WHC-EP--0421

DE92 002976

Hanford Waste Vitrification Systems Risk Assessment - Final Report

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Date Published
September 1991

Prepared for the U.S. Department of Energy
Office of Environmental Restoration and
Waste Management

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Hanford Operations and Engineering Contractor for the
U.S. Department of Energy under Contract DE-AC06-87RL10930

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DISCLM-1.CHP (1-91)

HANFORD WASTE VITRIFICATION SYSTEMS RISK ASSESSMENT - FINAL REPORT

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HANFORD WASTE VITRIFICATION SYSTEMS RISK ASSESSMENT - FINAL REPORT

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ABSTRACT

A systematic Risk Assessment was performed to identify the technical, regulatory, and programmatic uncertainties and to quantify the risks to the Hanford Site double-shell tank waste vitrification program baseline (as defined in December 1990). Mitigating strategies to reduce the overall program risk were proposed.

All major program elements were evaluated, including double-shell tank waste characterization, Tank Farms, retrieval, pretreatment, vitrification, and grouting. Computer-based techniques were used to quantify risks to proceeding with construction of the Hanford Waste Vitrification Plant on the present baseline schedule. Risks to the potential vitrification of single-shell tank wastes and cesium and strontium capsules were also assessed.

EXECUTIVE SUMMARY

INTRODUCTION

Uncertainty in the chemical compositions of defense nuclear wastes stored in tanks at the Hanford Site, delay in the startup of the U.S. Department of Energy's (DOE) waste vitrification plant located at the Savannah River Site, and technical, regulatory, and programmatic issues have challenged plans to vitrify high-level and transuranic (TRU) tank wastes at the Hanford Site. As a result, a Risk Assessment was performed to identify the technical, regulatory, and programmatic uncertainties and to quantify the attendant risks to the double-shell tank (DST) waste treatment program baseline as it was defined in December 1990.

All major elements of the DST waste treatment program were addressed in the Risk Assessment, including waste characterization, Tank Farms, retrieval, pretreatment, vitrification of the high-level and TRU wastes, and, to a lesser extent, grouting of the low-level waste. The capability of the Hanford Waste Vitrification Plant (HWVP) to process single-shell tank (SST) wastes and cesium and strontium capsules as future missions was also addressed.

This Risk Assessment was the first comprehensive attempt to identify and evaluate the uncertainties and risks associated with all elements of the DST waste treatment program.

A companion in-depth review of alternatives to resolve the risks identified in this document is currently underway and will be documented in conjunction with this report as a revision to the tank waste disposal strategy. That document will evaluate the findings from the Risk Assessment, as well as program options identified separately, and recommend a new strategy for the treatment of tank wastes that will reduce the overall risk to the program.

FINDINGS

The baseline plan (December 1990) to process high-level waste and TRU wastes stored in DSTs at the Hanford Site contains a number of uncertainties. Though many of these have minor consequences, the cumulative impact of all uncertainties has major potential consequences that result in substantial risk to the program. The viability of B Plant as a mixed waste treatment facility for waste pretreatment is questionable due not only to a regulatory compliance issue but also due to facility integrity concerns. Significant additional waste characterization data are needed to complete the development of retrieval, pretreatment, and vitrification processes. Schedule delays associated primarily with uncertainties in characterization, retrieval, and pretreatment activities could prevent startup of the HWVP in December 1999 and result in several years of outage during its operating lifetime.

A number of uncertainties associated with waste characterization, the development and implementation of waste retrieval and pretreatment processes and facilities, and construction and operation of the HWVP have the potential to cause significant schedule delays and to increase total costs of the program. The most probable collective impact of these uncertainties is a delay of up to 7 yr to complete vitrification of the DST wastes. A total life-cycle cost increase of up to $2 billion (in 1991 dollars) for the DST waste treatment program was estimated to result from these combined uncertainties and associated schedule delays, assuming B Plant is used. If B Plant is not used, the cost of the program could increase significantly to accommodate an alternative pretreatment capability.

These and other uncertainties identified in the Risk Assessment must be addressed in the development of a revised program strategy for the treatment of DST wastes to mitigate the program risks. Construction of the HWVP on the baseline schedule is appropriate only if the program redefinition resolves the most significant risks in a manner that will ensure timely and nearly continuous feed to the HWVP.

It is highly probable that HWVP will be capable of supporting future processing missions for SST wastes and cesium and strontium capsules based on scoping assessments performed to date. The plant has been designed with sufficient capacity assuming waste pretreatment capabilities such as TRU extraction are developed and implemented.

Additional DSTs are needed to store wastes to be generated during DST and SST waste stabilization, treatment, and disposal to avoid major delays in the pretreatment and vitrification operations.

Lack of integration of the DST and SST waste treatment programs could extend the time necessary for final cleanup of the Hanford Site and result in substantial costs, which may be avoidable. The current schedule for preparation of environmental and regulatory documentation will, most likely, not support closure of the SSTs by the year 2018 as currently identified in the *Hanford Federal Facility Agreement and Consent Order* (also known as the Tri-Party Agreement).[1] If the SST wastes are vitrified, costly and redundant pretreatment facilities may need to be constructed. Operation of the HWVP also may have to be curtailed up to 10 yr between the DST and SST vitrification campaigns. Recovery from an outage of this length could be difficult and costly due to the potential for changing regulatory requirements.

RECOMMENDATIONS

Pretreatment options that do not require the use of B Plant or AR Vault should be investigated due to the uncertainties in obtaining dangerous waste permits for these facilities. Alternate waste types, such as SST 106-C, which can be pretreated with mature, simple processes, should be evaluated as feed options to minimize HWVP standby during the DST campaign.

Construction of the HWVP should not be initiated until a revised tank waste disposal program strategy is accepted by all responsible agencies because implementation of some pretreatment options could substantially delay

[1] *Hanford Federal Facility Agreement and Consent Order*, Vols. 1 and 2, Washington State Department of Ecology, U.S. Environmental Protection Agency, and U.S. Department of Energy, Olympia, Washington, 1990.

supplying feed to HWVP. At the extreme, delivery of pretreated feed to HWVP could be delayed up to 10 yr if all waste types are to be processed in a new facility.

Delaying the start of HWVP hot operations may be appropriate if the likelihood of substantial interruptions in the supply of feed to the HWVP cannot be eliminated through the implementation of alternate pretreatment strategies or technologies. A delay of 2 to 4 yr would reduce, and perhaps eliminate, the HWVP standby periods identified in the December 1990 baseline plans.

Integrated planning for characterization of tank wastes to resolve tank safety issues and support waste stabilization and remediation should be expedited. New sampling and support equipment should be procured, and additional laboratory capabilities should be made available.

Activities necessary to retrieve the initial waste type to support the startup of pretreatment processing should receive higher priority. Laboratory- and full-scale retrieval process testing of subsequent waste types should be expedited.

The supplemental environmental impact statement for the closure of the SSTs should be targeted for completion earlier than currently planned. This will improve the probability of completing the milestone for closure of the tanks by 2018 and assist in the integration of the DST and SST waste treatment programs.

DOCUMENT SUMMARY

Section 1.0 provides a program overview, and a summary of the scope, approach, and findings from the Risk Assessment, together with the principal recommendations. Section 2.0 contains definitions of the purpose and scope of the assessment. Section 3.0 presents a description of the wastes, processes, and facilities, which were the baseline for the Risk Assessment. Section 4.0 contains definitions of the methodology and findings for the assessment of DST wastes, including the computer modeling techniques and results. Sections 5.0 and 6.0 present the methodology and findings for the assessments of SST wastes and cesium and strontium capsules, respectively. Section 7.0 provides a discussion of the assessment of DST space utilization.

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GLOSSARY

ABBREVIATIONS, ACRONYMS, AND INITIALISMS

A-E	Architect-Engineer
AEA	Atomic Energy Act
AISI	American Iron and Steel Institute
ALARA	as low as reasonably achievable
AMU	aqueous makeup unit
ANL	Argonne National Laboratory
ANSI	American National Standards Institute
AWF	Aging Waste Facility
CAA	Clean Air Act
CC	complexant concentrate
CDR	conceptual design report
CFR	Code of Federal Regulations
CPM	Critical Path Method
CS&R	codes, standards, and regulations
DBA	design basis accident
DBE	design basis earthquake
DBF	design basis fire
DMF	Dry Materials Facility
DOE	U.S. Department of Energy
DOE-HQ	U.S. Department of Energy-Headquarters
DOH	U.S. Department of Health
DSS	double-shell slurry
DSSF	double-shell slurry feed
DST	double-shell tank
DSTRA	Double-Shell Tank Risk Assessment
DSTWD	double-shell tank waste disposal
DWMP	Defense Waste Management Plan
DWPF	Defense Waste Processing Facility
Ecology	Washington State Department of Ecology
EIS	environmental impact statement
EPA	U.S. Environmental Protection Agency
FDC	functional design criteria
FSAR	final safety analysis report
FTS	feed transfer system
FY	fiscal year
GDF	Grout Disposal Facility
GPF	Grout Processing Facility
GTF	Grout Treatment Facility
HDW-EIS	Hanford Defense Waste-Environmental Impact Statement
HEPA	high-efficiency particulate air
HLW	high-level waste
HVAC	heating, ventilating, and air conditioning
HWMP	Hanford Site Waste Management Plan
HWVP	Hanford Waste Vitrification Plant
I&C	instrumentation and control
IDMS	integrated DWPF melter system
KfK	Kernforschungszentrum Karlsruhe

LATA	Los Alamos Technical Associates, Inc.
LERF	Liquid Effluent Retention Facility
LIP	lead-iron-phosphate
LLW	low-level waste
MIS	management information system
MOG	melter offgas
NCAW	neutralized current acid waste
NCRW	neutralized cladding removal waste
NEPA	National Environmental Policy Act
NESHAP	National Emission Standards for Hazardous Air Pollutants
NOI	Notice of Intent
NRC	U.S. Nuclear Regulatory Commission
OCRWM	Office of Civilian Radioactive Waste Management
OOS	out of scope
ORNL	Oak Ridge National Laboratory
OSHA	Occupational Safety and Health Administration
PC	personal computer
PCCS	product composition control system
PERT	Program Evaluation and Review Technique
PFP	Plutonium Finishing Plant
PHP	pneumatic hydropulse
PIH	portable instrument house
PNL	Pacific Northwest Laboratory
PSAR	Preliminary Safety Analysis Report
PSD	prevention of significant deterioration
PSE	preliminary safety evaluation
PSW	phosphate/sulfate waste
PUREX	plutonium-uranium extraction
QA	quality assurance
RAEP	Radioactive Air Emissions Program
RCRA	Resource Conservation and Recovery Act
RD&D	research, development, and demonstration
REDOX	reduction oxidation
RL	U.S. Department of Energy Field Office, Richland
RLST	receipt and lag storage tank
ROD	Record of Decision
RRF	relative risk factor
SAIC	Science Applications International Corporation
SAR	safety analysis report
SBS	submerged bed scrubber
SEIS	supplemental environmental impact statement
SEPA	State Environmental Policy Act
SME	slurry mix evaporator
SMECT	slurry mix evaporator condensate tank
SRAT	slurry receipt and adjustment tank
SRS	Savannah River Site
SST	single-shell tank
TBP	tributyl phosphate
TCLP	toxicity characteristic leaching procedure
TGE	transportable grout equipment
TGF	Transportable Grout Facility
TOC	total organic carbon
TRAC	track radioactive components

TRU	transuranic
TRUEX	transuranic extraction
TSA	technical safety appraisal
TWREHO	Tank Waste Retrieval Equipment, Handling, and Operation
UO	unusual occurrence
UPS	uninterruptible power supply
UT	ultrasonic tested
VERT	Venture Evaluation and Review Technique
WAC	Washington Administrative Code
WAP	waste acceptance process
WAPS	waste acceptance preliminary specifications
WAS	waste acceptance specifications
WBS	work breakdown structure
WCP	waste compliance plan
WESF	Waste Encapsulation and Storage Facility
Westinghouse Hanford	Westinghouse Hanford Company
WFQ	waste form qualification
WIPP	Waste Isolation Pilot Plant
WQR	waste qualification report
WRS	waste retrieval system
WSRC	Westinghouse Savannah River Company
WVDP	West Valley Demonstration Project

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1.0 SUMMARY, FINDINGS AND RECOMMENDATIONS

1.1 INTRODUCTION

Uncertainty in the chemical compositions of defense nuclear wastes stored in tanks at the Hanford Site, delay in the startup of the U.S. Department of Energy's (DOE) vitrification facility located at the Savannah River Site (SRS), and technical, regulatory, and programmatic issues have raised questions about the ability of processes and facilities to treat high-level radioactive wastes stored at the Hanford Site as planned in the December 1990 baseline. As a result, a Hanford Waste Vitrification Systems Risk Assessment (Risk Assessment) was performed to determine if there are significant programmatic risks due to technical, regulatory, or programmatic uncertainties in the program to treat the high-level and transuranic (TRU) tank wastes at the Hanford Site. This report documents the scope, approach, findings, and recommendations for the Risk Assessment. Potential mitigating strategies and suggested additional investigations to diminish the risks are included in the recommendations.

Programmatic risk assessment involves determining the unfavorable outcomes that could occur due to uncertainties and evaluating the likelihood and consequences of those outcomes. The Risk Assessment identified the uncertainties associated with the double-shell tank (DST) waste treatment program and quantified risks to the development, design, permitting, construction, and operation of the processes and facilities needed to implement the program plan.

The assessment was performed from November 1990 through April 1991 and reflects the status of the program to remediate Hanford Site DST wastes at that time. The program continues to evolve based on input from many sources, including this Risk Assessment. An in-depth review of alternatives to resolve the risks identified in this document is currently underway and will be documented separately as a revision to the tank waste disposal program strategy. That document will evaluate the findings from the Risk Assessment, as well as options identified separately, and recommend a preferred strategy for the treatment of DST wastes, which will reduce the overall risk to the program.

1.2 BACKGROUND

A brief summary of the background for the DST waste treatment program is presented in this subsection. A more detailed discussion is provided in Section 3.0.

1.2.1 History

The Hanford Site, which is located near Richland, Washington, was involved in the production of nuclear materials for national defense since the mid-1940's. Production and interim waste management operations at the site have resulted in the generation of tank wastes in the form of sludge, slurry, saltcake, and liquid; encapsulated cesium and strontium; solid wastes; and contaminated soils and sediment from liquid effluents. Tank wastes are stored in both DSTs and single-shell tanks (SST). However, the SSTs are no longer in active operating service.

The DOE defined a strategy for the cleanup of defense wastes produced and stored at all its major sites in DOE/DP-0015, *Defense Waste Management Plan* (DOE 1983). A program was established to sequentially design, construct, and operate high-level waste (HLW) treatment plants at the Savannah River and Hanford Sites and the Idaho National Engineering Laboratory.

The Record of Decision (ROD) (DOE 1988) from DOE/EIS-0113, *Final Environmental Impact Statement: Disposal of Hanford Defense High-Level, Transuranic, and Tank Wastes, Hanford Site, Richland, Washington* (HDW-EIS) (DOE 1987), directed that DOE design, construct, and operate the Hanford Waste Vitrification Plant (HWVP) to process existing and future waste from the double-shell storage tanks. The ROD further directed: (1) completion of pretreatment modifications and operation of the pretreatment facility, planned to be the B Plant at the time of the ROD; (2) vitrification of the radioactive HLW fraction into a borosilicate glass waste form for ultimate disposal in a geological repository; (3) solidification of the low-activity fraction as a cement-based grout for permanent disposal in near-surface vaults located at the Hanford Site; and (4) continued safe storage of encapsulated cesium and strontium waste until a geologic repository is ready to receive them.

The ROD deferred a decision on final disposal of SST wastes pending additional development and evaluation. The results of this development effort were to be analyzed in a subsequent supplement to the HDW-EIS. While not specifically addressing final disposal of SST wastes, the ROD required that the HWVP be capable of processing Hanford Site SST wastes should a decision be made to vitrify these materials.

The *Hanford Federal Facility Agreement and Consent Order* (also known as the Tri-Party Agreement) (Ecology 1990) established a timetable for implementing the ROD. Major milestones defined in the Tri-Party Agreement included completion of 14 grout campaigns (September 1994), initiation of B Plant operations (October 1993), and initiation of HWVP operations (December 1999). Milestones also were established to complete closure of all 149 SSTs (June 2018).

The B Plant has been a key element in the program to vitrify the Hanford Site DST wastes. This 47-yr old facility was being upgraded to install processes to pretreat the DST wastes which would separate the small volume of highly radioactive constituents from the much larger volume of low-level waste (LLW). A study performed in 1989 and documented in WHC-SP-0464, *Assessment of Double-Shell Tank Waste Pretreatment Options*, Revision 1 (WHC 1990), addressed issues relating to the viability of B Plant as well as facility options for waste pretreatment. This evaluation favored the use of B Plant for the pretreatment mission because several of the planned processes are similar to those previously performed in the plant. The evaluation suggested that B Plant could be modified at a reasonable cost to comply with current regulatory standards and DOE Orders. Additionally, B Plant was the only facility identified in the study that could be available in time to support the milestone to initiate hot startup of the HWVP by December 1999. The study recommended the use of another existing facility, the 244-AR Vault, in conjunction with B Plant. Larger tanks in the AR Vault allowed the relocation of certain process steps from B Plant and afforded the potential to reduce the B Plant pretreatment mission duration by more than 4 yr, thereby minimizing the potential for HWVP standby. Acceptance of this recommendation by the DOE Field Office, Richland, in late 1989 provided the basis for the present baseline for disposal of DST wastes.

1.2.2 Present Baseline

The DST wastes at the Hanford Site are classified as HLW, LLW, and TRU wastes. Definitions are provided in Section 3.0. There are currently four DST waste types planned to be treated and vitrified at the Hanford Site. These waste types and their quantities are as follows:

- Neutralized current acid waste (NCAW) - 7,600 m^3 (2.0 million gal)
- Neutralized cladding removal waste (NCRW) - 4,500 m^3 (1.2 million gal)
- Plutonium Finishing Plant (PFP) waste - 3,000 m^3 (0.8 million gal)
- Complexant concentrate (CC) waste - 18,200 m^3 (4.8 million gal)

The NCAW and CC wastes are classified as HLWs while NCRW and PFP wastes are classified as TRU wastes. These wastes, as well as the existing LLW, are more fully described in Section 3.4.3. The quantities shown above include wastes assumed to be generated by future operations to reprocess the remaining irradiated reactor fuel and cleanup of existing processing plants at the Hanford Site. A final decision on reprocessing the remaining reactor fuel has not been made.

The scope of the DST waste vitrification program includes the characterization, retrieval, pretreatment, and disposal (vitrification and grouting) of approximately 33,300 m^3 (8.8 million gal) of radioactive wastes. These wastes are stored in 3,800 m^3 (1 million gal) underground storage tanks. A schematic diagram of the major program elements is shown in Figure 1-1.

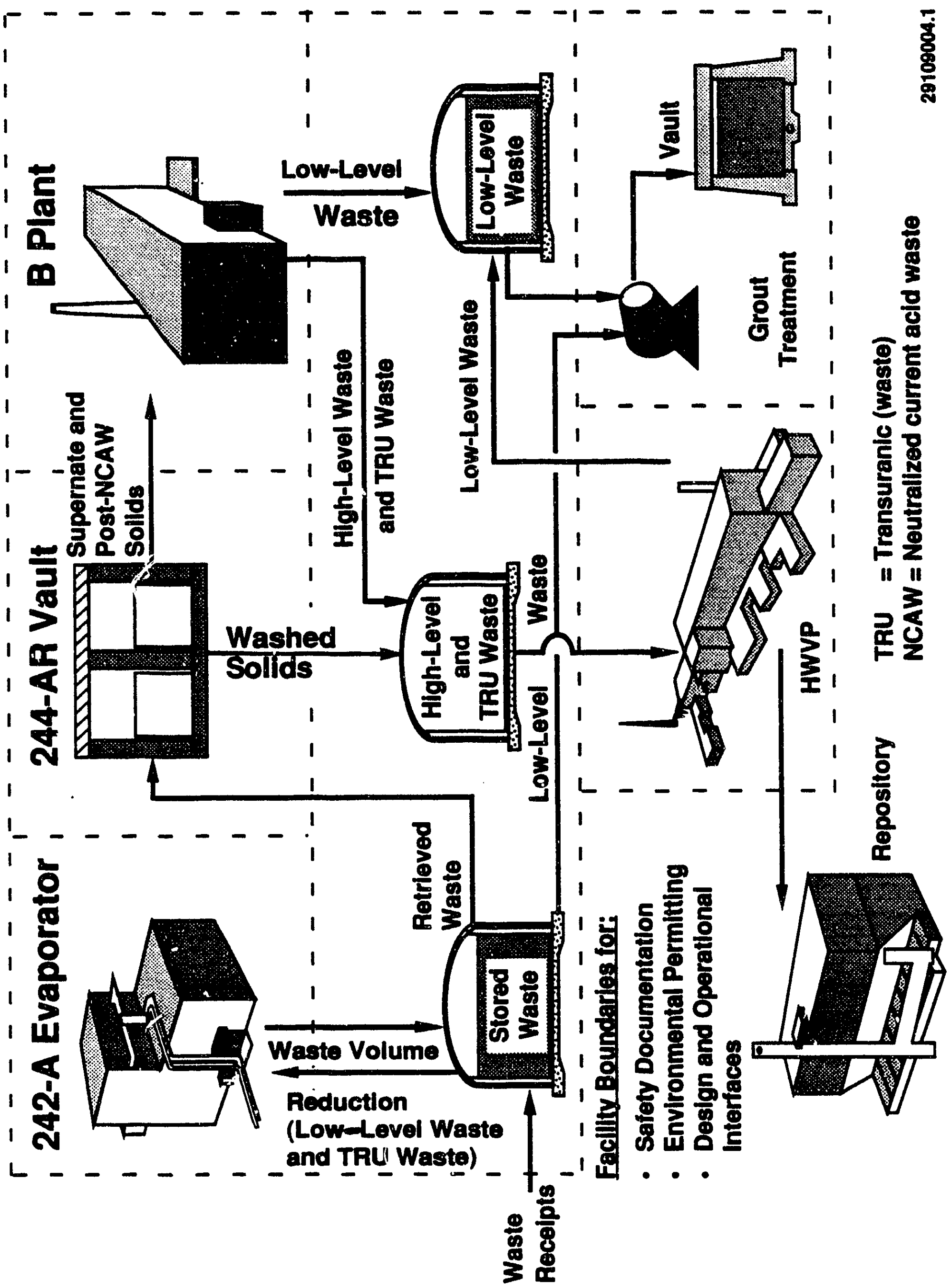
The wastes are being sampled to characterize their chemical constituents for the development of the pretreatment and vitrification processes and sampling also will identify physical properties, such as shear strength of sludges, needed to support the design of retrieval systems.

The tanks and their supporting infrastructure are to be upgraded to resolve current safety issues, achieve compliance with DOE Orders and environmental regulations, and support the retrieval and pretreatment operations.

Retrieval systems will mobilize the liquids and solids in the tanks for transport to the pretreatment facilities. Present plans are to retrieve the wastes using mixer-pump technology developed at the SRS.

Pretreatment processes will separate the small volume of highly radioactive HLW from the much larger volume of LLW. This separation minimizes the volume of waste to be vitrified. This process is necessary because the cost of treatment and disposal by vitrification is estimated to be approximately 70 times greater than treatment and disposal in grout. The technical baseline

Figure 1-1. Double-Shell Tank Waste Disposal Elements.



at the time the Risk Assessment was performed included processes for the following: (1) sludge washing to remove soluble chemicals from the radioactive sludge, (2) ion exchange to remove cesium from the supernatant, (3) dissolution of the sludges and transuranic extraction (TRUEX) to remove the TRU elements from the dissolved sludges; and (4) organic destruction for CC waste. The B Plant and the 244-AR Vault were planned to be the key pretreatment facilities.

The HLW separated by the pretreatment processes will be mixed with glass-forming materials and heated to high temperatures to form borosilicate glass. The molten glass will be poured into stainless steel canisters, cooled, sealed, and then stored at the Hanford Site until a geological repository is available for final disposal. The program baseline includes the construction of the HWVP, which is modeled after the Defense Waste Processing Facility (DWPF) at the SRS, as the vitrification facility. Site preparation for HWVP is currently scheduled to begin in April 1992.

The LLWs are mixed with cementitious materials and pumped into large, near-surface vaults where the grouted materials solidify. Once filled and solidified, the vaults are sealed and closed as landfills for permanent disposal. Disposal of several million gallons of existing LLW is required to provide tank space needed for retrieval and storage of the waste fractions following pretreatment. The grout processing facilities have been constructed; the first grout campaign has been completed; and 4 of the remaining 43 vaults were under construction when this report was issued.

Technology development needed to accomplish characterization, retrieval, pretreatment, vitrification of the HLW, and solidification of the LLW is included in the program scope.

The intent of the schedule baseline for the vitrification program was the sequential accomplishment of activities necessary to initiate the start of HWVP hot operations by December 1999. A summary level schedule is provided in Figure 2-1. More detailed schedules are provided in Figures 4-4 and 4-5 (see the pouches located at the back of this report).

1.2.3 Current Issues

Some phenomena in the DST wastes, such as the periodic release of potentially flammable gases from tank 101-SY, are not well understood. In addition, only a limited number of waste samples from the 28 DSTs have been analyzed due to necessary safety precautions, the complexity of collecting samples, and limited infrastructure available for analyzing radioactive materials. Though there is fairly complete information available for the first waste type to be processed (NCAW), limited information is available for the other waste types. This has led to questions about the adequacy of current knowledge of chemical composition of the wastes, and as a result, concern as to the suitability of planned processes and equipment.

Difficulties have been experienced in the startup of the first DOE vitrification plant, the DWPF at the SRS. Problems have been encountered in the DWPF distributed control, ventilation, and fire protection systems. Unexpectedly high hydrogen generation rates during formic acid addition have been observed in the DWPF feed preparation system. Safety classification requirements are being reassessed in light of requirements in DOE Order 6430.1A, *General Design Criteria* (DOE 1989), and startup planning has taken longer to complete than originally expected.

The DWPF provides much of the technology and the design basis for the HWVP. Many of the HWVP systems and equipment items are nearly identical to their counterparts in the DWPF. Delays in the startup of the DWPF have raised concerns that DWPF changes could impact the HWVP design.

The viability of B Plant as a mixed waste treatment facility for waste pretreatment has been questioned due to regulatory compliance and facility integrity concerns. Better understanding of the regulatory requirements and interactions with the Washington State Department of Ecology (Ecology) and the DOE suggested that the use of B Plant should be revisited because complex modifications, such as lining all the process cells for secondary containment, that were not currently planned might be required to achieve compliance. Corrosion of embedded piping by some of the pretreatment processes and the potential inability to continuously supply feed to the HWVP were additional concerns related to the use of B Plant.

The HWVP may be required to accommodate missions other than treatment of DST wastes. The ROD from the HDW-EIS required that HWVP be capable of processing Hanford Site SST wastes should a decision be made to vitrify these materials. In addition, recent studies have suggested that vitrification may be a more suitable means of treatment for the cesium and strontium capsules than over-packing prior to disposal in a geologic repository. The ability of HWVP to process these SST wastes had not been assessed.

These issues formed the basis for a reexamination of the technical, regulatory, and programmatic preparedness of the Hanford Site waste treatment program to proceed with construction of the HWVP.

1.3 SCOPE

All major elements of the DST waste treatment program were addressed in the Risk Assessment, as follows:

- Characterization of the wastes stored in the tanks
- Upgrades to the tanks and their supporting infrastructure
- Availability of storage tanks to support waste treatment and disposal operations
- Retrieval of the wastes from the tanks
- Pretreatment to separate the wastes into HLW (including TRU) and LLW fractions
- Vitrification of the HLW and TRU wastes

- Grouting of the LLW to the extent the Grout Program could delay or otherwise impact the completion of vitrification activities.

Assessments included: (1) complexity of the processes, (2) maturity of the technology, (3) compliance with regulations, (4) level of design definition, (5) capability to support safe and reliable operations, (6) state of development of safety and environmental documentation, (7) comparison with other waste vitrification programs, (8) and storage tank availability.

In addition, the capability and capacity of the HWVP to process SST wastes and cesium and strontium capsules were addressed in the Risk Assessment.

The in-depth evaluation of options and selection of a revised program strategy were not included in the Risk Assessment scope. But they are being accomplished as part of the tank waste disposal program strategy revision study, which will be documented separately.

A more detailed discussion of the scope of the Risk Assessment is presented in Section 2.0.

1.4 APPROACH

The Risk Assessment was performed as a joint project of the Westinghouse Hanford Company (Westinghouse Hanford) and Pacific Northwest Laboratory (PNL), with contract support from Science Applications International Corporation (SAIC). The Risk Assessment team consisted primarily of individuals knowledgeable of the program. Westinghouse Hanford performed most of the engineering assessments and provided management of the project; PNL provided technical leadership for the SST waste study and technical input on grout and vitrification issues; and SAIC performed the computer risk analysis and assessed compliance of the program activities to DOE Order 6430.1A.

An Advisory Board consisting of senior-level representatives from Westinghouse Hanford, PNL, DOE, Ecology, and the U.S. Environmental Protection Agency (EPA) provided interim and final review of the status and findings. Periodic technical reviews by Westinghouse Hanford and PNL experts not directly involved with the Risk Assessment also were held to provide independent appraisals of the approach and progress of the Risk Assessment.

The Risk Assessment provided a macroscopic review of the entire program to remediate DST wastes as it was defined at the time the assessment was performed. The program baseline, including scope, technical approach, cost, and schedule as of December 1990, was the basis against which uncertainties were identified and risks were estimated. As noted earlier, program options to mitigate the risks were not evaluated in this assessment but are under development based on the preliminary results from this Risk Assessment.

The DST waste treatment program has been underway for a number of years and the elements of the program are well defined. Consequently, it was possible to conduct a systematic and detailed assessment of the program. The evaluation identified and assessed uncertainties and attendant risks associated with the more than 200 activities required to characterize, retrieve, pretreat, vitrify, and grout DST wastes, including related technology development. Additionally, the program schedule was examined for completeness and accuracy of the logic ties between activities.

A network model of the DST waste program activities was created, and a computer analysis was performed to quantify the risks to the program. The Venture Evaluation and Review Technique (VERT) software package developed by the U.S. Army was used to estimate the programmatic risks associated with each element and to assess the overall risks to the program. The VERT results provided the basis to quantify the risks and identify the critical issues.

The VERT software is a Project Evaluation and Review Technique (PERT)-based program management tool that was used to model the program activities, including their logical ties. Cost estimates and schedule durations were developed for optimistic, most likely, and pessimistic cases. Probabilities of success were estimated for completing each activity within the most likely schedule duration. The definition of activities and their logical ties were derived mostly from existing program planning documents.

Estimates of probability of success were established based on a set of descriptive statements developed as part of the Risk Assessment (see Table 4.1.) Probabilities were assigned to each statement based on the judgment of the Risk Assessment management team. As such, the percentages are subjective, yet provide a consistent, relative measure of uncertainty for each activity. The cost and schedule distributions were developed by the program and project engineers and managers responsible for performing the activities, and they were reviewed by the Risk Assessment management team to minimize bias and provide proper balance. The activities, probabilities of success, and cost and schedule distributions are listed in Appendix A.

The VERT software package performs an iterative, Monte Carlo-type probabilistic analysis of the cost and schedule distributions to develop histograms of total program cost and duration as a function of probability (see Figures 4.9 and 4.10). Post-processing of the VERT results was used to quantify the relative risks for each activity and to aggregate these "relative risk factors" for each of the major areas of the DST program (see Section 4.6). It is important to note that these numerical quantities are based on relative, but subjective, scales and therefore are appropriate in comparing one activity or program area against another. But they are not an absolute measure of risk.

Risks were quantified in terms of the following: (1) risk to success, which is a measure of the perceived ability to resolve technical and regulatory uncertainties; (2) cost risk, which is a measure of the potential of not completing the program activities within the baseline cost estimates; and (3) schedule risk, which is a measure of the potential of not completing the program activities within the baseline schedules. Although these three measures of risks are not independent, this method of quantification provided the means to identify the dominant sources of risk in the program. These separate risk components provided a basis to help define the types of mitigating strategies needed to resolve the identified risks.

The risks also were assessed qualitatively using the judgment of the Risk Assessment management team and other technical and program experts to ensure that the numerical results represented a reasonable estimate of the state of the program. The combination of the numerical results and the qualitative judgments was used to identify the most substantial risks.

More detailed discussions of the numerical methods used to quantify risks, including the VERT software and its implementation for the Risk Assessment, are presented in Section 4.0 and Appendix A.

The scope of the Risk Assessment for SST wastes and cesium and strontium capsules was more limited because these materials are not currently part of the vitrification program, and plans for their disposal are still under development. Therefore, the approach taken to assess the risks associated with these materials focused on key issues and uncertainties that could impact the HWVP design. A less complex method of quantifying the risks was used for these assessments; no computer model was created. A risk matrix that utilized consequences of each uncertainty, estimated in terms of program cost and schedule impacts, and the probability of each uncertainty causing significant impacts was used to establish the relative risk for each uncertainty (see Section 5.0).

The risks identified by this assessment are those associated with the DST waste treatment program as it was defined in December 1990. The quantification of the risks does not attempt to account for the routine resolution of uncertainties and mitigation of risks that occur during the normal progression of a program. Therefore, these results are only relevant to the program as it existed in late 1990.

All costs presented in this document are normalized to 1991 dollars, i.e., they do not reflect escalation.

1.5 FINDINGS

The most significant uncertainties to the program and their potential consequences are summarized in this subsection. Uncertainties for each major program element, and recommendations of potential mitigating strategies to minimize the risks, are also discussed. Background and status information are provided as necessary to explain the uncertainties.

The DOE had requested that preliminary results from the Risk Assessment be provided by December 1990 to support out-year budget planning. Many of the uncertainties and associated risks identified in this document were defined in the "preliminary findings" presented to the DOE, Ecology, and the EPA in meetings held in December 1990 and January 1991. Potential mitigating strategies also were identified, some of which are included in the recommendations noted below. These preliminary findings provided the basis for the initiation of evaluations of program options and the development of a revision to the DST waste disposal program to resolve uncertainties and associated risks in the program. Those evaluations have been proceeding in parallel with the completion of the Risk Assessment and will be documented separately.

1.5.1 Major Uncertainties

The major uncertainties in the program are listed below. See Sections 1.5.4, 1.5.5, and 1.5.6 for further discussions on these uncertainties and the status of these resolutions. See Sections 4.3, 5.0, 6.0, and 7.0 for a complete discussion of all program uncertainties. An explanation of the major uncertainties follows:

- Acceptability of B Plant
- Waste composition variability
- Waste retrieval
- Tank safety issues and Tank Farm upgrades
- Pretreatment technology
- Lack of integration of DST and SST waste programs
- Closure of SSTs by 2018
- Availability of DST space
- Availability of funding.

Acceptability of B Plant--The dated design of B Plant and the potential inability to unequivocally demonstrate compliance to modern regulatory requirements is a significant uncertainty to the baseline program. Planned upgrades may not be sufficient to demonstrate compliance, and further upgrades may be substantially more difficult and costly to implement. The cumulative impact of other uncertainties, including corrosion of embedded piping and the ability to accommodate future process operations, further challenges the viability of using B Plant for the pretreatment mission.

Waste Composition Variability--Wastes stored in the DSTs have not been adequately characterized to bound the potential impacts on most retrieval and treatment processes, particularly those related to pretreatment. Though valuable for developing many of the treatment processes, the available data (except for NCAW) are insufficient to complete development activities. Waste sampling operations were delayed nearly 1 yr due to tank safety concerns, and competing priorities combined with limited resources may cause further delays in obtaining samples for the DST waste treatment activities.

Waste Retrieval--The substantial variation in physical properties of the four waste types, the uncertain condition of the storage tanks and the potential impacts those conditions could have on retrieval system designs, and delays in retrieval process development are major uncertainties to the program. The potential need to remove the existing sludge heel in the initial HWVP feed tank could delay availability of feed to HWVP to support startup. Additional time to resolve this issue could be available if in-tank sludge washing is used.

Tank Safety Issues and Tank Farm Upgrades--Unexplained releases of potentially flammable gas releases highlighted the uncertainty in waste compositions. These releases and other tank safety issues were a key reason for performing the Risk Assessment because of the implications these unresolved concerns could have on the processes for retrieval and treatment of the wastes. Though efforts are proceeding to resolve these issues, resolution could result in new insights into chemical interactions and processing requirements for these wastes. Similarly, planned Tank Farm compliance upgrades may require substantially more resources than currently envisioned.

Pretreatment Technology--Technically complex pretreatment processes are planned for three of the four waste types to dissolve the sludges and extract TRU elements. Furthermore, an organic destruction process must be developed for one of those three, the CC waste. Though these processes will substantially reduce the volume of wastes to be vitrified, and therefore the overall cost of waste disposal, only the dissolution and TRUEX processes have been demonstrated, and only in laboratory-scale experiments. Delays already experienced in their development and scaling of these processes to pilot- and full-scale plants represent uncertainties in the program.

Lack of Integration of Double-Shell and Single-Shell Tank Waste Programs--Lack of integration of the planning for the DST and SST waste disposal programs could extend the time to clean up the Hanford Site and result in substantial costs, which may be avoidable. Planned processes, facilities, and processing schedules for the treatment and disposal of the SST wastes have not been sufficiently developed to integrate with planning for disposal of DST wastes (the HDW-EIS ROD deferred the decision on disposal of SST wastes). As a result, redundant (and costly) pretreatment facilities may need to be constructed for DST and SST wastes. In addition, HWVP could be shut down for as long as 10 yr between the DST and SST processing campaigns. Recovery from an outage of that duration could be difficult and costly due to the potential for changing regulatory requirements.

Closure of Single-Shell Tanks by 2018--The current plan to prepare the supplemental environmental impact statement (SEIS) for the SST wastes and to receive a permit for the SST treatment facilities will not support closure of the SSTs by 2018 as required by the Tri-Party Agreement. Though not a direct risk to the DST waste treatment program, this uncertainty is related to the lack of integration between the DST and SST waste programs.

Availability of Double-Shell Tank Space--Available DST free volume is minimal due to the amount of wastes in storage and the need to keep each waste type separate. Pretreatment operations will increase the volume of the wastes. Because the high- and low-level waste streams must be segregated after pretreatment, additional tank space must be available beginning in the mid- to late-1990's. Grouting of the double-shell slurry (DSS) and double-shell slurry feed (DSSF) wastes must proceed to provide the needed space. The expected start date for grouting of DSS and DSSF wastes has been delayed (currently projected at 27 months) due to difficulties in developing a suitable grout formulation and the need to modify the grout vault diffusion barrier to meet leachability performance requirements. Further delays in grouting the DSS/DSSF wastes due to challenges to the amount of treatment planned for these wastes would deny the DST waste treatment program the tank space needed to support pretreatment of the HLWs and would result in a major delay in the startup of HWVP.

The magnitude of the consequences from the potential need to pretreat the DSS/DSSF wastes, coupled with growing demands for tank space, indicate that tank availability poses a significant risk. Waste streams from existing facilities, delays in restart of the 242A evaporator, required interim stabilization of SSTs, remediation of both DST and SST safety issues, and retrieval demonstrations from SSTs all may require additional tank space in the mid- to late-1990's. Results presented in Section 7.0 show there is a significant risk that the DST capacity could be insufficient in the next 5 to 10 yr if grouting operations do not proceed as planned. The potential DST program impacts are severe if the recently planned four new tanks, plus four additional tanks under consideration, are not constructed.

Furthermore, the DSTs are expected to be used to store SST wastes prior to treatment. Sufficient DST capacity to support the timely retrieval and pretreatment of the SST wastes may not be available to ensure closure of the SSTs by the year 2018. Retrieval from a significant number of SSTs would create a substantial volume of waste that could easily exceed the total volume of the existing DSTs.

Availability of Funding--Better definition of the major DST waste program elements and supporting and competing programs, such as Tank Farm safety issue resolution and facility upgrades, continues to provide a clearer understanding of the total resources required to perform all committed cleanup actions at the Hanford Site. Total capital and expense costs for all the DST waste treatment program activities necessary to begin operations of HWVP, including construction of HWVP and upgrades to the Tank Farms, are expected to be $3.0 billion to $3.5 billion in 1991 dollars. These funds, plus several hundred-million dollars more to prepare for follow-on feeds to HWVP, will be needed by 1999. Competition for funding will make completion of the DST waste treatment program within the baseline schedule a significant challenge. The ability to obtain sufficient funding in light of competing programs and other Tri-Party Agreement commitments, as well as pressures to reduce government deficits, is a significant uncertainty in the current program schedule.

1.5.2 Major Potential Consequences

The Risk Assessment Team identified a number of uncertainties with the DST waste treatment program. Though many of these have minor consequences, the major uncertainties presented in Section 1.5.1 and the cumulative impact of all other uncertainties have major potential consequences which result in significant risks to the program. All the uncertainties for each element of the program are addressed in Sections 4.0 through 7.0. The potential consequences of the major uncertainties include substantial cost increases and extended schedule delays. Numerical results, which quantify the risks in the DST waste treatment program, are presented in Section 4.5.

The most significant potential consequences that could result from the uncertainties and which must be resolved in the replanning of the DST waste treatment program are as follows:

- Need for new pretreatment capability
- Lack of feed for HWVP startup
- Lack of feed continuity to HWVP
- Increased total program duration and cost.

<u>Need for New Pretreatment Capability</u>--As noted earlier, the acceptability of B Plant and the resultant ability to obtain the necessary regulatory and environmental permits was identified as the most significant uncertainty in the DST waste treatment program as currently defined. Inability to use B Plant would require the identification of alternate facilities, and potentially different processes, to provide pretreated wastes to the HWVP. It may be possible to define alternate processes and facilities that could be implemented in time to proceed with the program in a timely manner. However, alternatives that require a new pretreatment facility could result in a substantial cost increase for the program and several years delay in startup of the HWVP. This could result in a substantial delay in completing the cleanup of the wastes stored in the DSTs.

<u>Lack of Feed for Hanford Waste Vitrification Plant Startup</u>--There is a significant probability that pretreated waste will not be available to support hot startup of the HWVP by December 1999 and that startup could be delayed by as much as 4 yr.

For the baseline program, the principal sources of delay are as follows: (1) the possible need to remove the sludge heel from the initial feed tank for the HWVP before it can be filled with pretreated waste, and (2) the postponement of waste retrieval system development due to changes in funding source, funding redistributions in fiscal year (FY) 1991, and reduced funding guidance for FY 1992.

If B Plant is determined to be unacceptable, alternative facilities and/or methods must be utilized for pretreatment of the wastes prior to vitrification. If a new pretreatment facility is constructed to provide all pretreated wastes to HWVP, hot startup of HWVP could be delayed substantially longer (by as much as 8 to 10 yr). Other alternative pretreatment processes and/or facilities, such as in-tank sludge washing and/or a simplified pretreatment head-end to HWVP, might provide continuous feed to HWVP for several years while a new, large pretreatment facility is designed and built. This could minimize the delay to HWVP startup assuming the other causes of the delay were mitigated.

<u>Lack of Feed Continuity to Hanford Waste Vitrification Plant</u>--Delays in the development and implementation of retrieval and pretreatment processes and equipment could deny a continuous supply of feed to HWVP. This could cause a significant increase in the life-cycle costs for this facility because the HWVP will be costly (approximately $75 million/yr) to maintain in a standby mode. Three or more years of HWVP outage after the NCAW campaign could result

from a lack of feed to the plant. In addition, if the remaining N Reactor fuel is not processed, the reduction in quantities of NCAW and NCRW could increase the total outage to approximately 4 yr.

Increased Total Program Duration and Cost--Delays in completing the DST waste treatment program would not only extend the time to complete cleanup of these wastes but also would introduce the risk of substantial cost increase for the program. The baseline program to vitrify DST wastes was scheduled to be completed in 2009. The VERT model identified the potential for delays of up to 7 yr to complete the program. Major sources of potential delay include: (1) the development and implementation of retrieval systems; (2) pretreatment processing; (3) waste characterization; (4) design, construction, and operation of the TRUEX pilot plant; and (5) HWVP. These items could also potentially delay HWVP startup. With an average cost of approximately $100 million to $150 million/yr (in 1991 dollars) to maintain the pretreatment and vitrification facilities in a standby mode as well as retain program management, engineering, full operating, maintenance, and other support staff throughout the life of the program, a 7-yr extension to the program could increase costs from $700 million to $1.0 billion. The VERT model also indicated the potential for an additional cost increase of up to $1.0 billion due to the impacts of the inherent uncertainties in the program. These represent a combined cost risk of $2.0 billion.

1.5.3 Future Processing Missions

The risk to the program that the HWVP will not be capable of supporting future processing missions is minimal due to the flexibility designed into the plant and the processing options available for preparing these materials for vitrification. Specifically:

- The current HWVP design appears to be adequate for the vitrification of the SST wastes. The production capacity will support the vitrification of all 149 SSTs if the wastes are pretreated to concentrate the HLW fraction. The process equipment planned for the DST wastes is appropriate for the SST waste compositions (see Section 5.0).

- Vitrification of the cesium and strontium capsules is feasible and cost effective as an alternative to the current plan to over-pack the existing capsules for disposal in a geologic repository. No significant uncertainties in the HWVP design were identified, based on the assumption that capsule disassembly occurs in a facility other than HWVP (see Sections 1.5.4 and 6.0).

1.5.4 Double-Shell Tank Wastes

The DST waste program activities that have the greatest technical and regulatory uncertainties (listed in the order of greatest risk) are: (1) the pretreatment facilities (B Plant and AR Vault); (2) pretreatment technology development; (3) waste retrieval development; and (4) HWVP (waste acceptance preliminary specifications). The greatest schedule risks to the program come from waste retrieval and pretreatment facility activities, in that order. The HWVP has the greatest cost risk, followed by retrieval and pretreatment facilities. Waste retrieval also has the greatest risk of delaying HWVP startup beyond December 1999. A full discussion of the technical assessments and findings is presented in Section 4.0. Quantification of the risks is presented in Section 4.5.

Significant results and recommendations relating to the assessment of vitrification of DST wastes are documented in the following subsections.

1.5.4.1 Results. Significant background information, uncertainties, and status of key issues (where appropriate) are presented in this section for each major element of the DST waste treatment program.

Characterization--Historical process data and the completion of approximately 25 percent of the planned sampling operations provide data needed to develop the processes for the treatment of these wastes. Data available for NCAW, plus experience with similar wastes at the Savannah River and West Valley Sites, minimize the level of uncertainty relative to this waste type. Delays in characterizing the DST wastes due to resolution of tank safety issues, limited availability of sampling and laboratory resources, competing characterization priorities, and funding redistributions are affecting the ability to finalize the processes and plans for retrieval, pretreatment, vitrification, and grout. The sampling program for these wastes was deferred nearly 1 yr until a new sample was taken from tank 101-SY in May 1991 to support resolution of the tank safety issues.

Delays in obtaining sufficient waste characterization data result in an associated uncertainty that changes to process systems or equipment may be required once the waste compositions are better known if the compositional variability of the wastes is significantly different than current data suggest. Significant progress was made in resolving the tank safety issues in the first half of 1991 as evidenced by the renewal of tank sampling operations. Plans are being developed to expedite characterization of the wastes once tank sampling operations are fully resumed, but the priority of sampling needs of retrieval, pretreatment, and vitrification will have to be balanced against the other sampling needs at the Hanford Site.

