSYSTEM
  - 1120 DETERMINE COMPOSITION OF IN-TANK WASTE
    - 1121 IDENTIFY CONSTITUENTS AND PROPERTIES
    - 1122 VALIDATE SAMPLING SYSTEM
    - 1123 SAMPLE TANK CONTENTS
    - 1124 ANALYZE TANK SAMPLES
    - 1125 EVALUATE SAMPLING INTEGRITY
    - 1126 DETERMINE SOURCE TERM
  - 1130 DETERMINE INTEGRITY OF ANCILLARY EQUIPMENT
    - 1131 DETERMINE FAILURE HISTORY OF EQUIPMENT
    - 1132 DETERMINE STATUS OF TRANSFER PIPING
    - 1133 DETERMINE STATUS OF VENTILLATION PIPING
    - 1134 DETERMINE STATUS OF INSTRUMENT PIPING
    - 1135 DETERMINE STATUS OF DIVERSION BOXES
    - 1136 DETERMINE STATUS OF IN-TANK EQUIPMENT
  - 1140 DETERMINE EXTENT OF SOIL CONTAMINATION NEAR LEAKS
    - 1141 IDENTIFY PLUME CONFIGURATION
    - 1142 IDENTIFY CONSTITUENTS BY LOCATIONS
    - 1143 VALIDATE SAMPLING SYSTEM
    - 1144 SAMPLE SOIL AS NEEDED
    - 1145 ANALYZE SOIL SAMPLES
    - 1146 DETERMINE SOURCE TERM
    - 1147 ASSESS MOVEMENT OF PLUME
  - 1150 [DETERMINE EXTENT OF SOIL CONTAMINATION IN CRIB/TRENCH] disabled
    - 1151 [IDENTIFY PLUME CONFIGURATION]
    - 1152 [IDENTIFY CONSTITUENTS BY LOCATIONS]
    - 1153 [VALIDATE SAMPLING SYSTEM]
    - 1154 [SAMPLE SOIL AS NEEDED]
    - 1155 [ANALYZE SOIL SAMPLES]
    - 1156 [DETERMINE SOURCE TERM]
    - 1157 [ASSESS MOVEMENT OF PLUME]
  - 1160 DETERMINE SOIL INTEGRITY OF ENVIRONS
    - 1161 VALIDATE SOIL DATA BASE
    - 1162 ASSESS NEW DATA BASE NEEDS
    - 1163 INSTALL NEW BORE HOLES AS NEEDED
    - 1164 VALIDATE MEASUREMENT EQUIPMENT
    - 1165 DETERMINE SOIL SEDIMENT CHARACTERISTICS
    - 1166 DETERMINE HYDROLOGIC PROPERTIES
    - 1167 DETERMINE GEOCHEMICAL PROPERTIES

TABLE A.1. (contd)

- 1200 PROVIDE INTERIM STABILIZATION/ ISOLATION
  - 1210 PROVIDE STABILIZATION (REDUCE LIQUID VOLUME)
    - 1211 PROVIDE STABILIZATION FOR NON-JET PUMPED TANKS
      - 1211.1 EVAL. TANK CONDITION FOR INTERIM STABILIZATION
      - 1211.2 PROVIDE PUMPING CAPABILITY FOR SUPERNATE
      - 1211.3 VERIFY TANK CONDITION AFTER PUMPING
      - 1211.4 OBTAIN APPROVAL FOR INTERIM STABILIZATION
    - 1212 PROVIDE STABILIZATION FOR JET PUMPED TANKS
      - 1212.1 EVAL. TANK CONDITION FOR INTERIM STABILIZATION
      - 1212.2 PROVIDE JET PUMPING CAPABILITY
      - 1212.3 VERIFY TANK CONDITION AFTER PUMPING
      - 1212.4 OBTAIN APPROVAL FOR INTERIM STABILIZATION
  - 1220 PROVIDE ISOLATION (ENCAPSULATE TANKS)
    - 1221 SEAL OPENINGS TO PREVENT WATER INTRUSION
    - 1222 PROVIDE FOAM COVER
    - 1223 PROVIDE RADIATION SHIELDING FOR RISERS
    - 1224 PROVIDE VENTILATION
    - 1225 PROVIDE EQUIPMENT DISPOSAL IF NEEDED
    - 1226 OBTAIN APPROVAL FOR INTERIM ISOLATION
  - 1230 PROVIDE SURVEILLANCE AFTER ISOLATION
    - 1231 MONITOR TEMPERATURE
    - 1232 MONITOR LIQUID LEVEL
    - 1233 MONITOR DRY-WELL RADIATION LEVEL

TABLE A.1. (contd)

1300 PROVIDE REGULATORY DOCUMENTS

- 1310 PREPARE PERFORMANCE ASSESSMENT
  - 1311 ESTABLISH DATA BASE
  - 1312 DEVELOP COMPUTER MODELS AND CODES
  - 1313 ANALYZE GENERATED DATA
  - 1314 DEVELOP CAPABILITY TO ANALYZE UNCERTANITY
  - 1315 DEVELOP AND IMPLEMENT QUALITY ASSURANCE PLAN
- 1320 PREPARE NEPA DOCUMENTATION
  - 1321 ISSUE NOTICE OF INTENT DOCUMENTS
  - 1322 DEFINE SCOPE OF DOCUMENT DOCUMENTS
  - 1323 PREPARE DRAFT DOCUMENT
  - 1324 INCORPORATE COMMENTS FOR FINAL DOCUMENT
  - 1325 PREPARE RECORD OF DECISION(ROD)
  - 1326 IMPLEMENT RECORD OF DECISION(ROD)
- 1330 PREPARE RCRA DOCUMENTS
  - 1331 SUBMIT PART A PERMIT
  - 1332 PREPARE CLOSURE PLAN
  - 1333 SUBMIT CLOSURE PLAN
  - 1334 RECEIVE APPROVAL FOR PLAN
  - 1335 IMPLEMENT CLOSURE PLAN
- 1340 PREPARE CERCLA DOCUMENTS
  - 1341 CONDUCT REMEDIAL INVESTIGATION
  - 1342 PREPARE FEASIBILITY STUDY
  - 1343 PREPARE AND ISSUE ROD
  - 1344 PREPARE REMEDIAL DESIGN
  - 1345 IMPLEMENT REMEDIAL DESIGN
- 1350 PREPARE ADDITIONAL REGULATORY DOCUMENT
  - 1351 PREPARE NECESSARY DOCUMENTS
    - 1351.1 COMPLY WITH RCRA SUBTITLE I
    - 1352.2 COMPLY WITH CLEAN WATER ACT
    - 1352.3 COMPLY WITH CLEAN AIR ACT
    - 1352.4 COMPLY WITH NRC
  - 1352 PREPARE APPROPRIATE DOCUMENTS
  - 1353 ISSUE DOCUMENTS
  - 1354 RECEIVE APPROVAL FOR DOCUMENTS

TABLE A.1. (contd)

- 1400 RETRIEVE SYSTEM COMPONENTS
  - 1410 RECOVER TANK WASTE
    - 1411 PRECONDITION WASTE
    - 1412 RETRIEVE WASTE
    - 1413 PACKAGE WASTE FOR TRANSPORTATION
    - 1414 TRANSPORT TANK WASTE
  - 1420 RECOVER CONTAMINATED SOIL
    - 1421 MINING CONTAMINATED SOIL
    - 1422 PACKAGE SOIL FOR TRANSPORTATION
    - 1423 TRANSPORT CONTAMINATED SOIL
  - 1430 RECOVER TANK SHELL
    - 1431 PREPARE FOR DISASSEMBLY
      - 1431.1 DECON TANK INTERIOR
      - 1431.2 REMOVE EQUIPMENT FROM TANK
      - 1431.3 DECON METAL PORTION OF TANK
      - 1431.4 DECON CONCRETE PORTION OF TANK
      - 1431.5 RECOVER DECON SOLUTION
      - 1431.6 DECON TANK EXTERIOR
      - 1431.7 DECON METAL PORTION OF TANK
      - 1431.8 DECON CONCRETE PORTION OF TANK
      - 1431.9 RECOVER DECON SOLUTION
    - 1432 DISASSEMBLE TANK
    - 1433 PACKAGE TANK SHELL
    - 1434 TRANSPORT TANK SHELL
  - 1440 RECOVER ANCILLARY EQUIPMENT
    - 1441 ISOLATE EQUIPMENT
    - 1442 DISASSEMBLE FROM OTHER COMPONENTS
    - 1443 DECON EQUIPMENT
    - 1444 TRANSPORT ANCILLARY EQUIPMENT

TABLE A.1. (contd)

1500 PERFORM PRETREATMENT OF SYSTEM COMPONENTS

- 1510 PRETREAT TANK WASTE IN-PLACE
  - 1511 REMOVE OXIDIZABLE CARBON COMPOUNDS
  - 1512 [REMOVE TRACE CONSTITUENTS] disabled
  - 1513 [REMOVE MINOR CONSTITUENTS] disabled
- 1520 PRETREAT RETRIEVED WASTE
  - 1521 PERFORM SOLID/LIQUID SEPARATION
  - 1522 DIGEST INSOLUBLES (ACIDIC MEDIA)
  - 1523 EXTRACT TRANSURANICS
  - 1524 REMOVE OTHER CONSTITUENTS
  - 1525 [PURIFY NON-RADIOACTIVE BULK (RECYCLE)] disabled
  - 1526 CONDITION STREAMS FOR WASTE PACKAGING
- 1530 PRETREAT RETRIEVED HARDWARE AND SOIL
  - 1531 DIGEST INSOLUBLES (ACIDIC MEDIA)
  - 1532 CONDITION SOLUBLES FOR TRANSFER TO 1520
  - 1533 CONDITION INSOLUBLES FOR WASTE PACKAGING
- 1540 PRETREAT HARDWARE AND SOIL IN PLACE
  - 1541 CONDITION AS NEEDED
  - 1542 IMMOBILIZE CONSTITUENTS

<u>TABLE A.1</u>. (contd)

1600 PROVIDE FINAL WASTE PACKAGE
- 1610 RECEIVE WASTE
- 1620 PREPARE FINAL WASTE FORM
  - 1621 PROVIDE STABILIZING AGENT
  - 1622 MIX WASTE AND STABILIZING AGENT
  - 1623 CONDITION WASTE FORM
- 1630 PLACE WASTE FORM IN CONTAINER
  - 1631 PROVIDE CONTAINER
  - 1632 FILL CONTAINER
  - 1633 SEAL CONTAINER
- 1640 PROVIDE MASS TRANSPORT BARRIER(S)
  - 1641 OBTAIN BARRIER MATERIALS
  - 1642 FABRICATE BARRIER(S)
- 1650 TRANSPORT FINAL WASTE PACKAGE

1700 PROVIDE LONG TERM ISOLATION
- 1710 SELECT SITE
  - 1711 IDENTIFY POTENTIAL SITES
  - 1712 COLLECT DATA ON POTENTIAL SITES
  - 1713 EVALUATE POTENTIAL SITES
- 1720 PROVIDE COMPLIANT BARRIER
  - 1721 BACKFILL AND GRADE SITE
  - 1722 CONSTRUCT BARRIER
- 1730 CONTROL RELEASE FROM SITE
  - 1731 CONTROL BIOINTRUSION INTO BARRIER
  - 1732 CONTROL WATER INFILTRATION AND GASEOUS RELEASES
  - 1733 CONTROL EROSION AND DEPOSITION
  - 1734 MAINTAIN STRUCTURAL STABILITY
  - 1735 CONTROL HUMAN INTRUSION
- 1740 MONITOR SITE AFTER BARRIER CONSTRUCTION
  - 1741 MONITOR SUBSIDENCE
  - 1742 MONITOR LINER/ LEACHATE COLLECTION SYSTEM
  - 1743 MONITOR GROUNDWATER
  - 1744 MONITOR SUBSIDENCE

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APPENDIX B

LINKAGE OF HIERARCHICAL SOURCE STATEMENTS TO ATTRIBUTES DEFINING SYSTEM REQUIREMENTS

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APPENDIX B

LINKAGE OF HIERARCHICAL SOURCE STATEMENTS TO ATTRIBUTES DEFINING SYSTEM REQUIREMENTS

The hierarchical statements shown in Table B.1 of this appendix were extracted from a review (Keller et al. 1989) of the applicable regulations and statutes that may influence the final disposition (closure) of the Hanford single-shell tank system. About 125 individual statements were extracted and assigned to one or more of 14 categories (see below) to link the 541 attributes identified in the requirements analysis as important to meeting the performance objectives.

Each of the 541 attributes was also assigned to one or more of the 14 categories as appropriate. Table B.2 shows the attribute numbers by category which connect to the attribute descriptions shown in Appendix C. With the aid of the category codes, the transformation of the hierarchical source statements to system requirements can be traced in either direction.

The categories selected were as follows:

ID CODE	Description of Category
CO	Constraint from hierarchical source
AIR	Atmospheric release
CA	Corrective action
DC	Design and Construction
ES	Employee Safety and Health
H2O	Water release
L	Landfill
MA	Maintenance and Surveillance
MC	Monitoring and Characterization
OP	Operations
PS	Public Health and Safety
RE	Reporting
RAC	Remedial Actions after Closure
RBC	Remedial Actions before Closure

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TABLE B.1. Extracted Statements from Hierarchical Sources Applicable

ID CODE	REGULATORY SOURCE	DESCRIPTION
CO		
L, CO	RCRA Sec 3004(c)(1)	Placement of bulk liquids in landfills in prohibited. See 40 CFR 264.314 and WAC 173-303-665(9).
DC,CO	40 CFR 191.14(e)	Disposal sites having a reasonable expectation as a future resource of minerals should be avoided.
OP,CO	CWA Sec 10(a)(1)	Discharge of any pollutant in navigable waters is prohibited.
OP,CO	CWA Sec 311(b)(1)	Discharge of oil or hazardous substance in navigable waters is prohibited.
OP,CO	CWA Sec 301(f)	Discharge of radiological, chemical or biological warfare agents in navigable waters is prohibited.
AIR		
AIR	WAC 173-303-430(3)(b)	Prevent degradation of air quality.
AIR,PS	40 CFR 61.92	Radionuclides released to the air from DOE facilities shall not exceed 25 mrem/yr to the whole body and 75 mrem/yr to the critical organs of a public member.
AIR,PS	WAC 173-480-050(1)	Radionuclides released to the air from DOE facilities should be as low as reasonably achievable (ALARA).
AIR,PS	DOE Order 5400.5 Ch.II., 1.,C.	Exposure shall not exceed an effective dose equivalent of 25 mrem/yr to the whole body of an individual public member and no more than 75 mrem to any organ from an atmospheric release.
CA		
CA	40 CFR 264.101(a)	Permit must contain a corrective action specification and must be instituted regardless of the age of the waste emplacement.
CA	40 CFR 264.101(b)	Completion of corrective actions must be supported by assurances of financial responsibility.
CA	WAC 173-303-145(2)	Upon release of hazardous waste, immediate notification of authorities is required.
CA	WAC 173-303-145(3)	Must take action to protect human health and the environment upon a release.
CA	WAC 173-303-145(2)(a)(i)	After a release, a facility may be required to clean up, treat, store or dispose of all contaminated materials, water or soil.
CA	WAC-173-303-645(2)(a)(i)	After a release ground water monitoring is required.
CA	WAC-173-303-645(2)(a)(iii)	If the compliance point specified by the permit is exceeded, corrective action is required.
CA	CERCLA Sec 103(a)	If a release >= an RQ, the National Response Center must be notified immediately. See RCRA 3004(u) and 52 FR 8172 for an update.
MC,CA	CERCLA Sec 102(b)	RQ for corrective action is listed in Table 302.4 of 40 CFR 302.4 and Section 102(b) of CERCLA.