Waste characterization supports the other elements in the program. Because of the method used to quantify risks, the numerical results presented in Section 4.5 understate the magnitude of the risk related to characterization. The impacts of delays in sampling and analysis, and the resultant uncertainties in the treatment process designs due to waste compositional uncertainties, are measured mostly with the affected activities, such as retrieval, and not as a risk to characterization.

Retrieval--Preparations for retrieval of NCAW are based on SRS mixer-pump technology and experience and are therefore reasonably well defined. However, due to the multiple waste types at the Hanford Site, application of this technology to the other three waste types is a significant uncertainty. Development and implementation of waste retrieval systems for DST wastes present the most significant schedule risk and one of the most significant technical risks to the program. This is due to: (1) technical challenges from the substantial variation in physical properties for the four waste types and lack of detailed characterization data available on those physical properties; (2) the uncertain condition of storage tanks and the potential impacts those conditions could have on the retrieval system designs; (3) competition for physical space and work force resources at the Tank Farms during construction and operations; and (4) changing the funding source for the retrieval projects from expense to capital (which delayed availability of funds until the conceptual design reports were completed), funding limitations in fiscal year (FY) 1991, and anticipated budget shortfalls in FY 1992.

One of the primary sources of potential delay to the startup of HWVP is the possible need to remove an existing sludge heel from the initial HWVP feed tank before it can be filled with pretreated waste. The heel is a collection of miscellaneous wastes resulting from using this tank as a receiver for cross-site transfers. This sludge has a high chloride content, which could cause accelerated corrosion of the stainless steel components in the HWVP. Removal of the heel, should that be required, may not be completed in time to support start of pretreatment operations. One of the new DSTs planned to be built at the Hanford Site could be used as the initial feed tank for HWVP if the tanks are constructed in time to support HWVP startup or in-tank sludge washing could provide additional time to resolve this issue.

Pretreatment Technology--Sufficient development and testing have been performed to provide relatively high confidence in the sludge washing, filtration, and ion-exchange processes required for NCAW, the first waste type to be pretreated. However, development of the waste pretreatment processes, particularly those involving sludge dissolution, TRUEX, and organic destruction for the post-NCAWs is one of the most significant technical uncertainties in the program.

A review of the Hanford Site waste pretreatment technology activities by an expert panel chartered by DOE-Headquarters indicated that a thorough job had been done in identifying and planning work needed to complete development of the pretreatment processes (sludge washing, ion exchange, filtration, TRUEX, and complexant destruction). Although much laboratory work remains to be done, especially for the post-NCAW processes, the panel found no significant problems that would prevent successful development of the processes, although the potential for schedule delays was recognized. The tank waste disposal strategy redefinition study will address a solution to this schedule concern.

However, implementation of the TRUEX and organic destruction processes must undergo a substantial amount of development before they can be implemented in a processing plant. The acid dissolution and TRUEX processes have only been demonstrated in laboratory-scale tests at this time, however, a pilot-plant is being planned to demonstrate this technology. Uncertainties in scaling these processes to pilot-scale, and ultimately full-scale, might result in changes that could delay availability of this system to provide feed to HWVP. Development of the organic destruction process is in its infancy; process and facility requirements are not well defined. The potential impacts of this process on facility requirements are not well understood.

The Risk Assessment model shows that the TRUEX process development falls on the critical path schedule for the program and, as a result, introduces a risk of program delay. Schedule delays already have occurred due to better definition of the work scope for the TRUEX pilot-plant and funding redistributions in FY 1991 to resolve tank safety issues. In addition, the schedule to implement TRUEX in B Plant appears to be overly optimistic. Technology development for pretreatment of the NCRW, and PFP and CC wastes may not be resolved on a schedule that would permit the timely design and construction of the TRUEX equipment.

The final step in the verification of the TRUEX technology is the operation of a pilot plant to be located in the Waste Encapsulation and Storage Facility (WESF) annex to B Plant, as well as selected process cells in B Plant. The pilot plant will be used to verify the waste processing flowsheets for the NCRW, and PFP and CC wastes, to confirm materials selection for the process equipment, and to provide feed to the HWVP bench-scale melter tests required for qualification of the glass waste form. Current planning completes testing with the first waste type (NCRW) in parallel with completing the design of the TRUEX plant systems approximately 3 yr before actual plant operation with NCRW is scheduled to commence. Significant technical issues uncovered during pilot-plant testing could necessitate redesign of the plant TRUEX system and jeopardize feed continuity to HWVP. Thus, it is prudent to reexamine the technical approach for development and implementation of the TRUEX process.

Pretreatment processing of CC wastes may take substantially longer than previously assumed and could cause a 1- to 2-yr delay in program completion if process equipment sizing is not optimized for this waste type.

Pretreatment Facilities--The B Plant is a large canyon-type facility with multiple process cells and a history of processes similar to those planned for DST waste pretreatment. The planned upgrades to the facility were previously estimated to be less costly and more readily implemented than the construction of a new facility. The B Plant has many attributes, such as process and operating flexibility, appropriate for the pretreatment mission. However, its dated design developed to standards less stringent than those in use today presents the most significant overall risk in the baseline program.

The principal issues concerning B Plant are compliance with current DOE Orders and regulatory requirements, the ability to accommodate the TRUEX and organic destruction processes, and numerous other, lesser uncertainties related to its age. The ability of the B Plant and the AR Vault to comply with regulatory requirements for double containment of radioactive and hazardous wastes as contained in DOE Order 6430.1A and *Washington Administrative Code* (WAC) 173-303, *Dangerous Waste Regulations* (Ecology 1991), must be demonstrated to the satisfaction of the DOE and Ecology. The objective has been to demonstrate full compliance of B Plant to the technical requirements of the applicable regulations. This has not been completed to date, though a report, WHC-SD-HWV-TI-017, *B Plant Secondary Containment System Description and Analysis* (Corcoran 1991), has been submitted to the DOE for their concurrence.

Unequivocal demonstration of compliance to current DOE Orders and regulatory requirements for B Plant will be difficult unless the facility is modified to provide specific technical features identified in the regulations. Current plans are to modify many, but not all, of the plant features to modern requirements. For example, plans do not include lining all the process cells to ensure double containment. Even if agreement can be reached in the near future on the approach to secondary containment, compliance will not be fully demonstrated until Ecology issues a dangerous waste permit for the facility. Preparation and approval of the permit application is not expected for several years, which would maintain B Plant as an open risk in the program.

Additionally, B Plant piping may not be compatible with corrosive solutions generated during pretreatment operations with the TRUEX process. Process changes and/or replacement of some of the embedded pipes with corrosion-resistant materials could resolve this uncertainty if the changes are shown to be feasible.

There are a number of other technical issues related to the use of B Plant, including seismic qualification and a number of facility upgrades (e.g., replacement of safety-class equipment and the canyon crane), that must be completed to qualify the plant for its pretreatment mission. (Recent analyses indicate that seismic problems may not be severe, but the analyses had not been independently reviewed when this report was issued.) Other uncertainties, such as the need for closed-loop cooling, could result in additional modifications not currently in the baseline plan. The B Plant also has experienced steam condensate and chemical leaks that, while not related to a new pretreatment mission, demonstrate cumulative problems with the design of B Plant. These uncertainties add risk to the program.

The uncertainties associated with B Plant also present potential risks to the TRUEX pilot plant because the WESF is dependent on B Plant for support services.

Hanford Waste Vitrification Plant--The HWVP will be a new, second-generation canyon and hot-cell facility modeled after the DWPF. The development of the HWVP process and facility design has benefitted from more than 20 yr of vitrification technology and pilot- and plant-scale operating experience in the United States and foreign countries, including France, Germany, Belgium, Japan, and Great Britain. Because of this experience, the basic technology and plant design for HWVP are not considered to be major uncertainties in the program.

However, a number of technical uncertainties that could result in process or facility changes remain to be resolved in implementation of the vitrification process in the HWVP. These uncertainties include: (1) lack of an approved set of waste acceptance criteria from the repository; (2) open technical issues under investigation at the SRS and Hanford Site such as hydrogen generation in the waste feed formating process and noble metals deposition in the glass melter; (3) lack of firm definition of feed composition to the plant for three of the four waste forms; and (4) lack of acceptance of the supplemental environmental analysis for the facility. In addition, the plant capacity may be inadequate to process the increased volume of wastes within a reasonable time if the TRUEX process is not successful in substantially reducing the total amount of wastes to be vitrified.

The HWVP will be the largest construction project on the Hanford Site in many years. This $1.06-billion plant will be subject to the inherent uncertainties of design changes, schedule delays, and cost increases experienced by all large nuclear construction projects. Because of its substantial cost and the noted uncertainties, it was identified as having the greatest overall cost risk to the program.

The HWVP Project has benefitted significantly from the lessons learned at DWPF and from technical exchanges with the West Valley Demonstration Project (WVDP) and foreign countries. A close working relationship has been developed and maintained with the DWPF Project Office. A Hanford Site manager has been in residence at DWPF since 1988, and technical exchange meetings between the DWPF and HWVP Projects have been ongoing routinely since 1985. Technical issues with the DWPF related to the distributed control, ventilation, fire protection, and safety-class systems have been resolved in the HWVP design as a result of these exchanges.

Because it is a second-generation design, the risks associated with HWVP are expected to be less significant than for a comparably complex, first-of-a-kind facility. The DWPF Project already has addressed, and will continue to address, issues that otherwise would have had to be resolved by the HWVP. Because of the schedule differences between the two plants, in all likelihood these issues will be resolved by DWPF before HWVP could be adversely impacted.

One of the primary purposes of the Risk Assessment was to address the risks associated with the start of construction of HWVP. Though there are a number of uncertainties to be resolved in the project, design features and program circumstances limit the risk that inordinate design changes will occur during the construction phase. However, as noted earlier, without changes in the baseline program planning there is a substantial uncertainty that feed will not be available to initiate hot operations. Long stand-by periods also could be experienced while waiting for the pretreated feed if construction proceeds on its present schedule.

The possible inability to maintain continuous feed to the HWVP following the NCAW campaign introduces a significant potential to increase HWVP life-cycle costs. Development and implementation of the waste retrieval and TRUEX processes for NCRW may take substantially longer than assumed in the baseline schedule, resulting in a potential 2 yr or more delay in providing NCRW feed to HWVP. The HWVP will be costly (approximately $75 million/yr) to maintain in a standby mode when feed is not available. Estimates from the VERT model show a potential for a total of 3 or more yr of outage for HWVP after the NCAW campaign as a result of a lack of feed to the plant for the DST waste program.

The baseline HWVP operations schedule includes the time required to vitrify additional NCAW and NCRW resulting from plutonium-uranium extraction (PUREX) processing of the remaining irradiated N Reactor fuel. If the PUREX Plant does not resume operation, HWVP downtime could be increased to 4 yr or more due to the lower volume of waste to process and the resultant shorter processing time in HWVP.

Double-Shell Tank Farms--Waste composition uncertainties highlighted by the tank safety issues were one of the key reasons for performing the Risk Assessment because of the potential implications the compositional uncertainties could have on retrieval and pretreatment processes. Substantial progress has been made in planning a program to address the safety issues and upgrade Tank Farm facilities to continue safe and environmentally sound storage of wastes. Tank Farm activities also have been identified to support pretreatment, vitrification, and grouting operations, further defining the scope of Tank Farm modifications. As a result, activities and resource requirements for Tank Farm upgrades have been identified that were not fully understood when the current DST waste treatment program baseline was established.

Uncertainties in the Tank Farms present a risk to successfully completing the upgrades as well as risks of cost increases and schedule delays. Significant uncertainties include: (1) the ability to resolve identified deficiencies with these older facilities; (2) the possibility that not all major upgrades have been identified because of the condition of the facilities; and (3) the total scope of the upgrades and the resultant competition for resources in terms of funding, personnel, and ultimately physical space that could hamper progress in the completion of the DST mission.

Delays in resolving tank safety issues, such as flammable gas releases, and completing upgrades to the facilities could delay waste sampling and characterization activities needed for the development of the DST waste treatment facilities. In addition, waste retrieval operations could be delayed. Delay in these activities would postpone the startup of HWVP and the completion of the DST waste treatment program.

A review of DST waste volume projections shows that adequate tank space will not be available to support the retrieval and pretreatment of the NCRW and PFP and CC wastes within the baseline schedule unless grout processing of existing LLW proceeds or new tanks are constructed (see Section 7.0). Four additional DSTs are currently planned to be constructed and commissioned, with four more under consideration. A lengthy delay in the grouting of the DSS and DSSF wastes would significantly delay the DST pretreatment and vitrification activities due to lack of tank space until additional DSTs, beyond those currently being planned, are constructed and commissioned.

Grout--Because the Grout Program is focused on the treatment of existing LLW for the next several years, the potential impacts to HLW treatment from this program are limited unless grout operations are delayed substantially. Therefore, the Risk Assessment did not address the overall technical adequacy of the Grout Program, but rather, it focused on potential impacts that could substantially delay the program and thereby affect tank space availability.

Delays have occurred due to uncertainties in the program. A 27-month delay is currently being negotiated in the Tri-Party Agreement milestones because of technical uncertainties. These uncertainties include: (1) the ability to establish a grout formulation which has suitable leachability characteristics for hazardous materials while limiting heat of hydration that can affect the grout performance; (2) structural requirements and analysis of an asphalt concrete diffusion barrier added to the vaults to limit leaching to the groundwater; (3) lack of waste composition data for multiple tanks of LLW; and (4) lack of formal acceptance of the performance assessment for the grout vaults.

The current ruling of the U.S. Nuclear Regulatory Commission (NRC) on the Hanford Site tank wastes resulted in the designation of DSS and DSSF wastes as LLW. However, the states of Washington and Oregon have submitted a petition to the NRC requesting a revision to their ruling that would require the treatment of all tank wastes to remove the largest technically achievable amount of radioactivity before grouting. The NRC's resolution of this petition could result in the need to pretreat some or all of the DSS/DSSF wastes. Because these wastes were designated LLW, the baseline program was established on direct grouting of the DSS and DSSF wastes with no pretreatment. No processing capacity currently exists to perform pretreatment of the LLW, so a substantial delay in the grouting activities could result if pretreatment is required. This could impact the availability of tank space to perform pretreatment operations for the DST HLW, and delay the vitrification of those wastes. The B Plant could be modified for an LLW pretreatment mission, but pretreatment of the LLWs in B Plant would delay pretreatment of the HLW, and would have similar uncertainties as those associated with the HLW pretreatment mission.

1.5.4.2 Recommendations. Recommendations to resolve the major uncertainties and mitigate the significant risks to successful completion of the vitrification mission for DST wastes are noted. Those recommendations being evaluated when this document was issued are identified.

Characterization--Estimates of waste composition variability for those elements important to the process designs should be established for all DST HLW and TRU wastes using process flowsheets from the plants that generated these wastes, and from existing tank sample data. Correlations should be drawn between the process and sample data to establish ranges of compositional uncertainty for each waste type. This activity is partially underway in the Tank Farms Projects organization.

Each of the process designs for retrieval, pretreatment, and vitrification should be reviewed against the waste composition uncertainties to be identified in the composition variability study. These results should be used to revise tank sampling needs and update or identify compositional variability requirements for the process designs. Problems due to compositional variability should be anticipated and evaluations performed to determine if current designs will be adequate. Requirements and/or designs should be modified accordingly. This activity cannot be completed until the waste variability study is completed.

Timely resolution of the Tank Farm safety issues is necessary to minimize risks associated with waste characterization. This activity is proceeding. Efforts to prioritize sampling and analysis of all Hanford Site tank wastes and to assess sampling and analysis needs should be completed expeditiously. Means to maximize use of existing sampling trucks and analytical laboratories should be examined, including the use of multiple operating shifts.

Acquisition of a third sampling truck (currently planned for FY 1994) should be expedited. Additional sampling system spare equipment should be procured and maintenance personnel trained to mitigate the high-failure rate of the sampling equipment. Alternate designs for weather screens, which perform more effectively than current designs, should be developed, and additional weather screens should be provided to allow sampling in inclement weather.

The use of alternate sites or facilities for analysis should be considered to support the Hanford Site mission. Additional laboratory capabilities should be constructed or procured, if detailed planning shows they are necessary. Analytical laboratories and/or services may be a possible target for privatization.

Retrieval--Retrieval activities necessary to support the startup and continuous operations of pretreatment and vitrification processes should receive higher priority for funding and staffing resources. Laboratory- and full-scale process testing of subsequent waste types should be expedited, including the acquisition of equipment, assessment of in-tank components, and waste characterization to reduce the related uncertainties and associated schedule risks. These recommendations are being considered in developing the revised program strategy, and they will be addressed in detail as the revised schedules are developed.

Programmatic and technical constraints to retrieval system design should be reexamined. For example, a review of alternate retrieval techniques, such as sluicing of some waste types, may be appropriate depending on the outcome of the DST program redefinition efforts and the wastes selected for early feed to HWVP. The program approach and/or priorities should be revised such that retrieval is removed from the program critical path for follow-on waste types after the initial feed to HWVP. These recommendations will be evaluated as part of the detailed planning for revising the tank waste disposal strategy.

Pretreatment Technology--A technology plan for pretreatment development should be established that includes: (1) development of pretreatment alternatives that close the gap in feed availability to HWVP prior to TRUEX being available; (2) alternate approaches for testing the TRUEX process to gain confidence in the implementation of TRUEX prior to the construction of the pilot plant; and (3) investigation of alternate, fall-back technologies for pretreatment of the post-NCAWs should significant technical problems be identified with the use of TRUEX. Development of alternate processes should begin on a small scale. Investigation of alternate or supplementary processes to TRUEX are a key element of the tank waste disposal strategy revision currently underway.

The schedule for the TRUEX pilot plant should be reevaluated based on the results of revised planning to test the TRUEX process and to evaluate alternate pretreatment technologies. If the revision to the DST waste disposal strategy requires the TRUEX process to provide early feed to HWVP, testing of the TRUEX process should be accelerated.

Permitting issues with locating the TRUEX pilot plant in the WESF and B Plant should be expeditiously investigated and resolved, particularly if B Plant is unacceptable for the HLW pretreatment mission.

Because post-NCAW pretreatment operations are consistently on the program critical path, with CC pretreatment having the longest duration of the three waste types, CC waste processing rates should be reexamined and appropriate process requirements (e.g., equipment sizing) defined to minimize the schedule duration for pretreatment of this waste.

Pretreatment Facilities--The DOE and Ecology review and determination on the adequacy of the study intended to demonstrate compliance of B Plant with double-containment requirements should be completed expeditiously.

If B Plant is demonstrated to comply with both DOE and WAC requirements for double-containment, the integrity of the resulting design should be assessed and preparation of the B Plant *Resource Conservation and Recovery Act* *of 1976* (RCRA) Part B permit application and safety analysis report should be expedited to identify any other significant issues with the plant design not presently documented.

As a fall-back position, alternate pretreatment process and facility options should be developed that do not require the use of B Plant or AR Vault.

The modification or replacement of selected B Plant piping with corrosion-resistant material should be evaluated.

Methods to avoid the generation of corrosive solutions during pretreatment operations should be investigated.

All except the second recommendation noted under Pretreatment Facilities are proceeding.

In addition, an integrated pretreatment technical baseline should be established to clearly define the technical process and facility requirements for implementation of the waste pretreatment technology. The identification of these requirements will allow their appropriate management and resolution. Where required, the scientific needs should be clearly identified such that the science and technology program resources at the Hanford Site can be deployed to resolve technical uncertainties.

If B Plant is accepted, an early-on, detailed examination of the spatial requirements within the plant to implement the TRUEX process also should be completed to ensure pretreatment equipment design issues and additional B Plant upgrades are identified. This will ensure that the CC waste processing rate is optimized within the confines of B Plant.

Management responsibilities for the success of all the pretreatment activities are currently distributed among at least three group managers; no one individual other than the division manager has complete responsibility for the successful planning and implementation of the pretreatment program. A single Westinghouse Hanford manager should be established as the overall project/program manager for development and implementation of the pretreatment processes, as exists for HWVP at this time. This organizational change will ensure that program priorities are consistently established and maintained, and is being evaluated for implementation at this time.

<u>Hanford Waste Vitrification Plant</u>--Because of the significant risk associated with the use of B Plant and the potential impacts some pretreatment options could have on the timely supply of initial feed to HWVP, construction of HWVP should not be initiated until the recommendation from the tank waste disposal program strategy revision study is accepted by the DOE. Recent agreements between the DOE and Ecology have deferred the Tri-Party Agreement milestone for start of construction of HWVP until April 1992. This should provide sufficient time to complete the study and obtain DOE acceptance.

Delaying the start of HWVP hot operations may be appropriate, particularly if an alternative to B Plant is required and the likelihood of substantial interruptions in the supply of feed to the HWVP cannot be eliminated through the implementation of alternate pretreatment strategies or technologies.

A delay of 2 to 4 yr would reduce, and perhaps eliminate, the HWVP standby periods projected for the December 1990 baseline plans. Longer delays may be necessary if B Plant is not utilized for pretreatment and waste retrieval activities cannot be accelerated.

However, delays in proceeding with the HWVP Project will adversely affect the current momentum in the DST waste disposal program, and may lead to cost increases and schedule delays that could be avoided through prudent program changes. These potential impacts must be addressed in the revision to the tank waste disposal program strategy.

Single-shell tank wastes that require simple pretreatment processes, such as sludge washing and ion exchange, should be considered for treatment during the DST campaign to minimize HWVP stand-by time. Wastes, such as those from tank retrieval demonstrations and from the resolution of tank safety issues, [e.g., tank 106-C stabilization (remediation) to alleviate problems associated with its high heat content], should be investigated. These wastes could be used to reduce or eliminate HWVP downtime during the DST vitrification campaign or between the DST and SST vitrification campaigns. These investigations are proceeding as part of the development of a revised program strategy.

Increased emphasis should be placed on obtaining approved waste acceptance preliminary specifications (WAPS) for borosilicate glass to be produced in the HWVP. The DOE-Office of Civilian Radioactive Waste Management is currently developing a unified WAPS that will be applicable to all U.S. vitrification facilities. This document has been drafted and is expected to be issued in early 1992.

The HWVP Project should, and is continuing to, participate in the resolution of the DWPF and the WVDP issues.

<u>Double-Shell Tank Farms</u>--Resolution of the tank safety issues should, and is continuing to, proceed expeditiously to conclusion. Resolution of these issues should be coordinated with plans for retrieval and treatment of the wastes to ensure compatibility of the mitigating strategies with the treatment requirements for the wastes. This effort has begun. A detailed integrated Tank Farm and DST processing schedule should be developed that identifies all significant interfaces. More closely coupled planning and management review avenues should be established to ensure consistency and compatibility between the programs. Construction of all eight new DSTs currently in the initial planning or consideration stage should begin as soon as practical.

<u>Grout</u>--Resolution of the uncertainties related to grout formulation and the performance assessment should, and is, being expedited. Resolution of the petition to the NRC on definition of waste types is critical to progression of the Grout Program. Efforts should, and are continuing to, support closure of this issue. Construction of the additional DSTs will alleviate, but not fully resolve, some of the risks to the DST waste treatment program from the Grout Program.

1.5.5 Single-Shell Tank Wastes

The examination of uncertainties associated with the potential vitrification of the SST wastes in the HWVP considered technical compatibility with the HWVP processes. This evaluation also assessed the ability to integrate the DST and SST processing schedules within the HWVP baseline schedule and HWVP design life and evaluated the programmatic changes needed to ensure successful integration of the DST and SST remediation schedules. The assessment did not include a complete evaluation of all uncertainties and associated risks with the treatment and disposal of SST wastes, such as the ability to retrieve saltcake from these tanks. These issues are being considered in separate system engineering studies.

The major results and recommendations from this assessment are noted in the following paragraphs. The complete assessment of SST wastes is presented in Section 5.0.

1.5.5.1 Results. The risk to successfully vitrifying SST wastes in the HWVP is low. The HWVP production capacity is properly sized to support the vitrification of all 149 SSTs within the HWVP design life if the wastes are pretreated to significantly concentrate the HLW fraction with a TRUEX or similar process. The HWVP process equipment planned for the DST vitrification mission for feed preparation, vitrification, and offgas abatement appears appropriate for an SST vitrification mission, based on present knowledge of waste compositions.

The presence of relatively high concentrations of phosphate in the SST wastes will require the development of a waste pretreatment process to reduce the level of phosphate in the high-level fraction of these wastes. The reduction in phosphate concentrations in the HWVP feed is needed to produce an acceptable borosilicate glass waste form. The TRUEX process is expected to substantially reduce the phosphate concentration in the HLW. However, because of the high concentrations in the SST wastes, there is a moderate risk that suitable methods to control the phosphates may not be found. This would require the development of alternate treatment processes or the production of a lead-iron-phosphate glass, either of which could have significant uncertainties in their development or qualification for repository acceptance.

A preliminary examination indicated that B Plant does not have sufficient cell space to pretreat the much larger volume of SST wastes in a reasonable time period. Thus, a different facility will be required.

There is a major risk that the necessary environmental and regulatory documentation to support the retrieval, pretreatment, and vitrification of the SST wastes will not be available on a schedule to support the efficient integration of the DST and SST vitrification missions. A potential schedule gap of up to 10 yr could occur between the DST and SST vitrification campaigns unless the preparation and approval of the SEIS and the permitting documentation needed for facilities to retrieve and pretreat the SST wastes and complete closure of the SSTs are performed earlier than defined in the Tri-Party Agreement. The time to complete environmental documentation also poses a significant risk to the closure of the SSTs by the year 2018 as required by the Tri-Party Agreement.

The need for additional DSTs to support the potential retrieval, pretreatment, and vitrification of the SSTs was evaluated. The review showed that the need for additional DSTs is dependent on the schedule for retrieval and pretreatment of the SST wastes and the decision on the number of SSTs to be retrieved. This review assumed that closure of the SSTs is completed by 2018 as agreed to in the Tri-Party Agreement and that the SEIS for closure of the SSTs can result in an ROD by 1996 (not currently planned until 2002). Under optimum conditions, 8 DSTs would be required for the retrieval of 22 SSTs, and 21 DSTs would be required for the retrieval of all 149 SSTs. Under less-favorable conditions, a total of up to 53 DSTs (some of which could be existing tanks depending on their condition at the time of SST waste retrieval) could be required to support the retrieval of all 149 SSTs. These cases also assume that the waste can be retrieved within 10 yr, which may not be practical for the 149-tank retrieval case.

1.5.5.2 Recommendations. The following actions should be undertaken to reduce the risks to the Hanford Site mission associated with the potential vitrification of the SST wastes in the HWVP.

The completion of the SEIS for the closure of the SSTs should be expedited from its current plan to better support the milestone for closure and to support integration of the DST and SST waste treatment programs. Waste characterization is the key factor in the current approach to the SEIS. An SEIS with an ROD targeted for the mid-1990's should be prepared. This acceleration could minimize or eliminate the potentially large schedule gap between the DST and SST vitrification campaigns. A proposal has been forwarded to DOE-Headquarters to initiate the SEIS early.

There is a possibility that up to 53 DSTs, some of which could be existing tanks, will be required to support the retrieval and immobilization of the SST wastes. The number of DSTs required to support these efforts is dependent on the following: (1) the number of SSTs retrieved; (2) the rate at which the SST waste is retrieved, pretreated, vitrified, and grouted; (3) the schedule for the start of waste retrieval; and (4) the closure date for the single-shell Tank Farms. A trade-off study should be completed that considers these factors, and others, to define an optimum program and schedule for the remediation of the SST wastes.

Vitrification of the SST wastes will require aggressive pretreatment processes to reduce the HLW fraction to a reasonable level. A preliminary examination indicated that B Plant does not have sufficient cell space to support the required processing operations for pretreatment of the SST wastes in a time period consistent with the HWVP lifetime. An engineering study should be completed to examine alternate facilities, both existing and new, to support the potential pretreatment of the SST wastes. Such a study is proceeding.

Development of the SST remediation activities has evolved to the point where a program office for the remediation of the SSTs should be established. The office would provide integration of this expanding program to ensure that resources are appropriately allocated. The initial activities of this program office should be to establish a technology baseline for remediation of the SSTs, provide input to an integrated schedule for the DST and SST remediation efforts, and establish a cost and schedule baseline for the completion of all tasks needed to ensure timely closure of the SSTs. A program office is planned to be established in FY 1992.

An SST technology program should be established along with the SST remediation program office to complete the necessary development of concepts and processes for the disposition of the SST wastes. Initial development of pretreatment flowsheets should occur in parallel with the tank characterization efforts. Initial development of borosilicate glasses for SST wastes should be undertaken to ensure an acceptable waste form can be developed during the next decade.

Potential schedule delays within the DST waste treatment program, coupled with the possibility of a multi-decade program to dispose of SST wastes, could ultimately exceed the 40-yr design life of HWVP. An assessment of the impacts of increasing the HWVP design life to 50 or 60 yr should be made to determine if there are changes that can be readily implemented at this time without significant impact to the current design effort to avoid significant costs in the future. If the impacts are minor, serious consideration should be given to implementing them in the current HWVP design. Substantial changes are not warranted at this time due to the lack of a decision regarding the disposal of SST wastes.

A survey of the SST wastes should be performed to identify candidate wastes that can be effectively pretreated with minimal processing before vitrification. These wastes could be used to reduce or eliminate a potential HWVP feed gap within the DST vitrification campaign or between the DST and SST vitrification campaigns. This activity is underway as part of the program strategy revision.

1.5.6 Cesium and Strontium Capsules

This section summarizes the significant results and recommendations related to the potential vitrification of the cesium and strontium capsules. The complete assessment is presented in Section 6.0.

1.5.6.1 Results. Preliminary technical assessments demonstrated that vitrification of the cesium and strontium capsules is both feasible and cost effective as an alternative to the current plan to over-pack the existing capsules for disposal in the geologic repository.

An initial examination indicated that the WESF could be a suitable location for performing the capsule dismantling should a decision be made to vitrify their contents. The WESF has hot-cell facilities and is the current location of the capsules. However, competing missions and/or regulatory considerations could require the use of another facility for this function. The HWVP could be used to perform the dismantling process, but currently has no requirement to provide space for that function. The capability also could be incorporated into other future facilities, such as a new pretreatment facility for SST wastes.

1.5.6.2 Recommendations. Development of appropriate supplemental environmental documentation should be initiated to reassess the disposal options for the cesium and strontium capsules and to establish a preferred position.

The feasibility of using the WESF for capsule dismantling, particularly because of its dependence on B Plant, should be examined further as part of the supplemental environmental documentation. Space requirements for dismantling the capsules in HWVP also should be examined, but no space should be reserved for that function until such time as a decision is rendered.

1.5.7 Other Observations

The DST waste treatment program should be reexamined based on known competition for resources and achievable funding profiles. Existing estimates should be updated for all activities to complete cleanup of the Hanford Site, and these should be integrated into a composite funding profile. The revision to DST waste treatment program planning should be based on realistically achievable funding profiles and overall ability to manage and execute work. Discussion of reasonable budget profiles to use in long-range planning assumptions for the Hanford Site should continue with the DOE, Ecology, and the EPA. Program plans and Tri-Party Agreement commitments then can be validated consistent with this planning base. The Hanford Site integrated planning activities will help achieve this planning base.

The Risk Assessment of the DST waste treatment program was the first attempt to simultaneously identify and evaluate the uncertainties and risks associated with all elements of the program. The systematic approach that was utilized defined and integrated all the key elements of the program, including interfacing facilities. An initial estimate of resources required throughout the life of the program also was developed.

The use of the VERT software was a key element of the Risk Assessment. The network model of the program established for the Risk Assessment could be a useful tool in the management of the program once the model is modified to reflect the new program strategy. This software also may have application to other Hanford Site programs or projects.

1.5.8 Revised Information

A number of activities were completed during the course of performing this Risk Assessment. Some of the most significant items, such as collecting a sample of waste from tank 101-SY, are recorded in this document and were considered in the findings. However, a number of other activities were also completed, but could not be effectively incorporated in the Risk Assessment. The most significant items are listed below. These activities are not expected to change the major uncertainties or resultant risks identified by this study.

The important activities completed since the assessments described in Section 4.0 were performed and that were not considered in the computer-based analyses include the following:

- Seismic analyses for B Plant were completed which demonstrate this facility could survive a design basis earthquake.

- Several separate B Plant upgrade projects were combined into on Major Line Item (Project W-207) for B Plant upgrades.
- Construction of the Tank Waste Retrieval Equipment, Handling, and Operation facility was begun.
- The advanced conceptual design for the TRUEX pilot plant was completed.
- The decision was made to construct four new DSTs, and to consider four additional new tanks.
- A waste acceptance preliminary specification applicable to HWVP was drafted.

1.6 REFERENCES

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2.0 INTRODUCTION

2.1 AUTHORIZATION

The Hanford Waste Vitrification Systems Risk Assessment (Risk Assessment) was authorized by the U.S. Department of Energy Field Office, Richland (RL) by letter from John D. Wagoner to R. C. Nichols (Wagoner 1990) (see Appendix D). Westinghouse Hanford Company (Westinghouse Hanford) was directed to perform a systems engineering risk assessment to evaluate the technical, safety, and regulatory uncertainties of all related elements of the Hanford Waste Vitrification Program (Program). The letter defined the purpose and scope of the assessment. The Program elements to be considered were waste characterization, retrieval from the storage tanks, pretreatment to separate the high- and low-level components of the waste, vitrification of the high-level waste (HLW) fraction, and grouting of the low-level waste (LLW) fraction.

The Risk Assessment was to address the viability of successful completion of the Hanford Waste Vitrification Plant (HWVP) mission, including potential performance, cost, and schedule impacts. The results of the study were intended to be used in the reevaluation of planning for the HWVP. This report documents the approach and findings.

The objectives and scope of the Risk Assessment were developed and set forth in WHC-EP-0391, *Hanford Waste Vitrification Systems Risk Assessment Action Plan* (Miller 1990), which was subsequently approved by Westinghouse Hanford, the Pacific Northwest Laboratory, and RL.

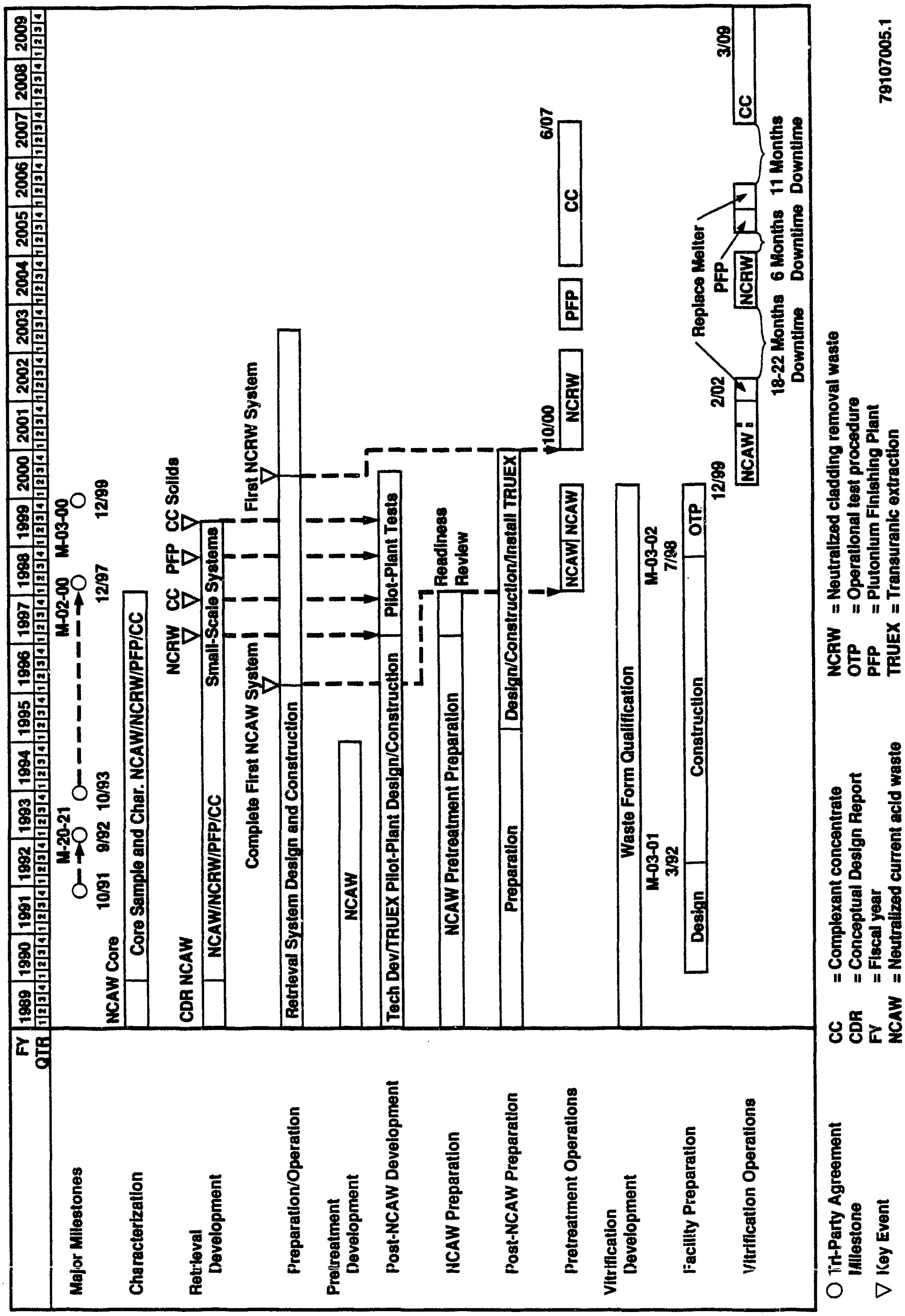
2.2 BASIS

Recent events indicated the need to conduct an assessment of the uncertainties and risks associated with proceeding with the planned Program. These include the following:

- The limited knowledge of the chemical composition of HLW in the storage tanks
- The technical- and programmatic-related delays that have occurred in the Defense Waste Processing Facility Project, delaying the resolution of technical issues that could impact the design of HWVP
- The undetermined scope of potential future vitrification missions, single-shell tank (SST) wastes, and cesium and strontium capsules.

The schedule for the performance of the Hanford Site waste disposal mission is defined in the *Hanford Federal Facility Agreement and Consent Order* (Ecology 1990). The scheduled start date for hot operations of the HWVP to vitrify double-shell tank (DST) wastes is December 1999 and the scheduled date for closure of the SSTs is June 2018. The baseline schedule for the DST program as of September 1990 is shown in Figure 2-1.

Figure 2-1. Hanford Waste Vitrification Plant
December 1999 Startup Schedule.



This Risk Assessment evaluates the uncertainties associated with the Program to identify significant risks resulting from the uncertainties, and to quantify programmatic risks and potential consequences if construction of the HWVP were to proceed according to the fiscal year (FY) 1991 budget Case 2 baseline and with the existing design. The timing of this report is critical to any programmatic restructuring of the DST program.

2.3 PURPOSE

The Risk Assessment was performed to identify and evaluate all significant uncertainties associated with the vitrification of Hanford Site high-level and transuranic (TRU) wastes. This study quantifies potential consequences resulting from the uncertainties and assesses their impacts on the successful startup of HWVP and completion of the Hanford Site vitrification mission within existing Program cost and schedule restraints. Recommendations for mitigating the more significant uncertainties and for further investigations of specific uncertainties are included.

The risks and mitigating strategies identified by this study will be used in the concurrent DST program redefinition study. This report also will provide technical background for modifications to existing planning or schedules that may result from this study.

Documented in this report are the process and methodology used to develop the uncertainties and assess the risks, quantification of potential consequences from the uncertainties, conclusions resulting from the analysis of the risk assessment, and recommendations for the mitigation of the more significant risks.

The record information used as bases for the assessments, and background information used during the analysis of the assessments, are included in a separate document, WHC-EP-0427, *Hanford Waste Vitrification Systems Risk Assessment - Final Report Supporting Information* (Miller et al. 1991).

2.4 SCOPE

2.4.1 Scope Definition

This Risk Assessment specifically assessed the risks associated with the successful completion of the following Program objectives:

- Compliance with environmental and safety regulations
- Construction and startup of the waste retrieval and pretreatment projects and the HWVP Project on schedule and within budget; achievement of the required operational performance without major process or design changes resulting from new or emerging data from other U.S. vitrification sites or the Defense High-Level Waste Technology Program(s)

- Pretreatment of the wastes to meet the composition limits defined in the HWVP feed specification
- Provision of pretreated feed for hot startup of HWVP, and maintenance of continuous or nearly continuous feed of pretreated DST wastes to HWVP
- Production of a glass waste form that meets waste acceptance criteria
- Ensurance that the HWVP design does not preclude the vitrification of other waste types not currently within the HWVP Project scope, such as SST wastes and cesium and strontium capsules.

The major activities associated with the vitrification of Hanford Site wastes considered in this assessment included the following:

- Characterization of the wastes stored in the tanks
- Upgrades to the tanks and their supporting infrastructure
- Availability of storage tanks to support waste treatment and disposal
- Retrieval of wastes from the storage tanks
- Development of pretreatment technology
- Pilot plants and pretreatment to separate the waste into high- and low-level fractions
- Vitrification of the high-level and TRU waste fractions
- Related activities, such as grouting of the LLWs, and processing of strontium and cesium capsules to the extent that they could delay or otherwise impact the completion of the vitrification activities.

A systems analysis of the major vitrification activities was performed, assessing and quantifying the potential impacts of the uncertainties on meeting mission objectives. The time required to resolve these uncertainties was evaluated with respect to the current schedules (FY 1991 budget Case 2) to identify potential changes that would reduce attendant risks. Alternatives to the currently defined technical approaches for the vitrification activities were not explicitly identified in the study, but selected program elements were identified for further evaluation and optimization.

Specific assessments were performed to ensure all known major uncertainties were identified for consideration. The planning and status for waste characterization activities were considered by assessing the ability of pretreatment processes to meet HWVP feed requirements. In addition, the following evaluations were performed: complexity of the chemical processes; maturity of the technology; compliance of the current design criteria to existing DOE, federal, and state requirements; level of design definition; capability to support safe and reliable facility operations; and state of development of safety and environmental documentation (e.g., safety analysis reports, environmental permit applications, and *National Environmental Policy Act of 1969* documents).

Other specific assessments included comparison of the waste vitrification activities and facilities at the Savannah River, West Valley (limited), and Hanford Sites. The goal of these assessments was to identify potential impacts on the Hanford Site vitrification activities from problems identified at the other vitrification facilities. Risks associated with the use of existing Hanford Site facilities for major vitrification activities were analyzed. Also, the possible impacts of potential future missions (including vitrification of Hanford Site SST wastes and cesium and strontium capsules) on the HWVP design were identified. The study also addressed uncertainties associated with the availability of DST storage space to support delays in the vitrification activities.

To the maximum extent possible, the study made use of existing documentation and previous or current assessments. For example, DOE's independent review team assessment of the pretreatment activities performed in October and November of 1990 was used as a key element in the evaluation of the pretreatment program.

2.4.2 Scope Limitations

Recommendations to refine the schedule were developed. Recommendations for assessments of technical alternatives for activities that posed substantial potential risks also were developed. However, recommendations on the implementation of specific process or design alternatives were considered beyond the scope of this study.

Because vitrification is a prime candidate for ultimate disposal of Hanford Site wastes other than those currently contained in the double-shell storage tanks, such as SST wastes and the cesium and strontium capsules, this study assessed the possible impacts of these potential future missions on the HWVP design and glass technology. However, no decision has been made to include these additional wastes in the vitrification mission. Therefore, the assessment of these waste types only addressed the capability and related uncertainties associated with the vitrification of these waste types in the HWVP, and did not include an assessment of all aspects or alternatives for disposal of the SST wastes and cesium and strontium capsules. Potential major modifications to the HWVP design to accommodate these future missions were evaluated.

The schedule for grouting of the low-level fraction of the liquid wastes affects the availability of double-shell storage tank space and could impact the vitrification activities. Therefore, the Grout Program was included in the study. However, coverage of the Grout Program was limited to an assessment of tank space and pretreatment impacts resulting from uncertainties in the waste composition in the storage tanks, uncertainties in the feed specification for grout due to environmental regulation considerations, and uncertainties in the schedule for the program. Uncertainties in grout formulation, production, and disposal related to the technology, process, and design were excluded from the study.

The interim storage of vitrified waste in sealed canisters at the Hanford Site was not addressed by the study because the uncertainties related to storage of the canisters are estimated to be insignificant compared with the other vitrification activities. Uncertainties associated with the final closure of vitrification facilities, vitrification support facilities, and empty tanks were excluded from the assessment scope (Miller 1990).

2.5 REFERENCES

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3.0 BACKGROUND

3.1 WASTE GENERATION

The Hanford Site near Richland, Washington, is a U.S. Department of Energy (DOE) installation that has been involved in the production of nuclear materials for the national defense of this country. In 1943, the U.S. Army Corps of Engineers selected the area, which encompasses 562 square miles, to build the first plutonium production reactors and processing facilities to assist in ending World War II. Since that time, the Site has been dedicated to defense nuclear materials production, research, and defense nuclear waste management.

Production and interim waste management operations at the Hanford Site have resulted in the generation of many different types of waste, including the following:

- Single-shell tank (SST) and double-shell tank (DST) wastes in the form of sludge, slurry, saltcake, and liquid
- Encapsulated cesium and strontium
- Solid wastes in drums and burial boxes
- Contaminated soils and sediment from liquid effluents disposed of in cribs, ponds, and ditches.

The use of tanks to store radioactive waste generated by the operation of processing plants began in the 1940's. Until the early 1970's, most processing wastes were stored in underground, concrete-encased SSTs. A total of 149 SSTs, having capacities from 200 m^3 to 3,800 m^3 (55,000 to 1 million gal), were constructed between 1943 and 1964. While these tanks are no longer in active service, they contain 141,000 m^3 (37 million gal) of radioactive wastes that may require retrieval, pretreatment, and solidification for disposal. Since 1971, newly generated processing wastes have been stored in underground, concrete-encased DSTs. Twenty-eight DSTs were constructed between 1970 and 1985, each having a nominal capacity of 3,800 m^3 (1 million gal). Four tanks (101-AZ, 102-AZ, 101-AY, and 102-AY) are equipped with airlift circulators and used for storage (aging) of high-heat wastes from the plutonium-uranium extraction (PUREX) process. By 1981, large quantities of liquid wastes had been removed from SSTs and placed in DSTs.

From 1968 to 1985, high-level wastes (HLW) from SSTs were reprocessed to remove heat-generating radionuclides. The radionuclides were solidified in the form of cesium and strontium salts, sealed in capsules, and stored in water basins in the Waste Encapsulation and Storage Facility (WESF) adjacent to B Plant. Some capsules were leased for beneficial use but are being returned to the Hanford Site as the result of concern about potential capsule failures.

3.2 FINAL ENVIRONMENTAL IMPACT STATEMENT

In April 1988, the Record of Decision (ROD) (DOE 1988a) on DOE/EIS-0113, *Final Environmental Impact Statement: Disposal of Hanford Defense High-Level, Transuranic, and Tank Wastes, Hanford Site, Richland, Washington* (HDW-EIS) (DOE 1987) was handed down as follows.