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TABLE B.1. (contd)

ID CODE	REGULATORY SOURCE	DESCRIPTION
DC		
DC	WAC 173-303-430(3)(d)	Prevent destruction of flora and fauna outside facility boundary.
DC	WAC 173-303-43-(3)(e)	Prevent excessive noise.
DC	WAC 173-303-430(3)(f)	Prevent a negative aesthetic impact for public and private concerns nearby.
DC	WAC 173-303-430(3)(h)	Avoid processes that do not treat, detoxify, recycle, reclaim, and recover waste.
DC	40 CFR 264.17	Facility design requirements. See 40 CFR 264.17: ignitable, reactive, incompatible wastes.
DC,OP	RCW 70.105.050	Must mitigate hazards of mixed EHW and operate in compliance with RCW 70.105.
RBC,DC	40 CFR 300.70(b)	Methods to remediate hazardous waste releases is listed in 40 CFR 300.70(b).
RBC,DC	40 CFR 300.70(b)	Methods required are: air emission, surface water, groundwater controls, contaminated water and sewer lines, gaseous emissions and direct waste treatment, contaminated soil and sediment.
DC,MC	40 CFR 191.13(a)	Provide a reasonable expectation that cumulative releases to accessible environment for 10,000 years after disposal is <.1% chance of exceeding 10 times the value in Table A.9.
H20,DC	40 CFR 191.13(a)	Provide a reasonable expectation that cumulative releases to accessible environment for 10,000 years after disposal is <10% chance of exceeding values in Table A.9.
H20,DC	40 CFR 191.13(a)	Provide a reasonable expectation that cumulative releases to accessible environment for 1,000 years after disposal is <5 picocuries/liter averaged over any one year of Ra-226 and Ra-228.
H20,DC	40 CFR 191.13(a)	Provide a reasonable expectation that cumulative releases to accessible environment for 1,000 years after disposal is <15 picocuries/liter averaged over any one year of alpha emitting isotopes.
H20,DC	40 CFR 191.13(a)	Provide a reasonable expectation that cumulative releases to accessible environment for 1,000 years after disposal is <4 millirems/year from 2 liters/day consumption by an individual.
H20,DC	40 CFR 191.13(a)	Provide a reasonable expectation that cumulative releases to accessible environment for 1,000 years after disposal will not increase incrementally by more than the limits established even if groundwater sources are already above the limit.
DC	40 CFR 191.14(d)	Disposal systems shall use different types of barriers to isolate the wastes from the accessible environment.
DC,CO	40 CFR 191.14(e)	Disposal sites having a reasonable expectation as a future resource of minerals should be avoided.
DC	10 CFR 60.113(a)ii(A)	After permanent closure, HLW must be substantially contained within the waste package barriers for at least 300 years.
DC,MC	10 CFR 60.113(a)ii(B)(2)	Pre-waste emplacement groundwater travel time shall be at least 1,000 years.
MC,DC	40 CFR 141.40-.43	Special monitoring regulations and prohibition on lead use (Subpart E of 40 CFR 141) shall apply.
DC,OP	WAC 173-218-100	Underground injection can not be used in a manner that allows the movement of fluid containing any contaminant into underground drinking water.
DC	40 CFR 146.11-.73	Design requirements for UIC wells found in 40 CFR 146 shall apply.
DC	40 CFR 146	Conditions for UIC shall be specified in the permit and include all known methods for prevention, control and treatment. Applicable requirements 146.1(a) in 40 CFR 124, 144, and 146 shall apply.
DC,MA,OP	DOE Order 5400.1, Policy(a) pg.6	DOE activities shall assure protection of the environment.
DC,PS,ES	DOE Order 5820.2A Ch.I.3.a(1)(a)	HLW designs must assure protection of the public and operating personnel.
DC	DOE Order 5820.2A Ch.I.3à(1)(c)	HLW designs must incorporate retrievable capability.
DC	DOE Order 5820.2A Ch.I.3a.(1)(c)	HLW designs must comply with DOE 6430.1, Hanford Plant Standard and Specifications and 40 CFR 264.
ES		
ES	WAC 173-303-430(3)(i)	Prevent endangerment of employee health.
ES,OP,MA	10 CFR 60.111(a)	Radiation exposures, levels and releases shall be maintained within 10 CFR 20 and applicable EPA limits through permanent closure of a disposal site.
OP,ES	10 CFR 61.43	Operations shall be conducted in compliance with the 10 CFR 20 radiation protection standards.
DC,PS,ES	DOE Order 5820.2A Ch.I.3.a(1)(a)	HLW designs must assure protection of the public and operating personnel.

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TABLE B.1. (contd)

ID CODE	REGULATORY SOURCE	DESCRIPTION
H2Ø		
H2Ø	WAC 173-303-430(3)(a) WAC 173-303-430(3)(c)	Prevent degradation of groundwater and surface water quality.
RAC,H2Ø	CERCLA Sec 104(c)(6)	Remedial action is completed when ground and surface water is restored to a quality level that assures protection of human health and environment.
H2Ø,DC	40 CFR 191.13(a)	Provide a reasonable expectation that cumulative releases to accessible environment for 1,000 years after disposal is <5 picocuries/liter averaged over any one year of Ra-226 and Ra-228.
H2Ø,DC	40 CFR 191.13(a)	Provide a reasonable expectation that cumulative releases to accessible environment for 1,000 years after disposal is <15 picocuries/liter averaged over any one year of alpha emitting isotopes.
H2Ø,DC	40 CFR 191.13(a)	Provide a reasonable expectation that cumulative releases to accessible environment for 1,000 years after disposal is <4 millirems/year from 2 liters/day consumption by an individual.
H2Ø,DC	40 CFR 191.13(a)	Provide a reasonable expectation that cumulative releases to accessible environment for 1,000 years after disposal will not increase incrementally by more than the limits established even if groundwater sources are already above the limit.
H2Ø	Draft Proposed 40 CFR 193 Subpart C	Class I groundwater cannot result in an increase in radioactivity level from disposal of LLW.
H2Ø	Draft Proposed 40 CFR 193 Subpart C	High yield Class II groundwater cannot result in an increase in radioactivity level from disposal of LLW by more than 4 mrem/year based on 2 liter/day consumption by an individual.
H2Ø	Draft Proposed 40 CFR 193 Subpart C	Connected groundwater cannot result in an increase in radioactivity level from disposal of LLW that is determined by the class to which it is hydrodynamically connected.
H2Ø	WAC 248-54-175(2)	State of Washington regulations require that compliance with secondary standards be enforced based on DSHS discretion as the public interest warrants.
MC,H2Ø	40 CFR 141.21-.30	Monitoring and analytical requirements in Subpart C of 40 CFR 141 shall apply.
H2Ø	40 CFR 141.11-.16	Maximum contaminant levels in Subpart B of 40 CFR 141 shall apply.
H2Ø	40 CFR 141.50-.52	Maximum contaminant level goals in Subpart F of 40 CFR 141 shall apply.
H2Ø	40 CFR 141.60-.63	Maximum contaminant levels for primary drinking water in Subpart G of 40 CFR 141 shall apply (currently being developed).
RE,H2Ø,MC	CWA Sec 402(a)(1)	Discharges to navigable waters must be permitted under the NPDES program.
L		
L	40 CFR 264.301(a)	Regulated units must have a liner for all portions of the unit.
L	WAC 173-303-665(2)(a)(i)	No migration of waste out of unit during active life.
L	40 CFR 264.301(i)	Properties of liner must prevent failure due to pressure gradients, physical contact with waste or leachate, climate, stresses due to installation or operation.
L	40 CFR 264.301(ii)	Liner must be on a base capable of supporting liner.
L	40 CFR 264.301(2)	A system must be installed immediately above liner to collect leachate and remove it.
L,OP	40 CFR 264.251(a)(2) 40 CFR 264.301(a)(2)	EPA specifies operating conditions to ensure leachate depth does not exceed 30 cm.
L	40 CFR 264.301(c)	New, replaced, expanded landfills must have two or more liners.
L	40 CFR 264.301(c)	New, replaced, expanded landfills must have a leachate system above and between the liners.
L,CO	RCRA Sec 3004 (c)(1)	Placement of bulk liquids in landfills is prohibited. See 40 CFR 264.314 and WAC 173-303-665(9).
L	40 CFR 264.310(a)(1)	Landfills cover must minimize long term migration of liquids from closed landfill.
L	40 CFR 264.310(a)(2)	Landfill cover must function with minimum maintenance.
L	40 CFR 264.310(a)(3)	Landfill cover must promote drainage and minimize erosion or abrasion of the cover.
L	40 CFR 264.310(a)(4)	Landfill cover must maintain its integrity after settling or subsidence.
L	40 CFR 264.310(a)(5)	Landfill cover permeability <= permeability of bottom liner or natural sub-soils present.
L,MA	40 CFR 264.310(b)(1)	Must perform maintenance to ensure and correct the effects of settling, subsidence and erosion.
L,MC	WAC 173-303-665(6)(b)(iv)	A groundwater monitoring program is required to monitor effectiveness of final cover.

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TABLE B.1. (contd)

ID CODE	REGULATORY SOURCE	DESCRIPTION
MA		
OP,MA	40 CFR 264.111(a)	Must minimize further maintenance after closure.
OP,MA	40 CFR 264.111(c)	Must control, minimize or eliminate escape after closure to surface and groundwater. Waste, constituents, leachate contaminated runoff, decomposition products.
L,MA	40 CFR 264.310(b)(1)	Must perform maintenance to ensure and correct the effects of settling, subsidence and erosion.
MA,MC	40 CFR 191.14(a)	Performance assessments shall not consider contributions from institutional controls for more than 100 years after disposal.
MA,MC	40 CFR 191.14(b)	Disposal systems shall be monitored after disposal to detect substantial and detrimental deviations without jeopardizing the isolation mechanisms.
MA,MC	40 CFR 191.14(c)	Disposal sites shall be designated by the most permanent markers, records and other passive controls practicable.
ES,OP,MA	10 CFR 60.111(a)	Radiation exposures, levels and releases shall be maintained within 10 CFR 20 and applicable EPA limits through permanent closure of a disposal site.
DO, MA,OP	DOE Order 5400.1 Policy(a), pg.6	DOE activities shall assure protection of the environment.
MC		
MC	WAC 173-303-910(6)	Analysis must completely describe the chemical and physical characteristics of the waste for petitions for exclusion.
L,MC	WAC 173-303-655(6)(b)(iv)	A groundwater monitoring program is required to monitor effectiveness of final cover.
M, MC	CERCLA Sec 102(b)	RQ for corrective action is listed in Table 302.4 of 40 CFR 302.4 and Section 102(b) of CERCLA.
RAC,MC	CERCLA Sec 121(d)	Compliance for a completed remedial action must attain Max Containment Level Goals of the SWDA and water quality criteria under Sections 304 or 303 of the CWA.
DC,MC	40 CFR 191.13(a)	Provide a reasonable expectation that cumulative releases to accessible environment for 10,000 years after disposal is <.1% chance of exceeding 10 times the values.
DC,MC	40 CFR 191.13(a)	Provide a reasonable expectation that cumulative releases to accessible environment for 10,000 years after disposal is <10% chance of exceeding values in Table A.9.
MA,MC	40 CFR 191.14(a)	Performance assessments shall not consider contributions from institutional controls for more than 100 years after disposal.
MA,MC	40 CFR 191.14(b)	Disposal systems shall be monitored after disposal to detect substantial and detrimental deviations without jeopardizing the isolation mechanisms.
MA,MC	40 CFR 191.14(c)	Disposal sites shall be designated by the most permanent markers, records and other passive controls practicable.
DC,MC	10 CFR 60.113(a)ii(B)(2)	Pre-waste emplacement groundwater travel time shall be at least 1,000 years.
MC,H20	40 CFR 141.21-.30	Monitoring and analytical requirements in Subpart C of 40 CFR 141 shall apply.
MC,DC	40 CFR 141.40-.43	Special monitoring regulations and prohibition on lead use in Subpart E of 40 CFR 141 shall apply.
RE,H20,MC	CWA Sec 402(a)(1)	Discharges to navigable waters must be permitted under the NPDES program.
MC,PS	WAC 402-80-070(4)	Best available radionuclide control shall be used to provide maximum reduction of emissions in the air.
MC	WAC 402-80-080(2)	Stack sampling, ambient air monitoring or other testing is required under DSHS.
MC	WAC 402-80-080(3)	Continuous monitoring is encouraged; otherwise alternative monitoring and reporting procedures will be established.
MC,OP	WAC 402-080-080(8)	Special sampling ports or platforms must be provided for use by DSHS for special emission tests.
MC	DOE Order 5820.2A Ch.I.3.b.(1)(a)	Liquid and solidified HLW must be characterized to determine its hazardous waste components
OP,MC		
MC	DOE Order 5820.2A Ch.II.3(a)(1)	Material suspected to be contaminated with TRU shall be evaluated and determined to be recoverable scrap, tRU waste, LLW as soon as practical to avoid intermingling.

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TABLE B.1. (contd)

ID CODE	REGULATORY SOURCE	DESCRIPTION
OP		
OP	40 CFR 264.17	Facility operating requirements, see 40 CFR 264.17: ignitable, reactive, incompatible wastes.
L,OP	40 CFR 264.251(a)(2) 40 CFR 264.301(a)(2)	EPA specifies operating conditions to ensure leachate depth does not exceed 30 cm.
DC,OP	RCW 70.105.050	Must mitigate hazards of mixed EHW and operate in compliance with RCW 70.105.
OP,MA	40 CFR 264.111(a)	Must minimize further maintenance after closure.
OP,MA	40 CFR 264.111(c)	Must control, minimize or eliminate escape after closure to surface and groundwater: Waste, constituents, leachate contaminated runoff, decomposition products.
ES,OP,MA	10 CFR 60.111(a)	Radiation exposures, levels and releases shall be maintained within 10 CFR 20 and applicable EPA limits through permanent closure of a disposal site.
OP,ES	10 CFR 61.43	Operations shall be conducted in compliance with the 10 CFR 20 radiation protection standards.
DC,OP	WAC 713-218-100	Underground injection can not be used in a manner that allows the movement of fluid containing any contaminant into underground drinking water.
OP,CO	CWA Sec 101(a)(1)	Discharge of any pollutant in navigable waters is prohibited.
OP,CO	CWA Sec 311(b)(1)	Discharge of oil or hazardous substance in navigable waters is prohibited.
OP,CO	CWA Sec 301(f)	Discharge of radiological, chemical or biological warfare agents in navigable waters is prohibited.
MC,OP	WAC 402-80-080(8)	Special sampling ports or platforms must be provided for use by DSHS for special emission tests.
OP,PS	DOE Order 5400.5 Ch.II.1.C	Exposure shall not exceed an effective dose equivalent of 25 mrem/yr to the whole body of an individual public member and no more than 75 mrem to any organ from management or storage of HLW.
DC,MA,OP	DOE 5400.1 Policy(a), pg.6	DOE activities shall assure protection of the environment.
PS		
PS	52 FR 15937-15940	RCRA yields to AEA when inconsistencies arise. ALARA > Waste characterization.
PS	40 CFR 191.03(a)(2)	Whole body dose shall not exceed 25 millirems.
PS	40 CFR 191.03(a)(2)	NRC: Doses to the thyroid shall not exceed 75 millirems and to other critical organs shall not exceed 25 millirems.
PS	40 CFR 191.03(b)	Non-NRC DOE op'd: Doses to any critical organ shall not exceed 75 millirems.
PS	40 CFR 191.04(a)(1)	Non-NRC, EPA reg'd: Continuous doses shall not exceed 100 mrems/yr dose equivalent, and infrequent doses of 500 mrems in a year from all sources, not natural or medical.
PS	Draft Proposed 40 CFR 193 Subpart A	Management and storage of LLW should not exceed 25 mr of exposure to any member of the public nearby.
PS	Draft Proposed 40 CFR 193 Subpart B	Disposal of LLW should not exceed 25 mr of exposure to any member of the public nearby.
PS	10 CFR 61.41	Doses to the thyroid shall not exceed 75 mrem/year and 25 mrem/yr to the whole body or any other organ.
PS	10 CFR 61.41	Releases of radioactivity in effluents to the general environments should be ALARA.
AIR,PS	10 CFR 61.92	Radionuclides released to the air from DOE facilities shall not exceed 25 mrem/yr to the whole body and 75 mrem/yr to the critical organs of a public member.
AIR,PS	WAC 173-480-050(1)	Radionuclides released to the air from DOE facilities should be as ALARA.
MC,PS	WAC 402-80-070(4)	Best available radionuclide control shall be used to provide maximum reduction of emissions in the air.
PS	DOE Order 5400.5 Ch.II.A.a	Exposure shall not exceed an effective dose equivalent of 100 mrem/yr to an individual public member.
AIR,PS	DOE Order 5400.5 Ch.II.1.C	Exposure shall not exceed an effective dose equivalent of 25 mrem/yr to the whole body of an individual public member and no more than 75 mrem to any organ from an atmospheric release.
OP,PS	DOE Order 5400.5 Ch.II.1.c	Exposure shall not exceed an effective dose equivalent of 25 mrem/yr to the whole body of an individual public member and no more than 75 mrem to any organ from management or storage of HLW.
H20,PS	DOE Order 5400.5c Ch.II.1.d	Exposure shall not exceed 4 mrem/yr from any person consuming drinking water.
PS	DOE Order 5400.5 Ch.I.4	Exposures to the public shall be ALARA.
DC,PS,ES	DOE Order 5820.2A Ch.I.3.a.(1)(a)	HLW designs must assure protection of the public and operating personnel.

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TABLE B.1. (contd)

ID CODE	REGULATORY SOURCE	DESCRIPTION
RE		
RE	40 CFR 264.112(b)(5)	Submit a closure plan for describing how performance standards will be satisfied.
RE	40 CFR 141.31-.35	Reporting, Public Notification and Recordkeeping in Subpart D of 40 CFR 141 shall apply.
RE,H20,MC	CWA Sec 402(a)(1)	Discharges to navigable waters must be permitted under the NPDES program.
RE	D/DOE Order 5480.12 Ch.(IV)	Environmental monitoring plans must be submitted and include design criteria, frequency of measurements and procedures for analyses.
RE	DOE Order 5820.2A Chapter I.3.b(1)(b)	Characterization data must be used in a Safety Analysis Report.
RE	DOE Order 5481.1B Chapter I.(3)(a)(3)	A safety analysis shall be performed to identify and demonstrate conformance with applicable guides, codes and standards.
RE	DOE Order 5481.1B Ch.I.(3)(a)(5)	A safety analysis shall be performed to demonstrate there is reasonable assurance that operations will protect the public, employees and the environment at a low risk.
RAC		
RAC,H20	CERCLA Sec 104(c)(6)	Remedial action is completed when ground and surface water is restored to a quality level that assures protection of human health and environment.
RAC	CERCLA Sec 121(b)(1)	Remedial action treatments that reduce volume, toxicity, or mobility of hazardous waste is preferred over treatments not involving such treatment.
RAC	CERCLA Sec 121(d)(1)	The remedial action cleanups must attain a degree sufficient to protect human health and the environment.
RAC,MC	CERCLA Sec 121(d)(2)(A)(ii)	Compliance for a completed remedial action must attain Max Contaminant Level Goals of the SWDA and water quality criteria under Sections 303 or 304 of the CWA.
RAC	40 CFR 300.65(b)(1)	Any release deemed a threat by EPA must be abated, minimized, stabilized, mitigated, or eliminated.
RAC	40 CFR 300.65(f)	Removal actions shall meet or exceed applicable federal, public health and environmental requirements.
RBC		
RBC	RCRA Subtitle I	All tanks taken out of service permanently must be emptied and either removed from the ground or filled with an inert solid.
RBC,DC	40 CFR 300.70(b)	Methods to remediate hazardous waste releases is listed in 40 CFR 300.70(b).
RBC,DC	40 CFR 300.70(b)	Methods required are: air emission, surface water, groundwater controls, contaminated water and sewer lines, gaseous emissions and direct waste treatment, contaminated soil and sediment.