"DECISION

The decision is to implement the "Preferred Alternative" as discussed in DOE/EIS-0113 (hereafter referred to as the HDW-EIS). The Department of Energy (DOE) has decided to proceed with disposal activities for the following defense wastes at the Hanford Site: double-shell tank wastes, retrievably stored and newly generated transuranic (TRU) waste, the only pre-1970 buried suspect TRU-contaminated solid waste site outside the central (200 Area) plateau, and strontium and cesium encapsulated wastes.

To process existing and future wastes from the double-shell storage tanks at Hanford for final disposal, the DOE will design, construct, and operate the Hanford Waste Vitrification Plant (HWVP); complete the necessary pretreatment modifications and operate the pretreatment facility, currently planned to be the Hanford B-Plant; and utilize the Hanford Transportable Grout Facility. The radioactive high-level waste fraction will be processed into a borosilicate glass waste form and stored at the HWVP until a geologic repository is built and ready to receive this waste. The low-activity fraction will be solidified as a cement-based grout and disposed of near surface at Hanford in preconstructed, lined concrete vaults. Existing and future double-shell tank waste will be characterized for hazardous chemical constituents, as well as other chemical constituents that might affect glass or grout formulation, before processing."

"Encapsulated cesium and strontium wastes will continue to be stored safely until such time as a geologic repository is ready to receive this waste for disposal. Prior to shipment to a geologic repository, these wastes will be packaged in accordance with repository waste acceptance specifications.

For the remainder of the waste classes covered in the HDW-EIS (single-shell tank wastes, TRU-contaminated soil sites and pre-1970 buried suspect TRU-contaminated solid waste within the 200 Area plateau), the DOE has decided to conduct additional development and evaluation before making decisions on final disposal. This development and evaluation effort will focus both on methods to retrieve and process these wastes for disposal as well as to stabilize and isolate the wastes near surface. Results from this work will be publicly available. Prior to decisions on final disposal of these wastes, the alternatives will be analyzed in subsequent environmental documentation, including a supplement to the HDW-EIS for decisions on disposal of the single-shell tank wastes."

With regard to the Hanford Site vitrification program, the ROD accomplishes the following:

- Establishes the bases for final disposal of existing and future DST wastes
- Necessitates the continued storage of encapsulated cesium and strontium pending availability of a geologic repository (the repository waste acceptance criteria and potential for capsule failures were not known in April 1988)
- Defers the decision on final disposal of SST wastes pending additional development and evaluation efforts and preparation of a supplement to the HDW-EIS.

The ROD also states that "the HWVP, in addition to vitrifying double-shell tank waste, will be designed with sufficient flexibility to accommodate all single-shell tank waste should the decision be made to recover the waste."

3.3 HANFORD FEDERAL FACILITY AGREEMENT AND CONSENT ORDER

In May 1989, the DOE, U.S. Environmental Protection Agency (EPA), and Washington State Department of Ecology (Ecology) signed the *Hanford Federal Facility Agreement and Consent Order* (a.k.a., Tri-Party Agreement), which was revised in 1990 (Ecology 1990). The Tri-Party Agreement established enforceable milestones for specific cleanup actions identified in the ROD. Major milestones established for the disposal of DST wastes are shown in Table 3-1.

The Tri-Party Agreement established a timetable for implementing the ROD and milestones for closure of SSTs, as shown in Table 3-2.

3.4 DOUBLE-SHELL TANK WASTE DISPOSAL

3.4.1 Objective

The objective of the DST waste disposal program is the retrieval, pretreatment, and solidification of existing and future DST wastes. Retrieval will be effected by the installation of mixer pumps to mobilize settled solids and sludges into a homogeneous mixture followed by the transfer of wastes to pretreatment facilities. Pretreatment will reduce the volume of solids for vitrification through dissolution and separate the wastes into high-level, transuranic (TRU), and low-level fractions. Solidification will be accomplished by vitrifying the high-level and TRU fraction for disposal in a geologic repository and converting the low-level fraction to grout for disposal in near-surface vaults. Certain DST waste types can be retrieved for disposal in grout without pretreatment.

Table 3-1. Double-Shell Tank Waste Major Milestones.

Number	Milestone	Due date
M-01-00[a]	Complete 14 grout campaigns of double-shell tank waste by September 1994 and maintain currency with waste feed thereafter	September 1994
M-01-01[a]	Complete 3 grout campaigns of double-shell tank wastes (includes one campaign of phosphate/sulfate waste)	September 1991
M-01-02[a]	Complete 6 grout campaigns of double-shell tank wastes	September 1992
M-01-03[a]	Complete 10 grout campaigns of double-shell tank wastes	September 1993
M-01-04[a]	Complete 14 grout campaigns of double-shell tank wastes	September 1994
M-01-05[a]	Commitments for additional grout campaigns after September 1994 will be incorporated as interim milestones	Biannually beginning September 1994
M-02-00	Initiate B Plant operations for pretreatment of double-shell tank waste	October 1993
M-02-01	Initiate pretreatment of neutralized current acid waste	October 1993
M-02-02	Commitments for pretreatment of additional tank wastes will be incorporated as interim milestones	Biannually beginning calendar year 1992
M-03-00	Initiate Hanford Waste Vitrification Plant operations	December 1999
M-03-01[b]	Initiate Hanford Waste Vitrification Plant construction	July 1991
M-03-02	Complete Hanford Waste Vitrification Plant construction	June 1998

[a]These milestones have been renegotiated with 14 campaigns to be completed by December 1996.
[b]This milestone was renegotiated to April 1992.

Table 3-2. Single-Shell Tank Waste Milestones.

Number	Milestone	Due date
M-09-00	Complete closure of all 149 single-shell tanks Closure and removal of required waste from the 149 single-shell tanks will be affected in accordance with the approved closure plan(s). As stated in the *Disposal of Hanford Defense High-Level, Transuranic, and Tank Wastes, Hanford Site, Richland, Washington; Record of Decision*,* a supplemental environmental impact statement will be prepared before making any final decisions regarding disposal of single-shell tank waste. The final closure plan(s) will address the recommendations of the supplemental environmental impact statement.	June 2018
M-09-01	Complete preparation of the supplemental environmental impact statement and issue a draft for public review	June 2002

**Disposal of Hanford Defense High-Level, Transuranic, and Tank Wastes, Hanford Site, Richland, Washington; Record of Decision*, U.S. Department of Energy-Headquarters, Washington, D.C., 1988.

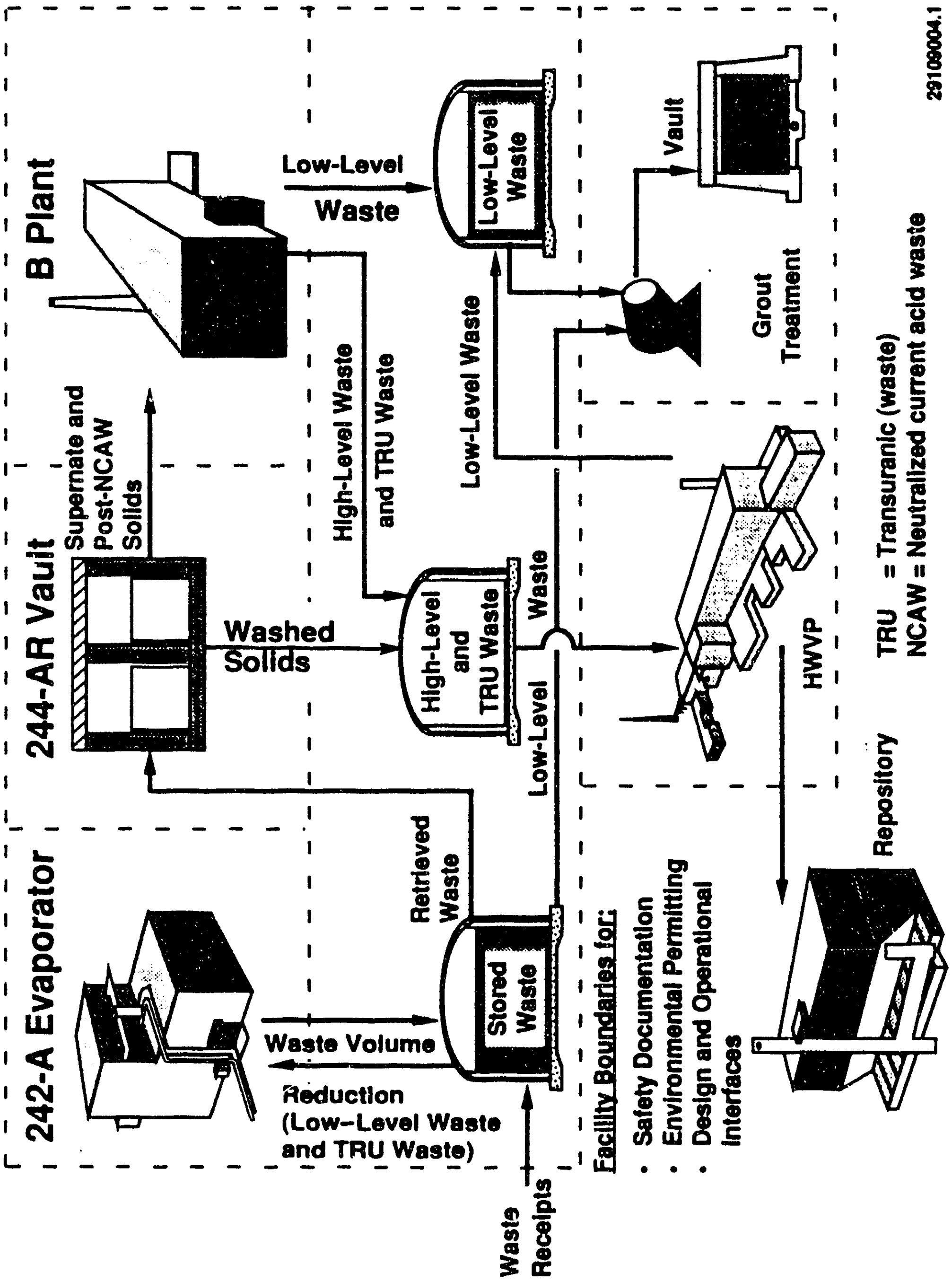
3.4.2 Elements

The principal elements of the DST waste disposal program are as follows:

- Double-shell tanks for storage of existing wastes and interim storage of pretreated wastes, together with retrieval systems to mobilize and transfer the waste (242-A Evaporator is provided for waste volume reduction)
- Pretreatment facilities, presently identified as the 244-AR Vault and B Plant
- HWVP
- Grout Treatment Facility (GTF).

The interrelationship of mission elements is shown in Figure 3-1. Each of these elements will be discussed in more detail following the discussion of waste types and technology.

Figure 3-1. Double-Shell Tank Waste Disposal Elements.



3.4.3 Waste Types

Past and present waste management practice at the Hanford Site is to separate HLWs, TRU, and low-level wastes (LLW), which are defined as follows.

High-Level Waste--The highly radioactive waste material that results from the reprocessing of spent nuclear fuel, including liquid waste produced directly in reprocessing and any solid waste derived from the liquid, that contains a combination of TRU waste and fission products in concentrations requiring permanent isolation.

Transuranic Waste--Without regard to source or form, waste that is contaminated with alpha-emitting TRU radionuclides with half-lives greater than 20 yr and concentrations greater than 100 nCi/g.

Low-Level Waste--Waste that contains radioactivity and is not classified as high-level waste, TRU waste, spent nuclear fuel, or 11e(2) byproduct material as defined in DOE Order 5820.2A, *Radioactive Waste Management* (DOE 1988b). Transuranic elements are limited to concentrations below 100 nCi/g.

First-cycle raffinates from the PUREX process are stored in aging waste tanks equipped with airlift circulators. Waste from the Plutonium Finishing Plant (PFP) is stored in one of the three DSTs available nearby in the 200 West Area. Wastes from past cesium and strontium recovery operations contain chelating agents which solubilize plutonium and are isolated to control dispersion of TRU elements. The LLW types are separated according to physical and radionuclide properties. There are a total of seven waste types. The current plan is to maintain this separation of waste so as not to preclude the disposal of vitrified TRU wastes in the Waste Isolation Pilot Plant located in Carlsbad, New Mexico.

Four waste types have been identified as feed for vitrification. Each of these four waste types has certain chemical properties and constituents that require specialized pretreatment to reduce the disposal cost. Pretreatment is accomplished by separating these wastes into a low-volume, high-level, and TRU waste fraction, and a relatively high-volume LLW fraction. The waste types and quantities for pretreatment are described as follows.

- Neutralized current acid waste (NCAW) is a high-heat, first-cycle waste from the PUREX process, principally, an iron-hydroxide sludge (20 percent volume) contaminated with actinides and strontium. The supernate also contains aluminum and sodium salts. The alkaline supernate is contaminated with ^{137}Cs. Present inventory is 5,300 m^3 (1.4 million gal). Future PUREX operations could generate 2,300 m^3 (0.6 million gal) of additional waste if the decision is made to process the remaining N Reactor fuel.

- Neutralized cladding removal waste (NCRW) is waste from the PUREX fuel cladding dissolution cycle. The NCRW is a zirconium-containing sludge contaminated with TRU. The alkaline supernate is an LLW. The present inventory is 3,400 m^3 (0.9 million gal) of sludge. Future operations could generate 1,140 m^3 (0.3 million gal) of additional waste sludge.

- The PFP waste is a low-heat, high-TRU waste from PFP operations. The sludge is principally metallic compounds. The TRU elements are present in the sludge in insoluble compounds. The alkaline supernate is an LLW. The present inventory is 400 m^3 (100,000 gal) of sludge with an additional 1,140 m^3 (300,000 gal) of sludge to be generated during future operations.

- Complexant concentrate (CC) comes from previous strontium and cesium recovery operations. The sludge contains metal compounds, degraded complexants, and precipitated TRU elements. The chemical and physical properties of CC waste vary considerably from tank to tank. The alkaline supernate contains cesium and TRU solubilized with complexants. Tank 101-SY, which is known to generate hydrogen, contains CC waste. The present inventory is 16,300 m^3 (4.3 million gal). Future saltwell pumping of complexed waste from SSTs will add 1,900 m^3 (0.5 million gal).

Additionally, three LLW types have been identified as being suitable for feed to grout without pretreatment. The LLW types are as follows:

- Double-shell slurry feed (DSSF)--LLW for disposal in grout. The DSSF is a dilute non-complexed waste that has been evaporated up to, but not past, the aluminate phase boundary and normally separates into sludge and supernate layers. Dilute non-complexed waste is any dilute LLW that does not contain sufficient organic materials to be a complexed waste.

- Double-shell slurry (DSS)--LLW similar to DSSF, which has been evaporated past the aluminate phase boundary. This waste stream is high in aluminates, highly viscous, gelatinous, and does not normally separate into sludge and supernate layers. Retrieval equipment will have to be installed in-tank to mobilize this waste before transfer.

- Phosphate/sulfate waste (PSW)--waste from N Plant decontamination. The PSW has a low radionuclide content and no chemically hazardous wastes. The total inventory of PSW was solidified in the first grout campaign, which was completed in July 1989.

The volume of DSSF and DSS varies depending on the quantity of wastes generated and operation of the waste volume reduction facilities. A total of 43 3,800 m^3 (1 million gal) grout campaigns are planned for completing the disposal of DST waste (the PSW campaign, completed in 1989, is not one of these planned campaigns).

3.4.4 Technology Development

Disposal of DST wastes requires specific technologies to be developed and demonstrated. Characterization of existing and future DST wastes, development of waste retrieval and transfer technology, and development of waste pretreatment process technology must be accomplished before the initiation of retrieval and pretreatment activities. Similarly, glass and grout formulations must be developed and conformance to waste form qualification (WFQ) and performance assessment criteria must be demonstrated before full-scale solidification operations can commence.

Vitrification and grout technology development is being accomplished as part of those programs, respectively. Vitrification technology for disposal of HLW has been successfully demonstrated and used in other countries. The process of grouting LLW has been demonstrated at the Hanford Site.

3.4.4.1 Characterization. Waste characterization is necessary to determine the chemical and physical properties of DST wastes as the basis for developing and designing retrieval systems, pretreatment processes, final disposal (i.e., glass or grout) processing systems, and WFQ criteria. Major tasks include the development of sampling and analytical methods, acquisition and analysis of samples, and maintenance of the characterization database. Sampling methods and most of the analytical methods have been developed and implemented.

Of the 28 DSTs, 10 contain wastes designated for pretreatment and vitrification. An additional tank, which is designated as the HWVP feed tank, contains a heel with a high chloride content that could have an adverse impact to stainless steel components in the HWVP, particularly in the receipt and lag storage tank. This heel must be analyzed to determine if pretreatment or tank cleanout is required. The need for tank cleanout is not a presently scheduled activity and could result in a delay to HWVP operations. Project W-236 will provide four new DSTs. Upon project validation, one of these tanks will be designated as the HWVP feed tank if the tanks are available in time to support HWVP startup, replacing the above tank.

Approximately 25 percent of the planned core samples had been acquired through fiscal year (FY) 1990. No core sampling is planned for FY 1991 pending the resolution of safety issues resulting from flammable gas generated in some DSTs.

3.4.4.2 Retrieval. Development and demonstration of retrieval systems for certain DST wastes are required. While existing pumping techniques and equipment are suitable for transfer of dilute wastes, these techniques will not be adequate for NCAW, NCRW, CC and PFP wastes, DSS, and pretreated sludges stored as HWVP feed. Characteristics of CC waste stored in the west area (SY) Tank Farms vary significantly from CC waste stored in the east area (AN, AY) Tank Farms.

Development activities will be performed to ensure the solids from each waste type (NCAW, NCRW, and CC and PFP wastes), can be mobilized, homogenized, and transferred to a pretreatment facility. Mixer pumps will be used for NCAW mobilization; other DST waste types will be evaluated for mobilization requirements and methods. Pump configurations may differ for the various DST waste types.

The NCAW is stored in tanks 101-AZ and 102-AZ. A prototype retrieval system (Project W-151) using two mixer pumps will be tested in tank 101-AZ to determine if such a system will adequately suspend NCAW solids for retrieval.

Figure 3-2 shows the planned mixer pump installation for tank 101-AZ. If the two-pump system does not mobilize sufficient solids to support production processing of NCAW, two additional pumps will be installed in Project W-148.

The baseline plan for CC sludge removal involves installation of mixer pump prototype retrieval systems in tanks 241-SY-101 and 241-AN-107. Demonstrations will be performed to determine the adequacy of retrieval systems to mobilize and suspend CC solids. A DST must be emptied before starting the CC retrieval demonstration. This tank will be used to store CC supernate and retrieved solids. Data acquired from the retrieval demonstrations will be used to design the remaining CC retrieval systems.

The NCRW is stored in tanks 241-AW-103 and -105. A process test, similar to that for CC waste, will be performed in tank 241-AW-103.

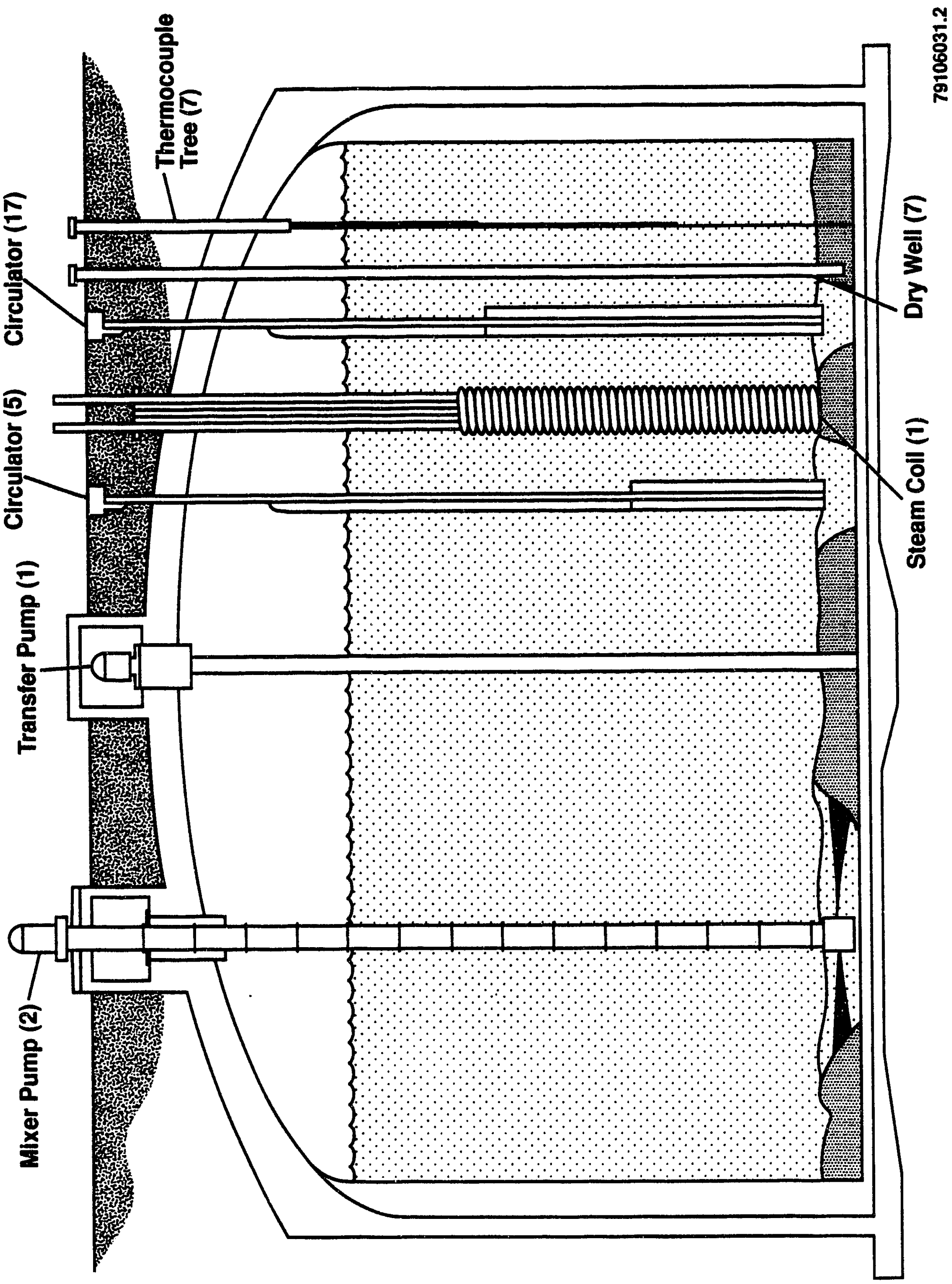
Future analytical work may show the characteristics of PFP waste stored in tank 241-SY-102 are not similar to other waste types. The PFP waste will require a process test if the waste characteristics do not fall within the characteristics envelope established for NCAW, NCRW, and CC waste.

Retrieval system characterization data have been obtained for eight tanks, and jet forces static testing on tank components is complete. Corrosion-erosion studies on NCAW are complete, a small-scale test tank apparatus is operational, and a conceptual design report (CDR) has been completed for the NCAW full-scale retrieval system. This retrieval system has been validated as a 1992 line item project. Engineering studies are in progress for NCRW and DSS retrieval systems.

3.4.4.3 **Pretreatment.** Preliminary requirements for acceptable feeds to the vitrification process have been established for NCAW. Requirements for NCRW, and PFP and CC waste types will be defined at a later date. The technical bases for the disposal of grouted NCAW supernatant have also been established and grout criteria for land disposal of restricted wastes are being developed. The waste pretreatment process technology development efforts are directed toward providing waste treatment processes that are economically achievable and will meet the grout and glass requirements. The waste pretreatment process objective is to provide feed-stock to grout and vitrification processes that are within the required chemical "envelopes," minimize process upsets, maximize waste throughput, and minimize the volume of glass requiring expensive disposal in a geologic repository. In actual processing situations, pretreated wastes may occasionally fall outside the desired bounds and require additional pretreatment, blending, or special measures during disposal operations (e.g., reduced waste loading in glass), to make a suitable waste form. The final determination will be based on appropriate technical and economic evaluations.

The pretreatment process for NCAW differs considerably from the pretreatment process for the other DST waste types. The pretreatment processes for NCRW and PFP and CC wastes, often referred to as post-NCAWs, will require the development of dissolution and separation methods and suitable offgas treatment systems. Pretreatment of CC waste may require destruction of organic constituents. Technology for pretreatment of NCRW and PFP and CC wastes will be tested in a pilot plant in the WESF and B Plant.

Figure 3-2. Neutralized Current Acid Waste
Retrieval System--Aging Waste.



The NCAW consists of sludge and supernatant resulting from neutralization of current acid wastes generated by the PUREX process. The NCAW sludge is a feed to the vitrification facility. A process for separating sludge and supernatant liquid in NCAW has been tested in B Plant. The sludge must be washed to remove sulfate, aluminum, and sodium salts. The supernatant liquid from the NCAW, following removal of cesium, together with salts removed from the sludge, constitutes feed to the GTF. An ion-exchange system, based on a nitric acid eluant for the removal and concentration of cesium, is undergoing laboratory testing to determine resin life expectancy and eluant concentrations. Cesium from the ion-exchange process will be combined with the NCAW sludge as feed for the vitrification process. The NCAW pretreatment flow diagram is shown in Figure 3-3.

The NCRW consists of sludge and supernatant resulting from neutralization of PUREX process cladding removal waste. The NCRW sludge produced to date contains concentrations of TRU elements that preclude disposal as grout. The supernatant liquid is an LLW that can be immobilized in grout. The baseline plan involves retrieval of the sludge and dissolution in nitric acid to prepare it as a transuranic extraction (TRUEX) process feed. The TRUEX process will be used to produce a concentrated TRU fraction suitable for vitrification. The remaining LLW volume will be suitable for disposal in grout. The NCRW pretreatment flow diagram is shown in Figure 3-4.

The PFP wastes are neutralized and stored in a DST. The sludge portion of the neutralized waste contains concentrations of TRU elements that preclude grout disposal. The supernatant liquid is an LLW that can be immobilized in grout. As with NCRW, the baseline plan involves sludge retrieval and dissolution in nitric acid. This will be followed by the TRUEX process to produce a concentrated TRU fraction suitable for vitrification and an LLW fraction suitable for disposal in grout. The PFP pretreatment flow diagram is shown in Figure 3-5.

Because of past B Plant operations, waste liquors in some DSTs (CC and potentially some DSS and DSSF waste) contain significant concentrations of organic materials that form chemical complexants with TRU elements. The TRUEX process is being developed to remove TRU components from CC waste liquors. Methods are also being developed to destroy organic complexants present in the TRUEX process raffinates because complexed species in grouted wastes may be unacceptably mobile. Regardless of radionuclide properties, destruction of organic components may be required to prepare suitable grout formulations. Additionally, organic destruction may be mandated by regulatory criteria for permissible concentrations of organic materials in disposed radionuclide wastes. The required degree of destruction of the organic components is unknown. (Environmental regulations establish the disposal limits for organic components. As a result of the lack of characterization data, the initial concentrations are not known, hence the required degree of destruction cannot be determined.) Multiple approaches to organic destruction are being investigated to select the one that will best provide the required degree of destruction. The pretreatment flow diagram for CC waste is shown in Figure 3-6.

Figure 3-3. Neutralized Current Acid Waste Pretreatment Flow Diagram.

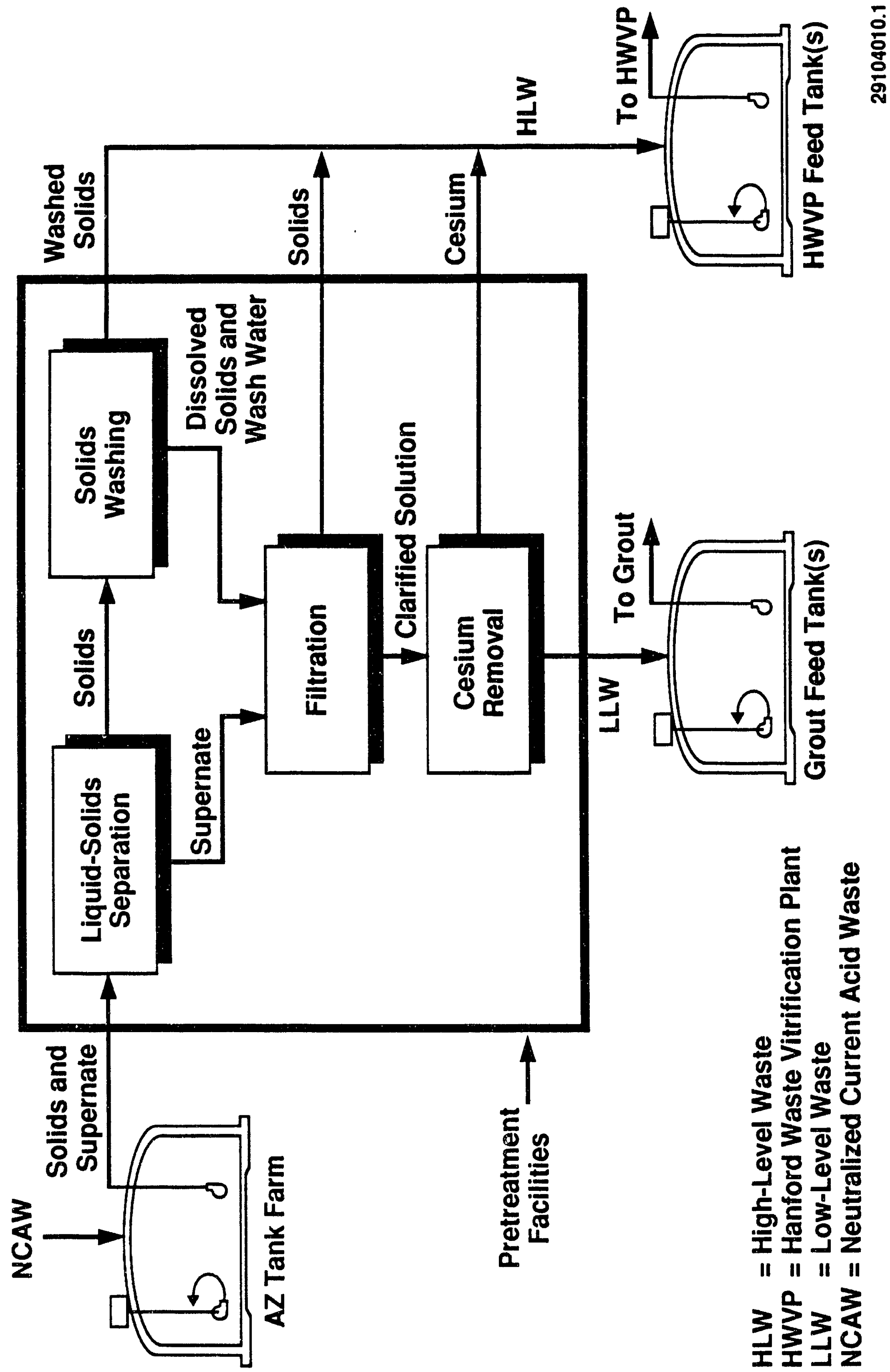


Figure 3-4. Neutralized Cladding Removal Waste Pretreatment Flow Diagram.

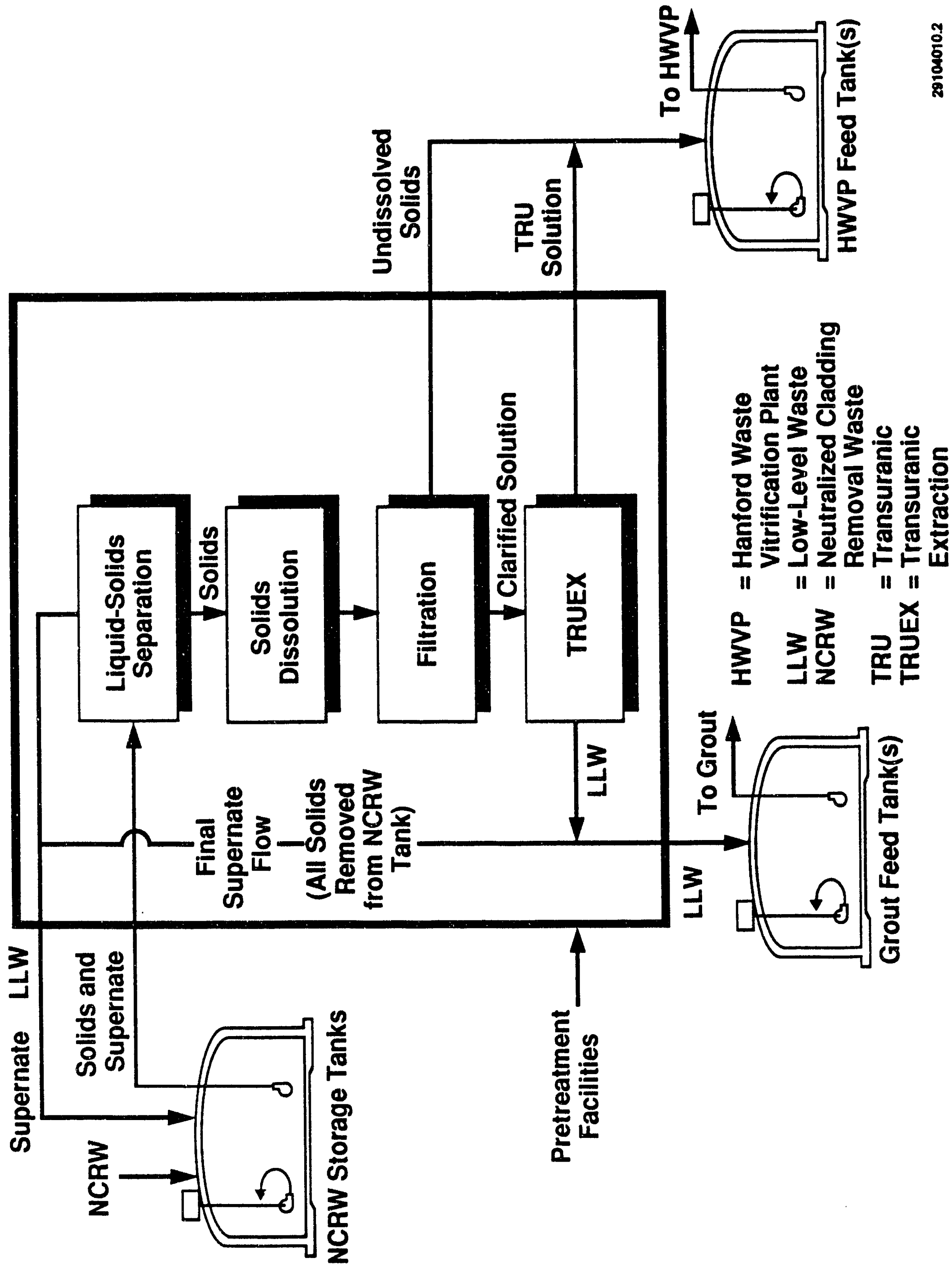


Figure 3-5. Plutonium Finishing Plant Waste Pretreatment Flow Diagram.

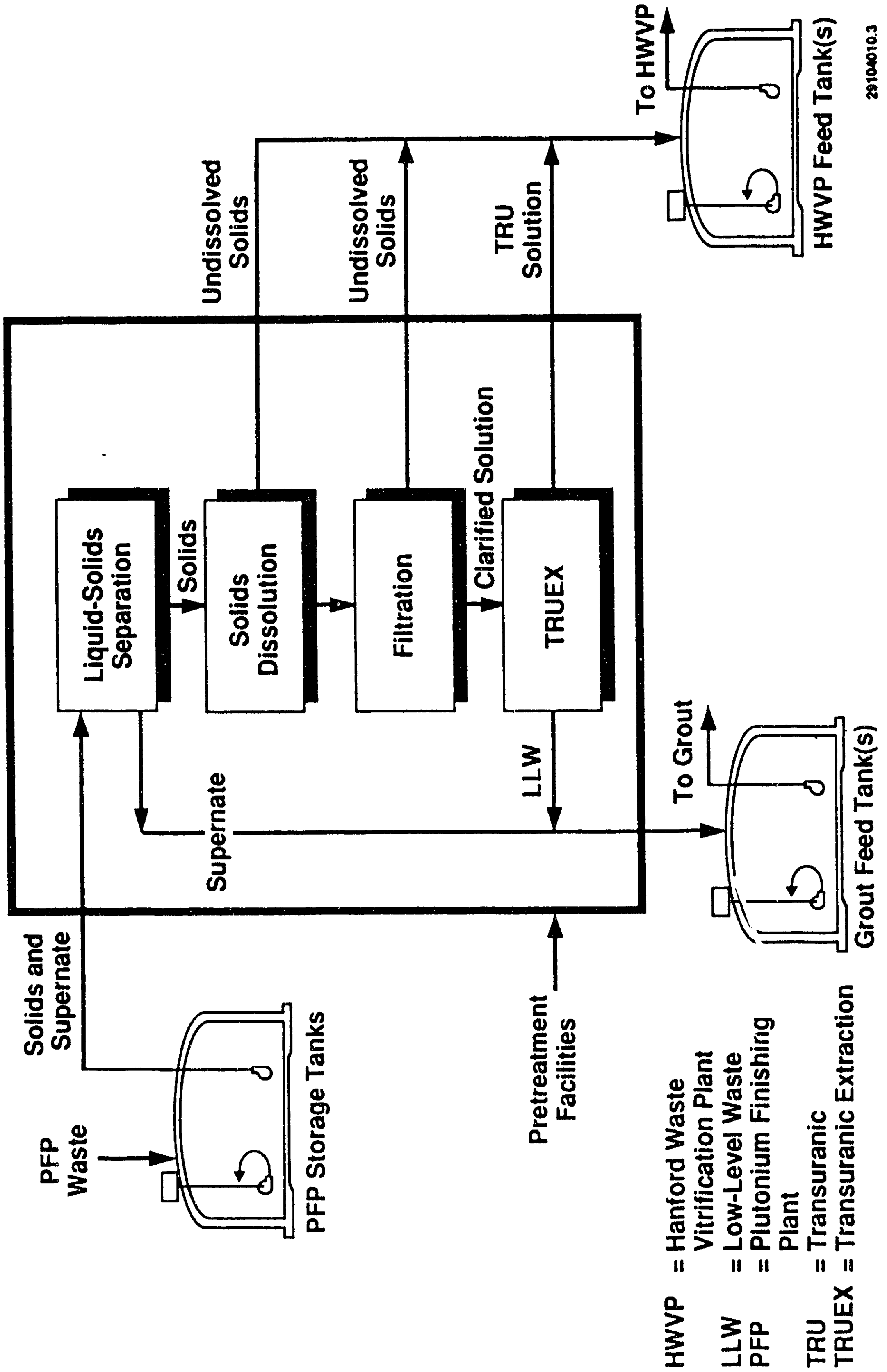
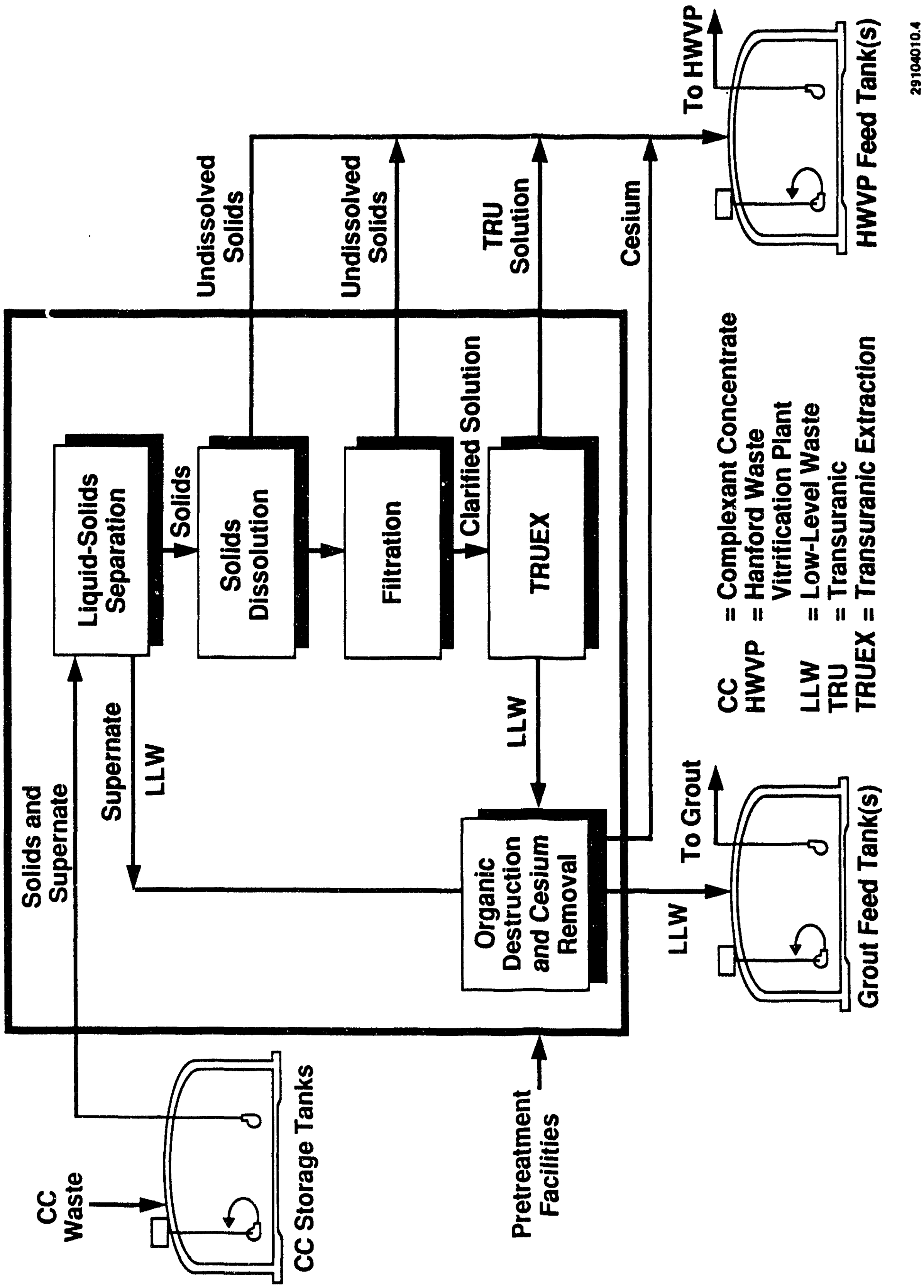


Figure 3-6. Complexant Concentrate Pretreatment Flow Diagram.



Negotiations between the DOE and the U.S. Nuclear Regulatory Commission (NRC) have resulted in a decision to remove 95 percent or more ^{137}Cs from CC to allow disposal of CC as LLW (Rizzo 1989; Bernero 1989). The impacts of this requirement on the processing rates for CC waste are being determined.

The NCAW pretreatment process is documented in two separate flowsheets. One flowsheet describes pneumatic hydropulse filtration and ion exchange in B Plant; the other describes settle-decantation and solids washing in the 244-AR Vault.

The NCAW solids-liquid separation and solid washing employing the settle-decantation and filtration process steps were demonstrated in B Plant in 1987. Recovery of cesium from supernate by means of an ion-exchange process was performed in B Plant from 1968 to 1985. The resin used in that process is no longer available and technology is being directed to process rate testing of the preferred replacement resin. Technology is also being directed to the development of analytical methods for pretreated wastes and process control equipment.

Preliminary TRUEX flowsheets have been prepared for NCRW and PFP waste. Preliminary dissolution tests on actual NCRW and CC waste have been successfully completed. Higher-than-anticipated dissolution percentages were achieved suggesting that further reduction in the number of glass canisters may be achievable. The TRUEX process distribution coefficients have been confirmed using actual NCRW and CC waste. The functional design criteria and CDR for the TRUEX pilot plant are complete. The definitive design has been initiated.

Screening studies are being performed to identify candidate organic destruction processes. The process for removal of cesium from CC waste (acidified as a result of the dissolution process) may differ substantially from the ion-exchange process used for cesium recovery from NCAW supernate. Candidate technologies remain to be identified.

3.4.4.4 Vitrification. Technology support of the HWVP Project encompasses a wide range of activities that collectively provide data required for HWVP detailed design, operation, and WFQ compliance. Development activities related to glass formulation and process verification, including vitrification testing, are described in WHC-EP-0350, *Hanford Waste Vitrification Plant Applied Technology Plan* (Kruger 1990). Vitrification testing and glass evaluation have been in progress for many years at the Pacific Northwest Laboratory (PNL), Westinghouse Savannah River Company (WSRC), West Valley Nuclear Services, and in Germany, Japan, the United Kingdom, and France. Therefore, the primary focus of the work for the HWVP is to provide data specific to the various Hanford Site DST waste types. Much of the site-to-site information flow is by periodic technology information exchanges.

A glass composition envelope is being developed for the HWVP pretreated feeds (NCAW, NCRW, CC, and PFP) that takes into account the major components of each waste type and the frit which must be used to make an acceptable glass. Preliminary acceptable glass composition boundaries that meet process and waste acceptance criteria for the borosilicate glass waste form have been established. Further refinement of the preliminary envelope is in progress and will continue for several years. Graphical display of the data into a format capable of being utilized for HWVP operation is also an important and continuing effort.

Feed processibility assessment is accomplished through continued interaction with waste management organizations responsible for flowsheet development and waste tank characterization. The information from the glass envelope definition is essential to determining impacts of feed pretreatment alternatives.

Nonradioactive integrated testing of a prototypic full-scale feed preparation system in conjunction with a pilot-scale ceramic melter and offgas system is a major activity planned to be continued at the Hanford Site until start of the HWVP cold runs. These tests are initially being conducted to provide specific design data required by the architect-engineer and to verify equipment performance and operation. Feed simulant compositions are based on flowsheet calculations and analytical results from radioactive core samples. Most of the integrated testing to date has been performed on the NCAW composition. Investigations of post-NCAW feed composition are planned to begin next fiscal year.

Vitrification testing is also being conducted at the integrated Defense Waste Processing Facility (DWPF) melter system (IDMS) located at the Savannah River Site (SRS) and at the Kernforschungszentrum Karlsruhe (KfK) in Karlsruhe, Germany. The IDMS test will provide design basis data from a pilot-scale vitrification system on hydrogen evolution during reaction of the NCAW feed containing noble metals with formic acid. Testing of the HWVP NCAW feed simulant with noble metals, in combination with the WSRC tests with similar feeds, provides a data set for linkage to the DWPF cold runs and hot operations. Additional information on melter performance with feeds containing noble metals that could precipitate and reduce melter life expectancy will be obtained from the IDMS tests. Noble metal studies also include melter performance testing at PNL and KfK and development of computer models to predict melter life expectancy for pretreated NCAW vitrification.

Most of the follow-on vitrification testing will be directed toward evaluation of process control methodology and determination of operating parameters to be used during HWVP cold-qualification runs. Current planning calls for operation of the full-scale feed system and pilot-scale melter (similar in design to the HWVP melter) under conditions identical to those to be required for the HWVP cold runs in order to provide a data set for plant operation comparison.

A major part of the overall technology development effort will be expended toward activities associated with ensuring compliance to the waste acceptance specifications (WAS). Although efforts to date have relied on the waste acceptance preliminary specifications (WAPS), there has been considerable progress toward issuing a WAS that will be generic for all waste producers in the near future. Development activities include process modeling to demonstrate process control within bounds that will ensure an acceptable glass product, preparation of radioactive glass from 3,800 m^3 (1 million gallon) tank core samples and subsequent measurement of glass properties, and bench-scale testing in the WESF to provide data for correlation with simulant feed results. As emphasis on HWVP shifts to preparations for the cold-qualification runs, direction must be provided to Plant Operations staff regarding data that will need to be taken to support the waste qualification report (WQR). Development of the waste compliance plan (WCP) and implementation strategy has been underway for some time. Planning for the cold-run tests and data set requirements, cold-run data evaluation, and compliance documentation are important steps that are required in the future to obtain permission for HWVP hot startup.

3.4.4.5 Grout. The grout disposal technology was successfully demonstrated in 1988 to 1989 with the processing of 3,800 m^3 (1 million gal) of PSW to form 5,300 m^3 (1.4 million gal) of grout. For each of the remaining LLWs to be grouted, grout formulations must be developed to meet all disposal regulations and processing requirements. Technology for demonstrating grout quality within the vaults requires further development. Some technology activities will be needed in support of safety and environmental documentation preparation and in support of future vault designs.

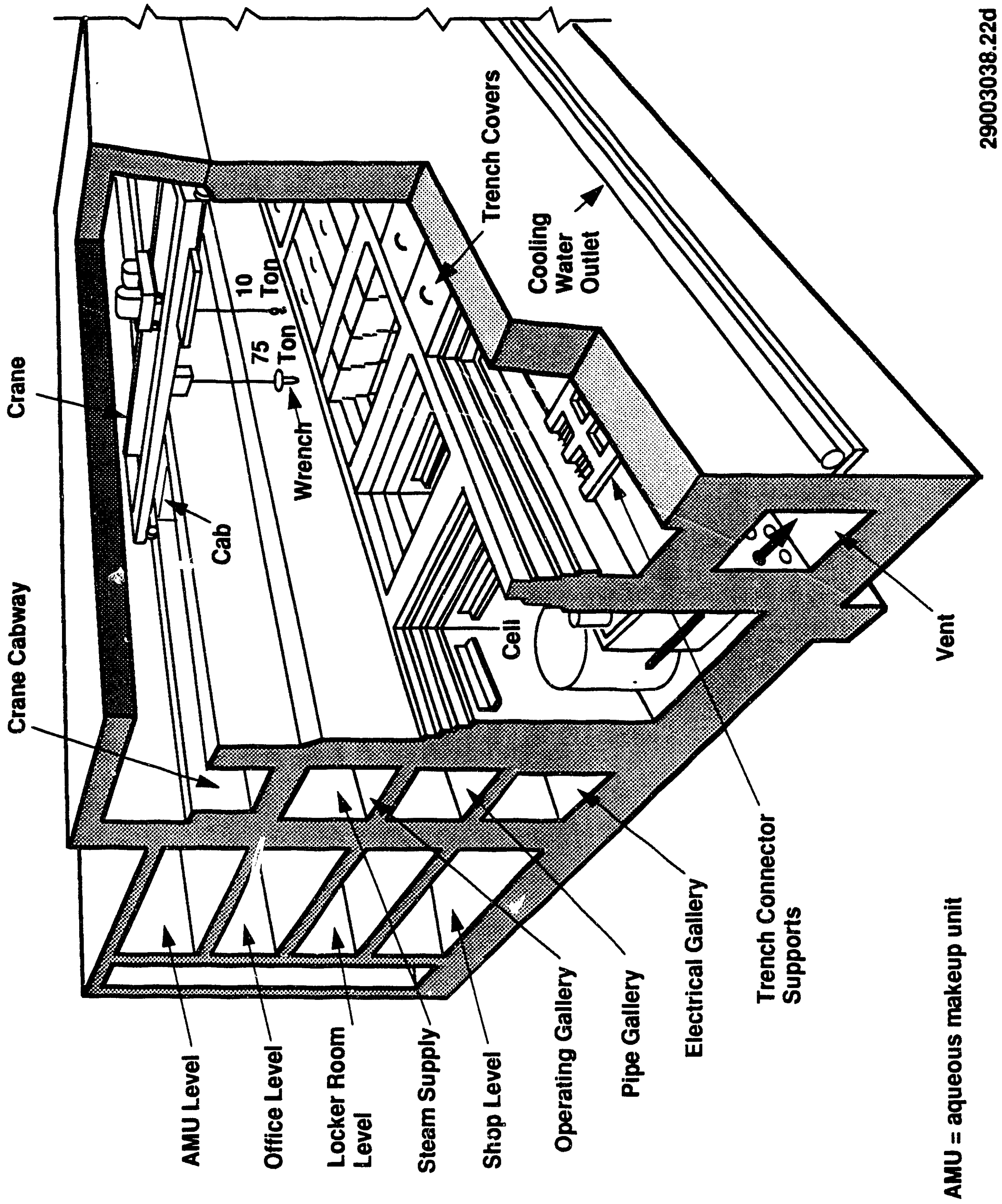
3.4.5 Pretreatment Facilities

An engineering study (Schulz et al. 1983) evaluated 3 facilities and 80 process options for the pretreatment of DST wastes requiring vitrification. The study selected B Plant as the preferred facility for pretreatment, citing significant economic and technical advantages. This resulted in the initiation of major facility upgrades and successful demonstration of the NCAW pretreatment process steps in 1987. In April 1988, the ROD for the HDW-EIS identified B Plant as the pretreatment facility. Concerns about aging facilities within the DOE complex raised doubts about the ability of B Plant to perform the DST pretreatment mission without significant risks to HWVP operations. These concerns resulted in preparation of an *Assessment of Double-Shell Tank Waste Pretreatment Options* (WHC 1989; WHC 1990). This assessment confirmed the viability of B Plant for pretreatment and recommended a second existing facility, the 244-AR Vault, for NCAW solids-liquid separation and sludge washing using the settle-decantation process. The availability of larger [160-m^3 (40,000-gal)] tanks in the AR Vault would allow the settle-decantation process rate to be doubled, reducing the NCAW pretreatment mission from 4½ to 2½ yr. Further, cell space needed for sludge washing in B Plant would be available for the TRUEX process installation during NCAW pretreatment. The net result in using the AR Vault was that pretreatment of post-NCAW types could be accelerated by 4 yr, potentially eliminating HWVP standby between the NCAW and post-NCAW campaigns. The recommendation was accepted by the U.S. Department of Energy Field Office, Richland (RL) in November 1989.

<u>B Plant Description</u>--Originally constructed in 1943, B Plant was used to process nuclear materials until 1956. The plant was modified and restarted in 1968 to recover cesium and strontium from stored waste, a mission that was completed in 1985. Since that time, the facility has been undergoing upgrades in preparation for the pretreatment mission.

The B Plant is a reinforced concrete canyon structure 260 m (850 ft) long, 20.7 m (68 ft) wide, and 21.9 m (72 ft) high. The processing portion of the building (221-B) consists of a canyon and crane-way, 40 process cells [4 m by 5.2 m by 6.4 m (13 ft by 17 ft by 21 ft) deep], a hot pipe trench, and an air tunnel. The service portion of 221-B includes an operating gallery, pipe gallery, and electrical gallery. Figure 3-7 shows the cell and gallery

Figure 3-7. B Plant Cutaway.



arrangement in B Plant. An attached service building (271-B) contains offices, cold-side ventilation equipment, and aqueous makeup facilities. The WESF, completed in 1968, extends the length of the B Plant complex [48 m (157 ft)] and provides safe storage for the cesium and strontium capsules. It is important to note that B Plant provides essential services to the WESF in support of this mission. In addition, the WESF is the only hot cell facility on the Hanford Site connected by pipeline to the B Plant and the Tank Farms.

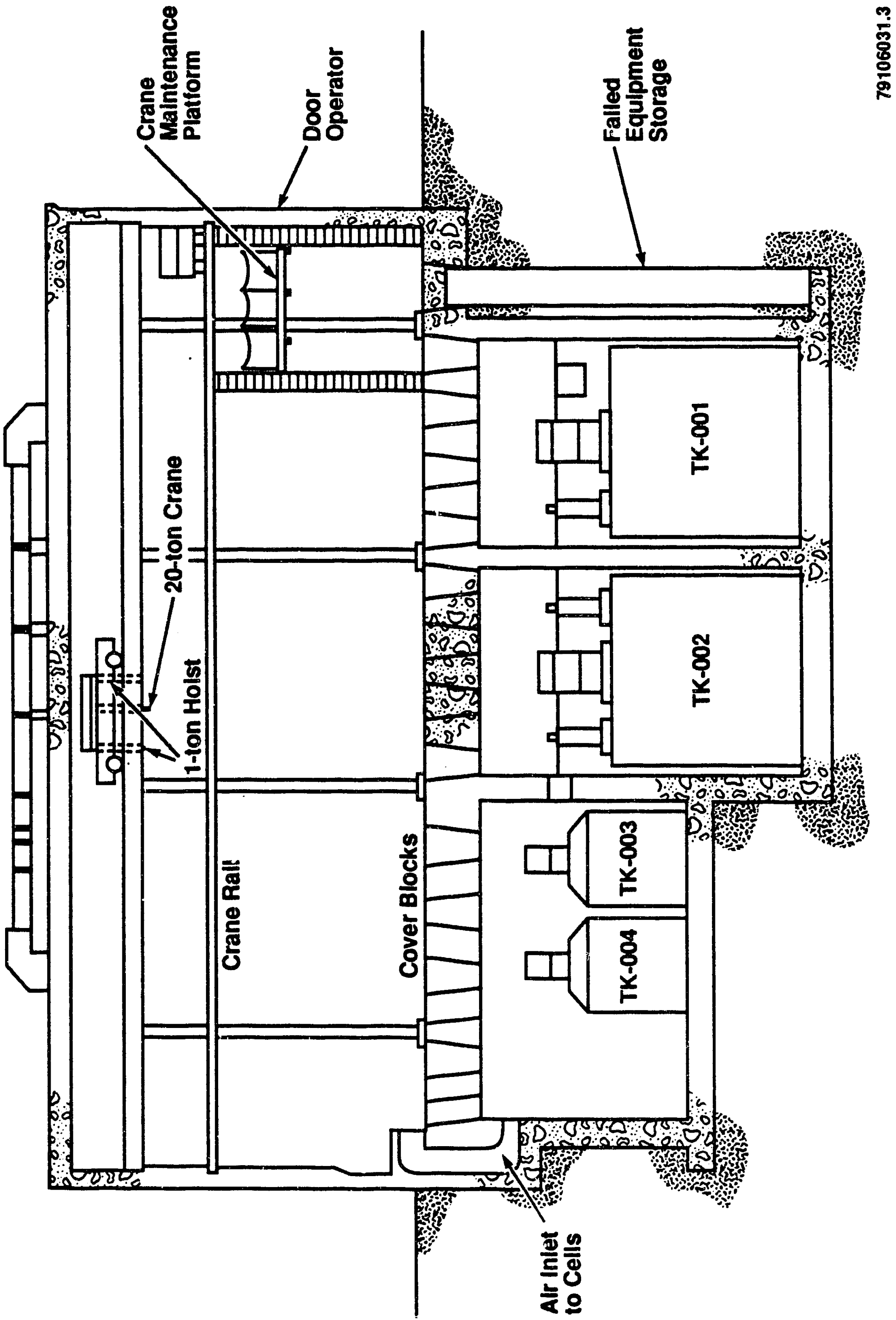
To achieve the milestones established by the Tri-Party Agreement, the B Plant upgrades will be accomplished as a series of 30 line item projects, general plant projects, and miscellaneous capital work orders totalling $420 million. The most significant line item projects are the TRUEX process installation ($320 million), safety class ventilation upgrade ($24.2 million), canyon crane replacement ($12.6 million), and radiological effluent containment upgrades ($12 million). Additionally, the TRUEX pilot plant ($25 million) is expense-funded and not included in the $420 million total.

The large number of small- to medium-sized projects results from the length of the Congressional funding cycle, which requires a 4-yr lead time to acquire capital funding in excess of $1.2 million, and the limited resources available to prepare the extensive engineering studies, functional design criteria, and CDR required for validation of a major project. Accordingly, the approach to B Plant modernization had been to implement a sequence of smaller, more manageable projects. This approach has been changed with many projects being consolidated in Project W-207, Major B Plant Upgrades. A more detailed discussion of the activities for upgrading pretreatment facilities is provided in Section 4.2.4.

There are specific concerns regarding the ability to bring the 244-AR Vault and B Plant into environmental compliance. The resolution of specific issues regarding the performance of tank integrity assessments and tank inspection and labeling in existing canyon facilities is difficult but assumed to be achievable. Other issues, such as the acceptability of unlined concrete vaults and a central cell drain header (in B Plant) as secondary containment barriers, will require concurrence by regulatory agencies and the DOE that B Plant is in compliance with environmental statues and DOE Orders.

<u>244-AR Vault Description</u>--The facility was completed in 1968 to support the cesium/strontium recovery and encapsulation operations and was used in that capacity until 1975. The facility served to (1) receive acid wastes from the PUREX Plant, (2) sluice and receive tank wastes being retrieved, (3) pretreat sludges before they were transferred to B Plant, and (4) receive neutralized HLWs being transferred from B Plant to Tank Farms. The AR Vault is a canyon facility located adjacent to the AY and AZ (aging waste) Tank Farms. The AR Vault is nominally 27.4 m (90 ft) long and 6.4 m (21 ft) wide with three below-grade cells. Cells No. 1 and 2 each have a 160-m^3 (40,000-gal) capacity stainless steel tank. Cell No. 3 is equipped with two 19 m^3 (5,000-gal) stainless steel tanks. An elevation view of AR Vault is shown in Figure 3-8. Other features include a control room, crane room, sample room, canyon ventilation system filters and stack, vessel ventilation system, filters and stack, and personnel accommodations. The facility was placed in a standby mode in 1978. In present operations, waste transfers from B Plant to Tank Farms are routed through the facility.

Figure 3-8. AR Vault Elevation View.



Numerous upgrades have been completed in the 244-AR Vault complex to support waste transfers through this facility. Ventilation system upgrades have installed new high-efficiency particulate air filter assemblies, instrumentation and controllers, and control room ventilation systems. A closed-loop cooling system was installed for the four waste tanks. A standby diesel generator, effluent monitoring system, air compressor, pumps, and agitators complete the list of recent upgrades. The following process and facility upgrades will be required to perform solids-liquid separation and to achieve environmental compliance:

- Aqueous makeup system and decontamination pumps
- Vessel ventilation heater upgrade
- Secondary containment upgrades for a ventilation seal pot, underground diesel fuel tank, and approximately 29 m (95 ft) of concrete-encased pipe
- Control room modifications.

The cost of these modifications is estimated to be $12 million.

3.4.6 Hanford Waste Vitrification Plant

Construction of the HWVP is an integral part of DOE/DP-0015, *Defense Waste Management Plan* (DWMP) (DOE 1983), which was submitted to Congress. To achieve the most efficient use of available resources, the DWMP called for a sequential approach for the development of liquid HLW immobilization facilities at two of the three DOE sites. The SRS would be the first to be developed, followed by the Hanford Site. An immobilization facility would then be developed for calcined wastes at the Idaho National Engineering Laboratory. This approach permits the experience gained at the first site to be applied to the other sites.

Consistent with the DWMP, RL published DOE-RL 89-32, *Hanford Site Waste Management Plan* (HWMP) (Merrick 1989) and its subsequent annual revisions, and the companion WHC-EP-0212, *Hanford Waste Management Technology Plan - Calendar Year 1988* (Powers 1989). With these plans, an integrated strategy for permanent disposal of Hanford Site defense wastes was established, involving the consideration of a broad spectrum of alternatives, subject to satisfactory completion of the appropriate *National Environmental Policy Act of 1969* steps. Included as part of this strategy is the processing of high-level defense wastes through a system that will ensure safe and acceptable disposal in a geologic repository. The process proposed for the Hanford Site HLW is the vitrification of waste in borosilicate glass in the HWVP. This process is based on the technology being used at the SRS in South Carolina, at the West Valley Demonstration Project (WVDP) in New York, and at waste processing plants in Mol, Belgium, and Tokai, Japan.

The HWVP process, material balance flowsheet, and product specifications have been established to provide a vitrified glass product that meets the requirements for WFQ as identified for the DWPF in OGR/B-8, *Waste Acceptance Preliminary Specifications for the Defense Waste Processing Facility High-*

Level Waste Form (DOE-OCRWM 1986). Recently, a draft WAPS document based on OGR/B-8 was prepared, which will be applicable to U.S. vitrification plants. These criteria account for HWVP-specific glass product characteristics.

To minimize the processing periods and operating costs for processing of DST wastes, and to provide the capability for processing the SST wastes, the HWVP melter capacity was established at 100 kg/h (220 lb/h) of vitrified product, the same as for the DWPF at the SRS. This processing capacity permits the maximum use of the technology and equipment developed for the SRS.

The HWVP will have storage capacity for 2,000 vitrified waste canisters. This capacity will allow the onsite storage of all vitrified waste from the NCAW, NCRW, and CC and PFP waste tanks, providing these wastes are pretreated as currently planned. The design will permit expansion for additional canister storage.

The design life of the plant facilities is 40 yr, which will accommodate the defense HLW vitrification needs at the Hanford Site during the next several decades. Located about 1.6 km (1 mi) west of B Plant, the HWVP site has access to existing railroads, utilities, and pipelines connected to B Plant. The estimated capital cost to construct the HWVP is $1,060 million.

The plant comprises nine buildings that will be used to house vitrification process and support systems and store glass canisters. The facilities will provide for remote operation and maintenance of the process with appropriate biological shielding for operator safety. The Vitrification Building is shown in Figure 3-9. Heating, ventilating, and air conditioning systems will provide additional confinement barriers to limit the potential spread of radioactive contaminants.

The process will comprise five major activities including feed preparation; vitrification; canister handling, decontamination, and welding; MOG and vessel vent treatment; and process waste treatment. Process equipment associated with these activities is remotely operated and maintained and will be located within cells in the Vitrification Building. Cold chemical and utility systems, and personnel support services required to support the vitrification process, will be located within buildings adjacent to the Vitrification Building. Wastes from the process and process support operations will be treated within the HWVP. The vitrification process will be controlled by a distributed control system.

The pretreated radioactive feed will be received from the double-shell Tank Farm, treated with chemicals and concentrated, then mixed with frit and/or glass-forming materials. This slurry will be fed to a joule-heated glass melter. The molten glass product will be poured into canisters that are then sealed, decontaminated, and stored for future shipment to a waste repository. Figure 3-10 shows the overall process flow for the HWVP.

3.4.7 Grout Treatment Facility

In accordance with the ROD (DOE 1988a) for the HDW-EIS, the DOE constructed a GTF at the Hanford Site. The GTF is located partly in the 200 East Area and partly in the adjacent 218-E-16 Area. The final EIS (DOE 1987)

Figure 3-9. Hanford Waste Vitrification Plant Cutaway.

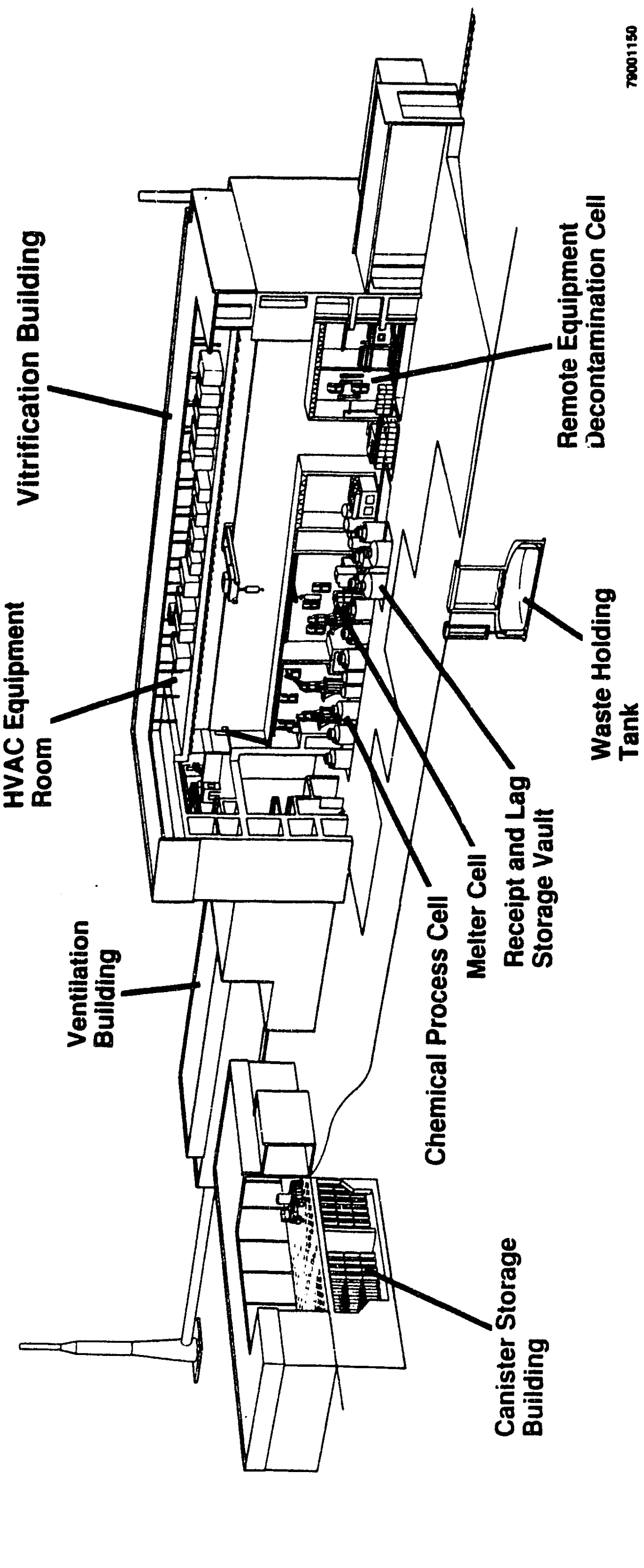
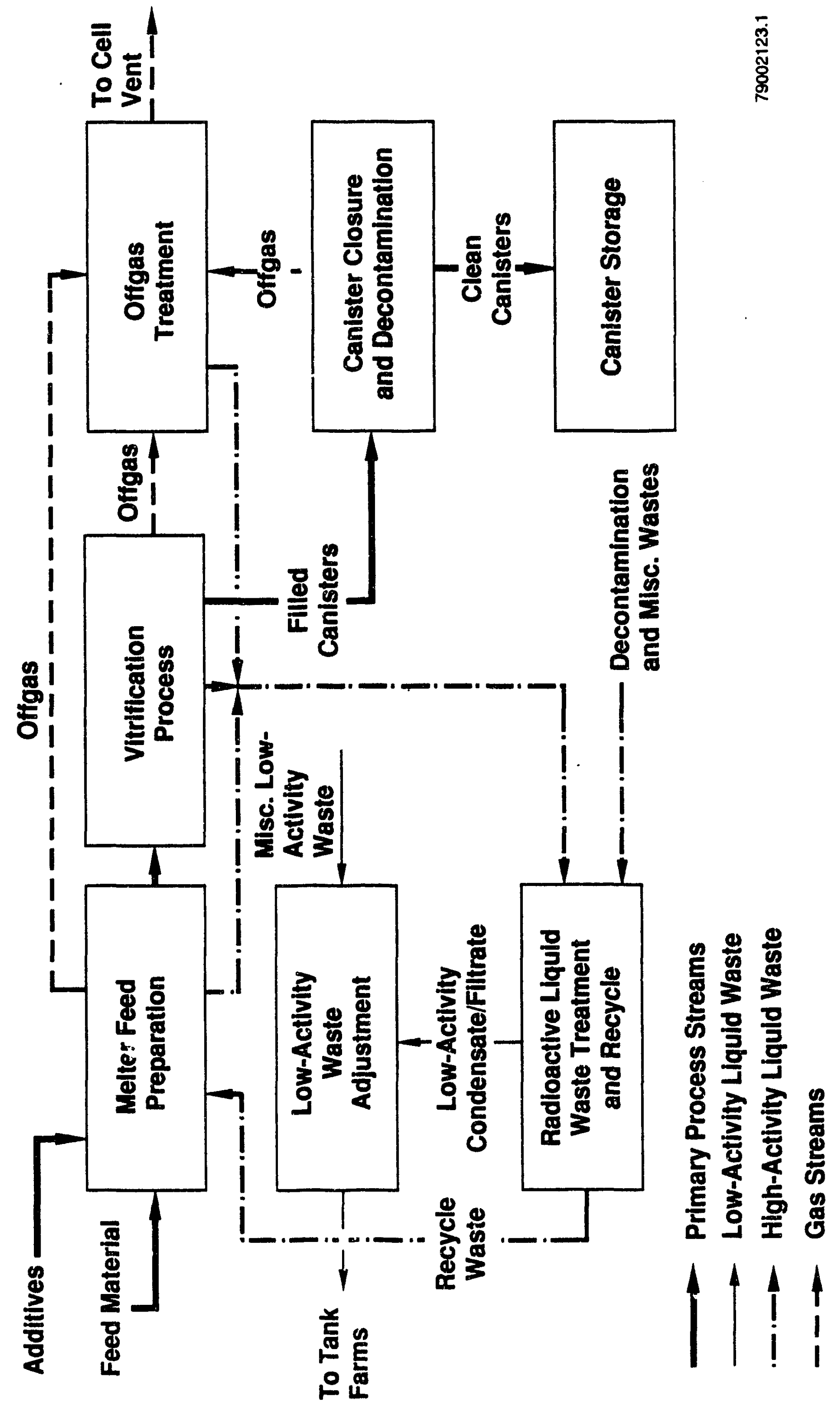


Figure 3-10. Overall Hanford Waste Vitrification Plant Process Flow.



refers to the GTF as the Grout Facility, which includes the transportable grout equipment (TGE), the Dry Materials Facility (DMF), the Grout Disposal Facility (GDF), and the feed transfer system. The name TGE evolved due to the modular nature of the units and equipment associated with the TGE. Initial concepts were to relocate the TGE units to disposal areas throughout the site as needed. The complexity of the systems and the current process mission versus life expectancy of the systems made the relocation concept impractical. However, the modular design will allow for ease of decontamination and decommissioning, when needed. The name of the TGE was changed to Grout Processing Facility (GPF) to better define the long-term nature and mission of the TGE. Construction of the DMF was completed in 1986 at a cost of $3.8 million and the GPF was completed in 1987 at a cost of $9 million. The grout disposal system is composed of the concrete vaults and associated barrier systems. Four vaults are nearing completion; their construction costs are estimated at $5.6 million per vault.

The DST waste is classified as an extremely hazardous waste because of the characteristics of the toxicity characteristic leaching procedure (TCLP) and toxicity [40 CFR 261 (EPA 1990)] (book method) as defined in *Washington Administrative Code* (WAC) 173-303-101, "Toxic Dangerous Wastes" (Ecology 1991). The waste is characteristically corrosive because of the hydroxide concentration and is characterized as toxic because of the high concentrations of nitrite and hydroxide ion. The waste is characterized as TCLP toxic because of the concentrations of chromium and lead and the detection-limit values for cadmium and silver.

Grout treatment is the process of mixing selected DST wastes with grout-forming solids, and possibly with liquid chemical additives, to form a grout slurry that is pumped into near-surface lined concrete vaults for solidification and permanent disposal. The radioisotope content of the liquid waste places it in Class C or below the NRC waste classification regulations (NRC 1991a).

The GPF is a treatment facility, and the GDF (which consists of the grout disposal vaults) is considered a disposal facility. The disposal vaults are managed as surface impoundments while the grout slurry is fluid and for a period of time after the grout slurry has solidified, before the vaults are closed as landfills.

Potential grout feed streams include the low-level fraction of DST wastes from past, current, and future Hanford Site operations. Waste from DSTs may require processing before it is considered acceptable as feed to the grout process.

Selected DST wastes are disposed in batch sizes (campaigns) of approximately 3,800 m^3 (1 million gal). The total grout volume, when dry solids are mixed with 3,800 m^3 (1 million gal) of liquid waste for one campaign, is approximately 5,300 m^3 (1.4 million gal).

The disposal of current and projected inventories of DST waste may take up to 25 yr to complete. During this time, vaults containing approximately 163,000 m^3 (43 million gal) of waste will be constructed, filled as surface impoundments, and closed as landfills, in accordance with WAC 173-303-650(6)(a)(ii), "Surface Impoundments" (Ecology 1991). At most, four campaigns will be conducted per year.

Sufficient quantities of DSS and DSSF have been identified to allow completion of a minimum of 16 grout campaigns before the LLW fraction from pretreatment is required for grout feed. During these campaigns, GTF operations are independent of the vitrification program activities. The vitrification program, however, depends on GTF operations to generate the DST space needed for retrieval and pretreatment operations. If grout campaigns are delayed, the vitrification program may be impacted.

3.4.8 Double-Shell Tank Farms

The double-shell Tank Farms, piping, and ancillary support systems serve to interconnect the pretreatment, vitrification, and grout treatment facilities. The facility relationships are shown in Figure 3-1. There are 28 DSTs in six Tank Farms. One Tank Farm, consisting of three tanks, is located in the 200 West Area. The remaining tanks are located in the 200 East Area. The AZ and AY farms have two tanks each, which are equipped with airlift circulators for the storage of high-heat wastes such as first-cycle raffinates from the PUREX process. The distribution of Tank Farms in the 200 East and 200 West Areas is shown in Figure 3-11.

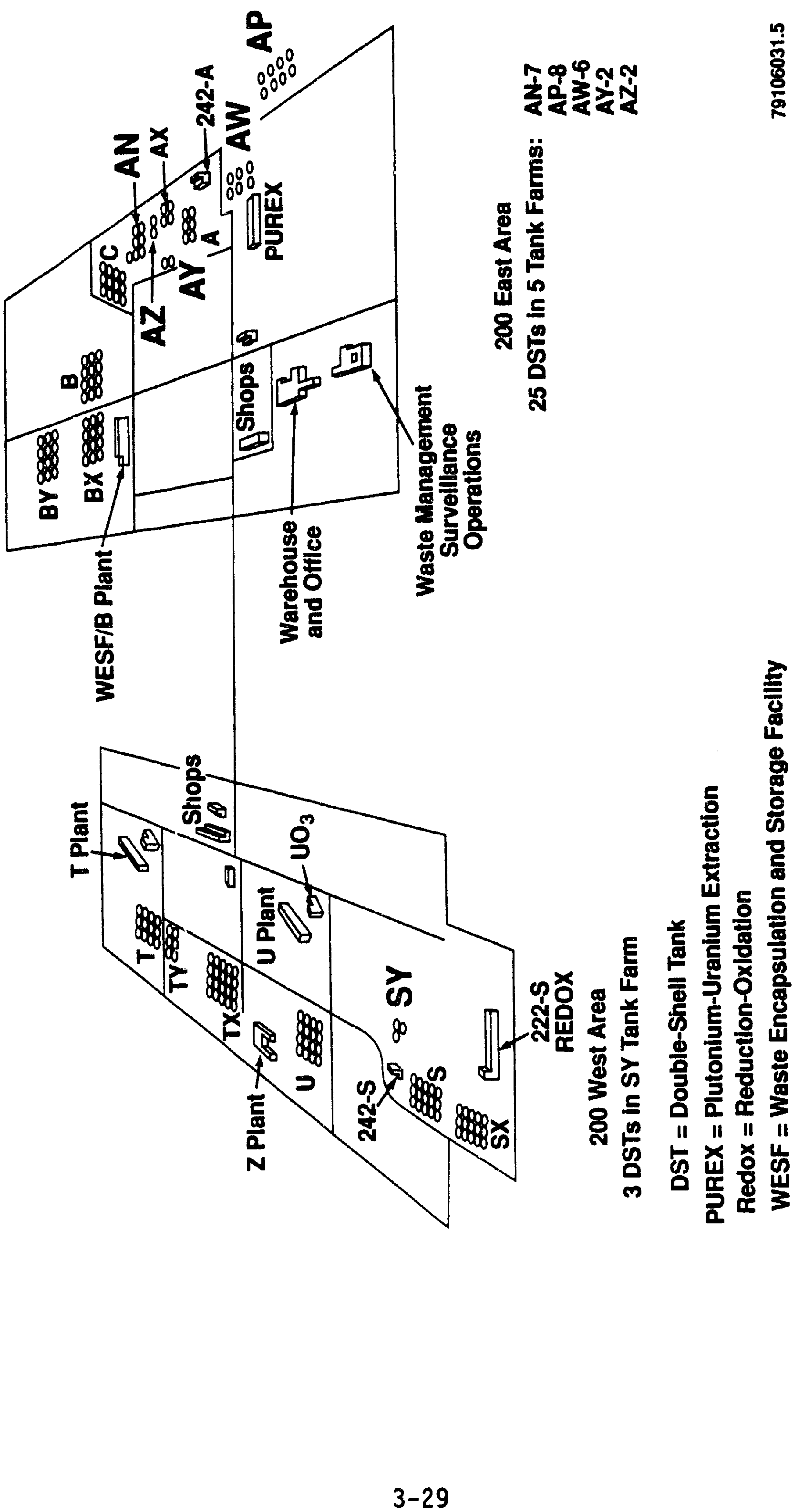
The primary mission of the Tank Farms is the containment and storage of tank wastes in a safe and environmentally compliant manner. In keeping with this mission, the single- and double-shell Tank Farms will undergo extensive upgrades projected to cost more than $700 million through FY 1997. These upgrades are focused primarily at bringing the facilities into environmental compliance, safe continuity of operation, and resolution of safety issues which include the following:

- The generation of flammable gases in some DSTs
- The presence of ferrocyanide in some SSTs and potential presence in DSTs
- Uncontrolled temperature and pressure buildup in tanks with the potential for radionuclide release.

While these upgrades are not part of the Hanford Site waste vitrification program per se, they must be accomplished, permits obtained, and operational readiness reviews completed in time to support the retrieval and transfer of DST wastes.

In addition, the vitrification program includes Tank Farm upgrades required for the retrieval and transfer of tank wastes. The present plan provides for the installation of SRS-type mixer-pump retrieval systems in up to 26 DSTs to complete the disposal of DST wastes. Mixer-pump technology was selected over sluicing, in part due to critical tank space limitations and the need to minimize water addition. Retrieval system installation projects will

Figure 3-11. Tank Farm Locations.



include electrical and ventilation system upgrades, transfer pumps, instrumentation and control systems, and provisions for removal and burial of abandoned equipment. The development and demonstration of full-scale prototype retrieval systems for the various waste types was previously discussed in Section 3.4.4. These prototype systems, successfully demonstrated, will be used to effect retrieval for pretreatment. Retrieval systems for the remaining DSTs will be procured and installed as a major project at an estimated cost of $375 million. A total of 26 retrieval systems will be installed to accomplish the disposal of DST wastes.

3.5 SINGLE-SHELL TANK CLOSURE

The 149 SSTs, located in the 200 East and 200 West Areas of the Hanford Site, have an estimated volume of 141,000 m^3 (37 million gal). These tanks contain various combinations of sludge, salt cake, and non-pumpable liquids generated from the early nuclear fuels reprocessing activities at the Hanford Site. The major waste types stored in the SSTs originated from the bismuth phosphate ($BiPO_4$) separations process (B and T Plants), uranium recovery process (U Plant), reduction oxidation (REDOX) process (S Plant), and early operations of the PUREX process (A Plant).

3.5.1 Single-Shell Tank Wastes

Early in the operation of the Hanford Site, the B and T Plants separated plutonium from uranium and the bulk of the fission products in irradiated fuel by co-precipitation with $BiPO_4$ from a uranyl nitrate solution. The plutonium was then further separated from fission products by successive precipitation cycles using $BiPO_4$ and lanthanum fluoride (LaF_3). The plutonium was isolated as a peroxide and, after dissolving in nitric acid, was concentrated as plutonium nitrate. Waste containing the uranium from which the plutonium had been separated was made alkaline (neutralized) and stored in underground SSTs. Other acid waste (which included much of the fission products) generated by this process was neutralized and stored in other SSTs. The specific volume of neutralized waste stored in SSTs was large, up to 40 m^3/ton (1,400 ft^3/ton) of irradiated uranium processed.

The B Plant was constructed between August 1943 and February 1945 and was operated as a separations plant until 1956. The T Plant was constructed between June 1943 and October 1944 and was operated until 1956.

Waste from the $BiPO_4$ process was first stored in SSTs. Later, the waste was mined by sluicing, dissolved in nitric acid, and processed through a solvent extraction process using a solvent consisting of tributyl phosphate (TBP) in kerosene to recover the uranium. The process was similar to that used later in the PUREX process except that plutonium was not recovered. The acid waste from the uranium recovery process was neutralized by the addition of NaOH and returned to SSTs. The recovery process, which operated from 1952 to 1958, resulted in an increase in nonradioactive salts and a small increase in waste volume.

The REDOX process was the first process to recover both plutonium and uranium. It used a continuous solvent extraction process to extract plutonium and uranium from dissolved fuel into a methyl isobutyl ketone (hexone) solvent. The slightly acidic waste stream contained the fission products and large quantities of aluminum nitrate that were used to promote the extraction of plutonium and uranium. This waste was neutralized and stored in SSTs. The volume of HLW from this process was much smaller than that from the $BiPO_4$ process, but larger than that from the PUREX process. The REDOX Plant was built between May 1950 and August 1951 and was operated until July 1967.

The PUREX process is an advanced solvent extraction process that uses a TBP in kerosene solvent for recovering uranium and plutonium from nitric acid solutions of irradiated uranium. It is the process generally used worldwide for recovering uranium and plutonium. Nitric acid is used instead of metallic nitrates (e.g., aluminum nitrate) to promote the extraction of uranium and plutonium from an aqueous phase to an organic phase. Most of the nitric acid in the waste is recovered by distillation and reused. The waste, containing residual nitric acid, is neutralized and stored in underground tanks. Initially, SSTs were used for this purpose. Double-shell tanks will be used for storing any future PUREX Plant waste. The volume of HLW per unit amount of fuel processed by the PUREX process is small compared to that from earlier processes. The PUREX Plant was built between April 1953 and October 1955 and then operated until 1972. It began operating again in November 1983.

3.5.2 Closure of the Single-Shell Tanks

The ROD (DOE 1988a) for the HDW-EIS (DOE 1987) did not make decisions regarding the disposition of the SST wastes. Thus, storage of SST waste will be continued. Before a decision is made regarding the disposal of this waste, additional development and evaluation will be performed as follows: radioactive and hazardous waste constituents will be characterized; barrier performance will be demonstrated by both instrumented field tests and modeling; the need and methods to improve the stability of the waste form will be determined, and destruction or stabilization alternatives for hazardous constituents will be evaluated; and methods for retrieving, processing, and disposing of this waste will be evaluated. Following this additional development and evaluation, alternatives for final disposal will be analyzed in a supplement to the HDW-EIS before the final disposal decision(s) are made. This supplement will be issued in draft form for public review and comment.

However, the ROD for the HDW-EIS stated that the HWVP, in addition to vitrifying DST waste, will be designed with sufficient flexibility to accommodate all SST wastes, should the decision be made to recover these wastes.

Retrieval of all SST wastes for disposal in a geologic repository could have greater short-term risks than for the readily retrievable wastes (DST). The SST wastes, including their hazardous components, are not well characterized. The efficiency of possible methods of treating and disposing of these wastes is not yet proven, and the consequences of such actions are not yet well defined. Therefore, additional waste characterization and additional engineering analysis of waste retrieval and disposal options are necessary before decisions for final disposition can be made. The SST wastes will continue to be stored safely and monitored while waste characterization, engineering development, and evaluation are completed.

3.6 CESIUM AND STRONTIUM CAPSULES

The ROD for the HDW-EIS requires that these wastes be packaged in accordance with repository WAS's. In July 1985, the U.S. DOE-Office of Civilian Radioactive Waste Management (OCRWM) established a waste acceptance process (WAP) as the means by which HLW producers would be allowed to dispose of wastes in a commercial repository. The WAP is generic because it is intended to accommodate any HLW form (other than spent fuel). The WAP requires that OCRWM prepare WAPS for each waste form. The WAPS have not been prepared for the cesium and strontium capsule waste form.

Although the WAPS for borosilicate glass are tailored for that waste form, much of their basis derives from the federal regulations or repository handling capability limitations. Because the existing WAPS are based on legal requirements or repository design constraints, they provide useful guidance for the development of non-borosilicate glass waste forms. The DWPF WAPS (DOE-OCRWM 1986) consist of 21 individual specifications. An overpack concept for disposal of the cesium and strontium capsules can comply with all but the following three specifications:

1. Radionuclide release properties

2. Chemical and phase stability

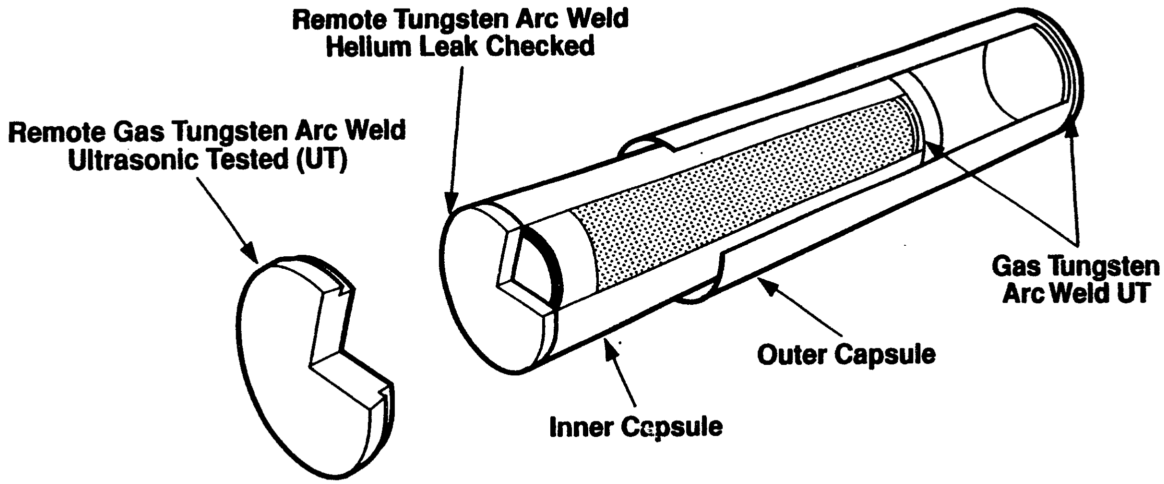
3. Chemical compatibility (between waste form and canister).

The overpacking concept will not comply with the statutory requirements for chemical and phase stability defined by Title 10, Code of Federal Regulations (CFR), Section 60.135(a)(2), or chemical compatibility defined by 10 CFR 60.135(a)(1) (NRC 1991). Thus, it will not be possible to dispose of the overpacked cesium and strontium capsules without seeking a waiver to at least these two repository disposal requirements.

In the overpack concept, four intact capsules would be placed in a canister having the same external dimensions as the canister used by the HWVP. On a 4:1 basis, the 1985 cesium and strontium capsules would result in 496 canisters for disposal in a geologic repository at an estimated repository cost of $174 million. If the capsule contents were vitrified as a standalone HWVP mission, 133 canisters would be required for capsule disposal at a cost of $65 million. On the basis of glass composition, this number could be further reduced if the halides were removed before vitrification. However, limitations on canister heat generation in the Canister Storage Building would minimize or eliminate this potential reduction. Given the ability to blend the cesium and strontium with NCAW or CC waste, as few as five additional canisters may be required and disposal costs will be in the range of $10 million to $18 million. The construction and dimension of the capsules is shown in Figure 3-12.

Given the likelihood that the overpack concept will not meet WAS's and the potential to significantly reduce the number of canisters for disposal, it is prudent, if not mandatory, to identify alternatives for disposal of encapsulated waste.

Figure 3-12. Construction and Dimensions of Cesium and Strontium Capsules.



	Capsule									
	Inner					Outer				
	Material	Wall Thickness	Outside Diameter	Total Length	Total Cap Thickness	Material	Wall Thickness	Outside Diameter	Total Length	Total Cap Thickness
Strontium Fluoride	Hastelloy C-276 (UT)	0.305 (UT)	5.72	48.39	1.02	Stainless Steel 316-L (UT)	0.277 (UT)	6.67	51.05	1.02
Cesium Chloride	Stainless Steel 316-L (UT)	0.241 (UT)	5.72	50.10	1.02	Stainless Steel 316-L (UT)	0.277 (UT)	6.67	52.77	1.02

Note: All dimensions are in centimeters. One centimeter equals 0.3937 inches.

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4.0 DOUBLE-SHELL TANK RISK ASSESSMENTS

4.1 METHODOLOGY

The goals of the Double-Shell Tank Risk Assessment (DSTRA) were to identify and quantify the risks to successful completion of the presently specified (as of December 1990) double-shell tank (DST) waste disposal (DSTWD) program, and to develop strategies for mitigating significant risks. The Venture Evaluation and Review Technique (VERT) computer program was selected as the means for quantifying programmatic risk. The VERT program requires the following information in order to calculate programmatic risk:

- Identification of individual program elements
- Definition of logical and time sequence relationships between program elements
- Determination of the performance consequences of each program element (in terms of cost and schedule impacts)
- The probability of successfully completing each program element.

A panel of knowledgeable individuals was formed to obtain this information. These individuals represented each of the seven major activities involved in the DSTWD program, specifically:

1. Sampling and characterization
2. Retrieval
3. Pretreatment technology
4. Pretreatment facilities
5. Hanford Waste Vitrification Plant (HWVP)
6. Grout
7. Tank Farms.