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TABLE B.2. Attribute Numbers Arranged by Category Identification Code

CODE--->	CO	AIR	CA	DC	ES	H2O	L	MA	MC	OP	PS	RE	RAC	RBC
TOTAL-->	63	4	10	220	22	111	50	114	7	185	22	18	7	42
LIST--->	ATT #	ATT #	ATT #	ATT #	ATT #	ATT #	ATT #	ATT #	ATT #	ATT #	ATT #	ATT #	ATT #	ATT #
	88	434	95	101	172	1	167	1	526	88	380	91	524	444
	89	435	96	102	173	2	168	2	527	89	381	92	525	445
	93	436	97	103	174	3	169	3	528	90	382	526	526	446
	98	500	533	104	175	4	170	4	529	91	383	527	527	447
	99		534	105	176	5	288	5	530	92	384	528	528	448
	100		535	126	177	6	289	6	531	93	385	529	529	451
	126		536	127	178	7	370	7	532	94	386	530	530	452
	127		537	128	179	8	371	8		111	387	531		453
	128		538	129	180	9	372	9		112	388	532		454
	129		539	130	181	10	373	10		113	389	533		455
	130			131	182	11	374	11		114	390	534		456
	131			132	183	12	375	12		115	391	535		457
	132			133	184	13	376	13		116	392	536		458
	133			134	488	14	377	14		117	393	537		459
	134			135	489	15	378	15		118	394	538		460
	135			150	490	16	379	16		119	395	539		461
	153			151	491	17	400	17		120	396	540		462
	154			152	492	18	401	18		121	397	541		463
	189			153	495	19	402	19		122	398			464
	190			154	496	20	403	20		123	399			465
	191			155	497	21	404	21		124	499			466
	192			156	498	22	405	22		125	500			467
	193			157		23	406	23		136				468
	246			161		24	407	24		137				469
	366			162		25	408	25		138				470
	367			163		26	409	26		139				471
	368			164		27	410	27		140				472
	369			165		28	411	28		141				473
	380			166		29	412	29		142				474
	381			169		30	413	30		143				475
	382			170		31	414	31		144				476
	383			171		32	415	32		145				477
	384			183		33	416	33		146				478
	385			185		34	417	34		147				479
	386			186		35	418	35		148				480
	387			187		36	419	36		149				481
	388			188		37	420	37		158				482
	389			189		38	421	38		159				483
	390			190		39	422	39		160				484
	391			191		40	423	40		172				485

TABLE B.2. (contd)

CODE--->	CO	AIR	CA	DC	ES	H2O	L	MA	MC	OP	PS	RE	RAC	RBC
TOTAL-->	63	4	10	220	22	111	50	114	7	185	22	18	7	42
LIST--->	ATT #	ATT #	ATT #	ATT #	ATT #	ATT #	ATT #	ATT #	ATT #	ATT #	ATT #	ATT #	ATT #	ATT #
	392			192		41	424	41		173				486
	393			193		42	425	42		174				487
	394			194		43	426	43		175				
	395			195		44	427	44		176				
	396			196		45	428	45		177				
	397			197		46	429	46		178				
	398			198		47	430	47		179				
	434			199		48	431	48		180				
	435			200		49	432	49		181				
	436			201		50	433	50		182				
	495			202		51		51		184				
	499			203		52		52		291				
	500			204		53		53		292				
	509			205		54		54		293				
	510			206		55		55		294				
	511			207		56		56		295				
	512			208		57		57		296				
	513			209		58		58		297				
	514			210		59		59		298				
	538			211		60		60		299				
	539			212		61		61		300				
	540			213		62		62		301				
	541			214		63		63		302				
				215		64		64		303				
				216		65		65		304				
				217		66		66		305				
				218		67		67		306				
				219		68		68		307				
				220		69		69		308				
				221		70		70		309				
				222		71		71		310				
				223		72		72		311				
				224		73		73		312				
				225		74		74		313				
				226		75		75		314				
				227		76		76		315				
				228		77		77		316				
				229		78		78		317				
				230		79		79		318				
				231		80		80		319				

TABLE B.2. (contd)

CODE--->	CO	AIR	CA	DC	ES	H20	L	MA	MC	OP	PS	RE	RAC	RBC
TOTAL-->	63	4	10	220	22	111	50	114	7	185	22	18	7	42
LIST--->	ATT #	ATT #	ATT #	ATT #	ATT #	ATT #	ATT #	ATT #	ATT #	ATT #	ATT #	ATT #	ATT #	ATT #
				232		81		81		320				
				233		82		82		321				
				234		83		83		322				
				235		84		84		323				
				236		85		85		324				
				237		86		86		325				
				238		87		87		326				
				239		106		88		327				
				240		107		89		328				
				241		108		90		329				
				242		109		91		330				
				243		110		92		331				
				244		380		93		332				
				245		381		94		333				
				246		382		95		334				
				247		383		96		335				
				248		384		97		336				
				249		385		98		337				
				250		386		99		338				
				251		387		100		339				
				252		388		101		340				
				253		389		102		341				
				254		390		103		342				
				255		391		104		343				
				256		392		105		344				
				257		393		106		345				
				258		394		107		346				
				259		395		108		347				
				260		396		109		348				
				261		397		110		349				
				262		398		415		350				
				263				416		351				
				264				419		352				
				265				420		353				
				266						354				
				267						355				
				268						356				
				269						357				
				270						358				
				271						359				

TABLE B.2. (contd)

CODE--->	CO	AIR	CA	DC	ES	H2O	L	MA	MC	OP	PS	RE	RAC	RBC
TOTAL-->	63	4	10	220	22	111	50	114	7	185	22	18	7	42
LIST--->	ATT #	ATT #	ATT #	ATT #	ATT #	ATT #	ATT #	ATT #	ATT #	ATT #	ATT #	ATT #	ATT #	ATT #
				272						360				
				273						361				
				274						362				
				275						363				
				276						364				
				277						365				
				278						366				
				279						367				
				280						368				
				281						369				
				282						434				
				283						435				
				284						436				
				285						437				
				286						438				
				287						440				
				288						444				
				289						445				
				290						446				
				366						447				
				367						448				
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				369						450				
				370						451				
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				374						455				
				375						456				
				376						457				
				377						458				
				378						459				
				379						460				
				400						461				
				401						462				
				402						463				
				403						464				
				404						465				
				405						466				
				406						467				

TABLE B.2. (contd)

CODE--->	CO	AIR	CA	DC	ES	H2O	L	MA	MC	OP	PS	RE	RAC	RBC
TOTAL-->	63	4	10	220	22	111	50	114	7	185	22	18	7	42
LIST--->	ATT #	ATT #	ATT #	ATT #	ATT #	ATT #	ATT #	ATT #	ATT #	ATT #	ATT #	ATT #	ATT #	ATT #
				407						468				
				408						469				
				409						470				
				410						471				
				411						472				
				412						473				
				413						474				
				414						475				
				415						476				
				416						477				
				417						478				
				418						479				
				419						480				
				420						481				
				421						482				
				422						483				
				423						484				
				424						485				
				425						486				
				426						487				
				427						488				
				428						489				
				429						490				
				430						491				
				431						492				
				432										
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				505										

TABLE B.2. (contd)

CODE--->	CO	AIR	CA	DC	ES	H20	L	MA	MC	OP	PS	RE	RAC	RBC
TOTAL-->	63	4	10	220	22	111	50	114	7	185	22	18	7	42
LIST--->	ATT #	ATT #	ATT #	ATT #	ATT #	ATT #	ATT #	ATT #	ATT #	ATT #	ATT #	ATT #	ATT #	ATT #
				506										
				507										
				508										
				509										
				510										
				511										
				512										
				513										
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APPENDIX C

SOURCE DATA FOR REQUIREMENTS ANALYSIS - SECTION 9.0

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APPENDIX C

SOURCE DATA FOR REQUIREMENTS ANALYSIS - SECTION 9.0

This appendix contains the inputs for the requirements analysis of the SST system. The attribute descriptions are listed in Tables C.1 and C.2. and are grouped into six major categories. Each category is subdivided further as described in the text. There 541 attributes, and each is given a number for identification.

In Table C.1, the attribute number, the attribute description, and the unit of measure for the attribute are listed respectively in the first three columns. In columns 4 and 5, the applicability of the attribute to the "In-place," "Retrieve" or both options is indicated by a YES or NO label. In column 6 the status of the attribute is indicated either blank if the choice of the value has not been made or by the letter "C" if the attributes is a constraint designated in the regulatory statutes and DOE orders discussed in Section 8.0 of the text.

The last column of Table C.1 assigns each attribute to one or more of 14 categories defined in Section 8.0. These categories are used to connect the performance objectives and constraints to the attribute list.

In Table C.2, the attributes have been ranked in order of importance to each of the seven first-level functions. The ranking values range from 1 to 10, with 10 being the most important to the function. A ranking of 1 signifies that the attribute has no importance to the function regardless of the stringency level assigned to it. Each function must have at least one attribute ranked as a 10. Intermediate rankings indicate a lesser degree of importance.

Table C.2 also shows the average value of the ranking by each function in the top row of the ranking matrix. The last column in the matrix lists the number of functions which ranked the attribute as "one" in importance. This term helps to understand the breadth of the importance of the attribute among the seven first-level functions. A few "number of ones" indicates that

achieving a consensus will involve many functions. A large "number of ones" indicates that the attribute has a narrow span of importance and that changes in its stringency level can be made with a lesser impact on the other functions.

TABLE C.1. Listing of Attributes, Units of Measure as Potential Requirements for Final Disposition of the SST System

ATTRIBUTE No.	5/31/89 Update ATTRIBUTE DESCRIPTION	UNITS OF MEASURE	CLASSIFICATIONS OF ATTRIBUTES: APPLICATION TO DISPOSAL OPTION IN-PLACE	RETRIEVE	STATUS: "C"= CONSTRAINT	SOURCE CODE See App B
	1.0 CHEMICAL ATTRIBUTES					
	1.1 Detection Limits (for Groundwater, Leaching Tests, Process Samples, etc.)					
	1.1.1 Radionuclides					
1	Ac-227	pCi	YES	NO		MA,H20
2	Am-241	pCi	YES	YES		MA,H20
3	Am-242	pCi	YES	NO		MA,H20
4	Am-243	pCi	YES	NO		MA,H20
5	C-14	pCi	YES	YES		MA,H20
6	Cm-242	pCi	YES	YES		MA,H20
7	Cm-244	pCi	YES	NO		MA,H20
8	Cm-245	pCi	YES	NO		MA,H20
9	Co-60	pCi	YES	YES		MA,H20
10	Cs-135	pCi	YES	YES		MA,H20
11	Cs-137	pCi	YES	YES		MA,H20
12	H-3	pCi	YES	NO		MA,H20
13	I-129	pCi	YES	YES		MA,H20
14	Ni-59	pCi	YES	NO		MA,H20
15	Ni-63	pCi	YES	YES		MA,H20
16	Nb-94	pCi	YES	YES		MA,H20
17	Np-237	pCi	YES	YES		MA,H20
18	Pa-231	pCi	YES	NO		MA,H20
19	Pb-210	pCi	YES	NO		MA,H20
20	Po-210	pCi	YES	NO		MA,H20
21	Pu-238	pCi	YES	NO		MA,H20
22	Pu-239	pCi	YES	YES		MA,H20
23	Pu-240	pCi	YES	NO		MA,H20
24	Pu-241	pCi	YES	NO		MA,H20
25	Pu-242	pCi	YES	NO		MA,H20
26	Ra-226	pCi	YES	NO		MA,H20
27	Ra-228	pCi	YES	NO		MA,H20
28	Ru-106	pCi	YES	NO		MA,H20
29	Se-79	pCi	YES	YES		MA,H20
30	Sm-151	pCi	YES	NO		MA,H20
31	Sn-126	pCi	YES	YES		MA,H20
32	Sr-90	pCi	YES	YES		MA,H20
33	Tc-99	pCi	YES	YES		MA,H20
34	Th-229	pCi	YES	NO		MA,H20
35	Th-230	pCi	YES	NO		MA,H20
36	Th-232	pCi	YES	NO		MA,H20
37	U-233	pCi	YES	NO		MA,H20
38	U-234	pCi	YES	NO		MA,H20
39	U-235	pCi	YES	NO		MA,H20
40	U-236	pCi	YES	NO		MA,H20
41	U-238	pCi	YES	YES		MA,H20
42	Zr-93	pCi	YES	YES		MA,H20

TABLE C.1. (contd)

ATTRIBUTE No.	5/31/89 Update ATTRIBUTE DESCRIPTION	UNITS OF MEASURE	CLASSIFICATIONS OF ATTRIBUTES: APPLICATION TO DISPOSAL OPTION IN-PLACE	RETRIEVE	STATUS: "C"= CONSTRAINT	SOURCE CODE See App B
	1.0 CHEMICAL ATTRIBUTES (contd)					
	1.1.2 Ionic Species					
43	Aluminum	ppm	NO	YES		MA,H20
44	Arsenic	ppm	YES	NO		MA,H20
45	Ammonia	ppm	YES	NO		MA,H20
46	Barium	ppm	YES	NO		MA,H20
47	Beryllium	ppm	YES	NO		MA,H20
48	Bismuth	ppm	YES	NO		MA,H20
49	Boron	ppm	YES	NO		MA,H20
50	Carbonate	gms/l	YES	NO		MA,H20
51	Cadmium	ppm	YES	YES		MA,H20
52	Calcium	ppm	NO	YES		MA,H20
53	Chloride	ppm	NO	YES		MA,H20
54	Chromium	ppm	YES	YES		MA,H20
55	Cobalt	ppm	YES	NO		MA,H20
56	Copper	ppm	YES	YES		MA,H20
57	Cyanide	ppm	YES	YES		MA,H20
58	Fluoride	ppm	YES	YES		MA,H20
59	Free Hydroxide	ppm	YES	NO		MA,H20
60	Hypochlorite	ppm	YES	NO		MA,H20
61	Iron	ppm	YES	YES		MA,H20
62	Lead	ppm	YES	NO		MA,H20
63	Magnesium	ppm	YES	NO		MA,H20
64	Manganese	ppm	YES	YES		MA,H20
65	Mercury	ppm	YES	YES		MA,H20
66	Nickel	ppm	YES	YES		MA,H20
67	Molybdenum	ppm	YES	NO		MA,H20
68	Nitrate	ppm	YES	YES		MA,H20
69	Nitrite	ppm	YES	YES		MA,H20
70	Phosphorus	ppm	YES	YES		MA,H20
71	Potassium	ppm	YES	NO		MA,H20
72	Selenium	ppm	YES	YES		MA,H20
73	Silicon	ppm	NO	YES		MA,H20
74	Silver	ppm	YES	NO		MA,H20
75	Sodium	ppm	YES	YES		MA,H20
76	Strontium	ppm	YES	NO		MA,H20
77	Sulfate	ppm	YES	YES		MA,H20
78	Sulfite	ppm	YES	NO		MA,H20
79	Titanium	ppm	YES	NO		MA,H20
80	Uranium	ugm/gm	YES	YES		MA,H20
81	Vanadium	ppm	YES	NO		MA,H20
82	Zinc	ppm	YES	NO		MA,H20
83	Zirconium	ppm	YES	NO		MA,H20
84	Total Organo-Halides(TOX)	g/l	YES	NO		MA,H20
85	TOX Species Identification	%	YES	NO		MA,H20
86	Total Organic Carbon (TOC)	g/l	YES	YES		MA,H20
87	TOC Species Identification	%	YES	YES		MA,H20

TABLE C.1. (contd)