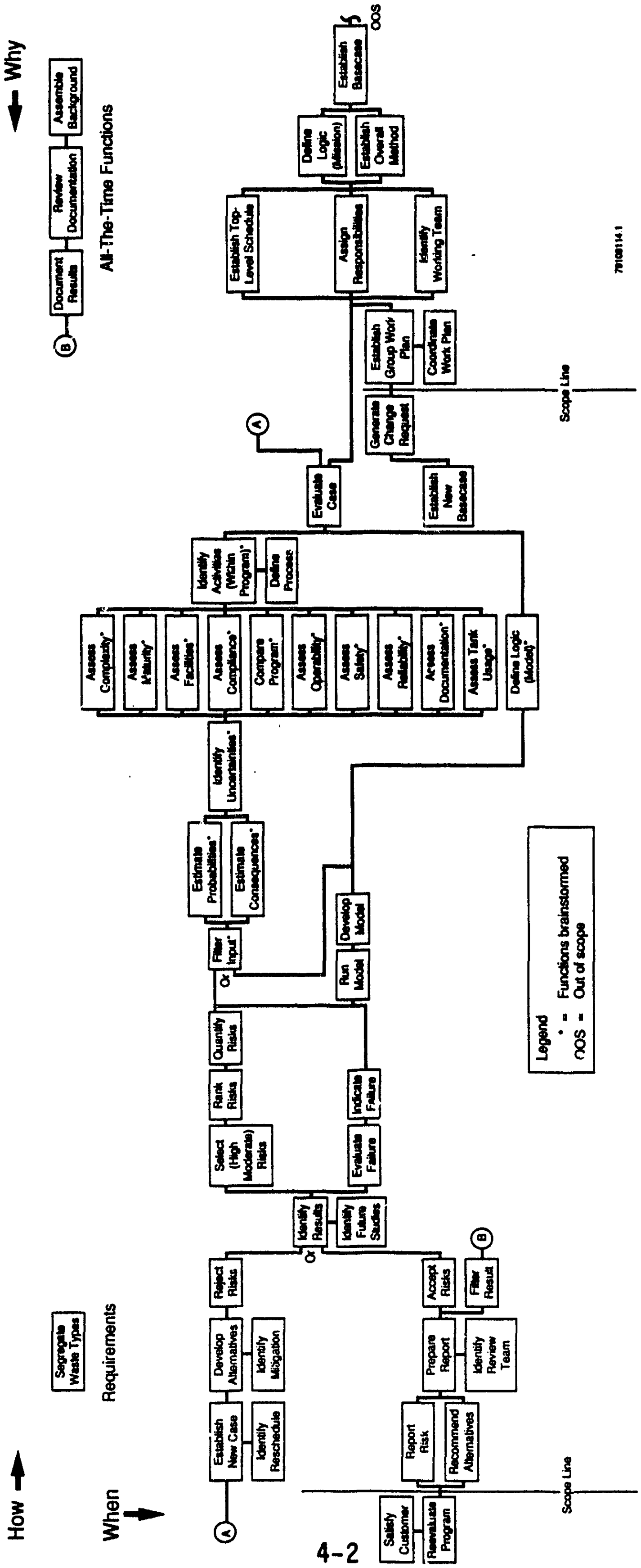
The panel established a detailed procedure for gathering the information required by the VERT, the technical base case, mission logic diagrams, top-level schedule, and the DSTRA working teams. Figure 4-1 depicts the process used during the DSTRA.

4.1.1 Technical Base Case Summary

The technical base case selected for the DSTRA, which was used to assess risks, can be summarized as follows:

- Waste quantities for pretreatment and vitrification

Figure 4-1. Double-Shell Tank Risk Assessment Process.



- Neutralized current acid waste (NCAW)--7,600 m^3 (2.0 million gal), 5,300 m^3 (1.4 million gal) existing plus 2,300 m^3 (0.6 million gal) from future plutonium-uranium extraction (PUREX) operations
- Neutralized cladding removal waste (NCRW)--4,540 m^3 (1.2 million gal), 3,400 m^3 (0.9 million gal) existing plus 1,140 m^3 (0.3 million gal) from future PUREX operations
- Plutonium Finishing Plant (PFP) waste--1,540 m^3 (0.4 million gal), 400 m^3 (0.1-million gal) existing plus 1,140 m^3 (0.3 million gal) from future PUREX operations
- Complexant concentrate (CC) waste--18,200 m^3 (4.8 million gal), 16,300 m^3 (4.3 million gal) existing plus 1,900 m^3 (0.5 million gal) from future single-shell tank (SST) stabilization and isolation

• Retrieval process

  - Savannah River Site (SRS) mixer-pump technology to minimize waste volume growth in retrieval

• Pretreatment processes

  - NCAW — Solid-liquid separation using settle decantation and pneumatic hydropulse (PHP) filtration, sludge washing for solids dissolution, and ion exchange for cesium removal from the supernate
  - NCRW — Solid-liquid separation, acid dissolution of solids, and transuranic extraction (TRUEX) (solvent extraction) process for removal of transuranics (TRU)
  - PFP waste — Solid-liquid separation, acid dissolution of solids, and TRUEX process for removal of TRUs
  - CC waste — Solid-liquid separation, acid dissolution of solids, TRUEX process for removal of TRUs, organic destruction, and ion exchange for removal of cesium

• Pretreatment facilities

  - 244-AR Vault and B Plant

• Vitrification facility

  - HWVP

• High-level and TRU waste disposal

  - Borosilicate glass waste form

- Low-level waste (LLW) disposal
    - Grout waste form.

4.1.2 Schedule Base Case

The activities identified in fiscal year (FY) 1991 Budget Case 2 (December 1990) were selected as the program elements that would be used in the VERT computer model. Budget Case 2 was selected because it represented the most complete and highly developed DSTWD program baseline in existence at that time.

4.1.3 Mission Logic Diagrams

To clearly establish the logical relationship between the various program elements, two DSTWD mission logic diagrams were developed. One diagram represented the program elements necessary to process NCAW, while the second represented the program elements needed to process post-NCAWs (NCRW and PFP and CC wastes). These diagrams are shown in Figures 4-2 and 4-3.

4.1.4 Top-Level Schedule

Review of the technical base case, mission logic diagrams, and schedule base case revealed that the logic between some of the program elements could not be defined. Additionally, while the activities necessary to reach startup of HWVP were well defined, not all activities necessary to complete the vitrification program were defined. For example, the schedule base case did not include the activity "replace first HWVP melter." Therefore, approximately 50 activities were added to the base case schedule. A new integrated schedule showing all the inter-related activities was created for the Risk Assessment and was designated the "top-level schedule." Program elements input into the VERT program model were developed from the top-level schedule. A review of the top-level schedule (see Figures 4-4 and 4-5 in pouches at the back of this document) will show baseline performance periods for principal vitrification activities as shown in Figure 4-6. The approach taken in providing the base case for this Risk Assessment used the mission logic diagrams in conjunction with the top-level schedule to define the analysis baseline.

4.1.5 Double-Shell Tank Risk Assessment Working Teams

To perform the DSTRA, a working team was established for each of the seven DSTWD major activities. The individual schedule activities fell wholly or mostly within one of these major activities. The working teams were assigned the responsibility of assessing all schedule activities, which fell within their major activity, and coordinating the results of the assessments with those of the other working teams.

Figure 4-2. Mission Logic Diagram--Neutralized Current Acid Wastes.

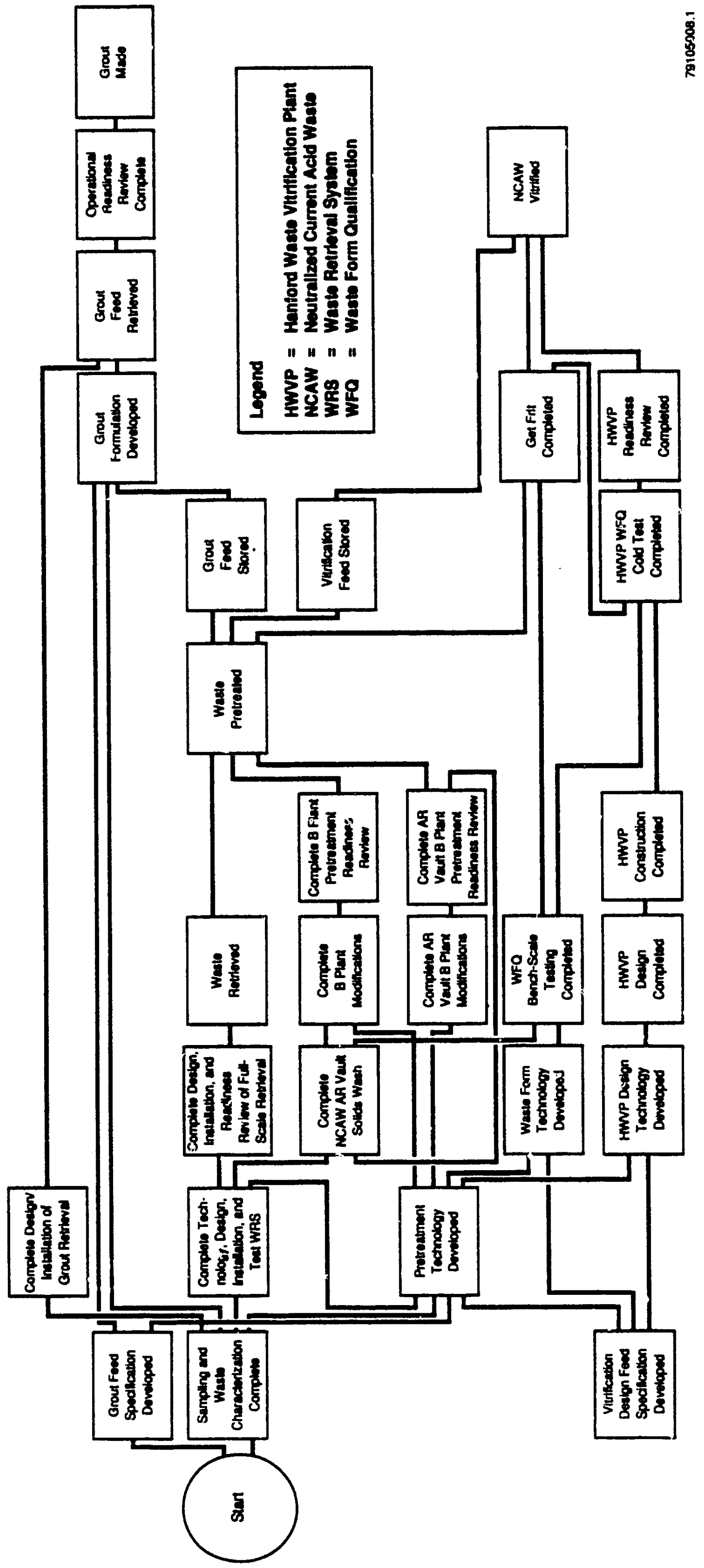


Figure 4-3. Mission Logic Diagram--Post-Neutralized Current Acid Wastes.

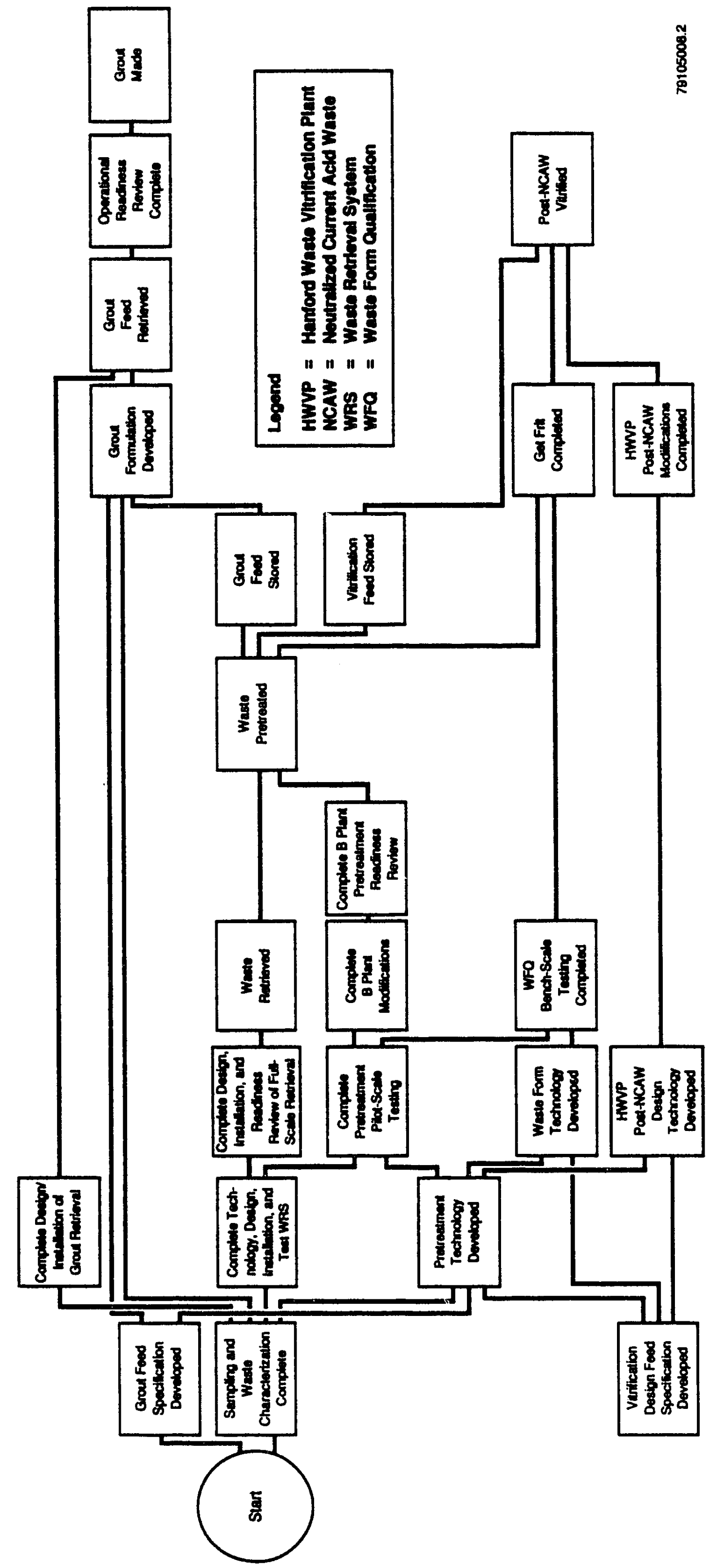
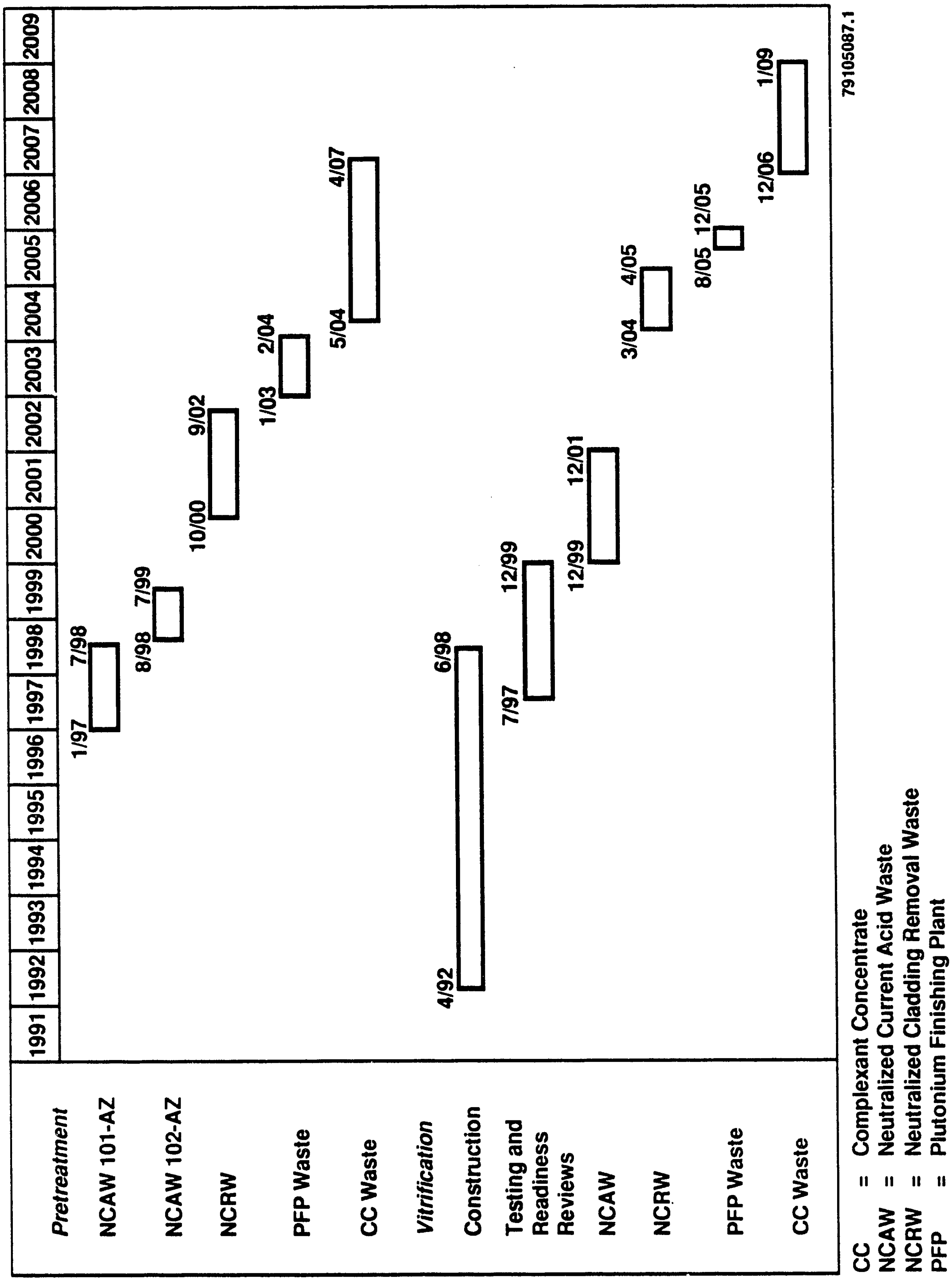


Figure 4-6. Baseline Schedule for Double-Shell Tank Waste Disposal.



4.1.6 Assessments

Each schedule activity was assessed against one or more specified categories. The categories assessed as specified in WHC-EP-0391, *Hanford Waste Vitrification Systems Risk Assessment Action Plan* (Miller 1990) were as follows:

1. Technological complexity
2. Process technological maturity
3. Adequacy of existing facilities
4. Compliance to orders and regulations
5. Compare programs and facilities to other vitrification facilities
6. Facility capability to operate reliably
7. Facility safety
8. Design definition
9. Safety and environmental documentation.

Not all the assessment categories apply to each schedule activity. For example, a schedule activity might be assessed for Categories 1, 2, and 4, but not 3, 5, 6, 7, 8, or 9. Determination of the categories applicable to each individual schedule activity was made by the major activity working team leader, with concurrence by the Risk Assessment Management Team.

When assessing a schedule activity against a category, specific considerations were addressed. These specific considerations were as follows:

1. Complexity
   a. Compared complexity with existing processes and technologies
   b. Assessed the extent of prior use in nuclear or commercial facilities
   c. Assessed the number and uniqueness of <u>major</u> process elements
   d. Assessed number and types (solid, slurry, etc.) of feed and discharge streams
   e. Assessed degree of automation.
2. Maturity
   a. Evaluated the depth and breadth of technology that supports the major process elements
   b. Assessed commercial availability of process equipment

c. Considered pilot-plant, bench-scale, reduced-scale, or end-scale, prototype, and commercial experience

d. Considered experience at the SRS and the West Valley Demonstration Project (WVDP).

3. Existing Facilities

a. Reviewed existing documentation used to support the use of existing facilities

b. Note that compliance to orders and regulations, specifically U.S. Department of Energy (DOE) Order 6430.1A, *General Design Criteria* (DOE 1989), and environmental and safety regulations, codes, and standards are the topic of a separate assessment (Category 4). Reviews focused on uncertainties associated with systems or equipment items that are not planned to be upgraded to comply with environmental or safety regulations. The control system may be adequate but outdated. Will maintenance be difficult because of space constraints? Will it be possible to add process equipment if difficulties arise during initial (cold or hot) operations?

4. Compliance

a. Reviewed design criteria for each major Hanford Site vitrification facility to determine if appropriate safety and environmental regulations are being used in the design process

b. Examined the design criteria documents for each of the major vitrification facilities to determine if applicable DOE Orders or federal and state regulations are properly referenced

c. Compared criteria to key DOE Orders and regulations, such as DOE Order 6430.1A (which required compliance with all federal, state, and local requirements), to assess their compliance with the applicable Orders and regulations.

5. Compare Program

a. Identified major elements of SRS and WVDP vitrification programs

b. Assessed similarities and differences between Hanford Site vitrification program elements (facilities or key process elements) and those at SRS and at WVDP

c. Identified any elements of the SRS or WVDP programs that are missing from the Hanford Site program and justified the differences

d. Identified current and evolving problems in the SRS and WVDP programs and identified their potential impacts to the program at the Hanford Site.

6. Reliable Operation

   a. Assessed facility layout for efficient operations (assumed identified modifications are complete)

   b. Assessed condition of plant equipment and availability of spares

   c. Assessed facility availability, or Operating Efficiency Analysis (if available).

7. Safety

   a. Assessed condition of engineered safety systems, including hazardous and radioactive material confinement barriers, ventilation systems, etc.

   b. Reviewed worker contamination, radiation exposure, and first aid records

   c. Assessed numbers and types of safety-related occurrences or audit findings [unusual occurrences, Tiger Team, Occupational Safety and Health Administration (OSHA), Technical Safety Appraisal (TSA), unreviewed or open safety issues]

   d. Assessed redundancy and separation of safety equipment.

8. Design Definition

   a. Assessed the level of design completion (design status) for construction or modification of each major Hanford Site facility

   b. Reviewed design criteria, schedules, and planning documents to ensure appropriate planning is in place to complete design in allotted time.

9. Documentation

   a. Assessed status of required safety analysis reports (SAR), *National Environmental Policy Act (NEPA) of 1969* documentation, Washington State Department of Ecology (Ecology) and U.S. Environmental Protection Agency (EPA) documentation, and environmental permit applications.

4.1.7 Documentation

In assessing each schedule activity, the working team gathered documentation or interviewed responsible individuals as required to address the questions or considerations associated with each assessment category. This information is provided in WHC-EP-0427, *Hanford Waste Vitrification Systems Risk Assessment - Final Report Supporting Information* (Miller et al. 1991)]. The documentation for each schedule activity includes a Risk Analysis Results

Form, an Input to Science Applications International Corporation (SAIC) Form, and one or more Uncertainty Report Forms, described as follows.

Risk Analysis Results Form--This form documents the assessments performed on a scheduled activity.

Input to SAIC Form--For the purpose of the Risk Assessment, risk was defined as the product of probability and consequence. The consequence of completing a schedule activity was quantified as cost and time. Based on the documentation reviewed and discussion with knowledgeable individuals, the teams developed optimistic, pessimistic, and most likely estimates of the cost and time required to complete each schedule activity. The teams were also required to identify the fixed and variable portions of the aforementioned cost estimates. If the schedule activity was an "initiating activity" (e.g., an activity that is not preceded by another activity), an estimate of the start date was also made. This information was documented on the Input to SAIC Form. With these estimates, it was possible to compare the cost and time required to complete the DSTWD program against the base case schedule and against models modified to include one or more mitigating strategies. These estimates are also used to identify cost and time critical paths. The teams were also required to determine the probability of the schedule activity being successfully completed within the "most likely" duration.

Uncertainty Report Form--In assessing a schedule activity, uncertainties associated with successful completion of the activity were identified. The bases for the uncertainties were also identified. A summary of uncertainties and additional discussion is provided in Section 4.3.

4.1.8 Probability of Success

The probability of success of an activity is, generally, not independent of the cost and schedule for that activity. To support the VERT program, a separate probability of success value had to be developed. A table of "descriptive phrases" was used to qualitatively describe the probability of successfully completing each schedule activity based on the assessment of the activities and the resulting uncertainties.

Table 4-1 correlates a numeric probability of successfully completing an activity to the descriptive phrases used in the assessments. Probabilities were assigned to each of the statements in Table 4-1 based on the judgment of the Risk Assessment management team. As such, the percentages are subjective, yet they provide a consistent, relative measure of uncertainty for each activity. These probabilities were used in the risk analysis model to define the probability of an activity being successfully completed within the "most likely" cost and duration.

With these probability estimates, it is possible to compare the probability of successfully completing the DSTWD program against modifications to the program to include one or more mitigating strategies.

The activity probability is documented on an Input to SAIC Form.

Table 4-1. Numeric Probability of Success.

Description	Probability
A. Done or nearly complete	1.0
B. Sure that it will be done	1.0
C. Routinely done now, here	1.0
D. Routinely done elsewhere	0.99
E. Sure that it can be done	0.99
F. Routinely done in past	0.99
G. Has been done here	0.98
H. Has been done elsewhere	0.98
I. Demonstrated in prototype facility tests	0.95
J. Demonstrated in pilot-plant tests	0.95
K. Demonstrated in bench-scale tests	0.90
L. Demonstrated in laboratory-scale tests	0.80
M. Think that it will be done	0.70
N. Think it can be done	0.70
O. Not sure it will be done	0.50
P. Not sure it can be done	0.50
Q. Doubt it will be done	0.20
R. Doubt it can be done	0.20
S. Virtually certain it will not be done	0
T. Virtually certain it cannot be done	0
U. Know it will not be done	0
V. Know it cannot be done	0
Special probability designators	Probability
A* Continuation of an activity where the actual probability of success is carried on the first part of the activity	1.0
M* A 0.70 rating, the lower probability rating has been assigned to the related cold test	0.99
N* A 0.70 probability spread over three activities	0.90
O* A 0.50 probability spread over five activities	0.87

NOTE: Assignment of probability was performed by members of the Risk Assessment management team based on their experience.

4.1.9 Filter Input

In this step, the probability and consequence data generated during the assessments were reviewed. The review consisted of a management level review and a review by the Risk Assessment management team. The purpose of the review was to filter out inconsistent and inaccurate data before these data were input for the final model run. Partial model runs were used to study the sensitivity of the model to the input data and to help identify data that were inconsistent or incorrect. The team members participated to ensure that any changes to the data to resolve inconsistencies or inaccuracies were acceptable.

4.1.10 Model Development

Probability and consequence (schedule and cost distributions) data generated for each of the schedule activities during the assessment process were input into the VERT model. The development of the model, plus a post-processing step, is described in Section 4.5.

4.1.11 Run Venture Evaluation and Review Technique Model, and Indicate and Evaluate Results

Subsequent to review and final revision of the input data, the model was used to identify program risks. The output of the model identified three categories of program risks and listed those activities that most influence each of the risk categories. The three categories are defined as follows.

Cost Critical--Cost-critical activities are ranked according to a factor derived by multiplying a constant by the difference between the most likely and pessimistic cost, or most likely and the baseline cost, whichever is greater. The potential increase in cost is utilized because mitigating strategies applied to activities with a large potential increase in cost have a better chance of decreasing overall program cost than mitigating strategies applied to activities for which the potential increase is initially small. The activities are ranked in descending order.

Time Critical--The string of activities through the network that has the greatest cumulative time is the time-critical path. The activities that appear on the time-critical path are ranked according to a factor derived by multiplying the frequency of occurrence on the critical path by the difference between the most likely and pessimistic duration, or most likely and baseline duration, whichever is greater. The potential increase in duration is included because mitigating strategies applied to activities with a large potential increase in duration have a better chance of decreasing overall program time than mitigating strategies applied to activities for which the potential increase is initially small. The activities are ranked in descending order.

Probability Critical--Activities that have probabilities of success less than one are ranked according to a factor derived by multiplying their probability of failure (one minus probability of success) by a ratio that reflects how far in the future the activity is performed. The probability critical factor was less the further an activity is in the future. The intent was to reflect the fact that as the program progresses, the likelihood of an activity being successful increases due to increased knowledge of the requirements and improved technology to satisfy the requirements.

4.1.12 Identify Significant Risks

The three lists of high-risk activities generated by the VERT program and post-processing were consolidated by Risk Assessment management review into a single-ranked list of significant risks. The risks are ranked according to their potential impact on the DSTWD program. The risk-ranking process is discussed in greater detail in Section 4.5.4.1 and in Appendix A.

4.1.13 Identify Future Studies and Develop Alternatives

Potential alternatives or mitigating strategies to the high-risk schedule activities were investigated. These alternatives require additional study to accurately define their probabilities, consequences, and overall impact on programmatic risk.

4.2 MAJOR ACTIVITY ASSESSMENTS

4.2.1 Characterization

4.2.1.1 Definition. Characterization of double-shell tank (DST) waste is required to provide fundamental data for Tank Farm operations, retrieval, pretreatment, the Grout Treatment Facility (GTF), and HWVP. Important physical and chemical properties need to be determined in order to identify appropriate methodology and equipment for retrieval of waste from DSTs to provide a feed source to the pretreatment facility. The chemical and radionuclide properties of the waste will dictate the appropriate waste pretreatment and facility design requirements for B Plant, HWVP, and the GTF. The acquisition of core samples also provides material for performing laboratory-scale tests of the waste pretreatment methodology. Characterization of DST waste will provide information for performing appropriate vitrification feed processibility tests, performing waste form qualification (WFQ) activities, designing vitrification equipment, and receiving permits for the vitrification facility. Flowsheets, production records, transfer records, and miscellaneous sample analyses have been used in conjunction with core sample results to characterize the waste.

The current tank waste composition projections for each of the four wastes to be vitrified, including data sources and uncertainty ranges where available, are provided in Appendix C.

4.2.1.2 Activities. Core sampling and analysis of NCAW, NCRW, and PFP and CC wastes is scheduled for FYs 1991 through 1996 (Table 4-2). The chemical, physical, and radionuclide properties of these wastes will be determined to

Table 4-2. Double-Shell Tank Characterization Sampling Plan.

Waste type	Tank	Samples required[a]	Samples taken through 12/90	FY 1991	FY 1992	FY 1993	FY 1994	FY 1995	FY 1996
NCAW	101-AZ 102-AZ	5 5	2 1	-- --	1 1	2 1	-- 2	-- --	-- --
Feed tank	102-AY	3	1	--	1	--	--	--	1
NCRW	103-AW 105-AW	8 8	2 3	-- --	1 1	2 1	1 1	1 1	1 1
PFP	102-SY	9	2	--	1	1	2	1	2
CC	101-SY 103-SY 102-AN 107-AN 101-AY	4 4 4 3 2	0 1 1 0 0	b -- b -- --	-- -- 4 -- --	-- -- 2 -- --	-- -- 3 -- --	-- -- 3 -- --	-- -- 3 -- --

[a]The number of samples is based on funding and equipment availability.
[b]Some samples will be acquired in 1991 to support resolution of tank safety issues.

CC = Complexant concentrate
FY = Fiscal year
NCAW = Neutralized current acid waste
NCRW = Neutralized cladding removal waste
PFP = Plutonium Finishing Plant

support waste retrieval, pretreatment, HWVP waste form, and feed processibility development. The activities evaluated in this Risk Assessment can be categorized as (1) the near-term (FY 1991) characterization work for each of the four waste types, and (2) the follow-on (FYs 1992 through 1996) core sampling and characterization work for each of the four waste types. Additionally, characterization of double-shell slurry (DSS) and double-shell slurry feed (DSSF) samples will be performed to support grout formulation development, verification, and permitting activities.

4.2.1.3 Assessments. Safety--Core sampling and characterization of DST waste has been delayed pending resolution of key tank safety issues. These delays in sampling and characterization increase the program risks for the follow-on activities (retrieval, pretreatment technology, pretreatment, vitrification, and GTF), which depend to varying extents on these data. The methodology used in this assessment quantifies these lack of adequate waste characterization data risks as risks to the follow-on activities rather than as characterization risks.

One of the key tank safety issues, mentioned earlier, results from organic complexants in some of the wastes, which degrade as a result of radiolysis and unknown chemical reactions to produce flammable gases. There is concern as to the potential for a combustion of these gases in the tanks. Core-sampling activities are presently suspended as a result of high temperatures observed during recent drill-bit testing. Restart of core-sampling activities depends on the ability to demonstrate that drill-bit temperatures can be controlled to within acceptable limits and samples safely obtained.

A phased approach involving push-mode sampling will be used to demonstrate that core sampling continues to be a safe and viable form of sample retrieval. More difficult methods of sample retrieval (rotation) then can be pursued at a later date as development activities allow bit temperature monitoring to be conducted in a rotational mode. A safety analysis and a readiness review will be performed before sampling can proceed in the push mode. Core sampling efforts resumed in May 1991 with tank 101-SY.

Certain DSTs and SSTs have been designated as Public Safety Law List tanks and will receive high priority for sampling and characterization and thus will take priority over non-list tanks. These list tanks are those containing either significant amounts of organic complexants (and thus potentially generating hydrogen), ferrocyanides, or high-heat-producing isotopes. Ferrocyanide compounds have been shown to react exothermically under certain conditions. Some of these list tanks (e.g., tank 101-SY) contain CC wastes and are thus candidates for retrieval and pretreatment as part of the Hanford Site waste vitrification program. Because these tanks will receive priority sampling, it is anticipated that sampling and characterization will serve both safety and vitrification program needs. Sampling of these tanks, however, may be delayed by waiting for optimum sampling 'windows' related to hydrogen gas release.

Again, core samples can be taken only in the push mode until safety issues are resolved. Sampling of other tanks resumed after completion of the readiness review conducted in June 1991. Many of the other tanks (e.g., tanks 101-AZ, 102-SY, and 103-AW) are candidates for the vitrification program mission. The priority for sampling these tanks will be reduced not only by the need for sampling tanks with safety-related issues, but by the need to sample SSTs to meet scheduled Tri-Party Agreement (Ecology 1990) milestones. Both factors have the potential to adversely impact the vitrification program.

Reliable Operation--Core samples are also needed to support the grout process of DSS and DSSF wastes. Several core samples are needed during FYs 1991 through 1996. A reliable core-sampling method and adequate characterization capabilities are needed to support development of systems requiring these data.

Only one core-sampling truck is currently available to sample both DST and SST waste. The sampling requirements for SST wastes will increase greatly in FY 1992. A second core-sampling truck will be available in FY 1992 to sample SST wastes; however, a third truck is not planned to be available until FY 1994. Experience has shown high failure rates for sampling equipment. Adequate spare parts and timely maintenance will be needed to support the aggressive sampling requirements. Procurement of additional equipment (including spare trucks) will likely be necessary to support the sampling schedules. Additional weather screens must be available to allow sampling during inclement weather conditions.

Presently, inadequate laboratory instrumentation and spares are available to allow development of key analyses (e.g., noble metals) on a required schedule and to support the routine characterization requirements. In addition, there is insufficient laboratory space available to handle the large projected sample loads. Efforts must be made to obtain the equipment, laboratory space, and personnel required to characterize DST and SST wastes without adverse impact to the vitrification program or Tri-Party Agreement milestones.

4.2.2 Retrieval

4.2.2.1 Definition. Retrieval is the mobilization and/or removal of in-tank sludges for transfer to a treatment, disposal, or other storage facility. Retrieval includes not only the activities necessary to mobilize and remove solids and supernate from the DST but also the support activities needed to qualify, install, and operate the system. Also included are activities needed to remove and dispose of the retrieval equipment, and any existing DST equipment that must be modified or replaced to accommodate the retrieval process. Equipment examples include failed retrieval system components and instrument trees.

4.2.2.2 Activities. Liquid and solid wastes stored in DSTs must be retrieved and transferred to existing or new facilities for treatment before the wastes can be immobilized. The retrieval activities addressed in this Risk Assessment can be categorized as follows:

- Technology development
- Design, development, and installation of prototypical retrieval systems including the conduct of process tests
- Final design and installation of each full-scale retrieval system.

The design and development of small-scale retrieval systems to obtain representative waste quantities for TRUEX pilot-plant operation (and pretreated wastes for WFQ testing) also were addressed. Considerable attention was given to near-term activities related to development of the first prototype (NCAW) retrieval system.

Tank 101-AZ has been selected as the first location for development and demonstration of a retrieval system at the Hanford Site. The material stored in tank AZ-101 (and other "aging waste tanks") has a high level of radioactive heat generation that requires special design parameters and extra equipment for agitation of the wastes during storage to maintain conditions within tank operating specifications and to monitor tank and waste conditions. The extra equipment includes airlift circulators, thermocouple assemblies, sludge radiation measurement dry wells, and a steam coil for use during the initial filling operations. This in-tank equipment will cause interference and special problems during the waste retrieval operations. Waste retrieval under these conditions has not been demonstrated at the Hanford Site.

Tank 101-AZ contains approximately 3,800 m^3 (1 million gal) of NCAW, including about 51 cm (20 in.) of settled solids, in addition to solids that are presently suspended in the supernate by the airlift circulators.

Mixer pumps were chosen as the planned method of sludge mobilization for waste retrieval from DSTs based on the following:

- Engineering technology studies

- Experience with hydraulic sluicing at the Hanford Site
- Experience with mixer pumps at the SRS and WVDP.

The operational goal of the tank 101-AZ retrieval system process test is to achieve 90-percent mobilization (mix sludge with supernate) of approximately 51 cm (20 in.) of settled solids and to demonstrate that a slurry suitable for transfer can be maintained within the tank. Instrumentation to verify sludge mobilization effectiveness includes gamma probes, ultrasonics, and temperature profiles. The information and experience gained during this process test is expected to: (1) confirm the mobilization characteristics, (2) provide bases to optimize the number and location of mixer pumps, (3) verify data from laboratory models, and (4) suggest design modification for other retrieval systems. The mobilization goal for final retrieval of waste sent to pretreatment is being studied. The study does not include final cleanout for the tank closeout.

Because the rheological and physical properties of each waste type are not well known, an assumption has been made that each high- and low-level waste type will require a different retrieval system or retrieval technique.

Except for NCAW, the differences anticipated for retrieval systems include the type of equipment needed for mobilization, ancillary equipment, and tank modifications. Retrieval of some waste such as NCRW may require mobilization equipment other than mixer pumps because of the high shear strength of the sludge waste. At this time, the basic retrieval system is assumed to include a transfer pump, mixer equipment, mixer equipment lowering or support mechanisms, burial containers, and instrumentation and controls. Before installation of this equipment can be performed, the following modifications to the tank may be required: installation of a waste cooling system, upgrades to the electrical power distribution system to the Tank Farms either by upgrading the Tank Farm power or using portable power, installation of a portable ventilation system or upgrading the current ventilation system, and removal and replacement of thermocouples.

Equipment requiring cold testing will be tested and modified, as necessary, before it is installed at the double-shell Tank Farms. After cold testing, the retrieval system will be installed in the specified DST and tested for operability and effectiveness of solids mobilization and suspension. The retrieval operation will be evaluated and changes made, as necessary, before turning the system over to the Operations staff for full-scale waste retrieval.

4.2.2.3 Assessments. Complexity--The systems for waste mobilization and retrieval are not complex. In most cases, centrifugal mixing pumps will be used to mobilize the tank waste. Turbine transfer pumps will be used to transfer the waste from the waste tanks for treatment. The SRS is using similar pumps. Automation is limited to microprocessors for pump controls.

Maturity--Retrieval installation and operations are based on existing pump technologies that are being applied to other nuclear facilities. Similar mixing pumps are being used at the SRS and WVDP for mobilization of radioactive sludge. One aspect of the Hanford Site mobilization and retrieval operation that may require development is a special impeller to meet the net positive suction head requirements if the tank is operated near boiling. This special impeller design is expected to result in a high equipment cost. There is limited experience in predicting the effectiveness of the pumps when used to mobilize waste in the Hanford Site tanks. The effectiveness of the mixing pumps will vary depending on the type of waste to be mobilized. An assumption is that if mixing pumps are not able to mobilize 90 percent of the sludge, alternate mixing methods may be required.

Work to date on retrieval methods, other than the 101-AZ NCAW method, is limited. New technology and development of methods still need to be determined for post-NCAW operations. Technical data analyzed to date indicate that mixer pumps may not be suitable for NCRW retrieval because of the high shear strength of this waste.

Initial reduced-scale testing has been completed by Pacific Northwest Laboratory (PNL) using simulated sludge mixtures. Additional PNL testing will be completed and an effective mixing equipment cleaning radius for each waste type will be established. Scale-up factors to plant unit equipment may not be as planned.

Mobilization of waste for small-scale tests involves mixing approximately the first foot of sludge to deliver 15 to 26 m^3 (4,000 to 7,000 gal) for pilot-plant operation. Mixing equipment installation, operation, and mobilization verification still have to be developed.

Retrieval equipment for tank 101-AZ (NCAW) is currently being developed. The required number of pumps or other equipment still has to be determined during process testing. The 90 percent mobilization goal may not be met in the tank 101-AZ process test using two pumps. A parallel project also being developed will install two additional pumps. The four-pump configuration is expected to meet the 90 percent goal. Also, sludge mobilization verification and tank cooling requirements during equipment operation have not been determined. Additional technology and equipment development may be required.

Results of sample analyses for each of the wastes will be used to size pumps and provide a basis for other engineering decisions during the detailed design stage.

Tank and component structural integrity need to be maintained during mobilization and retrieval operations. Corrosion allowance based on laboratory testing, current tank condition, and effects of pump jet forces on components will be determined and factored into the design of the systems. New technology and equipment development may be required to determine the current tank condition.

Existing ventilation systems are designed to handle particulates and small heat loads only. No redundant power supplies are available. Engineering studies to upgrade ventilation systems and electrical power supply capabilities for supporting retrieval activities will be completed. Process tests cannot be initiated unless ventilation and electrical power supply systems are adequate.

Of the 28 DSTs, 8 tanks currently containing various waste types will be used to store pretreated waste. Removal and pretreatment of the sludge heels in these tanks before adding the pretreated waste may save several millions of dollars in glass canister costs. Pretreating these heels will result in a small volume of TRU material being sent to the vitrification facility and a much larger volume of low-activity material being sent to the grout facility.

Waste sludge heels remaining in the tanks may also affect the glass formation process and/or vitrification facility equipment. High levels of various glass-forming components in the sludge heels may exceed critical limits requiring a decrease in waste-oxide loading per glass canister. The decrease in waste-oxide loading corresponds to an increase in glass canisters and overall cost. Other components in the sludge, such as chlorides, may adversely impact some process equipment material of construction, e.g., the receipt and lag storage tank (RLST) of the HWVP.

Tank 102-AY has been designated as the first receiver tank for pretreated NCAW. This tank contains a 25.4-cm (10-in.) sludge heel, which may need to be removed due to the high chloride content. Removal of the heel may also reduce the number of canisters made. The full impact of mixing this sludge heel with pretreated NCAW has not been fully evaluated. The schedule for cleanout of this heel is optimistic and could result in a delay to the HWVP operations. If Project W-236, which provide four new DSTs, is complete before the start of NCAW pretreatment, one of these tanks could replace tank 102-AY. The current schedule for completion of this project is December 1999.

Compare Program--Visits have been made to the SRS facilities to review retrieval systems and mixer pump installations. Contacts were made with WVDP and SRS to discuss pump seal problems. Pumps at the Hanford Site are larger--300 hp compared with 150 hp at SRS. The Hanford Site and SRS will have approximately the same number of pumps per tank, but pump placement will be different due to variation in riser locations. The WVDP has a greater number of smaller pumps because the design of its tank bottom includes structural members. The SRS and the WVDP are resolving problems that include an upper-seal leak.

Reliable Operation--Facilities in the six double-shell Tank Farms are similar. Equipment is installed through risers, and equipment controls are located nearby. There may be some interferences during the installation of mobilization equipment from other Tank Farm upgrade projects due to limited Tank Farm space. Once in place, operations will not be a problem. Plant equipment will be ordered with spare parts.

There may be limited tank space to support supernate transfers during retrieval operations.

A cold-test facility [Tank Waste Retrieval Equipment, Handling, and Operation (TWREHO)] will be constructed and used to develop equipment, verify plant unit hardware and procedures, and train plant operators for Tank Farm activities. The use of this facility is expected to eliminate most equipment installation problems.

Systems that have the most significant effect on plant availability are the mixer pumps, pump controls, transfer pumps, and equipment disposal equipment and methods.

In the past, transfer pumps have had limited life--3 to 4 months. A new transfer pump specification requires a minimum of 5,000 h of operational life for motor bearings.

Safety--The assessment of facility safety is the subject of current SAR upgrade efforts. An aging waste tank and other DST SARs will be completed and submitted to the DOE for approval. Tank Farm safety issues are discussed in more detail in Section 4.2.7. A preliminary safety analysis report (PSAR) will be written for Project W-211, Double-Shell Tank Retrieval Systems.

The improvements to the ventilation system (Project W-030) and aging waste transfer lines (Project W-028), which replace old piping, are designed to improve safe operation.

Tank confinement will be affected when risers are opened for installation of new equipment and while receivers are installed for equipment removal. Equipment will be provided to maintain the tank pressure and air-capture velocity at the top of the riser within allowable limits during these operations.

Design Definition--Design criteria have been established for NCAW retrieval methods, but criteria still need to be developed for the post-NCAW tanks. Post-NCAW retrieval activities have been limited to engineering studies. Planning is in place to complete the design in the allotted time, given adequate funding.

The conceptual design, a conceptual design report (CDR), functional design criteria (FDC), and a portion of the required development work on prototypes have been completed on tank 101-AZ (NCAW). The CDRs and FDCs also have been completed for Projects W-028, Aging Waste Transfer Lines; W-066, AZ Tank Farm Electrical Upgrade; and W-030, Ventilation Upgrade, which are all interfacing projects. A cost account authorization has been completed on capital work order Project W-106, TWREHO Facility. All projects were started; however, a hold has been applied to all but Projects W-028 and W-030 due to a lack of funding.

Planning documents completed on 101-AZ projects include a technology program plan and an engineering work plan.

Documentation--Changing requirements for permits, construction, operation, and disposal of equipment may increase preparation, review, and approval time cycles for environmental documentation. The initial *Resource Conservation and Recovery Act of 1976* (RCRA) Part B permit application for DSTs was submitted to Ecology on June 30, 1991. Future modifications to the tanks and/or supporting retrieval systems may require a modification to the permit, which will take approximately 1 yr for each modification. This time frame will vary depending on the significance of the modification and the outcome of permit modification negotiations conducted during the preparation of the initial permit.

In addition, permits from the Washington State Department of Health under the Radioactive Air Emissions Program (RAEP), and EPA under the National Emission Standards for Hazardous Air Pollutants (NESHAP) will be required if there is an increase in air emissions, and if the offsite dose is greater than 0.1 mrem using EPA methodology [40 CFR 61, Subpart H and Appendix D (EPA 1990)]. Under the RAEP, guidance has been given to the DOE that for sources with offsite doses less than 0.1 mrem, approval to construct is required; however, the required information is not as extensive as under full permitting. Additionally, permits from Ecology under the prevention of significant deterioration (PSD) regulations and toxic air pollutant regulations, for example, the *Washington Administrative Code* (WAC) 173-400 (Ecology 1991a) and WAC 173-460 (Ecology 1991b), may be required for other pollutants. In addition, future regulations are expected to be promulgated as a result of the *Clean Air Act (CAA) Amendments of 1990*, which may be applicable.

4.2.3 Pretreatment Technology

4.2.3.1 Definition. High-level and TRU DST wastes are so designated due to the radioactive components, which are a very small fraction of the total mass. The Record of Decision (ROD) (DOE 1988a) requires that these wastes will be converted to glass for disposal. These wastes are designated as hazardous by EPA designation procedures and as extremely dangerous by Ecology designation procedures. The current objective of the pretreatment process is to recover the bulk of the nonradioactive components in an LLW stream that can be disposed of in grout while leaving the high-level and TRU components in a form that can be disposed of in a greatly reduced volume of glass. Pretreatment does not reduce the hazardous property of the waste, but it does separate a hazardous waste into different streams to facilitate disposal. As more stringent disposal requirements emerge, reducing the hazardous components of the waste may be added to the scope of the pretreatment mission. Pretreatment technology is being developed in two parallel programs: one for NCAW and one for the post-NCAW (NCRW, and PFP and CC waste) types.

The baseline NCAW pretreatment process involves solids settling and decanting, solids washing with water, filtration of decanted solutions, and ion exchange of filtered solutions to remove cesium. Several activities are currently underway or planned to bring NCAW pretreatment technology development to completion. Recent plans to use an alternate facility for settling and decanting has raised questions about the optimum use of flocculants. No further technology development is planned for filtration. Independent reviews of the status of pretreatment technology identified numerous positive aspects of pretreatment, but also raised questions about the reference flowsheet for ion exchange. Additional ion-exchange testing has been planned. Three items also are being developed for process control purposes. These items include a solid-liquid interface and settling rate detector, an on-line TRU monitor for use on the process LLW stream, and corrosion/passivation probes (sometimes referred to as pH control) for controlling chemical additions to the glass plant feed stream.