ATTRIBUTE No.	5/31/89 Update ATTRIBUTE DESCRIPTION	UNITS OF MEASURE	CLASSIFICATIONS OF ATTRIBUTES: APPLICATION TO DISPOSAL OPTION IN-PLACE	RETRIEVE	STATUS: "C"= CONSTRAINT	SOURCE CODE See App B
	1.0 CHEMICAL ATTRIBUTES (contd)					
	1.2 Accuracy of Contents (Process Stream Control)					
	1.2.1 Tank Liquids (before stabilization)					
88	a) Total Volume (height)	+/- ft: .1ft=3000g	YES	NO		CO,OP,MA
89	b) Drainable Volume (height)	+/- ft: .1ft=3000g	YES	NO		CO,OP,MA
	1.2.2 Tank Solids (after stabilization)(plus or minus)					
90	a) Total Volume of solids	+/- ft: .1ft=3000G	YES	YES		OP,MA
91	b) TRU	+/- nCi/gm	YES	NO		RE,OP,MA
92	c) Total Beta, Gamma Activity Variance	+/- %	YES	YES		RE,OP,MA
93	d) Water Content Variance	+/- %	YES	NO		CO,OP,MA
94	e) pH	+/- pH units	YES	NO		OP,MA
	1.2.3 Spills and Leaks to Soil					
95	a) TRU Content	+/- % of source	YES	YES		CA,MA
96	b) Curie Content	+/- % of source	YES	YES		CA,MA
97	c) Total Mass	+/- % of source	YES	YES		CA,MA
	1.2.4 Composition of WP Waste Form-Accuracy					
98	a) Chemical Content	+/- wt%	NO	YES		CO,MA
99	b) Radionuclide Content	Activity %	NO	YES		CO,MA
100	c) Residual Liquid	vol%	NO	YES		CO,MA
	1.2.5 Composition of Waste Containers/Engineered Materials					
101	a) HLW Glass-304L Aus Steel (C<.03wt%)	+/- wt%	NO	YES		DC,MA
102	b) Grouts	+/- wt%	NO	YES		DC,MA
	Portland II Cement	+/- wt%				
	Fly Ash (ASTM Class F)	+/- wt%				
	Clay	+/- wt%				
103	c) Cements	+/- wt%	YES	YES		DC,MA
104	d) Fillers	+/- wt%	YES	YES		DC,MA
105	e) Soils/Clay	+/- wt%	YES	YES		DC,MA
	1.3 Sampling Frequency					
	1.3.1 Process Steam					
106	a) During Stabilization	#/yr	YES	NO		H20,MA
107	b) During Processing and Pre-Closure	#/State Change	YES	YES		H20,MA

TABLE C.1. (contd)

ATTRIBUTE No.	5/31/89 Update ATTRIBUTE DESCRIPTION	UNITS OF MEASURE	CLASSIFICATIONS OF ATTRIBUTES: APPLICATION TO DISPOSAL OPTION: IN-PLACE	RETRIEVE	STATUS: "C"= CONSTRAINT	SOURCE CODE See App B
	1.0 CHEMICAL ATTRIBUTES (contd)					
	1.4 Sampling Density of Solid Matter					
	1.4.1 Process Stream					
108	a) During Tank Characterization	#	YES	NO		H20,MA
109	b) During Soil Characterization	proced	YES	YES		H20,MA
110	c) Processing of Solids	#	NO	YES		H20,MA
	2.0 PHYSICAL ATTRIBUTES (all system components and contaminated soil)					
	2.1 Spatial Properties					
	2.1.1 Waste Form after Stabilization					
	a) Max Drainable Liquid (See 3.2.1 d)					
	2.1.2 Tank waste retrieval package dimensions					
111	a) Shape	descriptive	NO	YES		OP
112	b) Max Volume	ft^3	NO	YES		OP
113	c) Max I.D.	ft	NO	YES		OP
114	d) Max Height	ft	NO	YES		OP
	2.1.3 Soil Package Dimensions					
115	a) Shape	descriptive	NO	YES		OP
116	b) Max Volume	ft^3	NO	YES		OP
117	c) Max I.D.	ft	NO	YES		OP
118	d) Max Height	ft	NO	YES		OP
	2.1.4 Tank Retrieval Package Dimensions					
119	a) Max I.D.	ft	NO	YES		OP
120	b) Max Height	ft	NO	YES		OP
121	c) Max Gross Weight	lbs	NO	YES		OP
	2.1.5 Ancillary Equipment Package Dimensions					
122	a) Shape	descriptive	NO	YES		OP
123	b) Max Volume	ft^3	NO	YES		OP
124	c) Max I.D.	ft	NO	YES		OP
125	d) Max Height	ft	NO	YES		OP
	2.1.6 Final Waste Package					
	a) Containerized HLW Glass					
126	Length	m	NO	YES	C	DC,CO
127	Diameter	cm	NO	YES	C	DC,CO
128	Wall Thickness	cm	NO	YES	C	DC,CO
129	Weight	kg	NO	YES	C	DC,CO
130	Max Free Volume	vol %	NO	YES	C	DC,CO

TABLE C.1. (contd)

ATTRIBUTE No.	5/31/89 Update ATTRIBUTE DESCRIPTION	UNITS OF MEASURE	CLASSIFICATIONS OF ATTRIBUTES: APPLICATION TO DISPOSAL OPTION IN-PLACE	RETRIEVE	STATUS: "C"= CONSTRAINT	SOURCE CODE See App B
	2.0 PHYSICAL ATTRIBUTES (contd)					
	b) Containerized TRU Waste-Off Site WIPP					
	Contact Handled:	m				
131	Length/Width/Height		NO	YES	C	DC,CO
132	Weight	kg	NO	YES	C	DC,CO
	Remote Handled:	m				
133	Diameter/Height		NO	YES	C	DC,CO
134	Weight	kg	NO	YES	C	DC,CO
	c) Containerized Grout					
135	Max Free Volume	vol%	NO	YES		DC,CO
	2.2 Precision Limits Tank Waste					
136	a) Density	+/- %	YES	YES		OP
137	b) Particle Size Distribution	+/- %(.5 -150um)	YES	YES		OP
138	c) Viscosity	+/- %	NO	YES		OP
139	d) Thermal Output	+/- %	YES	YES		OP
140	e) Thermal Conductivity	+/- %	YES	NO		OP
141	f) Pentrometer Test on Salt Cake	+/- %	NO	YES		OP
142	g) Thermal Analysis	+/- %	NO	YES		OP
143	h) Specific Heat	+/- %	YES	YES		OP
144	i) Solids Settling Rate (sluicing retrieval)	+/- %	NO	YES		OP
145	j) Volume % Settled Solids (sluicing retrieval)	+/- %	NO	YES		OP
146	k) Volume % Centrifuged Solids (sluicing retrieval)	+/- %	NO	YES		OP
147	l) Miller Number (sluicing retrieval)	+/- %	NO	YES		OP
148	m) Shear Strength (sluicing retrieval)	+/- %	NO	YES		OP
149	n) Shear Stress-shear rate rheogram (sluicing retrieval)	+/- %	NO	YES		OP
	2.3 Physical Properties					
	2.3.1 HLW Glass Waste Form					
150	a) Monolith Temperature Limit	Deg C	NO	YES		DC
151	b) Heat Generation Rate	Watts/can	NO	YES		DC
	2.3.2 Grout Waste Form					
152	a) Temperature Limit	Deg C	NO	YES		DC
153 C	b) Unconfined Compressive Strength	psi	NO	YES		DC,CO
	2.3.3 Waste Package Containers					
154	a) HLW Glass-Max Internal Pressure	psig @25Deg C	NO	YES		DC,CO

TABLE C.1. (contd)

ATTRIBUTE No.	5/31/89 Update ATTRIBUTE DESCRIPTION	UNITS OF MEASURE	CLASSIFICATIONS OF ATTRIBUTES: APPLICATION TO DISPOSAL OPTION IN-PLACE	RETRIEVE	STATUS: "C"= CONSTRAINT	SOURCE CODE See App B
	2.0 PHYSICAL ATTRIBUTES (contd)					
	b) Grouted Waste-Vault					
155	Overburden Internal Pressure	%	NO	YES		DC
156	Strength	psi	NO	YES		DC
157	c) Single Shell Tank-Temp Limit	Deg C	NO	YES		DC
	d) TRU Waste-Dose Rates					
158	Surface-Contact TRU	mRem/hr	NO	YES		OP
159	Surface B/G-Remote	Rem/hr	NO	YES		OP
160	Surface Neutron-Remote	nRem/hr	NO	YES		OP
	2.3.4 Soils/Clays as Engineered Barriers					
161	a) Max Permeability	cm/sec	YES	YES		DC
162	b) Max Swelling Pressure	psi	YES	YES		DC
163	c) Min Thickness	cm	YES	YES		DC
164	d) Min Bearing Strength	psi	YES	YES		DC
	2.3.5 Cements-as structures/ barriers					
165	a) Min Permeability	cm^2/sec	YES	YES		DC
166	b) Min Compressive Strength	psi	YES	YES		DC
	2.3.6 Concrete Dome					
167	a) Permeability	Deff	YES	YES		L
168	b) Strength	psi	YES	YES		L
169	c) Allowable Dome Deformation after Closure		YES	YES		DC,L
170	d) Allowable Dome Deformation during Closure		YES	YES		DC,L
	2.3.7 Tank Filled Waste					
171	a) Max Porosity	vol %	YES	NO		DC
	2.4 Decontamination Factors					
172	2.4.1 Max Quantity of Tank Waste Residue After Retrieval % tank solids		NO	YES		ES,OP
173	2.4.2 Max Allowed Soil Contamination After Retrieval	pci/gm	NO	YES		ES,OP
	2.4.3 Max Residual Activity on Tank Exterior/ Interior	x				
174	a) Beta/Gamma	mr/hr	NO	YES		ES,OP
	2.4.4 Max Residual Contamination on Ancillary Equipment					
175	a) Beta/Gamma	mr/hr	NO	YES		ES,OP
176	2.4.5 Max Residual TRU in Cribs and Trenches	nCi/gm	NO	YES		ES,OP

TABLE C.1. (contd)

ATTRIBUTE No.	5/31/89 Update ATTRIBUTE DESCRIPTION	UNITS OF MEASURE	CLASSIFICATIONS OF ATTRIBUTES: APPLICATION TO DISPOSAL OPTION IN-PLACE	RETRIEVE	STATUS: "C"= CONSTRAINT	SOURCE CODE See App B
	2.0 PHYSICAL ATTRIBUTES (contd)					
	2.4.6 Max Smearable Release for Retrieval Package					
177	a) Alpha	dpm/cm^2	NO	YES		ES,OP
178	b) Beta/Gamma	dpm/cm^2	NO	YES		ES,OP
	2.4.7 Max Smearable Release of HLW Glass WP					
179	a) Beta/Gamma	dpm/cm^2	NO	YES		ES,OP
180	b) Alpha	dpm/cm^2	NO	YES		ES,OP
	2.4.8 TRU >Class C					
181	a) Alpha	pCi/cm^2	NO	YES		ES,OP
182	b) Beta/Gamma	pCi/cm^2	NO	YES		ES,OP
	3.0 ENGINEERED ENCLOSURES					
	3.1 Transport Containers (All Types)					
	3.1.1 Performance Attributes					
183	a) Integrity after Drop/ Thermal Test	Passes	NO	YES		ES,DC
184	b) Max Number Times Used	#	NO	YES		ES,OP
	3.2 Waste Packages					
	3.2.1 Performance Attributes					
	a) Min Lifetime					
185	HLW	yrs	NO	YES		DC
186	LLW	yrs	NO	YES		DC
187	Grouted Vault	yrs	NO	YES		DC
188	In-Place	yrs	YES	NO		DC
	b) Max Release Rate-HLW Glass					
189	Cs	microgm/cm^2/day	NO	YES	C	DC,CO
190	U	microgm/cm^2/day	NO	YES	C	DC,CO
191	Si	microgm/cm^2/day	NO	YES	C	DC,CO
192	B	microgm/cm^2/day	NO	YES	C	DC,CO
193	Na	microgm/cm^2/day	NO	YES	C	DC,CO
194	Sulphate	wt %	NO	YES		DC
195	Max Waste Loading	wt %	NO	YES		DC
	c) Max Release Rate-Grouted Waste					
196	Ag	Log(Deff cm^2/ sec)	NO	YES		DC
197	As	Log(Deff cm^2/ sec)	NO	YES		DC
198	Ba	Log(Deff cm^2/ sec)	NO	YES		DC
199	Cd	Log(Deff cm^2/ sec)	NO	YES		DC
200	Cl	Log(Deff cm^2/ sec)	NO	YES		DC
201	Cr	Log(Deff cm^2/ sec)	NO	YES		DC
202	Cu	Log(Deff cm^2/ sec)	NO	YES		DC

TABLE C.1. (contd)

ATTRIBUTE No.	5/31/89 Update ATTRIBUTE DESCRIPTION	UNITS OF MEASURE	CLASSIFICATIONS OF ATTRIBUTES: APPLICATION TO DISPOSAL OPTION IN-PLACE	RETRIEVE	STATUS: "C"= CONSTRAINT	SOURCE CODE See App B
	3.0 ENGINEERED ENCLOSURES (contd)					
203	F	Log(Deff cm^2/sec)	NO	YES		DC
204	Fe	Log(Deff cm^2/sec)	NO	YES		DC
205	Hg	Log(Deff cm^2/sec)	NO	YES		DC
206	Mn	Log(Deff cm^2/sec)	NO	YES		DC
207	NO2	Log(Deff cm^2/sec)	NO	YES		DC
208	NO3	Log(Deff cm^2/sec)	NO	YES		DC
209	Pb	Log(Deff cm^2/sec)	NO	YES		DC
210	Se	Log(Deff cm^2/sec)	NO	YES		DC
211	SO4	Log(Deff cm^2/sec)	NO	YES		DC
212	Zn	Log(Deff cm^2/sec)	NO	YES		DC
213	CN	Log(Deff cm^2/sec)	NO	YES		DC
214	PO4	Log(Deff cm^2/sec)	NO	YES		DC
215	Na	Log(Deff cm^2/sec)	NO	YES		DC
216	C-14	Log(Deff cm^2/sec)	NO	YES		DC
217	Sr-90	Log(Deff cm^2/sec)	NO	YES		DC
218	Tc-99	Log(Deff cm^2/sec)	NO	YES		DC
219	I-129	Log(Deff cm^2/sec)	NO	YES		DC
220	Cs-137	Log(Deff cm^2/sec)	NO	YES		DC
221	Ra-226	Log(Deff cm^2/sec)	NO	YES		DC
222	Np-237	Log(Deff cm^2/sec)	NO	YES		DC
223	U-238	Log(Deff cm^2/sec)	NO	YES		DC
224	Pu-239,240	Log(Deff cm^2/sec)	NO	YES		DC
225	Am-241	Log(Deff cm^2/sec)	NO	YES		DC
226	Se-79	Log(Deff cm^2/sec)	NO	YES		DC
227	Nb-93m	Log(Deff cm^2/sec)	NO	YES		DC

TABLE C.1. (contd)

ATTRIBUTE No.	5/31/89 Update ATTRIBUTE DESCRIPTION	UNITS OF MEASURE	CLASSIFICATIONS OF ATTRIBUTES: APPLICATION TO DISPOSAL OPTION IN-PLACE	RETRIEVE	STATUS: "C"= CONSTRAINT	SOURCE CODE See App B
	3.0 ENGINEERED ENCLOSURES (contd)					
228	Co-60	Log(Deff cm^2/sec)	NO	YES		DC
229	Ru-106	Log(Deff cm^2/sec)	NO	YES		DC
230	Sb-126m	Log(Deff cm^2/sec)	NO	YES		DC
231	Cs-135	Log(Deff cm^2/sec)	NO	YES		DC
232	Ce-144	Log(Deff cm^2/sec)	NO	YES		DC
233	Pu-241	Log(Deff cm^2/sec)	NO	YES		DC
234	Sm-151	Log(Deff cm^2/sec)	NO	YES		DC
235	Ba-137m	Log(Deff cm^2/sec)	NO	YES		DC
236	Sn-126	Log(Deff cm^2/sec)	NO	YES		DC
237	Zr-93	Log(Deff cm^2/sec)	NO	YES		DC
238	Ni-63	Log(Deff cm^2/sec)	NO	YES		DC
239	Cm-242	Log(Deff cm^2/sec)	NO	YES		DC
240	TOC Content	wt %	NO	YES		DC
241	Residual/Free Water	vol %	NO	YES		DC
242	Ten min Gel Strength	lbs/ft^2	NO	YES		DC
243	Critical Flow	gal/min	NO	YES		DC
244	30 Thermal Cycles	ASTM test	NO	YES		DC
245	Biodegradation	ASTM test	NO	YES		DC
	d) Max Release Rate In-Tank Waste Package					
246	Residual Water (up to 300 deg F)	vol %	YES	NO		CO,DC
247	Total Organic Carbon	%	YES	NO		DC
248	Ag	g/m^3	YES	NO		DC
249	As	g/m^3	YES	NO		DC
250	Ba	g/m^3	YES	NO		DC
251	Cd	g/m^3	YES	NO		DC
252	Cl	g/m^3	YES	NO		DC
253	Cr	g/m^3	YES	NO		DC
254	Cu	g/m^3	YES	NO		DC
255	F	g/m^3	YES	NO		DC
256	Fe	g/m^3	YES	NO		DC
257	Hg	g/m^3	YES	NO		DC
258	Mn	g/m^3	YES	NO		DC
259	NO2	g/m^3	YES	NO		DC
260	NO3	g/m^3	YES	NO		DC
261	Pb	g/m^3	YES	NO		DC
262	Se	g/m^3	YES	NO		DC

TABLE C.1. (contd)