The process technology for post-NCAW is evolving as experience with these wastes is gained in the laboratory and as new pretreatment requirements are identified. Treatment may entail water washing of caustic sludges to remove soluble and corrosive species followed by dissolution of the water-washed solids in acid. Finely divided TRU solids will be filtered out of the wash water and dissolver liquor, and dissolved TRU species will be recovered in the

TRUEX process. The CC waste treatment must ensure that the bulk of the cesium is separated for disposal in glass as well as provide for the destruction of organics in grout feed.

4.2.3.2 Activities. Process development for the extraction of NCAW is fairly complete; however, information for processing post-NCAW is still limited. Flowsheets for the NCAW process have been developed and refinement of the process details is in progress.

Neutralized Current Acid Waste - Engineering Evaluation of Flocculation Optimization--Will identify the optimum injection method and concentration for the ferric nitrate flocculating agent used in the NCAW process. The iron additive precipitates and initiates flocculation. It is important that this process occur uniformly throughout the tank or there will be pockets of suspended solids. Uniformity requires mixing, but mixing (shear) will tend to break up the flocculated solids. There must be a balance--enough mixing to achieve uniformity without negating the flocculation of the solids. This work became necessary with plans to perform settling and decanting in the large tanks within the AR Vault or perhaps in the 3,800 m^3 (1 million gal) storage tanks. The quantity of flocculating agent needs to be minimized without adversely impacting the process throughput.

Ion-Exchange Technology Development--Includes laboratory tests, pilot-scale tests, and an engineering evaluation of the test results to recommend the best application of ion exchange at B Plant. The testing consists of batch-loading tests and continuous-loading tests for the two resins (CS-100 and a resin developed at SRS) under consideration. Pilot-scale testing will be completed to resolve concerns about the physical and mechanical stability of the resins. An engineering evaluation of the test results will provide the basis for a final recommendation on how to apply ion exchange at B Plant.

Engineering Evaluation of pH Control--Includes laboratory tests and engineering evaluation of the test results. Because the objective of the test program is to demonstrate a probe that indicates when a test metal is passivated in the presence of process solution, "pH control" is a misnomer. The value of this probe is that it will permit the operators to add the minimum amount of chemicals to the HWVP feed stream to make it passive toward the carbon steel storage tanks without over-passivating. Over-passivating with chemicals results in unnecessary glass volume.

Transuranic Monitor Hot Prototype Test--A continuation of instrument development. Previous development advanced the on-line TRU monitor and interface detector sufficiently that testing of prototype designs is now warranted. The passivation probes discussed earlier, after appropriate cold testing, will also be tested in a radiolytically hot environment. The interface detector also has promise for measuring the rate of solids settling; this application will be explored. An engineering evaluation of the test results will result in a final recommendation on the application of these process control devices for processing NCAW.

Neutralized Current Acid Waste Draft Final Flowsheet--Will fully integrate AR Vault and B Plant operations for NCAW. The flowsheet will incorporate the results of flocculant optimization and ion-exchange testing.

Post-Neutralized Current Acid Waste--The TRUEX process development involves application of the TRUEX process to the pretreatment of NCRW and PFP waste sludges. The scope of the laboratory work entails dissolution chemistry that results in stable dissolver solutions and the filtration and processing of those solutions through the TRUEX process. Process optimization studies also will be performed. In addition, extensive corrosion studies are being conducted to support selection of construction materials for the TRUEX process.

The CC process development is being pursued independently because the waste has characteristics not found in NCRW and PFP waste. Consequently, additional pretreatment requirements exist. For example, organic complexants hold significant amounts of complexed metals in solution resulting in TRU supernates. The complexants and their degradation products may also have adverse effects on grout quality; thus, technology to destroy organics is being developed. The CC also contains relatively large quantities of fission products. At the very least, technology to separate cesium will be developed. These activities are in addition to the application of the TRUEX process to CC waste pretreatment.

TRUEX Pilot Plant--The TRUEX pilot plant also will be designed, fabricated, and installed in B Plant and the Waste Encapsulation and Storage Facility (WESF) to verify the TRUEX flowsheets developed by TRUEX process development and CC process development. The pilot plant also will provide sample quantities of treated glass plant feed for melter testing.

Oxidation Pilot Plant--An oxidation pilot plant will be designed, fabricated, and installed in a to-be-determined facility to verify the flowsheet for organic destruction. Before work on this pilot plant can begin, CC process development must progress to the point where an oxidation process can be selected.

4.2.3.3 Assessments--Neutralized Current Acid Waste Pretreatment Technology.
Complexity--Documentation on the flocculent optimization activity is not available and probably will not be available until late FY 1992. (Current budget guidance has caused the start date for this work to slip from FY 1991 to FY 1992.) Use of flocculants is a common industry practice, and it is anticipated that the intended application for NCAW processing will not raise complexity issues.

Ion exchange is a common industry practice, as well. However, operating a two-cycle, ion-exchange operation with the CS-100 resin may be unnecessarily complicated if the alternate SRS resin would permit a one-cycle operation. The SRS resin, with its higher selectivity for cesium, may have the potential to produce an adequately pure cesium product in a single pass. This potential will be investigated in the ion-exchange test program.

Several instruments are being developed for process control purposes. The interface detectors, passivation probes, and on-line TRU monitor add necessary complexity to the design, but without them, there would be no control on some parts of the process. In addition, other parts of the process would be controlled using the method of batch sampling and waiting for wet chemistry analysis. Without these special instruments, process throughputs would very likely be reduced. The conceptual flowsheet for the TRU monitor hot prototype test is quite simple. Processes of comparable or greater complexity have been successfully operated in the WESF.

Maturity--Flocculation of NCAW solids on the scale envisioned in current flowsheets has not been studied, although flocculation on a large scale is certainly a common industrial practice. With current budget guidance, flocculation studies to support the assumptions will not be completed until mid-1992. The schedules for pretreatment assume a throughput that must be maintained by the washing and settling operation. The ability to achieve this throughput may depend on the optimized use of flocculants.

Independent reviews of the NCAW technology program identified concerns regarding physical stability reported by some users of the CS-100 resin and that not enough had been done to optimize the ion-exchange operation. Therefore, testing will be conducted on a sufficiently large scale to evaluate these concerns. Based on budget guidance, these results will not be available until FY 1995. Similar testing of the alternate SRS resin also will be pursued to provide a fall-back position if a serious problem is identified with the preferred resin.

The interface/settling rate detector will be assembled from commercially available thermal dispersion elements, but the application as a settling rate detector may be a novel application. This instrument has yet to be designed for a remote installation. The passivation probes under consideration are a PNL design and are not commercially available; however, they are based on well-understood electrochemical principles. The probes have been the subject of an extended test in DST AN-107.

The TRU monitor prototype will be built from commercially available components. Boron trifluoride tubes are certainly not new, but combining them with the electronics and shielding to detect alpha particles without interference from the spontaneous fissions of ^{244}Cm and from beta-gamma sources is a novel development in on-line TRU monitor design. The design is based on promising laboratory results.

Existing Facilities--To support the TRU monitor prototype test, certain demolition and decontamination activities must be completed in cell 39 of B Plant and in the WESF to prepare cells for equipment installation.

The equipment removed during demolition must be packaged and buried. Regulations and internal requirements pertaining to packaging for burial are expected to become more stringent. The design and approval of packaging to satisfy new requirements could be time consuming and lead to delays in equipment removal scheduled to begin in early FY 1992. This would impact the technology development schedule. (NOTE: The full assessment of B Plant is given in Section 4.2.4.)

Reliable Operation--Current sample load-out practices at the WESF can support only a few samples per day. Hundreds of samples will be taken during the course of the TRU monitor test and many of them will require analysis. Improved sample load-out capabilities are likely to be required; currently, they are not within the scope of the test program.

Experience with the onsite analytical laboratories indicates that there is a very large sample burden and that samples from technology development activities have a lower priority than samples needed to resolve tank safety issues or specific Tri-Party Agreement (Ecology 1990) milestones. There are serious reservations about whether the onsite analytical laboratories can turn around test samples in a timely manner without reprioritization of the work load.

Safety--It is unlikely that a safety assessment will identify any serious deficiencies for the TRU monitor test. A recent preliminary safety evaluation (PSE) for the TRUEX pilot plant did not identify any deficiencies for processing NCRW and PFP and CC wastes. The WESF has a history of safe operations with highly radioactive process streams. The weakest area appears to be radiation exposure during sample handling. As noted earlier, sampling at the WESF is being reevaluated for other reasons.

Design Definition--The TRU monitor design is complete and has been issued for approval. Support equipment design is also complete and has been issued for review and comment.

Documentation--Requirements for safety and environmental documentation for the TRU monitor test will be determined during the development of the detailed test plan, which is currently underway. Safety documentation will be completed in FY 1992. It is unlikely that an SAR update will be required, but a PSE could be mandated. If NEPA documentation is required, the finding is expected to be of no significant impact based on experience with the TRUEX pilot plant.

The permitting status of this activity requires a timely review. Although this test does not involve treatment of the hazardous wastes that are already in storage at B Plant, the test plan calls for preparing potentially hazardous solutions for use in calibrating the test instruments. Some minimal oversight from Ecology and the EPA can be expected because both agencies have expressed an interest in research, development, and demonstration (RD&D) activities.

Introducing a new activity at the WESF also could invoke clean air permitting if it causes a change in stack emissions.

4.2.3.4 Assessments--Post-Neutralized Current Acid Waste Pretreatment Technology. Complexity--Preparing feed for the TRUEX process involves known chemical processing operations, although there is a potential for increased complexity as more experience is gained with actual waste sludges. For example, it now appears that simply dissolving NCRW sludge in acid and clarifying the dissolver solutions is an inadequate preparation. Washing the water-soluble components from NCRW before acid dissolution may be required to produce stable solutions. Additional chemical adjustments may be required to prevent complications in solvent extraction. Surface active agents in tank SY-102, apparently from the T Plant decontamination operations, may adversely affect solvent extraction. The preparation of TRUEX feed from PFP sludge will undoubtedly have to take these surface active agents into consideration. In addition, criticality limitations may need to be addressed in the facility designs for, and processing of, the post-TRUEX HLW stream from these PFP wastes.

The TRUEX process, as developed at Argonne National Laboratory (ANL) in Argonne, Illinois, and as adapted for pretreatment, is a relatively simple solvent extraction process. The number of feed and discharge streams is limited. The major process elements (dissolvers, filters, contacting devices) are familiar equipment. Other waste treatment solvent extraction processes of similar complexity have been operated successfully in B Plant. By comparison, the PUREX process, mainstay of nuclear fuel reprocessing for approximately 40 yr, is a much more complicated process.

While the sludge dissolution and TRUEX processes are simple in concept, they have only been demonstrated in laboratory-scale experiments. A number of problems arising largely from the widely varying composition of the wastes must be solved. An independent review of pretreatment technology completed early in FY 1991 did not identify any significant problems that would prevent successful development of the processes.

The CC processing is inherently more complex than NCRW/PFP waste processing because of the added requirements to recover cesium and destroy organics. Recent technology assessments suggest that strontium and technetium recovery, as well as denitration, may be added as future requirements.

Maturity--Experience with NCRW and PFP waste has identified processing requirements that were not anticipated. The solution stability problems mentioned earlier are an example. Experience with actual waste has shown that the chemistry of feed preparation is more complicated than originally anticipated but by no means fatal to the process. Some progress has been made on the filtration of synthetic dissolver solids, but filtration will continue to be a weak spot in the technology until it is demonstrated on a significant scale in the pilot plant.

The TRUEX process was developed at ANL with synthetic solutions under ideal laboratory conditions, and it would be highly unusual if the application to actual waste required no refinement of the chemistry. Laboratory, batch-contacting experiments have verified the ability of the TRUEX solvent to adequately decontaminate actual waste solutions, but chemistry adjustments are needed to demonstrate that interfacial crud can be eliminated. These adjustments are currently undergoing evaluation. The chemistry of the TRUEX process may require the specification of special materials of construction for some parts of the process. Corrosion studies are underway but not sufficiently advanced to make a final recommendation at this point.

A number of factors could adversely impact the processing rates for post-NCAW types. Chemistry adjustments needed to eliminate the previously mentioned interfacial crud and to eliminate foaming during the dissolution process could result in a reduced processing rate. Practical limitations on the replacement of existing plant piping could reduce the number of cells that are realistically available for the TRUEX process installation. The removal of cesium from CC waste could extend the processing duration. The unavailability of an acid-side ion-exchange process could necessitate neutralization and storage of TRUEX raffinates for later treatment using the existing basic-side ion-exchange technology. These factors drive the need for process optimization, particularly with respect to CC waste, which requires the added cesium removal and organic destruction pretreatment processes.

Less progress has been made than scheduled to advance CC pretreatment technology during the current fiscal year for a variety of reasons [e.g., PNL had to stop work on pretreatment while revising its environmental impact statement (EIS), delays to the core-sampling program, reprioritization of work at Westinghouse Hanford Company (Westinghouse Hanford)]. The possible imposition of additional requirements to remove strontium and technetium, and to destroy nitrates, would expand the scope of the presently planned technology effort. The delayed start of laboratory work and expanded scope would not necessarily affect the finish date for the overall technology program because the duration of the activity is long enough to absorb the changes. However, the activity would have to be funded at a much higher level.

The process equipment for pretreatment generally comprises commercially available components. Selection of a filter medium is not very far along, but it is expected to be commercially available. Annular centrifugal contactors do require custom machine shop work, but they have been made both at Westinghouse Hanford and ANL. Centrifugal contactors have been used at SRS. It is likely that some process control sensors will also be custom-made items. The ANL has operated a current TRUEX process with minimal annular centrifugal contractors. The TRUEX process was also operated on a pilot scale in a glovebox at PFP. The TRUEX pilot plant anticipated for the WESF uses the same size contractors as the PFP glovebox facility, so there is a reasonable level of confidence that the WESF pilot plant will be successful.

Use of Existing Facilities--The TRUEX pilot-plant project was sited in B Plant and the WESF under the assumption that certain facility upgrades would be completed. For example, the old-fashioned, hand-operated jet gang valves in several areas in the plant were to be replaced with computer-controlled, motor-driven jet gang valves. Upgrades required to support the TRUEX pilot plant have been included in Project W-207, Major B Plant Upgrades.

The solvent extraction operation in the WESF is expected to generate more samples than the current sample load-out system can handle. An engineered solution to this problem is not currently within the scope of the pilot-plant project.

Compliance--Methods for satisfying secondary containment requirements in the B Plant canyon and hot-pipe trench are being evaluated. The same issues have to be addressed during the pilot-plant permitting process. Ecology has the authority to require full compliance (Part B permit) or it can issue an RD&D permit.

Design Definition--The TRUEX pilot plant has an approved FDC and CDR. An advanced CDR is in the approval cycle. Definitive design has begun. Schedule delays have already occurred because of a better workscope definition for the TRUEX pilot plant and funding redistributions in FY 1991 to resolve tank safety issues.

Documentation--An NEPA determination of "finding of no significant impact" has been approved by the U.S. Department of Energy-Headquarters (DOE-HQ) for pilot-plant operation. The PSE was completed in conjunction with the CDR. Additional safety documentation in conjunction with definitive design is included in the project schedule. A permitting plan was prepared, and the requirements for hazardous waste and other permits are currently being researched within Westinghouse Hanford.

4.2.4 Pretreatment Facilities

4.2.4.1 Definition. The B Plant and the 244-AR Vault have been identified as the facilities to be used for pretreatment of DST wastes. The NCAW operations will utilize about 20 canyon cells within B Plant. Post-NCAW pretreatment (TRUEX) operations may use 32 cells, with 12 cells having to be completely refurbished. This section provides an assessment of the activities required to prepare these existing facilities for the pretreatment mission and the capability of the facilities to pretreat NCAW and the post-NCAW types.

4.2.4.2 Activities. Pretreatment facility activities include the activities required to ensure environmental compliance; safe operations; installation of process equipment and process controls; modernization of facilities for more efficient operation; preparation of documentation, including environmental permits and SARs; training of personnel; operational readiness reviews and preoperational testing; and pretreatment operations.

The B Plant and the AR Vault are existing operating facilities undergoing modifications designed to bring the facility into compliance with federal, state, and local environmental and safety standards, codes, and regulations. Additionally, modifications are being conducted so waste can be processed or pretreated at B Plant and the AR Vault.

Many of the existing systems at B Plant and the AR Vault are functional and operating. The systems can be categorized into three types: (1) safety, (2) environmental, and (3) process. Operational testing is a significant requirement for startup but it is not necessary for all systems. A general functional test of some systems will be adequate and will ease the task of operational testing.

The following systems require inspection and/or modifications because of some unresolved problems. For the most part, the problems are clearly resolvable from a technical viewpoint.

- The chemical sewer system is currently undergoing major modifications by several construction projects. Additional unidentified modifications may be required to comply with environmental regulations.

- A design basis fire (DBF) accident analysis for the facility has not been completed. The extent of new work has not been assessed.

- The condition of the cell drain system was investigated through the use of a video camera in FY 1990. This is a key component of the secondary containment system. Cleaning, inspection, and integrity assessments have been scheduled but have not been completed.

- The incell and hot-pipe trench leak detection system components have failed and require replacement. A program to design new, higher-reliability components is included in Project W-207.

- The condition of the canyon samplers is unknown. A significant number of samples may require replacement, which is high-dose-rate work. As low as reasonably achievable considerations may justify a replacement system or method. New best available technology studies and a project may be required at a later date.

- The 271-B aqueous makeup unit (AMU) system is undergoing an upgrade through Project W-004. Floor replacement and dikes surrounding the AMU tanks will be completed by January 1992.

- The ion-exchange system upgrade is on hold. Major modifications are required, but this is not a critical path item.

- The current cell 23 waste evaporator system has equipment problems that were noted during the last period of operation. Corrective actions have been identified but not yet implemented.

- The PHP filter system has been installed, but equipment alignment difficulties have occurred and corrective actions have not yet been implemented.

- Environmental requirements for the process condensate system must be clarified.

- The vessel ventilation system is scheduled for replacement. Normal construction project uncertainties and equipment alignment difficulties in cell 22 can be anticipated.

- The B Plant 221-B canyon crane is being evaluated for upgrades or replacement. This project was placed on hold pending resolution of the Risk Assessment findings.

- Documentation (including "as built" drawings, configuration control procedures, software verification and validation, etc.) are inadequate and will have to be updated to support the facility operations.

The existing jumpers can be expected to require replacement by the end of a complete pretreatment mission due to aging gaskets. The NCAW processing will require approximately 100 new jumpers and the use of 100 to 200 of the approximately 1,500 jumpers presently in place. The number requiring replacement by the end of NCAW operations is unknown, but an adequate plan for spares should avoid excessive production delays.

Processing NCAW only in B Plant does not require extensive new process equipment in addition to what is now in place. However, storage space for failed equipment is occupied. The plant may have difficulty storing the old equipment from cells 18 and 22. A disposal/burial plan for major equipment is needed to support the pretreatment options being considered.

The installation of the TRUEX pilot plant and the TRUEX process equipment in 12 cells in B Plant is a major increase in complexity over that required for NCAW operation. To complete the processing of all four waste types plus the pilot plant on schedule requires major construction activities comparable to the major refit of B Plant in the 1960's. Some canyon construction activities must be coordinated with operability testing for NCAW and possibly be completed during NCAW operations. Minor equipment upgrades will not likely be required at the AR Vault. Transfer lines, as well as instrumentation and control, will have to be upgraded.

4.2.4.3 Assessments. Existing Facilities--(NOTE: This narrative only addresses the use of existing facilities from a process standpoint. Regulatory issues are addressed under Compliance.)

The use of B Plant for pretreatment provides ample flexibility. The plant has approximately 100 embedded lines to each process cell and approximately 1,600 jumpers in place from the previous mission and for current operations. The B Plant jumper design and maintenance is well proven and failure is predictable even though a new design may be more reliable. It is expected that all the (1,600) jumpers used during an extended pretreatment mission will be replaced at least once. An NCAW-only-mission may not require many changes because a typical jumper gasket lasts 3 yr. Maintenance is not generally constrained by space, and room is available for new process equipment if the existing unused equipment can be disposed of (burial).

The facility layout is effective for conducting the NCAW process mission primarily due to the size and complexity of the original structure and modifications made for the previous mission. The B Plant operation does depend on routine canyon entry for process sampling and crane operation.

The B Plant canyon crane requires improvements not related to regulations, codes, and standards (e.g., installation of new rails, a new rail bed, and a television system to replace existing optics). A more reliable, easily controlled crane will enhance process changes and maintenance activities discussed earlier.

All process lines and tank systems (including secondary containment) will be assessed for integrity before operation. Standard methods for changing faulty processing equipment have been employed for many years at the plant and new enhanced methods are being developed for possible future use. Studies are currently being done on remote replacement of embedded piping and the use of a portable remote manipulator module for use in removing, refurbishing, and replacing incell equipment.

The use of the AR Vault for pretreatment of NCAW provides additional flexibility because the tanks in the AR Vault are larger than those of B Plant.

Compliance--The compliance assessment for B Plant and the 244-AR Vault was performed by Science Applications International Corporation (SAIC) to criteria in DOE Order 6430.1A (dated April 6, 1989). Both facilities were assessed against individual criteria lists. The B Plant was assessed for compliance to 610 items and the AR Vault was assessed for compliance to 670 items. Of these, B Plant was found to be noncompliant in 73 items and the AR Vault in 94. An additional 36 items at B Plant and 94 items at the AR Vault were categorized as "to be determined" for compliance. These noncompliance issues are being addressed by modification projects at B Plant and AR Vault or by the performance of additional studies. The assessment of design definition for

B Plant and AR Vault (discussed later in this section) describes the status of these projects. Those issues that are not being resolved by construction projects are being addressed administratively or are being studied (e.g., secondary containment issues detailed below).

The major noncompliance items are basically the same for both facilities. These items include the following.

1. It is not proven that existing safety class structure and ventilation systems remain operational and retain confinement during and after a credible design basis accident/earthquake (DBA/DBE). Project W-059, Canyon Safety Class Ventilation Upgrades, an FY 1992 line item, will resolve these noncompliance items.

2. The safety class ventilation system and effluent monitoring system do not have adequately qualified emergency power. Project W-059, Canyon Safety Class Ventilation Upgrades, an FY 1992 line item, will resolve these noncompliance items.

3. Fire protection analysis and subsequent facility modification, if any, must be performed to ensure that both are an "improved risk" facility.

4. The as low as reasonably achievable objectives can be enhanced in the areas of canyon sampling, steam system pressure relief, and operating gallery instrument dip-tube confinement.

5. Modifications to exhaust stack, filter cells, and exhaust tunnels may be needed to preclude unacceptable consequences during a DBE.

6. The once-through process cooling system in B Plant may have to be replaced to meet the requirement of a closed-loop cooling system for use in high-level radioactive liquid waste facilities. The AR Vault has already addressed this in a construction project upgrade. If needed, B Plant could also be modified to meet this requirement.

7. Many of the candidate safety class instrumentation and control (I&C) systems do not meet I&C safety class requirements including DBA resistance, redundancy, environmental qualification, and uninterruptible power supply (UPS) power.

Other issues identified by SAIC include the following:

1. A completed and approved final safety analysis report (FSAR) is required before initial operation of each facility.

2. A qualified independent organization review of the seismic design is needed to establish structural adequacy at each facility.

3. Decommissioning issues must be addressed at each facility as specified in DOE 6430.1A, Section 1300-11.

4. A comprehensive documentation system is required to properly facilitate quality assurance (QA) and safety audits as well as the mainte-

nance of operating records required by state and federal regulations. A document control and updating system meeting American Society of Mechanical Engineers (ASME) NQA-1-1989 (ASME 1989) criteria is necessary to ensure compliance to design criteria, and safety and environmental requirements.

5. The drawings need to be thoroughly reviewed and "as-built" to the current facility, system, and process configuration.

The adequacy of the B Plant secondary containment system is a major compliance issue. A tank system integrity assessment will be performed to assess the structural integrity of the tanks, process equipment, piping, and secondary containment system. This assessment is in support of the Part B permit application. The WAC 173-303-640, "Tank Systems" (Ecology 1991c), requires secondary containment of any tank and piping handling dangerous waste. A recent engineering document, *B Plant Secondary Containment System Description and Analysis*, WHC-SD-HWV-TI-017 (Corcoran 1991), was prepared to compare the B Plant secondary containment system design with the requirements in the WAC. The document supports the Westinghouse Hanford position that the design of the secondary containment system meets these requirements. Concurrence with this position is being requested from the DOE and Ecology. If it is determined that the B Plant system does not meet the regulatory requirements (either due to the design or physical condition), B Plant could be further modified at increased cost and schedule durations.

Summaries of the compliance reviews of B Plant and AR Vault prepared by SAIC are provided in Appendix B.

Reliable Operation--Facility layout is effective for conducting the NCAW processing mission. Both the 244-AR Vault and B Plant have been used for similar activities in the past, most recently in the extraction and purification of ^{90}Sr and ^{137}Cs before encapsulation. The B Plant uses a remote process cell design that is made up of 40 cells arranged linearly. This layout depends on piping in a covered concrete trench (hot pipe trench) within the building and embedded piping within concrete to move waste and materials between the appropriate process cells. These pipe routings are further connected to process equipment by means of jumpers. These jumpers are also used for electrical connectors, chemical makeup, steam, water, or anything else that needs to be added to, or moved within, the system. The design, fabrication, installation, and changeout of jumpers has been routinely handled throughout B Plant missions.

The original panel board operating configuration need for plant capital was updated by the facility/process monitor and control system. This system uses a microprocessor-based distributed control system with redundant communication loops incorporating two process control units and four operator interface units and one engineering workstation. This system is supported by a 30-min 15-kVA UPS and two data-archiving stations. Current projects are expanding this system in support of environmental and process monitoring needs.

The condition of plant equipment and spares is good. Expendable parts (pumps, motors, and critical jumpers) are maintained in spares inventory. Noncritical spares are available on short lead-time procurement or can be fabricated onsite or locally. Spare units for large, one-of-a-kind process equipment with expected low failure rates (i.e., cell 18 ion-exchange column) will not be purchased. In the event of a failure, a replacement can be fabricated onsite. The last mission at B Plant required, on average, the change-out/replacement of 100 jumpers per year. This number would be considerably less in the 244-AR Vault due to the limited number of tanks.

In 1990, a steam condensate leak occurred, which eventually lead to leakage of contaminated solution through a building expansion joint into the plant electrical gallery, a manned area. The source of this leak proved difficult to identify because of the series of two equipment (a condensate line failure and an inoperable leak detector) and one administrative (failure to remove a construction drain plug) failure that combined to allow the leak.

The B Plant is staffed for continuous operations, 24 h/day, 7 days/week. The projected operating efficiency is estimated to be 50 percent. This takes into account batch and operating inefficiencies as well as planned and unplanned outages.

Facility Safety--The B Plant and the AR Vault are generally in compliance with current codes and safety standards. The B Plant was completed in 1945 and was extensively modified in the mid-1960's to recover strontium and cesium from radioactive waste streams. Upgrades to instrumentation, controls, and electrical systems have been made to keep pace with continually evolving requirements. The AR Vault was constructed in 1969. Upgrades to the vessel and building ventilation systems have been completed recently.

Seismic analyses have indicated survival of B Plant and AR Vault confinement structures and exhaust filters. Considerable seismic analyses, including analysis of the end walls and safety class systems at B Plant, remain to be completed. Upgrades to the B Plant exhaust fans and stack are planned in order to meet seismic requirements. Testing has been, and is being, conducted to ascertain the condition of the structural concrete and steel. Analyses have not identified any deficiencies that cannot be corrected.

The B Plant is a heavily shielded facility, hence most exposure to workers is associated with manned entries into the canyon structure for sampling of process streams or maintenance of equipment. Radiation fields in the canyon generally range from 20 to 50 mR/h. This arrangement results in somewhat higher radiation exposure and contamination potential than for a new facility, but is well within the DOE radiation exposure limits. Planned upgrades to the sampling systems will further reduce radiation exposure by reducing canyon stay-time.

The B Plant and the AR Vault were constructed well before the implementation of DOE Order 6430.1A, and consequently, the implementation of redundancy and separation for Safety Class equipment is incomplete. Safety Class equipment for future processing of DST waste will be primarily related to confinement of airborne radionuclides. Planned upgrades to canyon/vault ventilation systems will provide the required redundancy and separation of Safety Class equipment. At B Plant, these upgrades will include isolation of retired high-efficiency particulate air (HEPA) filter facilities, new canyon exhaust fans, Safety Class emergency power, and a new exhaust stack with redundant stack monitoring. Similar upgrades at the AR Vault may be needed for exhaust fans, emergency power, and stack monitoring. The safety of process systems will be developed concurrently with the process flowsheets and equipment design.

Design Definition - B Plant Project Status--The modifications that need to be made to B Plant and AR Vault in order to support pretreatment fall into one of three categories: regulatory compliance (environmental), safety, and process improvements/modifications. To support NCAW pretreatment, only minor process modifications (route changes and instrumentation upgrades) are necessary. Most of the modifications needed for NCAW processing are required to bring the facility into regulatory compliance and to upgrade safety equipment. These modifications will also support post-NCAW treatment operations. Major process modifications will be required for NCRW, and PFP and CC waste types. The design of these post-NCAW process modifications is still in the very early stages of development. The only constraint on these designs is the physical sizing of the equipment to fit into the B Plant cells.

Los Alamos Technical Associates, Inc. (LATA) prepared an independent safety evaluation of the chemical processing for the pretreatment mission to evaluate technical viability and safety of plans. The LATA used the SAIC evaluation and other reports to evaluate the structural and seismic adequacy of the B Plant and 244-AR Vault and the compliance of plant systems to DOE Orders and other codes and standards.

These evaluations conducted by SAIC and LATA, along with Westinghouse Hanford-identified upgrades, form the basis for most of the B Plant/AR Vault planned modifications.

The initial engineering for B Plant facility modifications has been completed. Definitive design for several environmental compliance projects has been completed. Other environmental compliance projects are in the conceptual design phase. Facility modifications required for pretreatment processing are in various stages but are principally in the conceptual design phase.

Design Definition - AR Vault Status--An evaluation of 244-AR Vault compliance to DOE Order 6430.1A and other codes, standards, and regulations (CS&R) was prepared by SAIC on April 7, 1989 (see Appendix B). This report identified numerous facility modifications required for use of the 244-AR Vault in pretreatment of DST wastes.

Based on these evaluations, preliminary engineering studies have been prepared and identify capital improvements required for pretreatment processing at the 244-AR Vault. Completion of these engineering studies and initiation of capital improvement projects have been delayed due to redistribution of funding. Integrated program schedules that identify capital as well as expense-funded facility modifications have been prepared to coordinate 244-AR Vault modifications with the overall waste pretreatment mission.

Documentation--The B Plant SAR is in development. A draft for review by the U.S. Department of Energy Field Office, Richland (RL) is expected in August 1994. Following a year of review, an approved SAR is expected in 1995 provided funding is available. An additional update to the SAR will be necessary to address the processing of post-NCAWs.

The pretreatment process for DST wastes at B Plant is included in DOE/EIS-0113, *Final Environmental Impact Statement: Disposal of Hanford Defense High-Level, Transuranic, and Tank Wastes, Hanford Site, Richland, Washington* (DOE 1987a), known as the Hanford Defense Waste-Environmental Impact Statement (HDW-EIS). As such, no additional formal NEPA documentation is required. The *State Environmental Policy Act* (SEPA) checklist is incorporated in the Part B Application as required for a permit to operate B Plant.

Preparation of the Part B application for processing of NCAW is underway and expected to take 2½ yr to complete before submittal to Ecology and the EPA. State and federal review and approval can take 3 to 5 yr. Approval is contingent upon acceptance of current secondary containment or modifications to acceptable secondary containment configuration.

The requirements for the CAA will be addressed by the B Plant staff in a PSD program. The individual upgrade projects will prepare clean air permits as required and modify the PSD. The *Clean Water Act (CWA) of 1977* permits will be prepared by the projects effecting specific discharges.

All support for the determination of compliance of the 244-AR Vault is on hold pending an engineering study. The purpose of this study is to evaluate the possibility of performing sludge washing in a DST thereby eliminating the need to process the waste in the 244-AR Vault. If the study is successful, the 244-AR Vault will only be used as pass-through between Tank Farms and B Plant. The AR Vault SAR and environmental permits will reflect these study results.

4.2.5 Hanford Waste Vitrification Plant

4.2.5.1 Definition. The HWVP will immobilize Hanford Site defense high-level and TRU wastes in borosilicate glass in a new facility to be located in the 200 East Area of the Hanford Site, approximately 40 km (25 mi) north of Richland, Washington.

The HWVP will be a canyon facility designed for remote operation and control. It will receive pretreated, liquid, HLW feed slurries from Tank Farms; formate the feed slurries; add glass formers; concentrate process slurries; and produce a homogenous, vitreous melt in a liquid-fed ceramic melter. Glass-filled canisters then will be cooled, decontaminated, sealed, and stored before shipment to a federal waste repository. The annual production of the facility will be about 320 canisters, considering melter changeout.

4.2.5.2 Activities. Scheduled activities for HWVP can be divided into four categories: (1) technology development, (2) design and construction, (3) startup, and (4) operations. Following is a discussion of each activity.

Waste acceptance specifications were issued for the Defense Waste Processing Facility (DWPF) as OGR/B-8 (DOE-OCRWM 1986). A new Waste Acceptance Preliminary Specifications (WAPS) document is being prepared that will contain glass specifications for the federal waste repository. These new specifications will be applicable to all DOE facilities. Until the new WAPS is issued, technology is being developed to ensure that HWVP can produce glass to meet the requirements of OGR/B-8. Final approval may present uncertainties that impact the production of acceptable glass by the HWVP. A WCP must be produced to describe testing necessary to demonstrate compliance with the WAPS.

The WAPS has been revised and will be replaced by the WAPS for vitrification of HLW forms. Following the testing and technology development, a waste qualification report will detail how the HWVP met the WAPS. Technology must be developed to handle noble metals in the HWVP feed should this become a problem. Technology must also be developed to handle excess zirconium in the feed and hydrogen generation in the slurry receipt and adjustment tank (SRAT) during the formating reaction. Limited process verification testing is required to ensure that the HWVP NCRW, CC, and PFP feeds can be processed through HWVP without any operational or process problems.

The HWVP must be designed to perform according to its FDC, as well as to comply with all state and federal regulations and DOE Orders. Lessons learned from the DWPF and West Valley Demonstration Project (WVDP) must be factored into the design. The SARs must be produced and approved. Equipment must be procured in a timely fashion. Much of the equipment in the process cells is long-lead items, often with exotic materials of construction. The HWVP must be constructed in a quality manner in accordance with the schedule. Before HWVP can be turned over to Operations, it must successfully pass acceptance tests.

The HWVP startup process consists of preoperational tests, operational tests, WFQ tests, and readiness reviews. Preoperational tests are the final system integration tests performed before full plant cold operation during the operational testing phase. During preoperational testing, components are integrated into the final plant operational system configurations and tested at design conditions as a systematic verification of system design and construction. Operational (cold-startup) testing will be conducted to fully demonstrate operational readiness of all plant systems, including plant administrative/management systems. This testing also demonstrates the ability of the personnel to operate the HWVP facility and verifies the operation of support systems such as rail service, steam, and water. During WFQ testing, HWVP must be monitored and tested, and the product sampled, to demonstrate that glass quality is as WFQ models are predicting.

The HWVP must be able to produce an acceptable glass product with a range of feeds including NCAW, NCRW, CC, and PFP. Total operating efficiency must be maintained at 70 percent to process the feed in a reasonable period of time. Effluents must be controlled to permitted levels. In addition, plant operations must support ALARA concepts.

4.2.5.3 Assessment. Complexity--The HWVP process is substantially based on existing technologies well proven in nuclear and commercial facilities, or thoroughly tested during development at DWPF, WVDP and PNL. Batch chemical reactors in remotely maintained cells are no different from other plants on the Hanford Site. Compared to the PUREX Plant, HWVP has few process and discharge streams. The only aspects of the HWVP process that add complexity are the requirements imposed by WFQ and process waste treatment and recycle. The process and process additions must be strictly controlled so the glass product will be acceptable to the federal repository. There is no identified method of correcting an off-specification glass product.

The HWVP will start up in a computer-operated manual mode, not as an automated plant. From the distributed control system, operators will start transfers, begin boildowns, and add chemicals. As experience in plant operations is gained at HWVP, selected portions of the facility may be automated.

Maturity--The HWVP process consists of nine systems: (1) feed receipt and lag storage (RLST), (2) feed preparation, (3) melter feed, (4) melter, (5) melter offgas (MOG), (6) aqueous waste processing, (7) process vessel vent, (8) canister decontamination, and (9) canister handling/closure.

The RLST will use British Nuclear Fuel Corporation's "maintenance free" technology and will not be located in the Vitrification Building. The British technology is well demonstrated and commercially available.

Feed preparation consists of commercially available atmospheric pressure-stirred tank reactors with attached agitators and pumps. Because of the requirements to certify the waste form without extensively sampling and characterizing the glass in the canisters, the mixing and sampling requirements in feed preparation are very restrictive, the design is unique, and extensive testing is underway to ensure the equipment can perform to its functional requirements. The materials of construction and remote maintenance features similarly make these tanks unique.

The melter feed system must control the flow of an abrasive slurry stream into the melter. The DWPF has done extensive testing and successfully demonstrated the ability to control melter feed, although melter feed line pluggage does occur on occasion. The PNL continues to work on minimizing erosion due to abrasive slurries.

Liquid-fed ceramic melters have been operated for years, and most problems identified have been corrected. Potential problems do exist with noble metal precipitation in certain feed types. This situation could short-circuit melter electrodes. The melter may experience capacity problems with high-phosphate feed because an insulating layer of phosphate can form on top of the melt pool. The HWVP is investigating minor design enhancements that, if necessary, will mitigate these problems.

All parts of the MOG system have been tested at pilot-plant scale. The submerged bed scrubber (SBS) has been successfully tested at the WVDP. The PNL has tested MOG systems with nonradioactive simulated feed on a pilot scale. A full-scale integrated MOG system has never been operated with radioactive feed. Potential problems include foaming, scale buildup, and corrosion. The HWVP has the capability to add antifoam agents to the MOG. A mechanical device is included in the design to remove scale buildup at the point most likely to scale. To overcome the corrosion problem, high-nickel alloys have been specified where necessary.

All water entering HWVP will be sent back to Tank Farms as grout feed, which has restrictions on TRU and radionuclide content. The HWVP design has an extensive system of tanks, ion exchange, and filters devoted to processing aqueous wastes. While operation of each individual component of the system is well-demonstrated at the Hanford Site, operation of the entire system has never been demonstrated. Time-cycle analysis of HWVP indicates that the rate-limiting step is the aqueous waste handling system.

The process vessel vent system has many of the same components as the MOG, and similar problems are anticipated.

Existing Facilities--The HWVP will be a new installation in the 200 East Area. The only existing facilities that cause uncertainties are the utilities that HWVP will draw upon, such as the steam plant (for building heating, ventilation, and air conditioning), water import lines, and the electrical distribution system. These systems will be upgraded, as necessary, to support the Hanford Site and HWVP.

Compare Program--Both DWPF and HWVP produce borosilicate glass and package the vitrified waste in identical stainless steel canisters. The similarity of the waste form will facilitate WFQ activities. The HWVP and the DWPF are substantially alike. Building dimensions are roughly comparable, and glass production rate is identical at 100 kg/h (220 lb/h). There are some notable differences, however, brought about by differences in feed composition and pretreatment and because DWPF was built in a different state than HWVP and before issuance of DOE Order 6430.1A (DOE 1989). The DWPF must have process steps to remove organics and mercury from incoming feed whereas HWVP does not. The HWVP must have a process for treating internally generated liquid wastes to remove most radioactive components and recycle them to the melter whereas DWPF does not. The HWVP uses a different MOG system, incorporating components from the WVDP design. The HWVP uses shielded coverblocks over the process cells. The HWVP Canister Storage Building stacks canisters three high, versus one high for DWPF. The HWVP provides onsite lag storage tanks for feed and radioactive liquid process waste, which is not required at DWPF. The HWVP Vitrification Building Zone 1 ventilation and backup power meet DOE Order 6430.1A Safety Class criteria. The DWPF has an onsite storage facility for refurbished contaminated equipment and other critical spares not provided at HWVP. These and other minor differences are continually being monitored by an HWVP resident manager at DWPF and through routine technical exchange meetings with DWPF.

Several process problems identified at DWPF may affect the design of HWVP. These problems include the distributed control system, ventilation systems, fire protection systems, hydrogen generation in the SRAT, and noble metals in the melter. The DWPF distributed control system presented problems during process startup. The experience at DWPF has been factored into the HWVP control system design. The system has been designed to allow manually controlled process startup. The ventilation and fire protection systems at DWPF did not meet some of the DOE Order 6430.1A requirements; however, the HWVP ventilation and fire protection systems have been designed to meet the requirements of DOE Order 6430.1A.

During the formating reaction in the SRAT, hydrogen gas is generated at potentially flammable concentrations. The DWPF is currently studying the problem and should have a resolution long before HWVP startup. Because DWPF is already built, any modifications to accommodate hydrogen generation in the SRAT must fit within the DWPF. The HWVP is patterned after DWPF so any modifications to DWPF should fit within the HWVP design and be relatively easy to incorporate into the HWVP design. The PNL is studying precipitation of noble metals in the melter that could short-out the bottom electrodes and reduce melter life. Again, any modifications that DWPF makes to the melter should be relatively easy to accommodate in the HWVP design.

Compliance--The HWVP is a new facility and will comply with current DOE Orders as well as CS&Rs. A summary of the compliance assessment review performed by SAIC is provided in Appendix B. The non-compliance items identified in the review are being addressed during final facility design.

Reliable Operation--The HWVP is designed to achieve an average glass production rate of 100 kg/h (220 lb/h) and operate 70 percent of the time (not including melter replacement time). A study to confirm the effective availability for each system within HWVP was conducted by the Architect-Engineer (A-E). This study considered equipment mean time between failure, mean time to restore, and the storage effects of those items that allow production to continue during failure of certain upstream or downstream items. The results of this study indicated that the HWVP is currently predicted to achieve an effective availability of 74 percent, provided that maintenance crews are available on all shifts, repair material is located onsite, and sufficient canister storage spaces are available.

The systems that have the most significant effect on plant availability are the melter/turntable, the incell waste management system, the remote handling system (i.e., cranes and transporters), the MOG system, and the feed preparation system.

Safety--Information presented in WHC-EP-0250, *Hanford Waste Vitrification Plant Preliminary Safety Analysis Report* (Herborn et al. 1991), indicates the following results.

- Phenomena associated with common-cause failure initiators (e.g., earthquakes, wind storms, ash fall, aircraft crashes, fires, external events that incapacitate plant operators, etc.) are adequately described.

- Plant design criteria based on DOE Order 6430.1A (DOE 1989) and WHC-SD-C1.2ENG, *Hanford Plant Standards and National Codes and Standards* (Jordan 1989) are properly presented with adequate bases provided, and compliance is properly demonstrated.

- An appropriate safety classification methodology is presented, and a safety equipment list that is reasonable and adequately justified is provided.

- The dose assessment models and supporting input data are appropriate and adequately described.

- The accident analyses are systematic and comprehensive [i.e., the complete spectrum of potential accident initiators is considered (from high to low probability); the screening that selected the accidents to be analyzed, representing the major risk contributors, is appropriate; and the accident analyses are appropriately conservative].

The following elements are not complete.

- Evaluations or analyses that give reasonable assurance that Safety Class 1 and 2 systems have adequate redundancy and/or diversity (e.g., single-failure analyses; failure modes, effects, and criticality analyses; fault trees; event trees; etc.) are not complete.

- There is no evaluation and/or matrix that demonstrates the accident analysis assumptions, equipment safety classifications, and operational safety requirements are all completely consistent.

- There is no ALARA report that describes the features and evaluations that ensure ALARA concepts in design and operation.

Design Definition--Preliminary design was completed and documented in September 1990. Detailed design of the HWVP began in January 1990 and current plans are to complete design by June 1993. However, some delay to that date is anticipated. Reviews have been performed throughout the preliminary and detailed design phases. The A-E has prepared project design guides to ensure consistency throughout the design. Westinghouse Hanford has prepared the HWVP FDC, supplemented by technical data packages. These criteria have been updated throughout the design as necessary. Westinghouse Hanford maintains a staff of resident engineers at the A-E site to oversee design and to ensure communications with Hanford Site organizations.

Documentation--The status of safety and environmental documentation is as follows.

The PSAR has been approved by Westinghouse Hanford and issued as Revision 0 (Herborn et al. 1991). The FSAR is scheduled for completion by December 1999.

No RCRA Part B permits have been issued in Washington State, so HWVP is setting a precedent throughout the permitting cycle. An RCRA Part B permit is necessary before start of HWVP construction. The following documents have been published: (1) *Hanford Waste Vitrification Plant Dangerous Waste Permit Application*, DOE/RL 89-02 (DOE-RL 1989), and (2) *Hanford Waste Vitrification Plant Clean Air Act Permit Application*, DOE/RL 89-26 (DOE-RL 1990). The RCRA Part B permit is scheduled to be issued in April 1992 in support of start of construction. The initial permit will only allow the site preparation activities to be conducted because the site preparation design is the only design that is complete and will be included in the permit application. The initial permit will contain a compliance schedule identifying when the remaining design and construction activities will be conducted. Each phase of design/construction will require a modification to the initial permit. This is an innovative permitting approach for the HWVP in an effort to accelerate the cleanup of the wastes stored at the Hanford Site.

A revised RCRA Part B permit is necessary before operational testing of HWVP. The revised permit is scheduled to be issued by December 1998.

The ROD generated from the HDW-EIS required that the need for any additional NEPA documentation for the HWVP be evaluated prior to construction. To satisfy this requirement, an analysis was generated and submitted to the DOE-HQ for approval. This analysis updates the impacts for the HWVP that were described in the HDW-EIS published in 1987.

Acceptance of this analysis as complete will serve to meet the commitment made in the ROD to evaluate the need for any additional NEPA documentation for the HWVP prior to construction. The analysis indicates that, to date, changes to the plant design would not cause significant differences to the environmental impacts as described in the HDW-EIS.

This analysis will also be used by Ecology to fulfill its requirements under the SEPA. The SEPA process must be completed before Ecology can issue an RCRA permit to allow site preparation and construction of the HWVP. Ecology is currently looking at adopting those portions of the HDW-EIS that are pertinent to the HWVP along with this analysis as additional information and DOE/RL 90-0027, *Evaluation and Selection of Borosilicate Glass as the Waste Form for High-Level Waste* (Peterson 1990), as fulfilling SEPA documentation requirements. Once the SEPA determination has been made, the RCRA permit can be issued and site preparation can begin.

Acceptance of the analysis by the DOE-HQ is needed by September 30, 1991, so Ecology can begin the SEPA process in parallel with the RCRA permitting process, already on a tight schedule, to meet the site preparation date.

Failure to receive DOE-HQ approval of this analysis will delay Ecology's completion of the SEPA process and the start of site preparation.