ATTRIBUTE No.	5/31/89 Update ATTRIBUTE DESCRIPTION	UNITS OF MEASURE	APPLICATION TO DISPOSAL OPTION IN-PLACE	RETRIEVE	STATUS: "C"= CONSTRAINT	SOURCE CODE See App B
	3.0 ENGINEERED ENCLOSURES (contd)					
263	SO4	g/m^3	YES	NO		DC
264	Zn	g/m^3	YES	NO		DC
265	CN	g/m^3	YES	NO		DC
266	Na	g/m^3	YES	NO		DC
267	Al	g/m^3	YES	NO		DC
268	PO4	g/m^3	YES	NO		DC
269	C-14	Ci/m^3	YES	NO		DC
270	Se-79	Ci/m^3	YES	NO		DC
271	Sr-90	Ci/m^3	YES	NO		DC
272	Tc-99	Ci/m^3	YES	NO		DC
273	I-129	Ci/m^3	YES	NO		DC
274	Cs-137	Ci/m^3	YES	NO		DC
275	Sm-151	Ci/m^3	YES	NO		DC
276	Np-237	Ci/m^3	YES	NO		DC
277	U-238	Ci/m^3	YES	NO		DC
278	Pu-239/240	Ci/m^3	YES	NO		DC
279	Am-241	Ci/m^3	YES	NO		DC
280	Ni-63	Ci/m^3	YES	NO		DC
281	Zr-93	Ci/m^3	YES	NO		DC
282	Cm-242	nCi/g	YES	NO		DC
283	Pu-241	nCi/g	YES	NO		DC
284	Cs-135	Ci/m^3	YES	NO		DC
285	Total TRU	nCi/g	YES	NO		DC
286	Allowed pH Range after Pretreatment	pH units	YES	NO		DC
	e) Waste Package Closures					
287	HLW-Glass ANSI STD	Procedure	NO	YES		DC
288	Grouted Vault (see #165)		NO	YES		L,DC
289	In-Tank Disposal		YES	NO		L,DC
290	f) Drop Test of HLW Container	Procedure	NO	YES		DC
	3.2.2 Design/Process Attributes					
	a) Waste Stream Constraints to HLW Glass (wt % dry)					
291	Al2O3	Max wt %	NO	YES		OP
292	BaO	Max wt %	NO	YES		OP
293	CaO	Max wt %	NO	YES		OP
294	CdO	Max wt %	NO	YES		OP
295	Cr2O3	Max wt %	NO	YES		OP
296	FMax	wt %	NO	YES		OP
297	Fe2O3	wt %	NO	YES		OP
298	MnO2	Max wt %	NO	YES		OP
299	MoO3	Max wt %	NO	YES		OP
300	Na2O	wt %	NO	YES		OP
301	NiO	Max wt %	NO	YES		OP
302	P2O5	Max wt %	NO	YES		OP
303	SO3	Max wt %	NO	YES		OP
304	SiO2	Max wt %	NO	YES		OP

TABLE C.1. (contd)

ATTRIBUTE No.	5/31/89 Update ATTRIBUTE DESCRIPTION	UNITS OF MEASURE	CLASSIFICATIONS OF ATTRIBUTES: APPLICATION TO DISPOSAL OPTION: IN-PLACE	CLASSIFICATIONS OF ATTRIBUTES: APPLICATION TO DISPOSAL OPTION: RETRIEVE	STATUS: "C"= CONSTRAINT	SOURCE CODE See App B
	3.0 ENGINEERED ENCLOSURES (contd)					
305	TiO2	Max wt %	NO	YES		OP
306	U308	Max wt %	NO	YES		OP
307	ZrO2	Max wt %	NO	YES		OP
308	TOC	Max wt %	NO	YES		OP
309	Particle Size	Max size microns	NO	YES		OP
	b) Waste Stream Constraints to Grout					
310	Ag	g/m^3	NO	YES		OP
311	As	g/m^3	NO	YES		OP
312	Ba	g/m^3	NO	YES		OP
313	Cd	g/m^3	NO	YES		OP
314	Cr	g/m^3	NO	YES		OP
315	Hg	g/m^3	NO	YES		OP
316	Pb	g/m^3	NO	YES		OP
317	Se	g/m^3	NO	YES		OP
318	TOC	g/m^3	NO	YES		OP
319	Al	g/m^3	NO	YES		OP
320	Ca	g/m^3	NO	YES		OP
321	Cl	g/m^3	NO	YES		OP
322	CO3	g/m^3	NO	YES		OP
323	Cu	g/m^3	NO	YES		OP
324	F	g/m^3	NO	YES		OP
325	Fe	g/m^3	NO	YES		OP
326	K	g/m^3	NO	YES		OP
327	Mg	g/m^3	NO	YES		OP
328	Mn	g/m^3	NO	YES		OP
329	Mo	g/m^3	NO	YES		OP
330	Na	g/m^3	NO	YES		OP
331	Ni	g/m^3	NO	YES		OP
332	NH3	g/m^3	NO	YES		OP
333	NO2	g/m^3	NO	YES		OP
334	NO3	g/m^3	NO	YES		OP
335	OH	g/m^3	NO	YES		OP
336	PO4	g/m^3	NO	YES		OP
337	SO4	g/m^3	NO	YES		OP
338	Zn	g/m^3	NO	YES		OP
339	Zr	g/m^3	NO	YES		OP
340	U	g/m^3	NO	YES		OP
341	RE	g/m^3	NO	YES		OP
342	CN,not Fe(CN)6	g/m^3	NO	YES		OP
343	C-14	Ci/m^3	NO	YES		OP
344	Ni-59	Ci/m^3	NO	YES		OP
345	Ni-63	Ci/m^3	NO	YES		OP
346	Sr-90	Ci/m^3	NO	YES		OP
347	Co-60	Ci/m^3	NO	YES		OP
348	H-3	Ci/m^3	NO	YES		OP
349	Nb-94	Ci/m^3	NO	YES		OP
350	Tc-99	Ci/m^3	NO	YES		OP
351	I-129	Ci/m^3	NO	YES		OP
352	Cs-137	Ci/m^3	NO	YES		OP

TABLE C.1. (contd)

ATTRIBUTE No.	5/31/89 Update ATTRIBUTE DESCRIPTION	UNITS OF MEASURE	CLASSIFICATIONS OF ATTRIBUTES: APPLICATION TO DISPOSAL OPTION IN-PLACE	RETRIEVE	STATUS: "C"= CONSTRAINT	SOURCE CODE See App B
	3.0 ENGINEERED ENCLOSURES (contd)					
353	Pu-241	Ci/m^3	NO	YES		OP
354	Cm-242	Ci/m^3	NO	YES		OP
355	Ru/Rh-106	Ci/m^3	NO	YES		OP
356	Sb/Te-125	Ci/m^3	NO	YES		OP
357	Cs-135	Ci/m^3	NO	YES		OP
358	Ce/Pr-144	Ci/m^3	NO	YES		OP
359	Am-241	Ci/m^3	NO	YES		OP
360	TRU	nCi/gm	NO	YES		OP
361	pH	pH units	NO	YES		OP
362	Solids/Sludge	vol %	NO	YES		OP
363	Np-237	Ci/m^3	NO	YES		OP
364	U-238	Ci/m^3	NO	YES		OP
365	Pu-239/240	Ci/m^3	NO	YES		OP
	c) Constraints on In-Place Waste Package from Prior Design					
366 C	Max Heat Generation	BTU/hr	YES	YES	C	CO,OP,DC
367 C	Min Hydrostatic Load	in	YES	YES	C	CO,OP,DC
368 C	Max Tank Negative Pressure	in gage	YES	YES	C	CO,OP,DC
369 C	Vapor Space-Pressure Range	in	YES	YES	C	CO,OP,DC
	3.3 Barriers					
	3.3.1 Performance Attributes					
	a) Production Rate (see 4.1)					
370	b) Lifetime	yrs	YES	YES		DC,L
371	c) Drainage Rate	cm/yr	YES	YES		DC,L
372	d) Storage Capacity of Fine Soil Layer	% ann pptn	YES	YES		DC,L
373	e) Fine Content at -230 mesh	%	YES	YES		DC,L
374	f) Permeability of Loperm Soil	cm/sec	YES	YES		DC,L
375	g) Amount of Runoff		YES	YES		DC,L
376	h) Allowed Thickness Change from Erosion/ Deposition	m/10000 yrs	YES	YES		DC,L
377	i) Allowed Subsidence	cm	YES	YES		DC,L
378	j) Earthquakes	g's horiz	YES	YES		DC,L
379	k) Excavation Exclusion Period	yrs	YES	YES		DC,L
	l) Conc. in Vadose or Groundwater					
380	Arsenic	ppm	YES	YES	C	CO,H2O,PS
381	Barium	ppm	YES	YES	C	CO,H2O,PS
382	Cadmium	ppm	YES	YES	C	CO,H2O,PS
383	Chromium	ppm	YES	YES	C	CO,H2O,PS
384	Lead	ppm	YES	YES	C	CO,H2O,PS

TABLE C.1. (contd)

ATTRIBUTE No.	5/31/89 Update ATTRIBUTE DESCRIPTION	UNITS OF MEASURE	CLASSIFICATIONS OF ATTRIBUTES: APPLICATION TO DISPOSAL OPTION IN-PLACE	RETRIEVE	STATUS: "C"= CONSTRAINT	SOURCE CODE See App B
	3.Ø ENGINEERED ENCLOSURES (contd)					
385	Mercury	ppm	YES	YES	C	CO,H20,PS
386	Selenium	ppm	YES	YES	C	CO,H20,PS
387	Silver	ppm	YES	YES	C	CO,H20,PS
388	Endrin	ppm	YES	YES	C	CO,H20,PS
389	Lindane	ppm	YES	YES	C	CO,H20,PS
39Ø	Methoxychlor	ppm	YES	YES	C	CO,H20,PS
391	Toxaphene	ppm	YES	YES	C	CO,H20,PS
392	2-4-D	ppm	YES	YES	C	CO,H20,PS
393	2,4,5-TP Silex	ppm	YES	YES	C	CO,H20,PS
394	TRU	uci/l	YES	YES	C	CO,H20,PS
395	Radionuclide	uci/l	YES	YES	C	CO,H20,PS
396	n) Conc in Vadose or Groundwater Justified Chemical List Later		YES	YES		CO,H20,PS
397	o) Frequency of Tests for Direction and Rate of GW	#/yr	YES	YES	C	CO,H20,PS
398	p) Frequency of Tests for GW Levels	#/yr	YES	YES	C	CO,H20,PS
399	q) Detection Limit for Conc of Gases in Vadous Zone	ratio	YES	YES		PS
	3.3.2 Design Attributes					
4ØØ	a) Compaction of Backfill	%	YES	YES		DC,L
4Ø1	b) Number of Barriers/Tank	#	YES	YES		DC,L
	c) Barrier Thicknesses					
4Ø2	Fine Soil	m	YES	YES		DC,L
4Ø3	Gravel Mulch	m	YES	YES		DC,L
4Ø4	Sand	m	YES	YES		DC,L
4Ø5	Gravel	m	YES	YES		DC,L
4Ø6	Lo Perm	m	YES	YES		DC,L
4Ø7	Sand Cushion	m	YES	YES		DC,L
4Ø8	Riprap/pitrun gravel	m	YES	YES		DC,L
4Ø9	Total	m	YES	YES		DC,L
41Ø	d) Burrow Depth	ft	YES	YES		DC,L
411	e) Max Rain Intensity	yrs	YES	YES		DC,L
412	f) Max Wind Intensity	yrs	YES	YES		DC,L
413	g) Void Density	%	YES	YES		DC,L
414	h) Plant Density-deep rooting	%	YES	YES		DC,L
415	i) Marker Properties	Best Performer for	YES	YES		DC,L,MA
	Surface Abrasive Resistance					
	Water Absorption	%				
	Density	lb/ft^3				
	Compressive Strength	psi				
	Modulus of Rupture	psi				

TABLE C.1. (contd)

ATTRIBUTE No.	5/31/89 Update ATTRIBUTE DESCRIPTION	UNITS OF MEASURE	CLASSIFICATIONS OF ATTRIBUTES: APPLICATION TO DISPOSAL OPTION IN-PLACE	RETRIEVE	STATUS: "C"= CONSTRAINT	SOURCE CODE See App B
	3.0 ENGINEERED ENCLOSURES (contd)					
416	Subsurface Markers	Best Performer for	YES	YES		DC,L,MA
	Compressive Strength					
	Thermal Shock					
	Thermal Crazing					
	Alkali Resistance					
	Color Retention					
	Chemical Resistance					
	j) Marker Spacing					
417	Horizontal	m apart	YES	YES		DC,L
418	Vertical	m apart	YES	YES		DC,L
419	k) Marker Functional Lifetime	yrs	YES	YES		DC,L,MA
420	l) Well Network	#/Area	YES	YES		DC,L,MA
	3.3.3 Data Uncertainties (+ or -)					
421	a) Material Volumes	+/- %	YES	YES		DC,L
422	b) Growing Season	+/- days	YES	YES		DC,L
	c) Climatology					
423	EvapoTrans Rate	+/- %	YES	YES		DC,L
424	Root Depths	+/- ft	YES	YES		DC,L
425	Gravel Effects	oom	YES	YES		DC,L
426	Veg Effects	oom	YES	YES		DC,L
427	Marker Dimensions	+/- in	YES	YES		DC,L
428	Burrow Density	+/- %	YES	YES		DC,L
429	d) Hazards Probability		YES	YES		DC,L
	Volcanic Eruption					
	Earthquake					
	Tornado					
430	e) Barrier Hydrology Properties		YES	YES		DC,L
431	f) Erosion Rates from Wind and Water		YES	YES		DC,L
432	g) Deposition Rate from Wind		YES	YES		DC,L
433	h) Void Size on Site	+/- m	YES	YES		DC,L
	3.4 Site Facilities					
	3.4.1 Releases to the Environment					
434	a) NOX	microGms/M^3	NO	YES	C	AIR,OP,CO
435	b) SOX	ppm	NO	YES	C	AIR,OP,CO
436	c) Particulates	microGms/M^3	NO	YES	C	AIR,OP,CO
437	d) Process Liquid Discharge	Recycle	NO	YES		DC,OP
438	e) Process Solid Discards	nCi/gm Alpha	NO	YES		OP
	3.4.2 Design Attributes					
439	a) Seismic	DBE	NO	YES		DC
440	b) Max Wind Speed-Permanent Facility	mph	NO	YES		DC,OP

TABLE C.1. (contd)

ATTRIBUTE No.	5/31/89 Update ATTRIBUTE DESCRIPTION	UNITS OF MEASURE	CLASSIFICATIONS OF ATTRIBUTES: APPLICATION TO DISPOSAL OPTION IN-PLACE	RETRIEVE	STATUS: "C"= CONSTRAINT	SOURCE CODE See App B
	3.0 ENGINEERED ENCLOSURES (contd)					
441	c) Max Wind Speed-Transportable Facility during op'ns	mph	NO	YES		DC
442	d) Facility Operating Life	yrs	NO	YES		DC
443	e) Post-closure Life	yrs	NO	YES		DC
	4.0 OPERATING ATTRIBUTES (Retrieve, Pretreat, Waste Package, On-site Burial)					
	4.1 Production/Process Rates (System Level Only)					
444	4.1.1 Mean Disposition Rate	Tanks/yr	NO	YES		OP,RBC
445	4.2 Min In-Process Storage Times	yrs	NO	YES		OP,RBC
	4.3 Process Water Utilization Mgmt					
446	4.3.1 Retrieval Output/Input	Fraction	NO	YES		OP,RBC
447	4.3.2 Processing Output/Input	Fraction	NO	YES		OP,RBC
448	4.3.3 Waste Packaging Output/Input	Fraction	NO	YES		OP,RBC
	4.4 Acceptance Criteria					
	4.4.1 Retrieval Package					
449	a) Max Thermal Content/Package	Kw	NO	YES		OP
450	b) Max Mass Content/Package	Kgs	NO	YES		OP
	4.5 Process Separations					
	4.5.1 Species in Glass Stream after Pretreatment					
451	a) NaFrac of Input		NO	YES		OP,RBC
452	b) Al,Fe	Frac of Input	NO	YES		OP,RBC
453	c) SiFrac of Input		NO	YES		OP,RBC
454	d) U Frac of Input		NO	YES		OP,RBC
455	e) TOC,incl CN	Frac of Input	NO	YES		OP,RBC
	4.5.2 Species in Grout Stream after Pretreatment					
456	a) NaFrac of Input		NO	YES		OP,RBC
457	b) NO3	Frac of Input	NO	YES		OP,RBC
458	c) C-14	Frac of Input	NO	YES		OP,RBC
459	d) Ni-63	Frac of Input	NO	YES		OP,RBC
460	e) Sr-90	Frac of Input	NO	YES		OP,RBC
461	f) Tc-99	Frac of Input	NO	YES		OP,RBC
462	g) I-129	Frac of Input	NO	YES		OP,RBC
463	h) Cs-137	Frac of Input	NO	YES		OP,RBC
464	i) U-235,238	Frac of Input	NO	YES		OP,RBC
465	j) Np-237	Frac of Input	NO	YES		OP,RBC
466	k) Pu-239,240	Frac of Input	NO	YES		OP,RBC
467	l) Am-241	Frac of Input	NO	YES		OP,RBC

TABLE C.1. (contd)