4.2.6 Grout

4.2.6.1 Definition. The GTF provides the capability for disposal of low-level mixed wastes in accordance with requirements of the RCRA. Low-level mixed wastes from DSTs are mixed with cementitious solids to form a slurry that is then pumped into near-surface concrete vaults where the grout slurry hardens. The vaults are then sealed and closed as a landfill.

The schedule for grouting the LLW fraction of the liquid wastes affects the availability of tank space and could impact pretreatment and vitrification activities. Grout is therefore included in this Risk Assessment. The scope is limited to an assessment of tank space and pretreatment impacts resulting from uncertainties in (1) the waste composition in the DSTs, (2) the feed specification for grout due to environmental regulation considerations, and (3) the schedule for the Grout Program.

4.2.6.2 Activities. The grout activities addressed in this Risk Assessment are of two types: (1) those associated with the safety and environmental documentation required for approval to begin grouting DST wastes and, (2) those associated with actual processing of the wastes.

Safety and environmental documentation must be completed and approved before DST wastes are processed into grout. Required documents include an SAR; a Part B permit; a performance assessment; documentation for the NEPA, CAA, and CWA; and a readiness review. Each of these documents, except the NEPA documentation and the CWA permits, has an activity defined for it in the Risk Assessment model. All are addressed in the assessment itself.

More than 3,800 m^3 (1 million gal) of phosphate/sulfate wastes (PSW) have already been processed through the GTF and disposed of as a grout in a large vault. It is anticipated that an additional 43 5,300-m^3 (1.4 million gal) vaults will be filled with grouted wastes from DSTs. The same basic steps are planned for each vault filled. First, a candidate tank of waste will be sampled and the samples analyzed. Based on the results of that sampling and characterization, a determination will be made regarding the suitability of grouting those particular wastes. Second, given a favorable decision at the first step, testing will be initiated to verify that a grout meeting prescribed performance criteria can be made using existing dry blends (cementitious and pozzolanic) materials or to develop a new grout formulation that will meet the criteria. Third, the wastes will be retrieved and transferred to the grout feed tank. Fourth, the wastes in the grout feed tank will be sampled and characterized. Fifth, the appropriate reviews, notifications, and approvals will be completed; and sixth, the wastes will be processed into grout. Finally, the grouted wastes may be sampled and tested to verify grout quality.

For the Risk Assessment model, specific activities are identified for waste characterization, grout formulation, and waste retrieval in order to assess the impacts of uncertainty in waste composition on these activities. The entire seven-step process comprises waste-specific activities called grout operations. A grout operations activity is defined for each waste source to be grouted (DSS and DSSF, NCAW, NCRW, CC, and PFP).

4.2.6.3 Assessments. The assessment of uncertainties associated with grouting of DST wastes was purposely limited in scope relative to other vitrification activities evaluated. The assessment focused on the impacts to tank space utilization and pretreatment resulting from uncertainties in the waste composition in the DSTs and uncertainties in the feed specification for grout due to environmental regulation considerations. The Risk Assessment categories examined include (1) maturity, (2) compliance [with DOE Order 6430.1A (DOE 1989)], and (3) documentation. The impacts of grout operation on waste tank storage utilization were also assessed and are discussed in Section 7.0.

Maturity--Operation of the GTF was successfully demonstrated in 1988 to 1989 with the processing of 3,800 m^3 (1 million gal) of PSW to form 5,300 m^3 (1.4 million gal) of grout. Assessing the maturity of the processing equipment is outside the scope of the grout risk assessment. Because of the experience with the PSW campaign, however, risks associated with the GTF are expected to be manageable.

Grout is composed of the waste slurry and a blend of dry materials that may include cement, fly ash, blast furnace slag, and/or clays. Work is proceeding to develop/verify the grout formulations that will yield grout with acceptable processing and product properties. Testing has shown that there are components of the waste that have an adverse effect on grout properties. For example, ongoing work indicates that certain chemical forms of aluminum in the waste may lead to excessive heat generation during curing of the grout. A complete understanding of the impacts of the waste on the grout properties is lacking and needs development. The technology for developing acceptable grout formulations in response to the waste composition also needs development. Because the exact composition of the wastes in all but a few tanks is not known and because of the need for grout formulation technology development, it is expected that at least verification testing will be required for each tank of waste to be grouted. Grout schedules allow 1 yr for completion of this verification activity for each tank of waste to be processed. Development of new grout formulations is expected for each new waste type (DSS and DSSF, NCAW, NCRW, CC, and PFP). Baseline grout schedules include these development activities.

Changing regulatory guidance for waste form performance may require increased time and testing to verify the adequacy of a particular formulation. One solution to excessive heat generation during grout pouring is to fill the vault in lifts. These activities could prolong the processing of a waste through the grout facility.

Compliance--An assessment for compliance with design criteria specified in DOE Order 6430.1A (DOE 1989) was completed in 1990. Deficiencies were identified in the fire protection systems, seismic analyses, leak and gaseous effluent monitoring systems, radiological protection during maintenance, and redundancy of control system. A compliance plan for addressing the deficiencies has been developed and the analyses and facility modifications are underway. Baseline grout schedules include the required activities. Completion of these activities is required before approval of the grout SAR and completion of the operational readiness review.

A summary of the compliance assessment review performed by SAIC is provided in Appendix B.

Documentation--Safety and environmental documentation is being prepared to comply with federal and Ecology regulations and with DOE Orders.

The NEPA requires that an EIS be prepared for major federal activities "significantly affecting the quality of the human environment." The *Final Environmental Impact Statement: Disposal of Hanford Defense High-Level, Transuranic, and Tank Wastes, Hanford Site, Richland, Washington* (DOE 1987a) fulfills the need for an EIS. The ROD (DOE 1988a) specified that LLW from DSTs "will be solidified as a cement-based grout and disposed of near surface at Hanford in preconstructed, lined concrete vaults." A C-2 analysis is underway to determine if there are any significant changes in plans compared to the HDW-EIS that would require a supplemental EIS. Ecology also requires an EIS; plans are to use the HDW-EIS. Ecology is currently conducting its review. Should either review result in an unfavorable decision, project delays can be expected while the necessary documentation is prepared.

The DOE Order 5820.2A, *Radioactive Waste Management* (DOE 1988b), requires that "field organizations with disposal sites shall prepare and maintain a site-specific radiological performance assessment for the disposal of waste for the purpose of demonstrating compliance with the performance objectives.." Initial studies have been prepared by PNL. Testing and analyses to confirm assumptions and to validate computer codes used in the performance assessment are underway. The draft performance has been forwarded to the DOE-HQ for review and approval by the Performance Assessment Peer Review Panel.

A dangerous waste permit is required by Ecology and the EPA for the disposal of dangerous wastes. The original Part A permit application was submitted on September 1, 1987, and has been revised three times to reflect current plans for GTF operations. The Grout Treatment Facility Dangerous Waste Permit Application (Revision 0, Part A and Part B) was initially submitted to Ecology and the EPA on November 23, 1988. Revision 2 of the permit application is being prepared for submittal to Ecology and the EPA in 1991.

Permitting activities needed to achieve compliance with the CAA are nearing completion. Permits were previously approved for the PSW campaign. Applications for modifications to the permits for processing of additional DST wastes have been submitted. A modification application for a state implementation plan was submitted February 15, 1989, to the Benton-Franklin-Walla Walla Counties Air Pollution Control Authority per General Regulation 80-7. No response within 30 days implies approval. New Source Performance Standards are not applicable to the GTF. A National Emission Standards for Hazardous Air Pollutants permit modification application was approved July 1990. A PSD application was submitted February 1990; approval is expected by April 1992.

Operation of the GTF will not result in the discharge of any liquid effluents that would require a National Pollution Discharge Elimination System permit. Therefore, no permits or reviews pursuant to the CWA are required.

An FSAR is being prepared with completion expected in 1992. Operational readiness reviews for the grout disposal activities will be initiated at the end of FY 1991.

Uncertainties--One uncertainty associated with grouting of LLW is the lack of knowledge concerning the exact composition of the wastes to be grouted. In particular, it is not known if (1) the wastes contain unacceptable levels of organics that would exceed land disposal restrictions, (2) radionuclide concentrations exceed limits, or (3) unidentified constituents of the waste adversely affect grout properties such that an unacceptable grout would be produced. There are two issues with respect to the land disposal restrictions. First, will pretreatment be required for the DSS and DSSF wastes currently planned for direct disposal in grout; and second, will the pretreatment processes planned for NCAW, NCRW, and PFP and CC wastes produce an LLW stream acceptable for grouting. Wastes to be grouted must be classified as non-TRU (<100 nCi/g TRU elements) and must not contain radionuclide concentrations that would exceed those defined for Class C wastes in 10 CFR 61 (NRC 1991).

Only three tanks of DST waste for grout processing have been characterized. Each waste to be grouted must be chemically and radiochemically analyzed to ensure that the resulting grouted wastes will conform to environmental, safety, and design requirements. Testing is then required to verify that a grout with acceptable properties can be made from the wastes.

For a given tank of wastes to be grouted, a 610-day sequence of activities is planned leading to the successful grouting of the wastes. Activities include sampling and analyses of the wastes; verification of the grout formulation; retrieval and transfer of the wastes; additional sampling and analyses; and completion of the required notifications, reviews, and approvals before actually processing the wastes. The grout processing schedule would be delayed 3 to 7 months if the initial characterization indicated that the wastes were unacceptable. The offending tank of wastes would be tied up for as much as 2 yr while a treatability variance was pursued. Longer delays could be expected if it were determined that the offending wastes required pretreatment or additional pretreatment before grouting, or if safety and/or environmental documentation required revision.

The current ruling from the U.S. Nuclear Regulatory Commission (NRC) has resulted in designating DSS and DSSF wastes as LLW. However, resolution by the NRC of a petition submitted by the regulatory agencies to revise their ruling could result in the need to pretreat some or all of the DSS/DSSF wastes. If successful, the petition would require that the tank wastes be treated to remove the largest technically achievable amount of radioactivity before grouting. This would increase the burden on the pretreatment facility and could significantly increase the volume of wastes to be processed in the HWVP. The DST space would be limited until the pretreatment facility could be brought online to handle the additional wastes to be processed.

The availability of necessary resources is another source of uncertainty. Adequate supplies of the raw materials for the dry blend to be added to the wastes must be identified. Grout, DST and SST characterization, and HWVP will be competing for limited analytical laboratory resources. Core-sampling equipment must be available to support tank characterization and grout quality verification activities.

4.2.7 Tank Farms

4.2.7.1 Definition. All stored liquid mixed wastes resulting from various processing operations conducted on the Hanford Site will eventually pass through double-shell Tank Farm facilities on their way to further treatment and/or final disposal operations. In the future, the operational needs of normal waste storage activities will need to be balanced with those of the waste disposal programs. Recently, increased emphasis has been placed on waste management facilities at the Hanford Site due to the discovery of hazardous conditions that exist at these facilities. This added attention has accelerated efforts aimed at correcting deficiencies and upgrading facilities to meet current criteria and standards. The task of refurbishing waste management practices and facilities could be as large in scope as the retrieval, pretreatment, and vitrification programs are themselves.

The approach used in developing the Tank Farm portion of the Risk Assessment consisted of four major steps: (1) determining the ongoing Tank Farm activities that must be completed in order to support NCAW and post-NCAW processing; (2) determining the near-term (next 2 yr), long-term (next 2 to 5 yr), and future (greater than 5 yr) activities that affect these processing plans; (3) modifying the existing base case schedules for NCAW and post-NCAW processing to include any missing activities identified; and (4) grouping activities accordingly and performing individual risk analyses. Using this approach, 23 Tank Farm activities were identified. Of these 23 activities, 12 were already included on the existing base case schedules and 11 new activities were added as a result of conducting this Risk Assessment. All primary and ancillary Tank Farm facilities and systems required to support NCAW and post-NCAW processing were considered in the Tank Farm portion of this Risk Assessment.

Only DST facilities and systems were analyzed and included in the Tank Farm assessment because remediation of SST wastes is outside the scope of the Risk Assessment.

4.2.7.2 Activities. Three activities, which only serve to support retrieval functions and are not required for continuing Tank Farm storage operations, are addressed in Section 4.2.2. The remaining activities have been grouped accordingly into the seven risk analysis packages. The assessments of schedule activities can be further categorized into the areas of: (1) facility modifications, (2) facility operations, and (3) tank safety.

Facility Modifications--This category includes projects and upgrades in various stages of development. The types of modifications include the following categories: waste transfer systems; HVAC systems; I&C systems; electrical distribution systems; operational and maintenance support facilities; and new Tank Farms. The work scope includes project definition, preliminary design, project validation, definitive design, construction, permitting, safety documentation, and startup.

The 241-AY/AZ Tank Farm Ventilation Project W-030 and the Cross-Site Transfer Lines Project W-058 are activities that will replace existing systems that are deficient and cannot meet the long-term and future operational needs of Tank Farms. The Tank Farm Ventilation Project is applicable to the processing of the NCAW and will require integration with retrieval projects occurring near-term. New cross-site transfer lines will be required for the processing of DSS, CC, and PFP waste slurries and are a long-term operational need. The two available cross-site transfer lines, and their existing ancillary systems, are sufficient to meet the near-term needs for continued supernatant transfers. Project W-058 will provide the systems necessary to conduct slurry transfer and is scheduled to be in service prior to being needed for any retrieval- or disposal-related activities. No other uncertainties, other than those already identified for routine transfer activities, are deemed necessary for cross-site transfers. The piping and electrical projects for tank 104-AP will serve to provide another grout feed tank for added operational flexibility and will help alleviate tank storage space limitations thereby allowing retrieval activities to begin for other waste types. Capital and major maintenance upgrades are envisioned as part of the program plan for improvements to Tank Farm facilities. There are currently 88 individual projects that comprise the capital and major maintenance upgrade programs, with an estimated total cost of $543 million.

Facility Operations--Facility operations include administrative and documentation upgrades along with the actual conduct of retrieval/transfer operations. Administrative and documentation upgrades cover safety, environmental, and regulatory requirements not included elsewhere; operating procedures; conduct of operations; training; and configuration control issues encompassing "as-built" drawings, component labeling, master component index development, instrumentation and engineering flow diagram creation, and contamination zone reduction.

Operations and administration upgrades include the operating procedures, conduct of operations, training, and configuration control and are a portion of the same strategic program plan mentioned previously. The documentation upgrades include a diverse listing of safety, environmental, and regulatory needs. The safety documentation involved includes preparing SARs and addressing Tiger Team assessment findings and TSA concerns. Environmental documentation includes requirements from the NEPA, SEPA, WAC, RCRA, and CAA. Regulatory needs covering DOE Orders and Tri-Party Agreement (Ecology 1990) commitments are also included in this activity.

Safety--This area includes all DST safety issues. The Waste Tank Safety Program will address the activities in resolving safety issues with tanks 101-SY, 103-SY, and 103/104/105-AN, as well as all other safety-driven upgrades to the Tank Farms. Program elements include program planning, safety analysis documentation, process safety analysis, waste tank hydrogen stabilization, waste tank sampling and analysis, and waste tank organic stabilization.

Resolution of safety issues involving tanks 101-SY, 103-SY, and 103/104/105-AN is required before any action is taken to retrieve or process the wastes contained in them. These issues affect the processing of DSS and are near-term needs; CC and PFP wastes are long-term needs. Resolution of these safety issues will cover the definition of required upgrades, development of technical justification, laboratory and pilot-plant development work, cold-simulant and radioactive testing, and in-situ process demonstration. Applicable tank safety issues have been integrated into the facility modifications and facility operations categories (i.e., upgrades and documentation activities), but the management responsibility remains with the Waste Tank Safety Program. To date, the majority of attention and effort has been directed toward the remediation of the most urgent safety concern (i.e., tank 101-SY). Beginning in late FY 1991, work will begin on the other four DSTs in question.

4.2.7.3 Assessments

Existing Facilities--Many uncertainties regarding the use of existing Tank Farm facilities in support of the current storage mission and potential future missions have been identified. Those uncertainties that do not result in facility upgrades driven by environmental or safety regulations have been placed into the major maintenance or operations and administrative upgrades categories. The major maintenance upgrade activities are intended to be focused efforts for achieving facility enhancements that will improve the operating environment in Tank Farms. The activities consist of the following:

- Accelerated special issues pertaining to specialty equipment and facilities
- Evaluation of deferred/backlogged work scope including enhancements previously deemed not critical to continuing operations
- Engineering studies concerning specialty equipment and facility issues.

The operations and administrative upgrades consist of enhancements in conduct of operations and training; and improvements in operating procedures, procedure control systems, and configuration control.

If the above-mentioned activities are completed as planned, there should be no significant issues dealing with the use of existing Tank Farm facilities that preclude supporting storage and retrieval programs. However, the amount of work now envisioned in Tank Farms is so large that there are significant challenges to ensure (1) sufficient budget will be available to do all the work, (2) the resources necessary to accomplish all the work can be obtained, and (3) the integration of work can be accomplished without creating resource or schedule conflicts. If these necessary actions cannot be completed as planned, current conditions dictate that the retrieval activities be deferred to a later date.

Compliance--The compliance assessment review conducted by SAIC focused on the aging waste facilities (AWF) where NCAW is being stored. The review addressed primarily only compliance to DOE Order 6430.1A. The findings are a good indication of the extent of issues throughout all double-shell Tank Farms.

A total of 37 major noncompliance issues were identified for the AWF as a result of the DOE Order 6430.1A compliance assessment, mainly due to the age of some of the facilities in the AWF complex. It is apparent that the AWF, as currently configured, was compliant to the codes and standards when the AWF was constructed. However, as the criteria for safety-related systems and environmental protection became more stringent, the AWF was not brought up to these same standards. As a result of these non-compliant issues, 13 significant uncertainties were documented for consideration in the risk assessment model. The applicability of the uncertainties was expanded, as appropriate, to include additional double-shell Tank Farm facilities. These were then incorporated into the existing risk analysis packages as additional uncertainties. Currently, Tank Farm organizations have plans in place that address each of the 13 significant uncertainties identified as a result of the AWF compliance assessment.

Reliable Operation--The design and configuration of Tank Farm systems attempt to maintain operational flexibility to support the needs of waste management activities and those of various processing facilities at the Hanford Site. The same approach has been applied to current projects that support Tank Farm upgrades and future retrieval activities. In the past, the major disadvantage of maintaining such flexibility has been in the frequency of misrouting occurrences. Administrative improvements have decreased the frequency of misroutings, but this is partly due to a decrease in the total number of transfers taking place. In the future, the number of retrieval/transfer actions will again increase, but additional engineered barriers and administrative controls will be in place such that facility downtime is not expected to be adversely affected.

The condition and age of facilities and equipment must be taken into account when evaluating operational reliability. If the remaining useful life of existing systems is not sufficient to allow for the completion of their replacement projects, operational reliability will be diminished. Currently, the AWFs and cross-site transfer lines are the two systems in greatest jeopardy due to their age. Both systems have upgrade and replacement projects scheduled.

Safety--The condition of engineered safety systems in Tank Farms has degraded due to their age, years of neglect, and inadequate maintenance. A viable improvement program has been proposed that will compete with other programs for resources.

Double-shell Tank Farm facilities have been identified as non-compliant with many safety-related DOE Order requirements. The condition of radioactive material confinement barriers, including primary and secondary containment structures, transfer piping, and pits, has been listed as uncertainties due to their questionable integrity. Existing deficiencies in the ventilation, emergency power, fire protection, and effluent monitoring systems have also been documented. During the next several years, correcting these conditions will be the top priority of Tank Farm organizations. The safety-related issues have all been incorporated into a Tank Farms upgrades program plan, which has been developed [WHC-EP-0392 (Henderson 1991)].

A review of Tank Farms' operational safety requirement compliance, Tiger Team findings, technical safety appraisal concerns, and OSHA findings confirm that the majority of problems result from either the poor material condition of existing facilities or the deficiencies in the administrative systems that govern them.

Design Definition--Tank Farm projects use the standard project management approach identified in DOE Order 4700.1, *Project Management System* (DOE 1987b) and the implementing project management procedures used at Westinghouse Hanford. This should ensure that all projects use the appropriate design criteria, schedules, and planning documents to successfully complete the activities in the allotted time. The integration of multiple project activities is a serious concern in Tank Farms, however, and has been identified as an uncertainty in this Risk Assessment.

Defined and validated general plant projects and line item projects for the double-shell Tank Farms are normally integrated into more detailed facility-specific plans by the planning and scheduling and production control organizations within Tank Farms. As is the case for all near-term work, resource-loaded schedules are then produced for such activities. With the exception of some overlapping waste tank safety upgrades, none of the proposed projects in the Tank Farm upgrades program plan have been factored into detailed, integrated working schedules to identify conflicts. Such an evaluation remains to be completed, as the scope of projects within the program plan becomes more clearly defined.

Documentation--The Tank Farm SARs presently are being rewritten to meet the current requirements of *Regulatory Guide 3.26*. In the past, upgrading the SARs required approximately $6 million per SAR with schedule durations of 3 to 5 yr. All Tank Farm safety documentation is planned to be brought into compliance with new requirements; however, a need to expedite the process has been identified.

The current strategy for SAR upgrades includes a consolidation of existing Tank Farm SARs and other hazard identification and evaluation reports.

Three documents will be produced to further clarify the SAR requirements before initiating the Tank Farm SAR upgrades. The first is a concise listing of operations, design, and engineering inputs required from the respective organizations to prepare the SARs. The second document will be an expanded outline that converts the guidance of *Regulatory Guide 3.26* into specific requirements appropriate for Tank Farms. The third document will be a set of review criteria that will guide the reviewer in determining if the material presented is adequate. In addition to the consolidation of the safety documentation, the SARs will be annually updated to reflect changes in facilities or use of new facilities as they are constructed in the future. Projects that are completed before a defined closing date for new information will be described in the SAR upgrade. Projects with completion dates beyond the closing date will be incorporated by means of the annual update.

In accordance with the requirements of the NEPA, environmental documentation shall be written early in the process for a proposed action such as a project or program. Most of the planned Tank Farm activities will undergo some level of NEPA documentation. Existing NEPA documentation for Tank Farms addresses the interim storage and final disposal of Hanford Site wastes. The NEPA documentation for each proposed Tank Farm activity or upgrade will be prepared as it becomes defined. Tank Farms is operating under RCRA interim status as of December 1990. An RCRA Part B application has been submitted.

4.3 ACTIVITY/UNCERTAINTIES

The schedule activities and the uncertainties related to these activities, identified in the Risk Assessment, are listed in Tables 4-3 through 4-9. The uncertainty descriptions are brief summaries of uncertainties that are fully described on Uncertainty Report Forms [see WHC-EP-0427 (Miller et al. 1991)]. The reference refers to the uncertainty categories listed on the Summary List of Reference Uncertainties, Table 4-10. Separate tables are provided for each of the seven major activities. For completeness, <u>all</u> uncertainties identified during the Risk Assessment, regardless of significance, are included on these tables. Significant or key uncertainties, those which could result in significant impact to the program, are identified in Section 4.6. Table 4-10 is a consolidation of the detailed uncertainties into a more generalized list of 41 uncertainty categories.

4.4 ACTIVITIES, PROBABILITIES, AND CONSEQUENCES

As discussed in Section 4.1, the risk analysis methodology required that each activity be assessed as to the probability that the activity could be successfully completed within the "most likely" duration. Additionally, the working teams were required to determine optimistic and pessimistic activity durations as well as the costs to complete the activity within the most likely, optimistic, and pessimistic durations. Where possible, the costs were expressed as fixed and variable costs (dollars per year) to allow the computer model to calculate cost consequences as a function of time.

The probability, cost, and schedule data used in this risk analysis are listed in Appendix A.

Table 4-3. Characterization - Activities and Uncertainties.

ACTIVITY NUMBER	ACTIVITY DESCRIPTION	UNCERTAINTY	REFERENCE
212CE04NCAW1	CORE AND CHARACTERIZE NCAW FY 1991	1 TIMELY COMPLETION OF SAFETY DOCUMENTATION	D
		2 INADEQUATE SAMPLING EQUIPMENT AND FACILITIES	G
		3 FUNDING LIMITATIONS	I
212CE04NCAW2	CHARACTERIZE REMAINING CORES NCAW	2, 3	
		4 IMPACT OF TANK FARM SAFETY ISSUES	E
		5 TIMELY DEVELOPMENT OF ANALYTICAL METHODS	H
212CE05NCRW1	CORE AND CHARACTERIZE NCRW FY 1991	1, 2, 3	
212CE06NCRW2	CHARACTERIZE REMAINING CORES NCRW	2, 3, 4	
212CE07PFP1	CORE AND CHARACTERIZE PFP FY 1992	2, 3	
212CE07PFP2	CHARACTERIZE REMAINING CORES PFP	2, 3, 4	
212CE01CC1	CORE AND CHARACTERIZE CC FY 1991	1, 2, 3	
212CE02CC2	CHARACTERIZE REMAINING CORES CC	2, 3, 4	
212CE09DSS1	CHARACTERIZE GROUT FEED DSS/DSSF	4	
		6 INADEQUATE ANALYTICAL CAPABILITIES	G

Table 4-4. Retrieval - Activities and Uncertainties. (sheet 1 of 2)

ACTIVITY NUMBER	ACTIVITY DESCRIPTION	UNCERTAINTY	REFERENCE
213A	NCAW RETRIEVAL SYSTEM PROCESS TEST	1 TIMELY ACQUISITION OF PERMITS FOR INSTALLATION, OPERATION, AND DISPOSAL	B, D
		2 TANK AND COMPONENT STRUCTURAL INTEGRITY	M
		3 REMOVAL OF EQUIPMENT DUE TO UNKNOWN TANK CONDITIONS AND WASTE CLASSIFICATION	M, W
		4 INSTALLATION OF EQUIPMENT DUE TO UNKNOWN TANK CONDITIONS	M
		5 HARDWARE DEVELOPMENT FOR MOBILIZATION VERIFICATION	J
		6 TANK COOLING REQUIREMENTS	J
213A1088	NCAW TANK 101-AZ PROCESS TEST	7 PERCENT OF SLUDGE MOBILIZED, GOAL = 90%	J
		8 HIGH STRESS ON IN-TANK COMPONENTS MAY LIMIT PUMP SPEED AND POWER	J
213B	W-148 NCAW 4-PUMP RETRIEVAL MODS	1	
		9 INTERFERENCE FROM 2-PUMP PROCESS TEST OR OTHER TANK FARM PROJECT ACTIVITIES	V
75028	W-028 AGING WASTE TRANSFER LINES	NONE	
75066	W-066 AZ TANK FARM ELECTRICAL UPGRADE	10 APPROVAL OF TANK FARM SAR	C
75106	W-106 TANK WASTE RETRIEVAL AND HANDLING OPERATIONS	NONE	
AZ-102RS05	102-AZ RETRIEVAL SYSTEM	1, 2, 3, 4	
213.F.0024	CC PROCESS TEST WEST AREA	7	
213C	102-AY SOLIDS WASH OR RETRIEVE	1, 2, 11, 12, 13, 14	
213D	NCRW RETRIEVAL PROCESS TEST PREPARATION	1, 2, 11, 12, 13, 14	
213D.0024	NCRW PROCESS TEST	7	
213E	CC EAST RETRIEVAL PROCESS TEST PREPARATIONS	1, 2, 11, 12, 13, 14	
213E.0024	CC PROCESS TEST EAST AREA	7	
213F	CC WEST RETRIEVAL PROCESS TEST PREPARATIONS	1, 2	

Table 4-4. Retrieval - Activities and Uncertainties. (sheet 2 of 2)

ACTIVITY NUMBER	ACTIVITY DESCRIPTION	UNCERTAINTY	REFERENCE
		11 TYPE OF RETRIEVAL EQUIPMENT REQUIRED	J
		12 VENTILATION AND ELECTRICAL SYSTEM CAPABILITIES	N
		13 TANK HEEL COMPATIBILITY WITH FUTURE WASTES	K
		14 TANK SPACE AVAILABILITY FOR TRANSFER	L
AN102RS01A	CC EAST RETRIEVAL SYSTEM	1, 2, 11, 12, 13, 14	
AN102RS01B	CC EAST RETRIEVAL SYSTEM (CONT)	1, 2, 11, 12, 13, 14	
AN103RS01	DSS RETRIEVAL AND TRANSFER	1, 2, 7, 11, 12, 13, 14	
AN101RS03	DSSF RETRIEVAL AND TRANSFER	1, 2, 7, 11, 12, 13, 14	
AW103RS05A	NCRW RETRIEVAL SYSTEM	1, 2, 11, 12, 13, 14	
AW103RS05B	NCRW RETRIEVAL SYSTEM (CONT)	1, 2, 11, 12, 13, 14	
SY101RS09A	CC WEST RETRIEVAL SYSTEM	1, 2, 11, 12, 13, 14	
SY101RS09B	CC WEST RETRIEVAL SYSTEM (CONT)	1, 2, 11, 12, 13, 14	
SY102RS09	PFP RETRIEVAL SYSTEM	1, 2, 11, 12, 13, 14	
215.H.0A	SMALL SCALE NCRW RETRIEVAL SYSTEM	1, 5, 11	
215.H.0B	SMALL SCALE CC SUPERNATE TRANSFER SYSTEM	1, 5, 11	
215.H.0C	SMALL SCALE CC SOLIDS RETRIEVAL SYSTEM	1, 5, 11	
215.H.0E	SMALL SCALE PFP RETRIEVAL SYSTEM	1, 5, 11	

Table 4-5. Pretreatment Technology - Activities and Uncertainties. (sheet 1 of 2)

ACTIVITY NUMBER	ACTIVITY DESCRIPTION	UNCERTAINTY	REFERENCE
214A0	ION EXCHANGE TECHNOLOGY	1 INCOMPLETE FLOWSHEET AS BASIS FOR SAFETY ANALYSIS AND NEED FOR SECOND CYCLE	P
		2 RESIN SELECTION, CS100 vs SRL RESIN	P
		3 RESIN ATTRITION AND REDUCED RESIN CAPACITY	P
		4 SOLID WASTE DISPOSAL AND RELATED COST	W
214A1	TRU MONITOR HOT PROTOTYPE TEST	4	
		5 WESF SAMPLE LOADOUT CAPABILITY	T
		6 ANALYTICAL LABORATORY CAPABILITY	G
		7 ENVIRONMENTAL AND SAFETY DOCUMENTATION REQUIREMENTS	B, D
215A01	TRUEX PROCESS DEVELOPMENT	8 INTERFACIAL CRUD FORMATION	Q
		9 CORROSION OF EXISTING PIPING	Y
		10 LACK OF RELIABLE LABORATORY RESULTS	G
215A021	CC PROCESS DEVELOPMENT, PHASE I	11 PROCESS COMPLEXITY AND POTENTIAL NEED TO RECOVER ^{137}Cs, ^{90}Sr, ^{99}Tc	Q
		12 LACK OF CURRENT CHARACTERIZATION DATA	F
		13 FUNDING	I
215B	W-153 TRUEX PILOT PLANT	14 NEED FOR ADDED NCRW PROCESSING STEPS	Q
		15 DESIGN PARAMETERS AND DISSOLVER SOLUTION FILTERS	Q
		16 COMPLETION OF B PLANT UPGRADES TO SUPPORT PILOT PLANT	S, T
		17 B PLANT SECONDARY CONTAINMENT	B, S
		13	

Table 4-5. Pretreatment Technology - Activities and Uncertainties. (sheet 2 of 2)

ACTIVITY NUMBER	ACTIVITY DESCRIPTION	UNCERTAINTY	REFERENCE
215C0011	TRUEX PILOT PLANT SCALE TEST-NCRW	6, 15	
215C0013	TRUEX PILOT PLANT SCALE TEST-CC SUPERNATE	6, 15	
215C0015	TRUEX PILOT PLANT SCALE TEST-PFP WASTE	6, 15	
215C0017	TRUEX PILOT PLANT SCALE TEST--CC SOLIDS	6, 15	
215C052	FINAL TRUEX FLOWSHEET-NCRW	NONE	
215C0525	FINAL TRUEX FLOWSHEET-CC	NONE	
215C0526	FINAL TRUEX FLOWSHEET-CC DISSOLUTION	NONE	
215C0528	FINAL TRUEX FLOWSHEET-PFP	NONE	
	ENGINEERING EVALUATION OF FLOCC OPTIMIZATION TESTS	NONE	
215E	OXIDATION PILOT PLANT	18 WILL TECHNOLOGY BE SUFFICIENTLY ADVANCED TO SUPPORT PILOT PLANT SCHEDULE	a
215F001471	OXIDATION PILOT PLANT COLD TESTS	18	
215F001473	OXIDATION PILOT PLANT HOT TESTS	18	
215F052850	FINAL FLOWSHEET, CC ORGANIC DESTRUCTION	NONE	
215D0013	PILOT PLANT REDESIGN AND MINOR MODS-CC SUPER	19 SCOPE OF MODIFICATIONS	a
215D0015	PILOT PLANT REDESIGN AND MINOR MODS-PFP SOLIDS	19	
215D0019	PILOT PLANT REDESIGN AND MINOR MODS-CC SOLIDS	19	
21410305	FINAL FLOWSHEET FOR AR VAULT AND B PLANT	NONE	
215A022	CC PROCESS DEVELOPMENT, PHASE 2	11, 12, 13	

Table 4-6. Pretreatment Facilities - Activities and Uncertainties. (sheet 1 of 4)

ACTIVITY NUMBER	ACTIVITY DESCRIPTION	UNCERTAINTY	REFERENCE
137200	W-095 TRUEX PROCESS INSTALLATION	1 CORROSION DUE TO HFL	Y
		2 WHAT HAPPENS IF RELATED PROJECT(S) ARE NOT AUTHORIZED?	T
		3 CAN TRUEX EQUIPMENT BE INSTALLED DURING NCAW PRETREATMENT?	V
1372001	W-095 TRUEX PROCESS INSTALLATION (CONT)	1	Y
137300	PFP PROCESS MODIFICATIONS	4 SCOPE OF MODIFICATIONS UNDEFINED DUE TO LACK OF CHARACTERIZATION DATA, LAB (CORROSION) STUDIES	F
1373001	PFP PROCESS MODIFICATIONS (CONT) AND STARTUP	4	
137400	W-096 CC/OXIDATION PROCESS MODIFICATIONS	5 SCOPE OF MODIFICATIONS UNDEFINED DUE TO LACK OF LAB STUDIES, ACID SIDE CESIUM REMOVAL PROCESS, ORGANIC DESTRUCTION PROCESS DEVELOPMENT, AND B PLANT SPACE LIMITATIONS	Q
1374001	W-096 CC/OXIDATION PROCESS MODIFICATIONS (CONT)	5	
133200	CLEAN WATER ACT, BCE	NONE	
133201	CLEAN WATER ACT, BCP	NONE	
133202	CLEAN WATER ACT, BCS	NONE	
133203	CLEAN WATER ACT, CBC	NONE	
133300	CLEAN WATER ACT, PROJECT W-107	NONE	
133310	CLEAN WATER ACT, PROJECT W-098	NONE	
133320	CLEAN WATER ACT, NCAW PROCESSING	NONE	
133901	INTERIM STATUS ACTION ITEMS	NONE	
24422800	AR VAULT ENVIRONMENTAL PERMITTING	6 ABILITY TO MEET TSDF REQUIREMENTS	A
244235	AR VAULT ENVIRONMENTAL ANALYSIS	6	
24424	AR VAULT TANK INTEGRITY ASSESSMENT	6	
244253	AR VAULT SEISMIC ANALYSIS	6	
1339000	B PLANT PART B PERMIT	6	
1339000	B PLANT PART B PERMIT (CONT.)	7 ADEQUACY OF B PLANT SECONDARY CONTAINMENT	A
		8 EVALUATION OF RISKS ASSOCIATED WITH NONRADIOACTIVE HAZARDOUS WASTE NEEDS TO BE PERFORMED	A
1310	COMPLETE SYSTEMS OPERABILITY TESTING, B PLANT	9 TIME REQUIRED TO TEST ALL SYSTEMS	S
		10 SCHEDULE IMPACT OF TEST FAILURES	S
		11 ACCURACY OF FACILITY DRAWINGS - CONFIGURATION CONTROL	S

Table 4-6. Pretreatment Facilities - Activities and Uncertainties. (sheet 2 of 4)

ACTIVITY NUMBER	ACTIVITY DESCRIPTION	UNCERTAINTY	REFERENCE
133903	COMPLETE TANK INTEGRITY ASSESSMENT, B PLANT	12 SCOPE OF ASSESSMENT AND FUNDING	I
		13 TANK CONDITION	S
244110	W-110 AR VAULT TRANSFER LINE AND DIESEL FUEL TANK UPGRADES	14 EXTENT OF CONTAMINATION	U
244111	W-111 AR VAULT SEAL POT AND VESSEL VENT UPGRADES	14	
244135	W-135 AR VAULT PROCESS MODIFICATIONS	15 ABILITY TO DESIGN SOLID-LIQUID INTERFACE DETECTION INSTRUMENTATION	Q
		16 ABILITY TO RESTORE TERMINATED SAMPLE LINES	S
244136	W-136 AR VAULT CONTROL ROOM MODIFICATIONS	17 SPACE LIMITATIONS IN EXISTING CONTROL ROOM	S
24430241	AR VAULT CRANE INSPECTION	18 CONDITION OF CRANE	S
2443031	AR VAULT NEW EQUIPMENT	NONE	
132210	COMPLETE B PLANT SAR	19 EXTENT OF ADDITIONAL MODIFICATION THAT MAY BECOME NECESSARY TO GAIN SAR APPROVAL	C
		20 FIRE PROTECTION ANALYSIS MUST CONFIRM DESIGNATION AS "IMPROVED RISK FACILITY"	C
		21 ONCE-THROUGH PROCESS COOLING IN B PLANT WILL NEED TO BE REPLACED WITH CLOSED-LOOP	C
		22 POSSIBLE NEED TO UPGRADE INSTRUMENTATION AND CONTROL SYSTEMS TO 1E	C
		23 HEPA FILTERS LACK CAPABILITY FOR IN-PLACE TESTING OF INDIVIDUAL BANKS	C
2442135	COMPLETE FACILITY DESCRIPTION MANUAL, AR VAULT	NONE	
13233	B PLANT ADMINISTRATIVE MANUAL UPGRADE	NONE	
13243011	B PLANT TRAINING	NONE	
2442356	AR VAULT TRAINING	NONE	
130101	B PLANT READINESS REVIEW WHC/DOE	NONE	
AZ101T10	101-AZ NCAW PRETREATMENT IN AR VAULT AND B PLANT	24 CANYON ACCESS LIMITATIONS	S
AZ102T10	102-AZ NCAW PRETREATMENT IN AR VAULT AND B PLANT	24	
AW103T1	NCRW PRETREATMENT IN B PLANT	24	
		25 WHAT IS THE QUANTITY OF WASTE FOR PRETREATMENT?	Z
AW101T2	PFP PRETREATMENT IN B PLANT	24	

Table 4-6. Pretreatment Facilities - Activities and Uncertainties. (sheet 3 of 4)

ACTIVITY NUMBER	ACTIVITY DESCRIPTION	UNCERTAINTY	REFERENCE
AN102T1	CC PRETREATMENT IN B PLANT	24	
AN106T2	CC PRETREATMENT IN B PLANT (CONT)	24	
24400000	SOLIDS WASHING FOR WFQ IN AR VAULT	26 SOLIDS MAY NOT BE REPRESENTATIVE OF NCAW	AA
24400013	SYSTEM OPERABILITY TESTING, AR VAULT	NONE	
136160	W-160 IN-CELL AND HPT LEAK DETECTION	27 MAY NOT BE FEASIBLE DUE TO ELECTRICAL AND MECHANICAL EQUIPMENT INTERFERENCE. CLEARING DRAINS MAY BE REQUIRED.	S
136230	RADIATION AREA MONITOR	NONE	
136220	CAM UPGRADE	NONE	
136431	B PLANT SEISMIC ANALYSIS	28 EXTENT OF UPGRADES IDENTIFIED BY ANALYSIS	S
136250	B PLANT CANYON EXHAUST FILTER SYSTEM	NONE	
134002	W-002 CANYON CRANE REPLACEMENT	2	
		29 SAFETY CLASS DESIGN ISSUES	D
		30 COST	I
134040	W-040 ION EXCHANGE INSTRUMENTATION UPGRADE	31 ADDED REQUIREMENTS IDENTIFIED BY HAZARDS ANALYSIS OR RESIN STUDIES	D, P
134056	W-056 LLWC AND PHP CONTROL VALVE UPGRADES	32 COMPETITION FOR SPACE AND RESOURCES	V
134059	W-059 CATEGORY I VENTILATION UPGRADE	NONE	
134065	W-065 WH/IX CONTROL VALVE UPGRADE	32	
134077	W-077 CT/CS PROCESS CONTROL VALVE UPGRADE	32	
134103	W-103 ON-DECK SAMPLING UPGRADE	33 UNDEFINED PROJECT SCOPE	S
134159	W-159 CT/CS INSTRUMENTATION UPGRADE	32	
134161	W-161 TRU MONITOR INSTALLATION	34 ABILITY OF MONITOR TO FUNCTION IN A HIGH RADIATION ENVIRONMENT	P
134162	W-162 ION EXCHANGE MECHANICAL EQUIPMENT UPGRADE	35 PSAR MAY REQUIRE SAFETY CLASS EQUIPMENT	C
134163	W-163 CELL DRAIN AND VESSEL VENTILATION INSTRUMENTATION UPGRADE	NONE	
136027	W-027 271B HVAC UPGRADE	NONE	
		36 AVAILABILITY OF ADEQUATELY QUALIFIED SAFETY CLASS POWER	C
136104	W-104 B PLANT OPERATIONS SUPPORT BUILDING	33	
136168	W-168 FILTER SYSTEM TIE-IN	37 FUNDING	
1362501	W-094 291B FILTER INSTRUMENTATION UPGRADE	NONE	

Table 4-6. Pretreatment Facilities - Activities and Uncertainties. (sheet 4 of 4)

ACTIVITY NUMBER	ACTIVITY DESCRIPTION	UNCERTAINTY	REFERENCE
136260	B-625 SAND FILTER VENTILATION DUCT UPGRADE	NONE	
134700	NCAW JUMPER CONSTRUCTION	38 JUMPER FABRICATION RESOURCES, COST, AND SCHEDULE OVERRUNS	X
137128	W-128 B PLANT CELL CLEANOUT AND LINING FOR TRUEX	2, 33	
		39 UNKNOWN DECONTAMINATION AND MANPOWER REQUIREMENTS, POTENTIAL DOSE RATES	S
		40 RESTRICTIONS ON EQUIPMENT BURIAL	W
133003	W-003 CHEMICAL SEWER ENVIRONMENTAL UPGRADES	41 ADDED SCOPE TO MEET REGULATORY REQUIREMENTS	B
133004	W-004 AMU UPGRADE	42 271B BUILDING MAY NOT BE SEISMICALLY QUALIFIED. CONDITION OF STRUCTURAL COMPONENTS.	S
133007	W-007 PROCESS CONDENSATE TREATMENT FACILITY	43 NEED TO INCLUDE TREATMENT FOR ORGANICS	B
133008	W-008 CHEMICAL SEWER NEUTRALIZATION SYSTEM	NONE	
133010	W-010 ENVIRONMENTAL COMPLIANCE UPGRADE	NONE	
133024	W-024 RADIOLOGICAL EFFLUENT CONTAINMENT UPGRADE	44 FEASIBILITY OF LINING CELL DRAIN HEADER	A, S
		45 SPACE LIMITATIONS AND CONDITION OF ELECTRICAL WIRING IN CELL 22	S
133098	W-098 HAZARDOUS WASTE STORAGE FACILITY	NONE	
136102	W-102 GALLERY VENTILATION	33	
133107	W-107 BCS TREATMENT	NONE	
133108	W-108 BSE TREATMENT	33	
2440001	AR VAULT READINESS REVIEW WHC/DOE	NONE	
244207	AR VAULT SAR	19	
244091	AR VAULT COMPRESSOR UPGRADE	NONE	

Table 4-7. Tank Farm - Activities and Uncertainties. (sheet 1 of 2)

ACTIVITY NUMBER	ACTIVITY DESCRIPTION	UNCERTAINTY	REFERENCE
75030	W-030 AZ/AY FARM VENTILATION UPGRADES	1 COMPETITION FOR RESOURCES AND SPACE, CONFLICT WITH OTHER TANK FARM WORK/ACTIVITIES	V
		2 CONDITION OF VENT HEADER MAY EXPAND PROJECT SCOPE	M
75058	W-058 CROSS SITE TRANSFER LINES	3 EXTENT OF CONTAMINATION	U
75062	104-AP GROUT FEED TANK PIPING MODIFICATION	NONE	
75340	104-AP GROUT FEED TANK ELECTRICAL MODIFICATIONS	NONE	
75AN103S1	TANK 103/104/105-AN SAFETY ISSUE RESOLUTION	1	
		4 SAFE ACQUISITION OF CORE SAMPLES AND ANALYSIS DATA	E
		5 UNDEFINED SCOPE AND POTENTIAL IMPACT ON COSTS AND SCHEDULES	E
		6 AVAILABILITY OF REQUIRED TANK SPACE	L
75SY101S1	TANK 101SY SAFETY ISSUE RESOLUTION	1, 4, 5, 6	
75SY10351	TANK 103SY SAFETY ISSUE RESOLUTION	1, 4, 5, 6	
75TF01	TANK FARM CAPITAL UPGRADES	1, 5	
		7 ABILITY OF AGING WASTE FACILTY (AWF) CONFINEMENT SYSTEMS TO SURVIVE DBA	C, E
		8 ADEQUACY OF AWF LIQUID EFFLUENT RETENTION AND MONITORING SYSTEMS	A, O
		9 ADEQUACY OF SUPPORT SYSTEM TRANSFER LINES	A, O
		10 "PITS" NOT ADEQUATE AS CONFINEMENT STRUCTURES	A, O
		11 ABILITY OF AWF PRIMARY VENTILATION TO SURVIVE DBA	C
		12 ADEQUACY OF EMERGENCY POWER SYSTEMS	C
		13 IMPACT OF ELIMINATING AWF LIQUID EFFLUENT DISCHARGES TO SOIL COLUMN	A, O
		14 SAFETY CLASS SYSTEMS NOT SEISMICALLY QUALIFIED	O
		15 ADEQUACY OF AWF FIRE PROTECTION SYSTEMS	C
75TF02	TANK FARM MAJOR MAINTENANCE UPGRADES	1, 5	
		16 ADEQUACY OF HVAC STACK MONITORING SYSTEM	O
		17 IMPACT OF REMEDIATING ASBESTOS USED IN ORIGINAL CONSTRUCTION	O
75TF03	TANK FARM OPERATIONS AND ADMINISTRATION UPGRADES	1, 5	

Table 4-7. Tank Farm - Activities and Uncertainties. (sheet 2 of 2)

ACTIVITY NUMBER	ACTIVITY DESCRIPTION	UNCERTAINTY	REFERENCE
75TF04	TANK FARM DOCUMENTATION UPGRADES	1, 5	
		18 AWF FSAR REVISION INCOMPLETE	C
		19 AWF SEISMIC ANALYSES INCOMPLETE	C
SY101T	AVAILABLE EAST AREA TANK, CC TRANSFER	6	
		20 AVAILABILITY OF TRANSFER LINES AND JUMPERS	N
		21 AVAILABILITY OF ADEQUATE TRAINED STAFF	AO
		22 POSSIBILITY OF "NEW" SAFETY ISSUES	C
SY102T	AVAILABLE EAST AREA TANK, PFP TRANSFER	6, 20, 21, 22	
AZ101T1020	RETRIEVAL/TRANSFER OPERATIONS	6, 20, 21, 22	
AZ102T1001	RETRIEVAL/TRANSFER OPERATIONS	6, 20, 21, 22	
AY101T2015	RETRIEVAL/TRANSFER OPERATIONS	6, 20, 21, 22	
AY102T2015	RETRIEVAL/TRANSFER OPERATIONS	6, 20, 21, 22	
AZ101T2015	RETRIEVAL/TRANSFER OPERATIONS	6, 20, 21, 22	
53G03	RETRIEVAL/TRANSFER OPERATIONS	6, 20, 21, 22	
AN103AW101T	RETRIEVAL/TRANSFER OPERATIONS	6, 20, 21, 22	
AN104AN105T	RETRIEVAL/TRANSFER OPERATIONS	6, 20, 21, 22	

Table 4-8. Grout - Activities and Uncertainties.