ATTRIBUTE No.	5/31/89 Update ATTRIBUTE DESCRIPTION	UNITS OF MEASURE	CLASSIFICATIONS OF ATTRIBUTES: APPLICATION TO DISPOSAL OPTION: IN-PLACE	RETRIEVE	STATUS: "C"= CONSTRAINT	SOURCE CODE See App B
	4.0 OPERATING ATTRIBUTES (contd)					
	4.5.3 Species in Tank Waste after In-Place Treatment					
468	a) CdFrac of Input		NO	YES		OP,RBC
469	b) CrFrac of Input		NO	YES		OP,RBC
470	c) CNFrac of Input		NO	YES		OP,RBC
471	d) F Frac of Input		NO	YES		OP,RBC
472	e) FeFrac of Input		NO	YES		OP,RBC
473	f) MnFrac of Input		NO	YES		OP,RBC
474	g) HgFrac of Input		NO	YES		OP,RBC
475	h) NO3	Frac of Input	NO	YES		OP,RBC
476	i) NO2	Frac of Input	NO	YES		OP,RBC
477	j) NaFrac of Input		NO	YES		OP,RBC
478	k) SO4	Frac of Input	NO	YES		OP,RBC
479	l) C-14	Frac of Input	NO	YES		OP,RBC
480	m) Sr-90	Frac of Input	NO	YES		OP,RBC
481	n) Tc-99	Frac of Input	NO	YES		OP,RBC
482	o) I-129	Frac of Input	NO	YES		OP,RBC
483	p) Cs-137	Frac of Input	NO	YES		OP,RBC
484	q) Np-237	Frac of Input	NO	YES		OP,RBC
485	r) Pu-239,240	Frac of Input	NO	YES		OP,RBC
486	s) Am-241	Frac of Input	NO	YES		OP,RBC
487	t) TRU	nCi/gm	NO	YES		OP,RBC
	4.6 Personnel Qualification/ Training					
	4.6.1 Personnel Qualification					
488	a) Decon Qualification	DOT Stds	YES	YES		ES,OP
489	b) Operating Equipment Qualification	Procedure	YES	YES		ES,OP
	4.6.2 General Personnel Training					
490	a) Minimum Skill Level	Procedure	YES	YES		ES,OP
491	b) Chemical Hazards	Procedure	YES	YES		ES,OP
492	c) Radiation Hazards	Procedure	YES	YES		ES,OP
	4.7 Design Practices					
493	a) Min Soil Overburden Thickness	ft	YES	YES		DC
494	b) Codes and Standards	Prior Projects	YES	YES		DC
	4.8 Employee Health and Safety					
495	4.8.1 Criticality Control K effective	Fraction	YES	YES	C	ES,CO
	4.8.2 Exposure Limits					
496	a) Hazardous Chemicals	Procedure	YES	YES		ES
497	b) Whole Body Radiation	MRem/yr	YES	YES		ES
498	c) Alpha Ingestion	dpm/cc	YES	YES		ES
	4.9 Public Protection and Practices					

TABLE C.1. (contd)

ATTRIBUTE No.	5/31/89 Update ATTRIBUTE DESCRIPTION	UNITS OF MEASURE	CLASSIFICATIONS OF ATTRIBUTES: APPLICATION TO DISPOSAL OPTION IN-PLACE	RETRIEVE	STATUS: "C"= CONSTRAINT	SOURCE CODE See App B
	4.0 OPERATING ATTRIBUTES (contd)					
499	4.9.1 Exposure Limits to Water Consumption at Boundary	MRem/yr	YES	YES	C	PS,CO
500	4.9.2 Radiation Exposure Limits at Boundary	MRem/yr	YES	YES	C	PS,CO,AIR
	5.0 SITE SELECTION ATTRIBUTES					
	5.1 Performance Measures					
501	a) Number of Potential Sites	#	YES	YES		DC
	5.2 Design Attributes					
502	a) Proximity to 200 Area	m	YES	YES		DC
503	b) Distance from other waste sites	m	YES	YES		DC
504	c) Distance to Wilderness Area	m	YES	YES		DC
505	d) Distance to Sensitive Area	m	YES	YES		DC
506	e) Dist to State/Fed Wildlife Refuge	m	YES	YES		DC
507	f) Distance to Rec, Scenic, Park Boundary	m	YES	YES		DC
508	g) Dist to Archeological/ Historic Areas	m	YES	YES		DC
509	h) Inside 100 yr Flood Plain?	condition	YES	YES	C	DC,CO
510	i) Distance from perenial source of surface water	ft	YES	YES	C	DC,CO
511	j) Over a sole source aquifer?	condition	YES	YES	C	DC,CO
512	k) Distance from downgradient drinking water intake	ft	YES	YES	C	DC,CO
513	l) Distance from upgradient drinking water intake	ft	YES	YES	C	DC,CO
514	m) Outside potable well head area of influence	condition	YES	YES	C	DC,CO
515	n) Distance from boundary to residence zone	ft	YES	YES		DC
516	o) Distance from boundary to non-residence zone	ft	YES	YES		DC
517	p) Distance from fault active in Holocene	ft	YES	YES		DC
	5.3 Data Uncertainties (plus or minus)					
518	a) Depth to Groundwater	+/- ft	YES	YES		DC
519	b) Groundwater travel time (Vadose Travel Time)	+/- yrs	YES	YES		DC
520	c) Groundwater Mass Flow	+/- yrs	YES	YES		DC
521	d) Lithology	descriptive	YES	YES		DC
522	e) Strength	+/- kPa	YES	YES		DC
523	f) Permeability	+/- log(m/s)	YES	YES		DC
524	g) Particle Size Distribution	+/- %	YES	YES		DC
525	h) Site Size Necessary	+/- acres	YES	YES		DC

TABLE C.1. (contd)

ATTRIBUTE No.	5/31/89 Update ATTRIBUTE DESCRIPTION	UNITS OF MEASURE	CLASSIFICATIONS OF ATTRIBUTES: APPLICATION TO DISPOSAL OPTION IN-PLACE	RETRIEVE	STATUS: "C"= CONSTRAINT	SOURCE CODE See App B
	6.0 RECORDS AND REPORTING ATTRIBUTES					
	6.1 Performance Assessments (Levels of Conservatism)					
	6.1.1 Inputs					
526	a) Measured Data	Added Margin	YES	YES		MC,RE,RAC
527	b) Estimated Data-Effect on Final Result	Margin Factor	YES	YES		MC,RE,RAC
	6.1.2 Algorithms Used-Effect on Final Result					
528	a) First Principles	Margin Factor	YES	YES		MC,RE,RAC
529	b) Extrapolations of Empirical Relationships	Margin Factor	YES	YES		MC,RE,RAC
	6.1.3 Assessment Margins					
530	a) Temperatures	% of Calc'd Value	YES	YES		MC,RE,RAC
531	b) Escape Rate from Sequestered Waste Forms	Margin Factor	YES	YES		MC,RE,RAC
532	c) Transport Rate in Carrier System	Margin Factor	YES	YES		MC,RE,RAC
	6.2 Notifications for Spills/Releases					
533	6.2.1 Release Points	Value > Limit by	YES	YES		CA,RE
534	6.2.2 Reporting Condition	Location	YES	YES		CA,RE
535	6.2.3 Reporting Window after Occurence	days	YES	YES		CA,RE
536	6.2.4 Report Contents	Condition	YES	YES		CA,RE
	6.3 Notification for RCRA Documentation					
537	6.3.1 Hammer Dates	years	YES	YES		CA,RE
538	6.3.2 Reporting Method	Procedure	YES	YES	C	CA,RE,CO
539	6.3.4 Reporting Contents	Procedure	YES	YES	C	CA,RE,CO
	6.4 Waste Form Record Update					
540	6.4.1 Volume of solids	Frequency	YES	YES	C	CO,RE
541	6.4.2 Total H20 volume	Frequency	YES	YES	C	CO,RE

TABLE C.2. Listing of Rankings of Attributes by Function

ATTRIBUTE No.	ATTRIBUTE DESCRIPTION	RANKINGS BY FUNCTION 1100	1200	1300	1400	1500	1600	1700	NUMBER OF ONES
	AVERAGE->	4.5	2.0	6.4	2.4	3.7	6.3	4.7	
	1.0 CHEMICAL ATTRIBUTES								
	1.1 Detection Limits (for Groundwater, Leaching Tests, Process Samples, etc.)								
	1.1.1 Radionuclides								
1	Ac-227	10	1	10	3	1	5	5	2
2	Am-241	10	3	10	3	10	7	5	0
3	Am-242	10	3	10	3	1	5	5	1
4	Am-243	10	3	10	3	1	6	5	1
5	C-14	10	1	10	3	5	8	5	1
6	Cm-242	10	1	10	3	1	7	5	2
7	Cm-244	10	1	10	3	1	5	5	2
8	Cm-245	10	3	10	3	1	5	5	1
9	Co-60	10	1	10	3	1	7	5	2
10	Cs-135	10	1	10	3	1	5	5	2
11	Cs-137	10	1	10	3	10	9	5	1
12	H-3	10	1	10	3	1	7	5	2
13	I-129	10	1	10	3	5	9	5	1
14	Ni-59	10	1	10	3	1	5	5	2
15	Ni-63	10	1	10	3	1	7	5	2
16	Nb-94	10	1	10	3	1	5	5	2
17	Np-237	10	1	10	3	10	7	5	1
18	Pa-231	10	1	10	3	1	5	5	2
19	Pb-210	10	1	10	3	1	5	5	2
20	Po-210	10	1	10	3	1	2	5	2
21	Pu-238	10	3	10	3	1	5	5	1
22	Pu-239	10	3	10	3	10	7	5	0
23	Pu-240	10	3	10	3	10	7	5	0
24	Pu-241	10	1	10	3	1	7	5	2
25	Pu-242	10	3	10	3	1	5	5	1
26	Ra-226	10	1	10	3	1	5	5	2
27	Ra-228	10	1	10	3	1	5	5	2
28	Ru-106	10	1	10	3	1	5	5	2
29	Se-79	10	1	10	3	1	9	5	2
30	Sm-151	10	1	10	3	1	9	5	2
31	Sn-126	10	1	10	3	1	7	5	2
32	Sr-90	10	1	10	3	10	9	5	1
33	Tc-99	10	1	10	3	5	9	5	1
34	Th-229	10	1	10	3	1	5	5	2
35	Th-230	10	1	10	3	1	5	5	2
36	Th-232	10	1	10	3	1	5	5	2
37	U-233	10	1	10	3	1	5	5	2
38	U-234	10	1	10	3	1	5	5	2
39	U-235	10	1	10	3	3	5	5	1
40	U-236	10	1	10	3	3	5	5	1
41	U-238	10	1	10	3	5	7	5	1
42	Zr-93	10	1	10	3	1	7	5	2
	1.1.2 Ionic Species								
43	Aluminum	10	1	10	1	1	2	5	3
44	Arsenic	10	1	10	1	1	9	5	3
45	Ammonia	10	1	10	1	1	2	5	3
46	Barium	10	1	10	1	1	8	5	3

TABLE C.2. (contd)

ATTRIBUTE No.	ATTRIBUTE DESCRIPTION	RANKINGS BY FUNCTION 1100	1200	1300	1400	1500	1600	1700	NUMBER OF ONES
	AVERAGE->	4.5	2.0	6.4	2.4	3.7	6.3	4.7	
	1.0 CHEMICAL ATTRIBUTES (contd)								
47	Beryllium	10	1	10	1	1	2	5	3
48	Bismuth	10	1	10	1	1	2	5	3
49	Boron	10	1	10	1	1	5	5	3
50	Carbonate	10	1	10	1	1	5	5	3
51	Cadmium	10	1	10	1	1	9	5	3
52	Calcium	10	1	10	1	1	2	5	3
53	Chloride	10	1	10	1	5	5	5	2
54	Chromium	10	1	10	1	5	9	5	2
55	Cobalt	10	1	10	1	1	2	5	3
56	Copper	10	1	10	1	1	5	5	3
57	Cyanide	10	1	10	1	7	9	5	2
58	Fluoride	10	1	10	1	5	7	5	2
59	Free Hydroxide	10	1	10	1	1	9	5	3
60	Hypochlorite	10	1	10	1	1	2	5	3
61	Iron	10	1	10	1	1	5	5	3
62	Lead	10	1	10	1	1	9	5	3
63	Magnesium	10	1	10	1	1	2	5	3
64	Manganese	10	1	10	1	1	5	5	3
65	Mercury	10	1	10	1	3	9	5	2
66	Nickel	10	1	10	1	3	5	5	2
67	Molybdenum	10	1	10	1	1	5	5	3
68	Nitrate	10	2	10	1	5	9	5	1
69	Nitrite	10	1	10	1	5	9	5	2
70	Phosphorus	10	1	10	1	1	7	5	3
71	Potassium	10	1	10	1	1	2	5	3
72	Selenium	10	1	10	1	1	9	5	3
73	Silicon	10	1	10	1	1	2	5	3
74	Silver	10	1	10	1	1	8	5	3
75	Sodium	10	2	10	1	1	8	5	2
76	Strontium	10	1	10	1	1	9	5	3
77	Sulfate	10	1	10	1	5	9	5	2
78	Sulfite	10	1	10	1	3	9	5	2
79	Titanium	10	1	10	1	1	2	5	3
80	Uranium	10	1	10	1	5	7	5	2
81	Vanadium	10	1	10	1	1	2	5	3
82	Zinc	10	1	10	1	1	5	5	3
83	Zirconium	10	1	10	1	3	5	5	2
84	Total Organo-Halides(TO)	10	1	10	1	5	8	5	2
85	TOX Species Identification	10	1	10	1	3	8	5	2
86	Total Organic Carbon (TOC)	10	1	10	1	10	9	5	2
87	TOC Species Identification	10	1	10	1	3	7	5	2
	1.2 Accuracy of Contents (Process Stream Control)								
	1.2.1 Tank Liquids (before stabilization)								
88	a) Total Volume (height)	3	10	7	2	1	5	2	1
89	b) Drainable Volume (height)	3	10	7	2	1	9	2	1

TABLE C.2. (contd)

ATTRIBUTE No.	ATTRIBUTE DESCRIPTION	RANKINGS BY FUNCTION 1100	1200	1300	1400	1500	1600	1700	NUMBER OF ONES
	AVERAGE->	4.5	2.0	6.4	2.4	3.7	6.3	4.7	
	1.0 CHEMICAL ATTRIBUTES (contd)								
	1.2.2 Tank Solids (after stabilization)(plus or minus)								
90	a) Total Volume of solids	3	3	5	3	1	8	2	1
91	b) TRU	10	3	9	3	1	10	2	1
92	c) Total Beta,Gamma Activity Variance	10	3	9	7	1	8	2	1
93	d) Water Content Variance	10	3	9	5	1	8	2	1
94	e) pH	10	3	9	2	1	8	2	1
	1.2.3 Spills and Leaks to Soil								
95	a) TRU Content	10	8	10	8	1	1	2	2
96	b) Curie Content	10	8	10	8	1	1	2	2
97	c) Total Mass	10	8	10	7	1	1	2	2
	1.2.4 Composition of WP Waste Form-Accuracy								
98	a) Chemical Content	1	3	8	1	1	10	2	3
99	b) Radionuclide Content	1	3	8	1	1	10	2	3
100	c) Residual Liquid	1	8	8	3	1	10	2	2
	1.2.5 Composition of Waste Containers/Engineered Materials								
101	a) HLW Glass-304L Aus Steel (C<.03wt%)	1	1	1	1	1	7	1	6
102	b) Grouts Portland II Cement Fly Ash (ASTM Class F) Clay	1	1	1	1	1	9	1	6
103	c) Cements	1	1	1	1	1	5	1	6
104	d) Fillers	1	1	1	1	1	8	1	6
105	e) Soils/Clay	1	1	1	1	1	5	1	6
	1.3 Sampling Frequency								
	1.3.1 Process Stream								
106	a) During Stabilization	10	7	8	3	1	2	4	1
107	b) During Processing and Pre-Closure	8	1	8	3	5	7	4	1
	1.4 Sampling Density of Solid Matter								
	1.4.1 Process Stream								
108	a) During Tank Characterization	10	7	5	7	1	8	4	1
109	b) During Soil Characterization	10	3	5	5	1	2	4	1
110	c) Processing of Solids	10	1	5	2	5	8	4	1
	2.0 PHYSICAL ATTRIBUTES (all system components and contaminated soil)								
	2.1 Spatial Properties								
	2.1.1 Waste Form after Stabilization								
	a) Max Drainable Liquid (See 3.2.1d)								

TABLE C.2. (contd)

ATTRIBUTE No.	ATTRIBUTE DESCRIPTION	1100	1200	1300	1400	1500	1600	1700	NUMBER OF ONES
		RANKINGS BY FUNCTION							
	AVERAGE->	4.5	2.0	6.4	2.4	3.7	6.3	4.7	
	2.0 PHYSICAL ATTRIBUTES (contd)								
	2.1.2 Tank waste retrieval package dimensions								
111	a) Shape	1	1	1	9	3	1	1	5
112	b) Max Volume	1	1	1	10	3	1	1	5
113	c) Max I.D.	1	1	1	8	3	1	1	5
114	d) Max Height	1	1	1	7	3	1	1	5
	2.1.3 Soil Package Dimensions								
115	a) Shape	1	1	1	9	1	1	1	6
116	b) Max Volume	1	1	1	10	1	1	1	6
117	c) Max I.D.	1	1	1	8	1	1	1	6
118	d) Max Height	1	1	1	7	1	1	1	6
	2.1.4 Tank Retrieval Package Dimensions								
119	a) Max I.D.	1	1	1	8	1	1	1	6
120	b) Max Height	1	1	1	7	1	1	1	6
121	c) Max Gross Weight	1	1	1	10	1	1	1	6
	2.1.5 Ancillary Equipment Package Dimensions								
122	a) Shape	1	3	1	10	1	1	1	5
123	b) Max Volume	1	3	1	8	1	1	1	5
124	c) Max I.D.	1	3	1	8	1	1	1	5
125	d) Max Height	1	3	1	10	1	1	1	5
	2.1.6 Final Waste Package								
	a) Containerized HLW Glass								
126	Length	1	1	1	1	1	10	1	6
127	Diameter	1	1	1	1	1	10	1	6
128	Wall Thickness	1	1	1	1	1	10	1	6
129	Weight	1	1	1	1	1	10	1	6
130	Max Free Volume	1	1	1	1	1	10	1	6
	b) Containerized TRU Waste-Off Site WIPP								
	Contact Handled:								
131	Length/Width/Height	1	1	1	1	1	10	1	6
132	Weight	1	1	1	1	1	10	1	6
	Remote Handled:								
133	Diameter/Height	1	1	1	1	1	10	1	6
134	Weight	1	1	1	1	1	10	1	6
	c) Containerized Grout								
135	Max Free Volume	1	1	1	1	1	10	1	6
	2.2 Precision Limits Tank Waste								
136	a) Density	10	1	1	7	3	5	1	3
137	b) Particle Size Distribution	10	1	1	7	5	2	1	3
138	c) Viscosity	10	5	1	8	3	5	1	2
139	d) Thermal Output	10	10	1	6	2	5	1	2
140	e) Thermal Conductivity	10	10	1	6	1	2	1	3
141	f) Pentrometer Test on Salt Cake	10	1	1	3	1	2	1	4
142	g) Thermal Analysis	10	1	1	8	1	5	1	4
143	h) Specific Heat	10	10	1	7	1	2	1	3
144	i) Solids Settling Rate (sluicing retrieval)	10	1	1	8	5	1	1	4

TABLE C.2. (contd)

ATTRIBUTE No.	ATTRIBUTE DESCRIPTION	1100	1200	1300	1400	1500	1600	1700	NUMBER OF ONES
	AVERAGE->	4.5	2.0	6.4	2.4	3.7	6.3	4.7	
	2.0 PHYSICAL ATTRIBUTES (contd)								
145	j) Volume % Settled Solids (sluicing retrieval)	10	1	1	7	5	1	1	4
146	k) Volume % Centrifuged Solids (sluicing retrieval)	10	1	1	6	3	1	1	4
147	l) Miller Number (sluicing retrieval)	10	1	1	7	3	1	1	4
148	m) Shear Strength (sluicing retrieval)	10	1	1	8	3	1	1	4
149	n) Shear Stress-shear rate rheogram (sluicing retrieval)	10	1	1	8	3	1	1	4
	2.3 Physical Properties								
	2.3.1 HLW Glass Waste Form								
150	a) Monolith Temperature Limit	1	1	1	1	1	10	1	6
151	b) Heat Generation Rate	1	1	1	1	1	10	1	6
	2.3.2 Grout Waste Form								
152	a) Temperature Limit	1	1	1	1	1	10	1	6
153 C	b) Unconfined Compressive Strength	1	1	1	1	1	10	1	6
	2.3.3 Waste Package Containers								
154	a) HLW Glass-Max Internal Pressure	1	1	1	1	1	10	1	6
	b) Grouted Waste-Vault								
155	Overburden Internal Pressure	1	1	1	1	1	10	1	6
156	Strength	1	1	1	1	1	10	1	6
157	c) Single Shell Tank-Temp Limit	1	1	1	8	1	9	8	4
	d) TRU Waste-Dose Rates								
158	Surface-Contact TRU	1	1	1	1	1	10	1	6
159	Surface B/G-Remote	1	1	1	1	1	10	1	6
160	Surface Neutron-Remote	1	1	1	1	1	10	1	6
	2.3.4 Soils/Clays as Engineered Barriers								
161	a) Max Permeability	1	1	1	1	1	8	6	5
162	b) Max Swelling Pressure	1	1	1	1	1	5	6	5
163	c) Min Thickness	1	1	1	1	1	1	6	6
164	d) Min Bearing Strength	1	1	1	1	1	8	6	5
	2.3.5 Cements-as structures/ barriers								
165	a) Min Permeability	1	1	1	1	1	8	1	6
166	b) Min Compressive Strength	1	1	1	1	1	8	1	6
	2.3.6 Concrete Dome								
167	a) Permeability	1	1	1	1	1	8	5	5
168	b) Strength	1	1	1	1	1	8	9	5
169	c) Allowable Dome Deformation after Closure	1	3	1	1	1	8	9	4
170	d) Allowable Dome Deformation during Closure	1	3	1	7	1	2	9	3
	2.3.7 In-Tank Filled Waste								
171	a) Max Porosity	10	1	1	1	1	5	3	4
	2.4 Decontamination Factors								
172	2.4.1 Max Quantity of Tank Waste Residue After Retrieval	1	1	10	10	1	8	7	3

TABLE C.2. (contd)

ATTRIBUTE No.	ATTRIBUTE DESCRIPTION	RANKINGS BY FUNCTION 1100	1200	1300	1400	1500	1600	1700	NUMBER OF ONES
	AVERAGE->	4.5	2.0	6.4	2.4	3.7	6.3	4.7	
	2.0 PHYSICAL ATTRIBUTES (contd)								
173	2.4.2 Max Allowed Soil Contamination After Retrieval	1	5	10	10	1	2	7	2
	2.4.3 Max Residual Activity on Tank Exterior/Interior								
174	a) Beta/Gamma	1	5	8	3	1	8	2	2
	2.4.4 Max Residual Contamination on Ancillary Equipment								
175	a) Beta/Gamma	1	5	8	9	1	8	2	2
176	2.4.5 Max Residual TRU in Cribs and Trenches	1	1	8	10	1	5	2	3
	2.4.6 Max Smearable Release for Retrieval Package								
177	a) Alpha	1	1	8	9	1	2	1	4
178	b) Beta/Gamma	1	1	8	9	1	2	1	4
	2.4.7 Max Smearable Release of HLW Glass WP								
179	a) Beta/Gamma	1	1	8	1	1	8	1	5
180	b) Alpha	1	1	8	1	1	8	1	5
	2.4.8 TRU >Class C								
181	a) Alpha	1	1	8	1	1	8	1	5
182	b) Beta/Gamma	1	1	8	1	1	8	1	5
	3.0 ENGINEERED ENCLOSURES								
	3.1 Transport Containers (All Types)								
	3.1.1 Performance Attributes								
183	a) Integrity after Drop/Thermal Test	1	1	1	8	1	1	1	6
184	b) Max Number Times Used	1	1	1	10	1	1	1	6
	3.2 Waste Packages								
	3.2.1 Performance Attributes								
	a) Min Lifetime								
185	HLW	1	1	1	1	1	5	6	5
186	LLW	1	1	1	1	1	10	6	5
187	Grouted Vault	1	1	1	1	1	10	6	5
188	In-Place	1	3	1	5	1	10	6	3
	b) Max Release Rate-HLW Glass								
189	Cs	1	1	9	1	1	10	1	5
190	U	1	1	9	1	1	10	1	5
191	Si	1	1	9	1	1	10	1	5
192	B	1	1	9	1	1	10	1	5
193	Na	1	1	9	1	1	10	1	5
194	Sulphate	1	1	9	1	1	8	1	5
195	Max Waste Loading	1	1	9	1	1	8	1	5
	c) Max Release Rate-Grouted Waste								
196	Ag	1	1	9	1	1	9	7	4
197	As	1	1	9	1	1	9	7	4
198	Ba	1	1	9	1	1	7	7	4
199	Cd	1	1	9	1	1	9	7	4

TABLE C.2. (contd)

ATTRIBUTE No.	ATTRIBUTE DESCRIPTION	RANKINGS BY FUNCTION 1100	1200	1300	1400	1500	1600	1700	NUMBER OF ONES
	AVERAGE->	4.5	2.0	6.4	2.4	3.7	6.3	4.7	
	3.0 ENGINEERED ENCLOSURES (contd)								
200	Cl	1	1	9	1	1	5	7	4
201	Cr	1	1	9	1	1	10	7	4
202	Cu	1	1	9	1	1	5	7	4
203	F	1	1	9	1	1	9	7	4
204	Fe	1	1	9	1	1	5	7	4
205	Hg	1	1	9	1	1	9	7	4
206	Mn	1	1	9	1	1	5	7	4
207	NO2	1	1	9	1	1	10	7	4
208	NO3	1	1	9	1	1	10	7	4
209	Pb	1	1	9	1	1	9	7	4
210	Se	1	1	9	1	1	10	7	4
211	SO4	1	1	9	1	1	5	7	4
212	Zn	1	1	9	1	1	5	7	4
213	CN	1	1	9	1	1	5	7	4
214	PO4	1	1	9	1	1	10	7	4
215	Na	1	1	9	1	1	10	7	4
216	C-14	1	1	9	1	1	10	7	4
217	Sr-90	1	1	9	1	1	7	7	4
218	Tc-99	1	1	9	1	1	10	7	4
219	I-129	1	1	9	1	1	10	7	4
220	Cs-137	1	1	9	1	1	7	7	4
221	Ra-226	1	1	9	1	1	5	7	4
222	Np-237	1	1	9	1	1	8	7	4
223	U-238	1	1	9	1	1	5	7	4
224	Pu-239,240	1	1	9	1	1	7	7	4
225	Am-241	1	1	9	1	1	7	7	4
226	Se-79	1	1	9	1	1	7	7	4
227	Nb-93m	1	1	9	1	1	7	7	4
228	Co-60	1	1	9	1	1	7	7	4
229	Ru-106	1	1	9	1	1	7	7	4
230	Sb-126m	1	1	9	1	1	7	7	4
231	Cs-135	1	1	9	1	1	7	7	4
232	Ce-144	1	1	9	1	1	7	7	4
233	Pu-241	1	1	9	1	1	7	7	4
234	Sm-151	1	1	9	1	1	7	7	4
235	Ba-137m	1	1	9	1	1	7	7	4
236	Sn-126	1	1	9	1	1	7	7	4
237	Zr-93	1	1	9	1	1	7	7	4
238	Ni-63	1	1	9	1	1	7	7	4
239	Cm-242	1	1	9	1	1	7	7	4
240	TOC Content	1	1	9	1	5	7	7	3
241	Residual/Free Water	1	1	9	1	1	7	7	4
242	Ten min Gel Strength	1	1	9	1	1	7	7	4
243	Critical Flow	1	1	9	1	1	7	7	4
244	30 Thermal Cycles	1	1	9	1	1	7	7	4
245	Biodegradation	1	1	9	1	1	7	7	4
	d) Max Release Rate In-Tank Waste Package								
246	Residual Water (up to 300 deg F)	10	10	9	2	1	9	7	1

TABLE C.2. (contd)

ATTRIBUTE No.	ATTRIBUTE DESCRIPTION	1100	1200	1300	1400	1500	1600	1700	NUMBER OF ONES
	AVERAGE->	4.5	2.0	6.4	2.4	3.7	6.3	4.7	
	3.0 ENGINEERED ENCLOSURES (contd)								
247	Total Organic Carbon	10	5	9	1	1	9	7	2
248	Ag	10	3	9	1	1	9	7	2
249	As	10	3	9	1	1	9	7	2
250	Ba	10	3	9	1	1	8	7	2
251	Cd	10	3	9	1	1	9	7	2
252	Cl	10	3	9	1	1	5	7	2
253	Cr	10	3	9	1	1	10	7	2
254	Cu	10	3	9	1	1	5	7	2
255	F	10	3	9	1	1	9	7	2
256	Fe	10	3	9	1	1	5	7	2
257	Hg	10	3	9	1	1	9	7	2
258	Mn	10	3	9	1	1	5	7	2
259	NO2	10	3	9	1	1	10	7	2
260	NO3	10	3	9	1	1	10	7	2
261	Pb	10	3	9	1	1	9	7	2
262	Se	10	3	9	1	1	10	7	2
263	SO4	10	3	9	1	1	5	7	2
264	Zn	10	3	9	1	1	5	7	2
265	CN	10	3	9	1	1	5	7	2
266	Na	10	3	9	1	1	5	7	2
267	Al	10	3	9	1	1	2	7	2
268	PO4	10	3	9	1	1	10	7	2
269	C-14	10	3	9	3	1	10	7	1
270	Se-79	10	3	9	3	1	10	7	1
271	Sr-90	10	3	9	3	1	9	7	1
272	Tc-99	10	3	9	3	1	10	7	1
273	I-129	10	3	9	3	1	10	7	1
274	Cs-137	10	3	9	3	1	9	7	1
275	Sm-151	10	3	9	3	1	9	7	1
276	Np-237	10	3	9	3	1	9	7	1
277	U-238	10	3	9	3	1	7	7	1
278	Pu-239/240	10	8	9	3	1	9	7	1
279	Am-241	10	8	9	3	1	9	7	1
280	Ni-63	10	3	9	1	1	9	7	2
281	Zr-93	10	3	9	1	1	9	7	2
282	Cm-242	10	3	9	1	1	9	7	2
283	Pu-241	10	3	9	3	1	9	7	1
284	Cs-135	10	3	9	1	1	9	7	2
285	Total TRU	10	8	9	3	1	10	7	1
286	Allowed pH Range after Pretreatment	1	8	9	2	1	8	7	2
	e) Waste Package Closures								
287	HLW-Glass ANSI STD	1	1	2	1	1	10	1	5
288	Grouted Vault (see #165)	1	1	2	1	1	8	1	5
289	In-Tank Disposal	8	7	2	1	1	8	1	3
290	f) Drop Test of HLW Container	1	1	2	1	1	10	1	5
	3.2.2 Design/Process Attributes								
	a) Waste Stream Constraints to HLW Glass (wt % dry)								
291	Al2O3	1	1	3	1	5	8	1	4
292	BaO	1	1	3	1	5	8	1	4

TABLE C.2. (contd)

ATTRIBUTE No.	ATTRIBUTE DESCRIPTION	1100	1200	1300	1400	1500	1600	1700	NUMBER OF ONES
	AVERAGE->	4.5	2.0	6.4	2.4	3.7	6.3	4.7	
	3.0 ENGINEERED ENCLOSURES (contd)								
293	CaO	1	1	3	1	5	8	1	4
294	CdO	1	1	3	1	5	9	1	4
295	Cr2O3	1	1	3	1	5	10	1	4
296	F	1	1	3	1	5	9	1	4
297	Fe2O3	1	1	3	1	5	9	1	4
298	MnO2	1	1	3	1	5	9	1	4
299	MoO3	1	1	3	1	5	9	1	4
300	Na2O	1	1	3	1	5	10	1	4
301	NiO	1	1	3	1	5	8	1	4
302	P2O5	1	1	3	1	5	9	1	4
303	SO3	1	1	3	1	5	9	1	4
304	SiO2	1	1	3	1	5	5	1	4
305	TiO2	1	1	3	1	5	7	1	4
306	U3O8	1	1	3	1	5	7	1	4
307	ZrO2	1	1	3	1	5	7	1	4
308	TOC	1	1	3	1	5	10	1	4
309	Particle Size	1	1	3	1	5	8	1	4
	b) Waste Stream Constraints to Grout								
310	Ag	1	1	3	1	3	9	1	4
311	As	1	1	3	1	3	9	1	4
312	Ba	1	1	3	1	3	8	1	4
313	Cd	1	1	3	1	3	10	1	4
314	Cr	1	1	3	1	7	10	1	4
315	Hg	1	1	3	1	3	9	1	4
316	Pb	1	1	3	1	3	9	1	4
317	Se	1	1	3	1	3	10	1	4
318	TOC	1	1	3	1	3	7	1	4
319	Al	1	1	3	1	3	2	1	4
320	Ca	1	1	3	1	3	2	1	4
321	Cl	1	1	3	1	3	5	1	4
322	CO3	1	1	3	1	3	5	1	4
323	Cu	1	1	3	1	3	5	1	4
324	F	1	1	3	1	3	5	1	4
325	Fe	1	1	3	1	3	5	1	4
326	K	1	1	3	1	3	5	1	4
327	Mg	1	1	3	1	3	5	1	4
328	Mn	1	1	3	1	3	5	1	4
329	Mo	1	1	3	1	3	5	1	4
330	Na	1	1	3	1	3	10	1	4
331	Ni	1	1	3	1	3	5	1	4
332	NH3	1	1	3	1	3	7	1	4
333	NO2	1	1	3	1	7	10	1	4
334	NO3	1	1	3	1	7	10	1	4
335	OH	1	1	3	1	3	9	1	4
336	PO4	1	1	3	1	3	9	1	4
337	SO4	1	1	3	1	3	9	1	4
338	Zn	1	1	3	1	3	5	1	4
339	Zr	1	1	3	1	3	5	1	4
340	U	1	1	3	1	3	5	1	4
341	RE	1	1	3	1	3	5	1	4

TABLE C.2. (contd)

ATTRIBUTE No.	ATTRIBUTE DESCRIPTION	RANKINGS BY FUNCTION 1100	1200	1300	1400	1500	1600	1700	NUMBER OF ONES
	AVERAGE->	4.5	2.0	6.4	2.4	3.7	6.3	4.7	
	3.0 ENGINEERED ENCLOSURES (contd)								
342	CN,not Fe(CN)6	1	1	3	1	3	5	1	4
343	C-14	1	1	3	1	5	10	1	4
344	Ni-59	1	1	3	1	1	5	1	5
345	Ni-63	1	1	3	1	1	9	1	5
346	Sr-90	1	1	3	1	10	10	1	4
347	Co-60	1	1	3	1	1	9	1	5
348	H-3	1	1	3	1	1	10	1	5
349	Nb-94	1	1	3	1	1	5	1	5
350	Tc-99	1	1	3	1	5	10	1	4
351	I-129	1	1	3	1	5	10	1	4
352	Cs-137	1	1	3	1	10	10	1	4
353	Pu-241	1	1	3	1	5	9	1	4
354	Cm-242	1	1	3	1	1	9	1	5
355	Ru/Rh-106	1	1	3	1	1	5	1	5
356	Sb/Te-125	1	1	3	1	1	5	1	5
357	Cs-135	1	1	3	1	1	5	1	5
358	Ce/Pr-144	1	1	3	1	1	5	1	5
359	Am-241	1	1	3	1	10	9	1	4
360	TRU	1	1	3	1	10	10	1	4
361	pH	1	1	3	1	3	8	1	4
362	Solids/Sludge	1	1	3	1	3	8	1	4
363	Np-237	1	1	3	1	10	9	1	4
364	U-238	1	1	3	1	5	7	1	4
365	Pu-239/240	1	1	3	1	10	9	1	4
	c) Constraints on In-Place Waste Package from Prior Design								
366 C	Max Heat Generation	8	10	2	8	1	8	1	2
367 C	Min Hydrostatic Load	1	10	2	8	1	5	1	3
368 C	Max Tank Negative Pressure	1	10	2	9	1	2	1	3
369 C	Vapor Space-Pressure Range	1	10	2	7	1	2	1	3
	3.3 Barriers								
	3.3.1 Performance Attributes								
	a) Production Rate (see 4.1)								
370	b) Lifetime	1	1	9	1	1	7	10	4
371	c) Drainage Rate	1	1	9	1	1	7	10	4
372	d) Storage Capacity of Fine Soil Layer	1	1	9	1	1	7	10	4
373	e) Fine Content at -230 mesh	1	1	9	1	1	5	10	4
374	f) Permeability of Loperm Soil	1	1	9	1	1	7	10	4
375	g) Amount of Runoff	1	1	9	1	1	2	10	4
376	h) Allowed Thickness Change from Erosion/Deposition	1	1	9	1	1	5	10	4
377	i) Allowed Subsidence	1	1	9	1	1	7	10	4
378	j) Earthquakes	1	1	9	1	1	5	10	4
379	k) Excavation Exclusion Period	1	1	9	1	1	5	10	4
	l) Conc. in Vadose or Groundwater								
380	Arsenic	10	1	10	1	1	8	7	3
381	Barium	10	1	10	1	1	8	7	3
382	Cadmium	10	1	10	1	1	8	7	3

TABLE C.2. (contd)

ATTRIBUTE No.	ATTRIBUTE DESCRIPTION	RANKINGS BY FUNCTION 1100	1200	1300	1400	1500	1600	1700	NUMBER
	AVERAGE->	4.5	2.0	6.4	2.4	3.7	6.3	4.7	OF ONES
	3.0 ENGINEERED ENCLOSURES (contd)								
383	Chromium	10	1	10	1	5	8	7	2
384	Lead	10	1	10	1	1	8	7	3
385	Mercury	10	1	10	1	1	8	7	3
386	Selenium	10	1	10	1	1	8	7	3
387	Silver	10	1	10	1	1	8	7	3
388	Endrin	10	1	10	1	1	1	7	4
389	Lindane	10	1	10	1	1	1	7	4
390	Methoxychlor	10	1	10	1	1	1	7	4
391	Toxaphene	10	1	10	1	1	1	7	4
392	2-4-D	10	1	10	1	1	1	7	4
393	2,4,5-TP Silex	10	1	10	1	1	1	7	4
394	TRU	10	1	10	1	10	8	7	2
395	Radionuclide	10	1	10	1	10	8	7	2
396	n) Conc in Vadose or Groundwater Justified Chemical List Later	10	1	10	1	1	8	7	3
397	o) Frequency of Tests for Direction and Rate of GW	10	1	10	1	1	5	4	3
398	p) Frequency of Tests for GW Levels	10	1	10	1	1	5	4	3
399	q) Detection Limit for Conc of Gases in Vadous Zone	10	1	8	1	1	5	4	3
	3.3.2 Design Attributes								
400	a) Compaction of Backfill	1	1	5	1	1	5	10	4
401	b) Number of Barriers/Tank	1	1	10	1	1	5	7	4
	c) Barrier Thicknesses								
402	Fine Soil	1	1	5	1	1	2	10	4
403	Gravel Mulch	1	1	5	1	1	2	10	4
404	Sand	1	1	5	1	1	2	10	4
405	Gravel	1	1	5	1	1	2	10	4
406	Lo Perm	1	1	5	1	1	2	1	4
407	Sand Cushion	1	1	5	1	1	2	10	4
408	Riprap/pitrun gravel	1	1	5	1	1	2	10	4
409	Total	1	1	5	1	1	8	10	4
410	d) Burrow Depth	1	1	5	1	1	5	8	4
411	e) Max Rain Intensity	1	1	5	1	1	5	8	4
412	f) Max Wind Intensity	1	1	5	1	1	5	8	4
413	g) Void Density	1	1	5	1	1	5	8	4
414	h) Plant Density-deep rooting	1	1	5	1	1	5	8	4
415	i) Marker Properties Surface Abrasive Resistance Water Absorption Density Compressive Strength Modulus of Rupture	1	1	5	1	1	1	8	5
416	Subsurface Markers Compressive Strength Thermal Shock Thermal Crazing Alkali Resistance Color Retention Chemical Resistance	1	1	5	1	1	1	8	5

TABLE C.2. (contd)

ATTRIBUTE No.	ATTRIBUTE DESCRIPTION	RANKINGS BY FUNCTION 1100	1200	1300	1400	1500	1600	1700	NUMBER OF ONES
	AVERAGE->	4.5	2.0	6.4	2.4	3.7	6.3	4.7	
	3.0 ENGINEERED ENCLOSURES (contd)								
	j) Marker Spacing								
417	Horizontal	1	1	5	1	1	1	8	5
418	Vertical	1	1	5	1	1	1	8	5
419	k) Marker Functional Lifetime	1	1	10	1	1	1	8	5
420	l) Well Network	1	1	10	1	1	1	8	5
	3.3.3 Data Uncertainties (+ or -)								
421	a) Material Volumes	1	1	5	1	1	1	5	5
422	b) Growing Season	1	1	5	1	1	1	5	5
	c) Climatology								
423	EvapoTrans Rate	1	1	7	1	1	5	9	4
424	Root Depths	1	1	7	1	1	5	9	4
425	Gravel Effects	1	1	7	1	1	5	9	4
426	Veg Effects	1	1	7	1	1	1	9	5
427	Marker Dimensions	1	1	7	1	1	1	9	5
428	Burrow Density	1	1	7	1	1	1	9	5
429	d) Hazards Probability Volcanic Eruption Earthquake Tornado	1	1	7	1	1	1	9	5
430	e) Barrier Hydrology Properties	1	1	7	1	1	8	9	4
431	f) Erosion Rates from Wind and Water	1	1	7	1	1	5	9	4
432	g) Deposition Rate from Wind	1	1	7	1	1	1	9	5
433	h) Void Size on Site	1	1	7	1	1	1	9	5
	3.4 Site Facilities								
	3.4.1 Releases to the Environment								
434	a) NOX	7	1	10	10	10	1	1	3
435	b) SOX	7	1	10	10	5	1	1	3
436	c) Particulates	7	1	10	10	3	1	1	3
437	d) Process Liquid Discharge	1	1	10	10	5	5	1	3
438	e) Process Solid Discards	1	1	10	10	10	5	1	3
	3.4.2 Design Attributes								
439	a) Seismic	1	1	5	5	3	1	1	4
440	b) Max Wind Speed-Permanent Facility	1	1	5	1	3	1	1	5
441	c) Max Wind Speed-Transportable Facility during op'ns	1	1	5	8	3	1	1	4
442	d) Facility Operating Life	1	1	5	5	3	1	1	4
443	e) Post-closure Life	1	1	10	1	3	1	1	5
	4.0 OPERATING ATTRIBUTES (Retrieve, Pretreat, Waste Package, On-site Burial)								
	4.1 Production/Process Rates (System Level Only)								
444	4.1.1 Mean Disposition Rate	1	10	1	10	5	5	10	2
445	4.2 Min In-Process Storage Times	1	10	1	10	5	5	1	3
	4.3 Process Water Utilization Mgmt								
446	4.3.1 Retrieval Output/Input	1	1	1	10	5	5	7	3
447	4.3.2 Processing Output/Input	1	1	1	3	5	5	7	3
448	4.3.3 Waste Packaging Output/ Input	1	1	1	2	1	5	7	4

TABLE C.2. (contd)

ATTRIBUTE No.	ATTRIBUTE DESCRIPTION	RANKINGS BY FUNCTION 1100	1200	1300	1400	1500	1600	1700	NUMBER OF ONES
	AVERAGE->	4.5	2.0	6.4	2.4	3.7	6.3	4.7	
	4.0 OPERATING ATTRIBUTES (contd)								
	4.4 Acceptance Criteria								
	4.4.1 Retrieval Package								
449	a) Max Thermal Content/Package	1	1	1	9	1	1	1	6
450	b) Max Mass Content/Package	1	1	1	10	1	1	1	6
	4.5 Process Separations								
	4.5.1 Species in Glass Stream after Pretreatment								
451	a) Na	1	1	5	1	10	10	7	3
452	b) Al,Fe	1	1	5	1	10	10	7	3
453	c) Si	1	1	5	1	10	10	7	3
454	d) U	1	1	5	1	10	10	7	3
455	e) TOC, incl CN	1	1	5	1	10	10	7	3
	4.5.2 Species in Grout Stream after Pretreatment								
456	a) Na	1	1	5	1	10	10	7	3
457	b) NO3	1	1	5	1	10	10	7	3
458	c) C-14	1	1	5	1	10	10	7	3
459	d) Ni-63	1	1	5	1	10	8	7	3
460	e) Sr-90	1	1	5	1	10	9	7	3
461	f) Tc-99	1	1	5	1	10	10	7	3
462	g) I-129	1	1	5	1	10	10	7	3
463	h) Cs-137	1	1	5	1	10	9	7	3
464	i) U-235,238	1	1	5	1	10	8	7	3
465	j) Np-237	1	1	5	1	10	8	7	3
466	k) Pu-239,240	1	1	5	1	10	8	7	3
467	l) Am-241	1	1	5	1	10	8	7	3
	4.5.3 Species in Tank Waste after In-Place Treatment								
468	a) Cd	8	2	5	1	1	10	7	2
469	b) Cr	8	2	5	1	10	10	7	1
470	c) CN	8	2	5	1	10	8	7	1
471	d) F	8	2	5	1	10	8	7	1
472	e) Fe	8	2	5	1	1	5	7	2
473	f) Mn	8	2	5	1	1	5	7	2
474	g) Hg	8	2	5	1	1	8	7	2
475	h) NO3	8	2	5	1	1	10	7	2
476	i) NO2	8	2	5	1	1	10	7	2
477	j) Na	8	2	5	1	1	5	7	2
478	k) SO4	8	2	5	1	1	7	7	2
479	l) C-14	8	2	5	3	5	10	7	0
480	m) Sr-90	8	2	5	3	10	9	7	0
481	n) Tc-99	8	2	5	3	5	10	7	0
482	o) I-129	8	2	5	3	5	10	7	0
483	p) Cs-137	8	2	5	3	10	9	7	0
484	q) Np-237	8	2	5	3	10	7	7	0
485	r) Pu-239,240	8	3	5	3	10	7	7	0
486	s) Am-241	8	3	5	3	10	7	7	0
487	t) TRU	8	3	5	3	10	10	7	0

TABLE C.2. (contd)

ATTRIBUTE No.	ATTRIBUTE DESCRIPTION	1100	1200	1300	1400	1500	1600	1700	NUMBER OF ONES
	AVERAGE->	4.5	2.0	6.4	2.4	3.7	6.3	4.7	
	4.0 OPERATING ATTRIBUTES (contd)								
	4.6 Personnel Qualification/ Training								
	4.6.1 Personnel Qualification								
488	a) Decon Qualification	10	10	7	10	3	1	1	2
489	b) Operating Equipment Qualification	10	10	7	9	5	5	1	1
	4.6.2 General Personnel Training								
490	a) Minimum Skill Level	10	10	7	7	5	5	1	1
491	b) Chemical Hazards	10	10	7	8	5	5	1	1
492	c) Radiation Hazards	10	10	7	8	5	5	1	1
	4.7 Design Practices								
493	a) Min Soil Overburden Thickness	1	1	2	7	1	9	1	4
494	b) Codes and Standards	1	1	2	2	5	5	1	3
	4.8 Employee Health and Safety								
495	4.8.1 Criticality Control K effective	10	5	8	5	5	10	1	1
	4.8.2 Exposure Limits								
496	a) Hazardous Chemicals	10	10	8	9	5	9	1	1
497	b) Whole Body Radiation	10	10	8	10	5	9	1	1
498	c) Alpha Ingestion	10	10	8	10	5	9	1	1
	4.9 Public Protection and Practices								
499	4.9.1 Exposure Limits to Water Consumption at Boundary	3	10	9	2	5	9	10	0
500	4.9.2 Radiation Exposure Limits at Boundary	3	10	9	2	5	9	10	0
	5.0 SITE SELECTION ATTRIBUTES								
	5.1 Performance Measures								
501	a) Number of Potential Sites	1	1	2	1	1	2	8	4
	5.2 Design Attributes								
502	a) Proximity to 200 Area	1	1	2	1	1	2	10	4
503	b) Distance from other waste sites	1	1	8	1	1	2	10	4
504	c) Distance to Wilderness Area	1	1	8	1	1	2	10	4
505	d) Distance to Sensitive Area	1	1	8	1	1	2	10	4
506	e) Dist to State/Fed Wildlife Refuge	1	1	8	1	1	2	10	4
507	f) Distance to Rec, Scenic, Park Boundary	1	1	8	1	1	2	10	4
508	g) Dist to Archeological/Historic Areas	1	1	8	1	1	2	10	4
509	h) Inside 100 yr Flood Plain?	1	1	8	1	1	5	10	4
510	i) Distance from perenial source of surface water	1	1	8	1	1	5	10	4
511	j) Over a sole source aquifer?	1	1	8	1	1	5	10	4
512	k) Distance from downgradient drinking water intake	1	1	8	1	1	5	10	4
513	l) Distance from upgradient drinking water intake	1	1	8	1	1	5	10	4
514	m) Outside potable well head area of influence	1	1	8	1	1	5	10	4

TABLE C.2. (contd)

ATTRIBUTE No.	ATTRIBUTE DESCRIPTION	1100	1200	1300	1400	1500	1600	1700	NUMBER OF ONES
		RANKINGS BY FUNCTION							
	AVERAGE->	4.5	2.0	6.4	2.4	3.7	6.3	4.7	
	5.0 SITE SELECTION ATTRIBUTES (contd)								
515	n) Distance from boundary to residence zone	1	1	8	1	1	2	10	4
516	o) Distance from boundary to non-residence zone	1	1	8	1	1	2	10	4
517	p) Distance from fault active in Holocene	1	1	8	1	1	2	10	4
	5.3 Data Uncertainties (plus or minus)								
518	a) Depth to Groundwater	1	1	9	1	1	5	8	4
519	b) Groundwater travel time (Vadose Travel Time)	1	1	9	1	1	8	8	4
520	c) Groundwater Mass Flow	1	1	9	1	1	8	8	4
521	d) Lithology	1	1	9	1	1	2	8	4
522	e) Strength	1	1	9	1	1	5	8	4
523	f) Permeability	1	1	9	1	1	8	8	4
524	g) Particle Size Distributio	1	1	9	1	1	8	8	4
525	h) Site Size Necessary	1	1	9	1	1	2	8	4
	6.0 RECORDS AND REPORTING ATTRIBUTES								
	6.1 Performance Assessments (Levels of Conservatism)								
	6.1.1 Inputs								
526	a) Measured Data	10	10	9	1	2	9	10	1
527	b) Estimated Data-Effect on Final Result	1	10	9	1	2	9	10	2
	6.1.2 Algorithms Used-Effect on Final Result								
528	a) First Principles	1	1	9	1	1	8	7	4
529	b) Extrapolations of Empirical Relationships	1	1	9	1	1	9	7	4
	6.1.3 Assessment Margins								
530	a) Temperatures	1	7	9	1	1	8	10	3
531	b) Escape Rate from Sequestered Waste Forms	1	1	9	1	1	9	10	4
532	c) Transport Rate in Carrier System	1	1	9	1	1	5	10	4
	6.2 Notifications for Spills/ Releases								
533	6.2.1 Release Points	10	10	9	10	3	5	1	1
534	6.2.2 Reporting Condition	10	3	9	10	3	5	1	1
535	6.2.3 Reporting Window after Occurence	10	10	9	10	3	5	1	1
536	6.2.4 Report Contents	8	8	9	10	3	5	1	1
	6.3 Notification for RCRA Documentation								
537	6.3.1 Hammer Dates	3	3	9	1	3	5	1	2
538	6.3.2 Reporting Method	3	3	9	1	3	5	1	2
539	6.3.4 Reporting Contents	3	3	9	1	3	5	1	2
	6.4 Waste Form Record Update								
540	6.4.1 Volume of solids	10	10	5	3	1	2	1	2
541	6.4.2 Total H20 volume	10	10	5	3	1	7	1	2

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