ACTIVITY NUMBER	ACTIVITY DESCRIPTION	UNCERTAINTY	REFERENCE
AP000	GROUT FEED SPECIFICATION/OPERATIONS DSS, DSSF	1 DO WASTES IN A GIVEN TANK CONTAIN HAZARDOUS WASTES THAT VIOLATE LAND DISPOSAL RESTRICTIONS?	AK
		2 DO WASTES IN A GIVEN TANK EXCEED RADIONUCLIDE LIMITS?	AL
AP001	GROUT FEED SPECIFICATION/OPERATIONS-NCAW	1, 2	
AP002	GROUT FEED SPECIFICATION/OPERATIONS-NCRW	1, 2	
AP003	GROUT FEED SPECIFICATION/OPERATIONS-PFP	1, 2	
AP004	GROUT FEED SPECIFICATION/OPERATIONS-CC	1, 2	
53G07	GROUT PERFORMANCE ASSESSMENT	2	
52G08	GROUT TREATMENT FACILITY PART B PERMIT	3 RESOLUTION OF OUTSTANDING RCRA PART B ISSUES	A
53G09	GROUT SAFETY ANALYSIS REPORT	4 FUNDING	C, I
		5 TIMING OF FSAR APPROVAL	C
		6 WASTE COMPOSITION CONSISTENT WITH SAR SOURCE TERM	C
		7 ABILITY TO FULLY COMPLY WITH 6430.1A REQUIREMENTS	C
53G02	DEVELOP/VERIFY GROUT FORMULATIONS	8 WASTE COMPOSITION, CHARACTERIZATION DATA	F
		9 DRY MATERIALS SOURCES AND AVAILABILITY	AM
		10 ABILITY TO ACHIEVE APPROPRIATE GROUT FORMULATIONS	AM
53G05	GROUT READINESS REVIEW, TYPE 2	11 IMPACT OF ISSUES IDENTIFIED DURING READINESS REVIEW	AN
53G06	GROUT READINESS REVIEW, TYPE 3	11	
75062	W-062 GROUT FEED TANK PIPING MODIFICATIONS	NONE	
75340	B-340 GROUT FEED TANK ELECTRICAL MODIFICATIONS	NONE	
53G10	GROUT FACILITY MODIFICATIONS AND VAULT CONSTRUCTION	4	
53G11	GROUT FILL VAULTS	1, 2	

Table 4-9. Hanford Waste Vitrification Plant - Activities and Uncertainties. (sheet 1 of 2)

ACTIVITY NUMBER	ACTIVITY DESCRIPTION	UNCERTAINTY	REFERENCE
4122320	FEED PROCESSING DEVELOPMENT	1 IS THE ASSUMED FEED COMPOSITION SUFFICIENTLY ACCURATE?	P
4122310	WASTE FORM DEVELOPMENT	2 WILL CANISTERS MEET REPOSITORY/WFQ REQUIREMENTS?	AA
417500102	PREPARE FINAL WASTE COMPLIANCE PLAN	3 CAN AN ACCEPTABLE WASTE COMPLIANCE PLAN BE PRODUCED?	AA
		4 ACCEPTABILITY OF BOROSILICATE GLASS AS A WASTE FORM	AH
4123210	ANALYZE AND INTEGRATE TECHNOLOGY	5 WILL UNANTICIPATED RESULTS FROM BENCH SCALE TESTING IMPACT HWVP STARTUP?	P
4121	INPUT COMPOSITION REQUIREMENT NCAW FRIT	6 CAN ACCEPTABLE FRIT COMPOSITIONS BE IDENTIFIED BASED ON EXPECTED HWVP FEED COMPOSITIONS?	P
4122340	TRANSFER TECHNOLOGY TO DESIGN	7 TIMELY SOLUTION TO NOBLE METALS PROBLEM	AB, AC
		8 HYDROGEN GENERATION DURING FORMATE REACTION	AF
4121020	DESIGN/CONSTRUCTION EXCHANGE	9 DESIGN PROBLEMS IDENTIFIED IN DWPF STARTUP AND OPERATIONS	AC
4110110	DESIGN SUFFICIENT TO START CONSTRUCTION	10 CAN FAST TRACK CONSTRUCTION BE USED ON HWVP?	AD
4113104	COMPLETE HWVP DESIGN	11 COMPLETION OF DETAILED DESIGN WELL IN ADVANCE OF OPERATIONS MAY PRECLUDE USE OF EMERGING TECHNOLOGY.	AD
41MD015	DOE-RL PSAR APPROVAL	12 WILL PSAR BE ACCEPTABLE TO DOE-HQ?	C
41MD0469	ECOLOGY ISSUE RCRA PART B/CAA PERMITS	13 WILL PERMITS BE ISSUED IN TIME TO START CONSTRUCTION?	A
41MD0004	DOE-HQ DECISION TO START CONSTRUCTION	14 WILL DOCUMENTATION AND FUNDING BE IN PLACE?	A, I
413333	WHC INSPECT AND ACCEPT CONSTRUCTION	15 WILL CONSTRUCTION CONFORM TO ALL PLANS AND SPECIFICATIONS?	AD
41W1	PROCURE EQUIPMENT	16 WILL LONG-LEAD-TIME EQUIPMENT PROCUREMENT MEET CONSTRUCTION SCHEDULE?	AD
4100013	PERFORM CONSTRUCTION/ATP/CAT	17 DOES THE CONSTRUCTION SCHEDULE ALLOW SUFFICIENT TIME TO ACHIEVE QUALITY IN CONSTRUCTION OR TIME TO CORRECT DEFICIENCIES IDENTIFIED DURING ATP/CAT?	AD
4133070	PERFORM PREOPERATIONAL TESTS	18 HWVP MAY NOT FUNCTION AS DESIGNED	AD
		19 CONSTRUCTION MAY DELAY SYSTEM TURNOVER FOR TESTING	AD
41DD1	RECEIVE ACCEPTABLE FRIT FOR TESTING	20 ADEQUACY OF FRIT BASED ON ESTIMATED FEED COMPOSITIONS	AA
41DD2	RECEIVE ACCEPTABLE FRIT FOR HOT STARTUP	20	
41I11	PERFORM COLD TEST ORR	21 DOES THE CONSTRUCTION SCHEDULE ALLOW SUFFICIENT TIME FOR COLD TEST ORR?	AD
41MW053	PERFORM OPERATIONAL TESTING	22 WILL HWVP OPERATE TO DESIGN CAPACITY?	AE
4122530	PERFORM WFQ TESTING	2, 4	
4125110	ISSUE/APPROVE WQR	4	
		23 WILL HWVP BE ALLOWED TO START HOT OPERATIONS?	AA

Table 4-9. Hanford Waste Vitrification Plant - Activities and Uncertainties. (sheet 2 of 2)

ACTIVITY NUMBER	ACTIVITY DESCRIPTION	UNCERTAINTY	REFERENCE
41MD0531	ISSUE REVISED RCRA PART B PERMIT	24 ECOLOGY APPROVAL TO PERFORM OPERATIONAL TESTING	A
41MD057	ISSUE/APPROVE FSAR	25 WILL THE FSAR BE APPROVED?	C
41MW0050	DOE-RL HOT OPERATION READINESS REVIEW	26 DOE-RL APPROVAL TO START HOT OPERATIONS	AD
41MW0053	INITIATE HWVP HOT OPERATIONS	NONE	
AY102T20	CHARACTERIZE TANK 102-AY AND PROCURE FRIT	20	
		27 WHAT HAPPENS IF FEED IS OUT OF SPECIFICATION?	AI
AY102T21	TRANSFER AND VITRIFY 102-AY NCAW SOLIDS	22	
		28 WHAT HAPPENS IF GLASS IS OUT OF SPECIFICATION?	AJ
AZ101T20	CHARACTERIZE TANK 101-AZ AND PROCURE FRIT	20, 27	
AZ101T21	TRANSFER AND VITRIFY 101-AZ NCAW SOLIDS	22, 28	
		29 WHAT IS THE QUANTITY OF WASTE FOR VITRIFICATION?	Z
		30 WILL PUREX PROCESS N REACTOR FUEL	Z
41001	INPUT COMPOSITION REQUIREMENT FOR FRIT PROCUREMENT-NCRW	6	
41002	INPUT COMPOSITION REQUIREMENT FOR FRIT PROCUREMENT-PFP WASTE	6	
41003	INPUT COMPOSITION REQUIREMENT FOR FRIT PROCUREMENT-CC WASTE	6	
AN101T20	NCRW FRIT PROCUREMENT	20, 27	
AW103T2	PFP FRIT PROCUREMENT	20, 27	
AW101T24	CC FRIT PROCUREMENT	20, 27	
MELTER 1	REPLACE MELTER, TEST, AND STARTUP	31 SCOPE AND DURATION OF MELTER REPLACEMENT	AG
		32 MELTER DISPOSAL REQUIREMENTS	AG
MELTER 2	REPLACE MELTER, TEST, AND STARTUP	31, 32	
41000030	COMPLETE POST-NCAW PROCESS DEVELOPMENT	33 CAN HWVP BE MODIFIED TO PROCESS NCRW, PFP, AND CC WASTES?	AE
AN101T21	NCRW OPERATIONS-HWVP	28, 29, 30, 33	
AW101T25	CC OPERATIONS-HWVP	28, 33	
AW103T20	PFP OPERATIONS-HWVP	28, 33	
41F1	INPUT DESIGN POST NCAW FEED SPECIFICATIONS	34 IS THE ASSUMED FEED COMPOSITION SUFFICIENTLY ACCURATE?	Q

Table 4-10. Summary List of Reference Uncertainties.
(sheet 1 of 2)

No.	Title
A	Acquisition of RCRA Part B Permits
B	Acquisition of Other Facility or Project Environmental Permits (CAA, CWA, etc.)
C	Approval of Safety Analysis Reports (PSAR and SAR)
D	Preparation and Approval of Other Safety Documentation
E	Resolution of Tank Farm Safety Issues
F	Availability of Adequate Characterization Data
G	Adequacy of Sampling and/or Laboratory Resources
H	Analytical Methods Development
I	Funding
J	Retrieval Technology Development
K	Need to Retrieve and/or Pretreat Tank Heels
L	DST Space Availability
M	Structural Integrity of DSTs and Internal Components
N	Tank Farm Upgrades to Support Retrieval
O	Tank Farm Compliance Upgrades
P	NCAW Pretreatment Process Development
Q	Post-NCAW Pretreatment Process Development
R	WESF Sample Loadout Capability
S	Acceptability of B Plant and AR Vault
T	Impact of Multitude of B Plant Projects
U	Extent of Contamination
V	Competition for Resources and Lay-down Space; Construction Area Congestion
W	Solid Waste Disposal
X	Jumper Fabrication Resources
Y	Corrosion of Equipment and Pipes due to HFL
Z	Volume of Waste for Pretreatment and Vitrification
AA	Waste Form Qualification and Acceptance
AB	Melter Design for Noble Metals
AC	DWPF Lessons Learned, to be Learned
AD	HWVP Schedule Adequacy, Design through ORR and Startup
AE	HWVP Capability to Operate as Designed
AF	Hydrogen Generation during Formating Process

Table 4-10. Summary List of Reference Uncertainties. (sheet 2 of 2)

No.	Title
AG	Melter Replacement Activity Scope and Duration
AH	Acceptability of Borosilicate Glass as Waste Form
AI	What Happens if HWVP Feed is Out of Specification?
AJ	What Happens if HWVP Glass is Out of Specification?
AK	Impact of Land Disposal Restrictions on Grout Operations
AL	Potential Requirement to Reduce Radionuclides in Grout
AM	Dry Materials Availability for Grout Operations
AN	Grout Operational Readiness Review
AO	Availability of Qualified Staff

CAA = Clean Air Act
CWA = Clean Water Act
DST = Double-shell tank
DWPF = Defense Waste Processing Facility
HWVP = Hanford Waste Vitrification Plant
NCAW = Neutralized current acid waste
ORR = Operational readiness review
PSAR = Preliminary safety analysis report
RCRA = Resource Conservation and Recovery Act
SAR = Safety analysis report
WESF = Waste Encapsulation and Storage Facility

4.5 RISK ANALYSIS MODELING

This section provides an overview of the DST Vitrification Program risk analysis process and results. A more detailed discussion of the risk analysis is contained in the SAIC report included in WHC-EP-0427 (Miller et al. 1991).

4.5.1 Summary of Activities

The SAIC, in conjunction with Westinghouse Hanford, evaluated the impact of identified uncertainties to the Hanford Waste Vitrification Program (Program). This section is a description of SAIC's application of standard risk management techniques as they were implemented for the DST Vitrification Program.

The following methodology was followed in performing the risk analysis.

- The SAIC conducted a software review to select the most appropriate techniques and computer software. The risk analysis technique of probabilistic network analysis was selected and the software package VERT was selected as the network analysis tool.

- In conjunction with the Westinghouse Hanford DST Working Group, a DST Vitrification Program model network was defined and the required data were collected. The data were entered into the VERT program files.
- The DST Vitrification Program model logics were verified and the data were validated.
- The DST Vitrification Program model was run and the output data were analyzed to develop various types of results including critical paths, overall time to completion, total costs, and critical activities lists. Based on the preliminary DST model results, some program changes were evaluated to aid the DST Working Group in developing mitigating strategies for high-risk activities.
- Finally, conclusions and recommendations were developed.

4.5.2 The Double-Shell Tank Risk Analysis Model

The DST Vitrification Program model portrays all activities associated with the disposal of waste currently in the DSTs and anticipated from future PUREX operations and saltwell pumping of SSTs. This includes construction or modification of facilities to handle DST waste and the operation of all necessary facilities for processing the waste. The time frame spans from the beginning of FY 1991 (October 1, 1990) through the completion of the DST Vitrification Program excluding final disposal of the vitrified waste to a geologic repository.

The components of the DST model are the network diagrams and the VERT computer model. These are discussed further in the following paragraphs.

4.5.2.1 Double-Shell Tank Network Diagrams. Network diagrams are used to visually illustrate sequential (predecessor and successor) and logical relationships between activities. The network diagrams and relationships were developed from the top-level schedule as discussed in Section 4.1 (see Figures 4-4 and 4-5 in pouches located at the back of this document).

Two network diagrams were used to illustrate all program activities. The first includes the preparation for, and processing of, NCAW. The second diagram illustrates the activities associated with preparations for, and processing of, the NCRW, and PFP and CC wastes. The two diagrams maintain consistency with the top-level schedule developed by the DST Working Group. Copies of the network diagrams are included as Figures 4-7 and 4-8 in pouches located at the back of this document. The initial node on each diagram is the state of the program on October 1, 1990.

The terminal nodes on the two diagrams are different. The NCAW terminal node represents the end of NCAW activities and the completion of NCAW processing. This includes grout and vitrification activities associated with NCAW. The terminal node on the post-NCAW network diagram represents the end of processing of all the remaining DST waste types.

The two networks have four activities in common: the grouting operations for the low-level fraction of NCAW, melter replacement after vitrification of NCAW, and two precedence activities. The first precedence activity requires that AR Vault and B Plant facilities be available to process NCRW. The second requires that grouting operations make tank space available for PFP and CC waste transfers from the 200 West Area to the 200 East Area.

4.5.2.2 The Computer Model. The VERT is a management tool used to model program cost, schedule, and performance risk. The VERT is a computer-supported, network modeling and simulation technique, similar in concept to the Program Evaluation and Review Technique, but with greater modeling and analysis capabilities. Since its development in 1973, VERT has been employed on numerous projects throughout the U.S. Department of Defense.

A VERT network consists of arcs and nodes. The arcs are used to depict activities or to convey status from one point in the network to another. Nodes represent decision logic rules that direct flow through the network. Decision logics within a node may evaluate the status of incoming activities and/or may determine the method for executing outgoing activities.

Once an accurate network has been developed, it is input to a computerized model, which simulates the program. The simulation is a Monte Carlo-based iterative process; that is, the VERT program simulates the actual program a number of times. On each iteration of the simulation, cost, time, and performance data for each activity are generated randomly based on the user-provided distributions. Activity cost, time, and performance data are then aggregated into total project cost, time, and performance values for that iteration. At the conclusion of the simulation, these data are transformed into summary statistics and histograms for time, cost, and performance measures for the program. Additional data on internal activities of the network, such as individual activity start and completion dates and completion costs, may also be generated.

4.5.2.3 Verification and Validation. Because the use of the VERT software in the Risk Assessment risk analysis is the first known use of this software within the DOE complex, appropriate verification/validation steps were considered essential. The VERT model was tested to validate the results produced by the program, i.e., to ensure that reasonable, reproducible results were produced. These tests included (1) a manual calculation check, (2) a baseline verification run, and (3) a management review of the program logic network and model input data. For additional discussion of the model verification and validation, refer to WHC-EP-0427, *Hanford Waste Vitrification Systems Risk Assessment - Final Report Supporting Information* (Miller et al. 1991).

The manual calculation check involved manually calculating the overall network probabilities of success for a demonstration network and comparing that result to the one produced by VERT for the same network. In the baseline verification run, the DST Vitrification Program schedule baseline time frames were input into the VERT model and the resulting model run program duration results were compared to the program baseline schedule. Both tests produced positive results.

The final check conducted was a management review of both the model network diagram as final verification that the depicted logical relationships were appropriate and that the model input probability, cost, and schedule data provided by Westinghouse Hanford and PNL were reasonable. Inconsistencies identified in these reviews were addressed and corrected.

4.5.3 Risk Analysis Modeling Results

A summary of the analysis results produced by the VERT model of the DST Waste Vitrification Program is presented in this section. For a more detailed explanation of the VERT software, the modeling process, and the results, refer to WHC-EP-0427 (Miller et al. 1991).

4.5.3.1 Program Completion Schedule Risks. The VERT software produces probabilistic assessments of the schedule duration and cost total for the program or project being analyzed. In the case of the Vitrification Program, these risks were measured as probabilistic deviations from the FY 1991 budget Case 2 used as the baseline. The mean values of the VERT estimated DST Waste Vitrification Program cost and schedule are presented in Figures 4-9 and 4-10.

The model estimates that the DST Vitrification Program completion date could potentially slip about 7 yr to 2016, if actions are not undertaken to reduce the program uncertainties quantified by this Risk Assessment and discussed in Section 4.3.

This estimated schedule increase is the result of the aggregation of individual activity schedule ranges which, for the most part, had pessimistic and most likely values that were longer than the baseline values. Generally, the Risk Assessment Team and its direct management assessed the baseline durations as optimistic estimates for the activities. Additionally, the difference between the pessimistic and most likely durations were frequently greater than the difference between the most likely and optimistic durations. In this case, the Monte Carlo analysis technique used by the VERT software tends to produce a mean value for an activity duration somewhat longer than the most likely duration input value.

The probabilistic program completion time distribution profile is shown in Figure 4-9. This figure shows the cumulative probability of program completion by the indicated date. The completion dates depicted include the vitrification of all DST wastes but not the grouting of the low-level fractions of these wastes. The information is depicted based on fiscal years rather than calendar years.

The results show that without implementation of mitigating actions, the DST activities:

- Have minimal probability of being completed before the year 2014 (a very optimistic estimate of completion if mitigating actions are not undertaken)

- Have a 100 percent probability of being completed in the year 2019 (a pessimistic date for completion)

Figure 4-9. Program Completion Time.

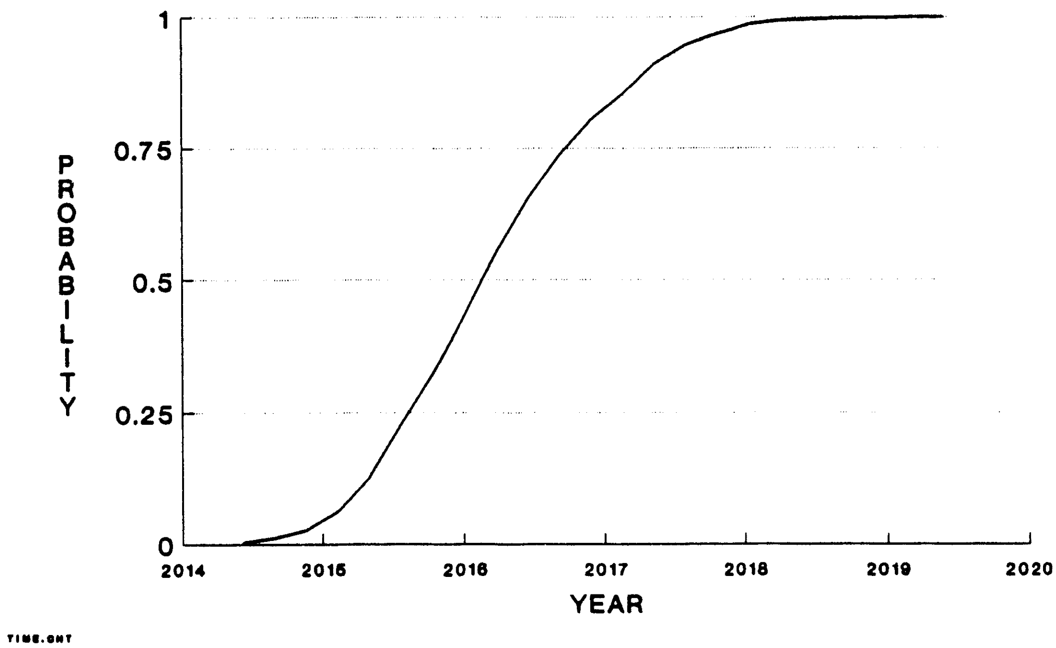
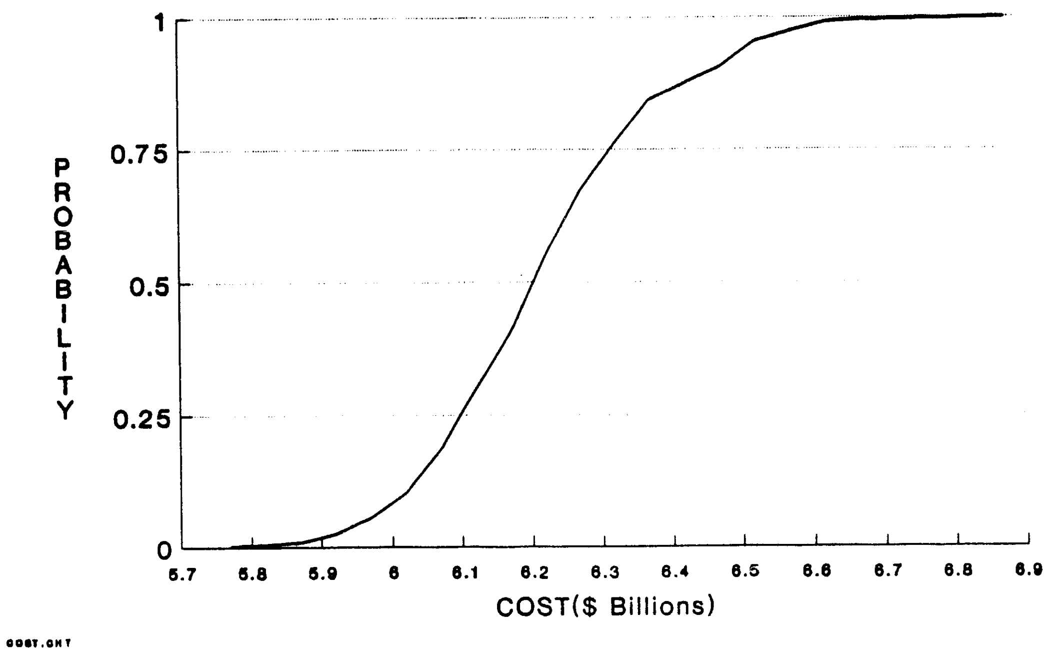


Figure 4-10. Overall Cost for Completion of the Double-Shell Tank Waste Disposal Program.



- Have a 50 percent probability of being completed on or before February 2016 (considered to be the most likely time of completion without mitigation).

A discussion of the program elements that are the major contributors to the potential for schedule slippage is provided in Section 4.5.3.3.

In addition to analyzing the program completion schedule, the model was used to evaluate a selected group of intermediate program milestones. These included the start and completion dates for B Plant, HWVP, and GTF operations for each of the four DST waste types that require vitrification. The results of these analyses are presented in Table 4-11.

4.5.3.2 Program Completion Cost Risks.* A potential cost increase of $2.1 billion in 1991 dollars was estimated for the DST Waste Vitrification Program. This figure was derived through comparison of baseline model verification runs with fully distributed model runs. A baseline cost analysis run of the model produced a cost of $4.2 billion in 1991 dollars. The fully distributed model run, which includes all cost and schedule range data developed by the program experts, produced a cost of $6.3 billion.

The above cost and risk figures should be considered within the context of the methodology that produced the actual input costs. No budget baselines exist beyond 5 yr. The risk analysis that produced the potential cost overrun estimate quoted earlier was based on order-of-magnitude cost estimates for activities beyond 1996, i.e., for more than two-thirds of the total program duration. Other than costs for the HWVP, for which formal estimated cost

Table 4-11. Potential Processing Start and Complete Dates by Waste Type Without Mitigation.

		Pretreatment - B Plant operations		HWVP operations		GTF operations	
		Start	Complete	Start	Complete	Start	Complete
NCAW	Baseline	1997.3	1999.8	2000.3	2002.2	2000.7	2001.8
	Model	2001.2	2003.8	2004.4	2006.8	2003.8	2008.2
NCRW	Baseline	2001.0	2002.9	2004.4	2005.5	2003.0	2005.0
	Model	2006.2	2008.2	2009.7	2011.2	2008.2	2009.6
PFP	Baseline	2003.3	2004.4	2005.9	2006.2	2005.3	2006.4
	Model	2008.5	2009.6	2011.2	2011.6	2009.6	2012.7
CC	Baseline	2004.7	2007.5	2007.2	2009.3	2006.6	2009.5
	Model	2010.0	2015.5	2013.0	2016.5	2012.7	2016.5

NOTE: Dates shown are fiscal year dates, i.e., 2005.5 is March 31, 2005.

CC = Complexant concentrate
GTF = Grout Treatment Facility
HWVP = Hanford Waste Vitrification Plant
NCAW = Neutralized current acid waste
NCRW = Neutralized cladding removal waste
PFP = Plutonium Finishing Plant

*All cost figures are in constant FY 1991 dollars.

documentation exists, the costs are rough-order-of-magnitude values. No attempt should be made to construe the costs in this Risk Assessment as true estimates of the total Vitrification Program. Rather, cost estimates quoted here should be considered as indications of relative costs for comparative purposes only.

Roughly $3/4 to 1 billion* of this potential $2 billion cost increase is the result of the 7-yr schedule extension risk identified in Section 4.5.3.1, i.e., increased overhead cost durations and creation of operating facility downtimes. The remaining $1 billion to 1¼ billion dollar increase is the result of uncertainties in the costs of individual program activities.

Figure 4-10 depicts the estimated cost to complete the DST Waste Vitrification Program as a function of probability. This figure shows the cumulative probability of completion at or below the indicated cost. The completion costs depicted in Figure 4-10 include both the vitrification and grouting of all DST wastes.

These results indicate that without implementation of mitigating actions.

- The total cost will be greater than $5.7 billion.*
- The total cost will not exceed $6.9 billion.*
- There is a 50 percent probability that the cost will be less than $6.3 billion.*

The model accounts for direct costs of performing the included activities. Facility standby time costs, or costs associated with idle time at facilities waiting for operations to begin, are also included. The facilities addressed include those for vitrification, pretreatment, and grout.

<u>Cost Distribution and Spending Growth Analysis</u>--Analysis of the annual distribution of these costs shown in Figure 4-11 identified the following concerns.

The first is the significant near-term growth in program spending required to support the DST program. The current annual program costs are on the order of $100 million excluding Tank Farm costs. A series of cost distribution analyses (shown in Figure 4-11) developed from the distributed run of the program model show annual expenditures in the $500 plus million/yr range, including Tank Farm costs. The substantial increase in annual program costs represented by these figures may be difficult to support due to pressures to reduce government deficits. Future analysis of the program spending profile is warranted after the program redefinition changes are identified. This analysis may provide early identification of unsupportable levels of program activity that can be either expediting or deferring the selected work scope from critical years.

4.5.3.3 Program Critical Path Analyses. The VERT program has the capability of estimating the probability that an activity will fall on the program

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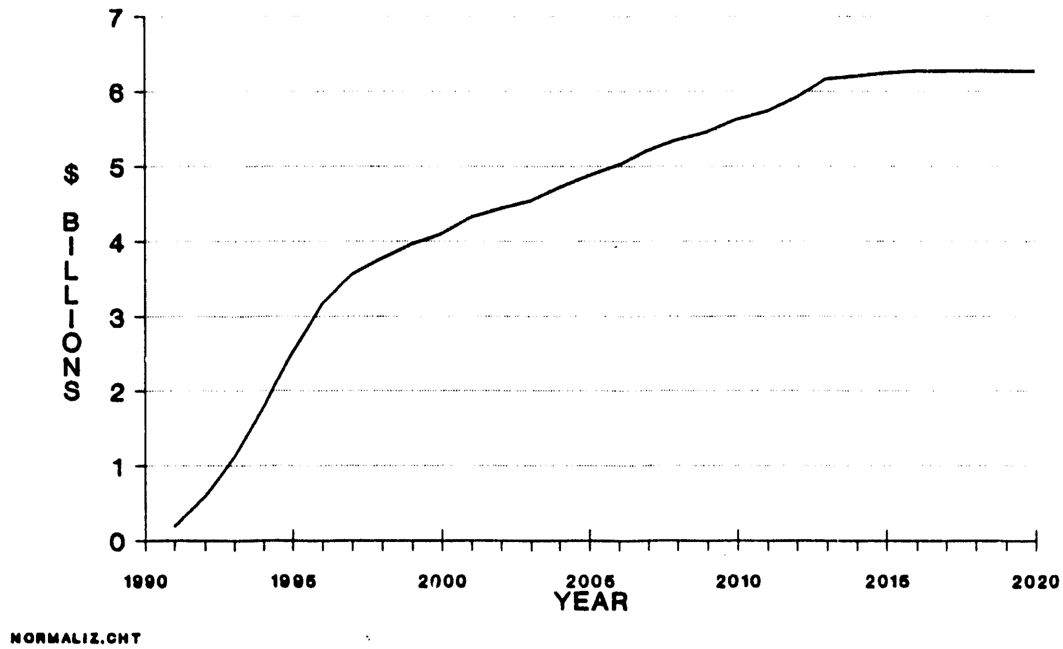
*All cost figures are in constant FY 1991 dollars.

Figure 4-11. Average Costs Normally Distributed During Duration of Activity.



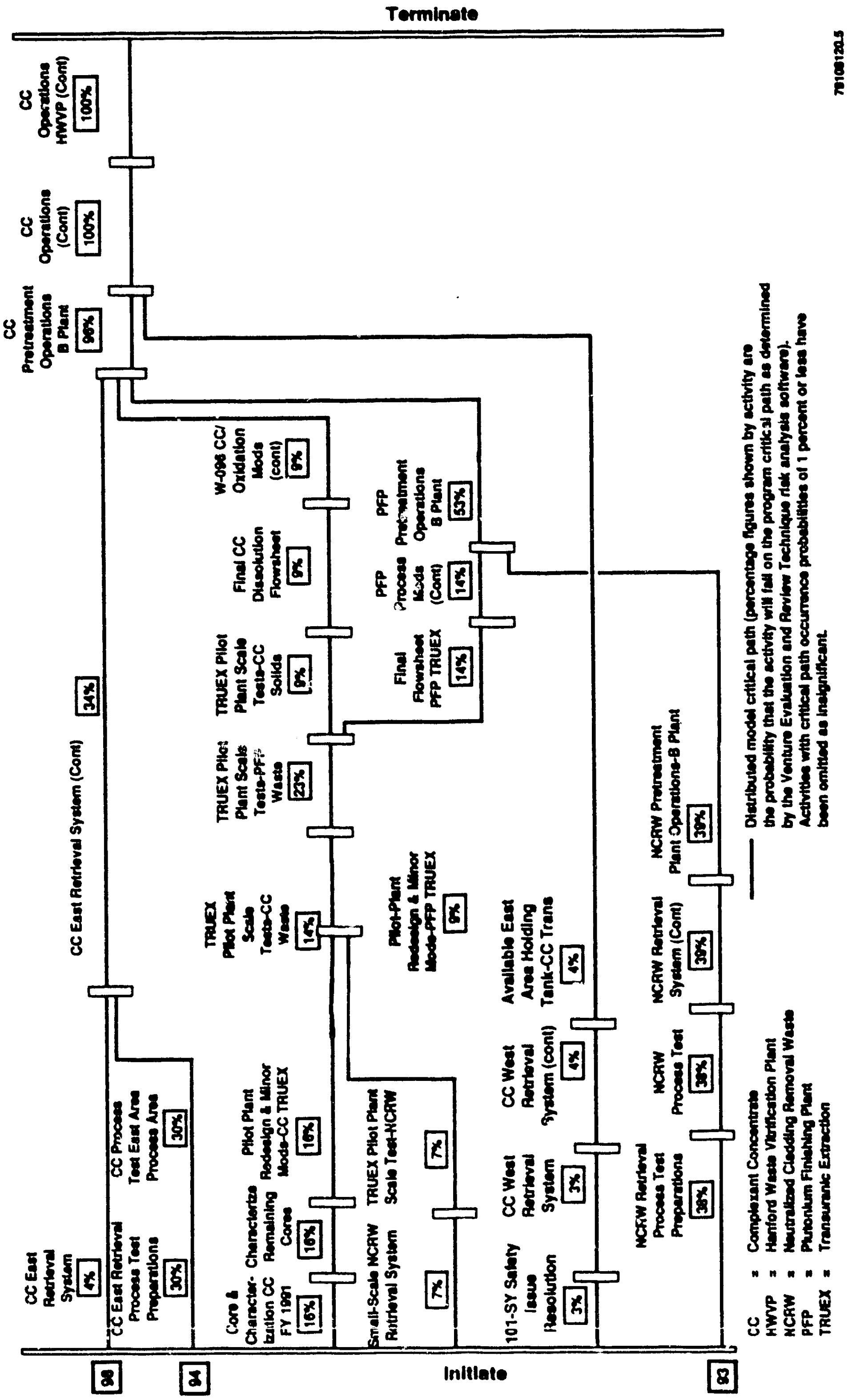
critical path. The results of the critical path analysis of the DST Vitrification Program are shown in Figure 4-12. The results show the primary program schedule critical path passing through tank retrieval activities and the post-NCAW pretreatment options. Activity "lag links," e.g., LAG602, used in the VERT model to maintain appropriate activity precedence relationships, have been omitted from this figure, if trivial. Non-trivial lag links have been retained to clarify activity flow logic.

The percentage figures shown for each of the activities in Figure 4-12 represent the percentage of the time that the VERT model determined that the critical path passed through that activity. The schedule values of the final model network elements for grout operations have been suppressed (i.e., set equal to zero), to determine the critical path for the vitrification program. Special-case critical paths (baseline case and cases for estimates of only optimistic, most likely, and pessimistic durations) are depicted in Appendix A.

An analysis of the critical path shown in Figure 4-12 indicates the following.

- There are two main areas of the network through which the critical path may pass.

Figure 4-12. Distributed Model Critical Path.



- The critical path at the beginning of the program will most likely be made up of retrieval activities. The probability that this will occur is 76 percent.
- There is a 24 percent probability that activities leading to TRUEX pilot-plant redesign and modification will be on the critical path at the beginning of the program.
- The critical path passes through post-NCAW pretreatment activities with a 40 to 100 percent probability depending on the waste type.

4.5.4 Estimates of Probability of Success

Estimates of probability of success were developed for each activity using a set of descriptive statements and related percentages as shown in Table 4-1. As noted earlier, the probabilities were assigned to each statement based on the judgment of the Risk Assessment management team. The percentages are therefore subjective, yet consistent, relative measures of uncertainty for each individual activity.

The probabilities of success were accumulated for related activities to ascertain the relative probabilities of success for major program activities. Figure 4-13 shows the distribution of the relative probabilities of success by major activity for each waste type. The probability values shown in the boxes with the activities titles are the relative, incremental probability of success for that activity.

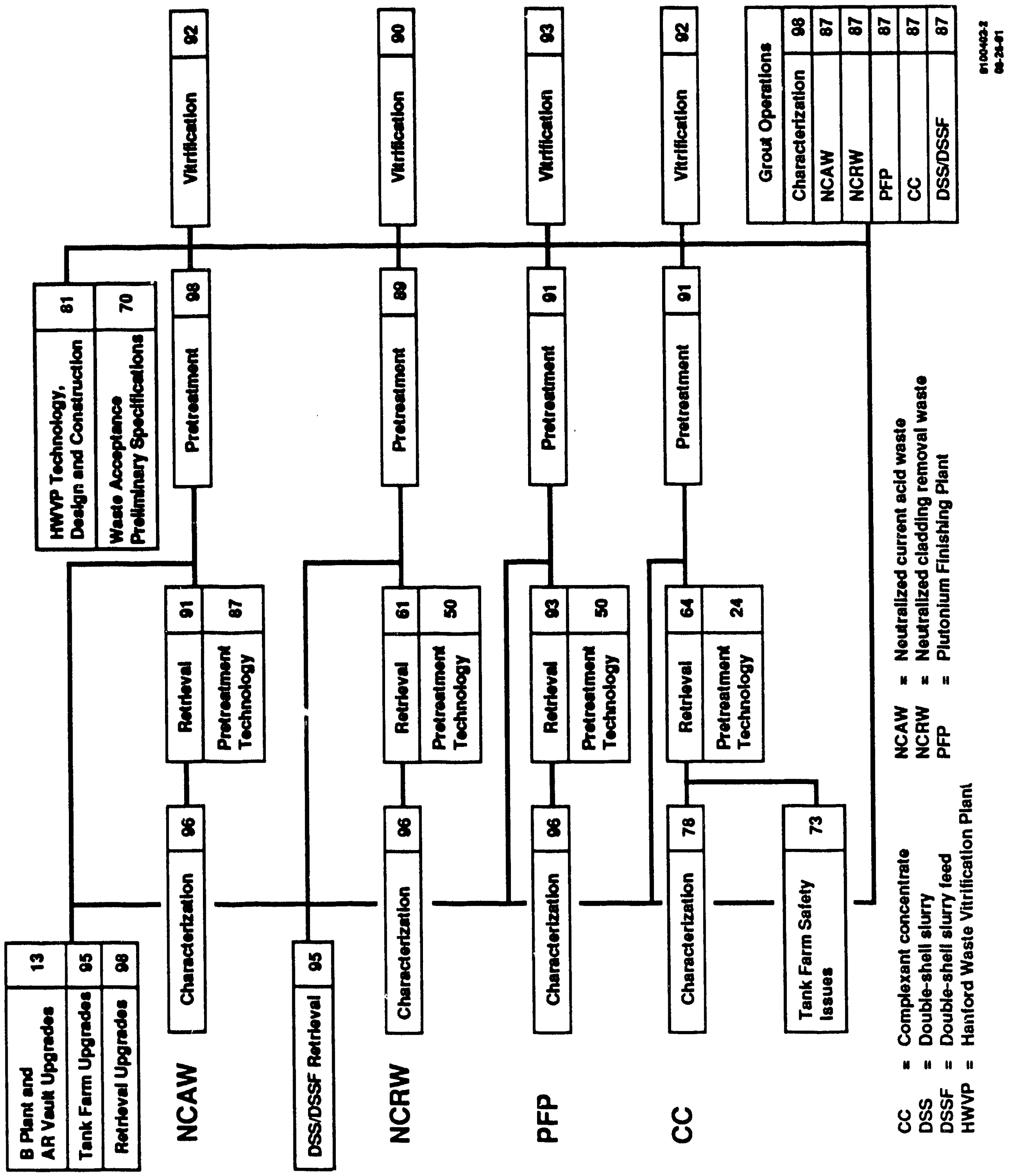
Figure 4-13 identifies the major activities of the baseline program with the most uncertainty. However, caution must be exercised in interpreting these results as "absolute" measures of success. There is no known method to accurately assign "true" probabilities of success to the varied activities, both present and future, that must be performed to complete the program. Therefore, the value of this figure is in comparing one major activity against another, but not in comparing against an absolute measure such as 100 percent probability of success.

Furthermore, these estimates take no credit for future actions that will improve the probability of success, including the following:

- Management actions to correct problems encountered during the execution of the program plan
- Improvements in probabilities due to the completion of supporting development activities
- Additional knowledge and experience gained in developing processes for and processing operations of each subsequent waste type.

Even though the probabilities of success are relative values, the cumulative uncertainties identify several major activities which may require reevaluation. Near-term activities with a relatively low probability of success should receive immediate attention.

Figure 4-13. Relative Probabilities of Success (%) for Major Double-Shell Tank Program Activities by Waste Type.



4.5.4.1 Ranking of Program Risks. The program risks resulting from uncertainties impacting the cost, schedule, and/or probability of success of each of the program activities were developed by the Risk Assessment. These cost, schedule, and probability risks were then aggregated to produce an integrated activity program risk using a relative risk factor (RRF) calculation. The RRF calculation (see Appendix A) relates the risks introduced by cost, schedule, and probability of success uncertainties by establishing index values for cost, schedule, and probability impacts. The RRF calculation also sums the values from each of these elements to produce an integrated RRF value by which the activities were then ranked. A summary of the relative risk represented by the seven major activities (characterization, grout, pretreatment facilities, etc.), is presented in Table 4-12. The table presents the major activities in descending order of total program risk. It also documents the schedule, cost, and probability of success RRFs contributing to the total risk for each major activity. These summary RRF values are relative and should not be construed as absolute values for the activity risks. Table A-5 provides a complete listing of ranked activities used to develop Table 4-12. Separate listings ranking activities by the cost, schedule, and probability of success RRFs are provided in Appendix A. These lists were used as input in developing Section 4.6.

An RRF analysis was also performed on the activities leading to the hot startup of HWVP. This analysis uses the same data as the above analysis but substitutes the HWVP hot startup critical path for that used in the above analysis. A summary of the relative risks represented by the seven major activities is presented in Table 4-13. As in Table 4-12, the major activity risks are presented in descending order and the schedule, cost, and probability of success values for each are documented. Table A-6 provides a listing of the ranked risks used to develop Table 4-13.

4.5.5 Hanford Waste Vitrification Plant Startup Analyses

Because of the importance of the hot startup of the HWVP facility, a subset of the DST model was created to analyze that portion of the DST Program leading up to the initiation of vitrification of NCAW. This HWVP startup model did not include any activities that were solely involved in follow-on waste processing. For example, retrieval activities required to transfer waste from the first NCAW tank are included, but subsequent NCAW, NCRW, and PFP and CC waste retrieval activities are not. The intent of the HWVP startup model analysis was to focus on those requirements involved in preparing for vitrification of NCAW.

Additional discussion of this special analysis is provided in WHC-EP-0427, *Hanford Waste Vitrification Systems Risk Assessment - Final Report Supporting Information* (Miller et al. 1991).

4.5.5.1 Hanford Waste Vitrification Plant Startup Timing. The HWVP startup model was stochastically quantified to determine the probability distribution for the time span within which startup would be expected to occur. This distribution was compared with the results from the point value cases (the baseline, and the optimistic, most likely, and pessimistic estimate cases) with the results shown in Figure 4-14.

Table 4-12. Integrated Relative Risk Factor Summary.

Activity	Schedule	Cost	Success	Total
Waste retrieval	9.5	1.3	6.1	16.9
Pretreatment facilities	5.0	1.1	9.7	15.8
Pretreatment technology	0.7	0.5	7.0	8.2
Hanford Waste Vitrification Plant	0.4	4.2	3.2	7.8
Tank Farm upgrades	0.5	0.7	1.8	2.9
Waste sampling and characterization	0.9*	0.2	1.7*	2.8*
Grout	0.0	0.1	1.5	1.6**

*Impacts from waste sampling and characterization are reflected in affected activities (e.g., retrieval) and are greater than indicated by the relative risk factor.
**Risk quantification for grout is incomplete because the Risk Assessment did not include a full technical program review.

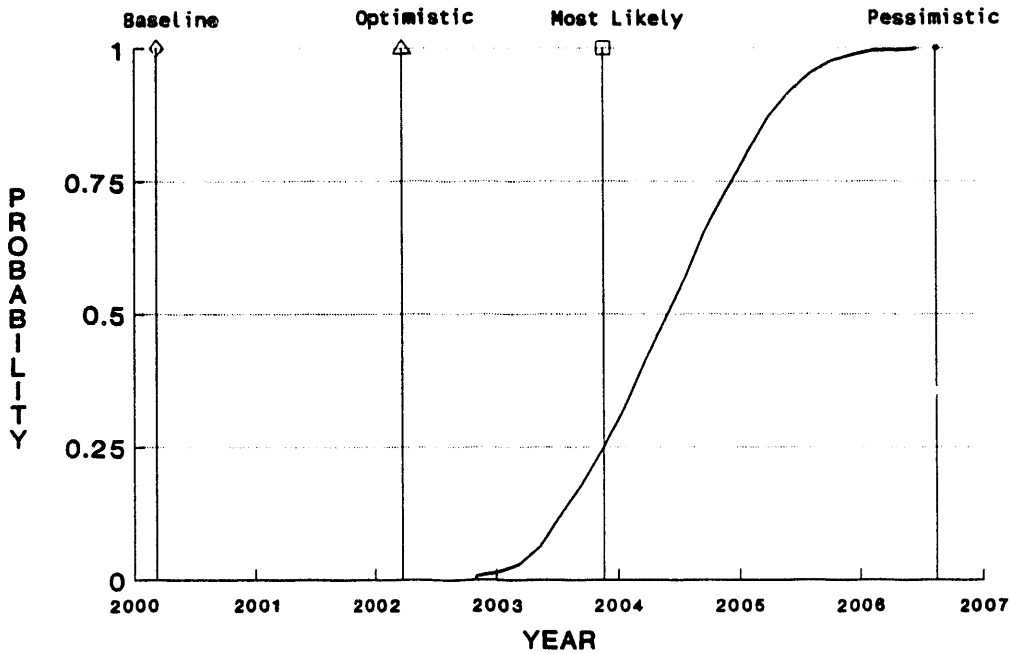
Table 4-13. Hanford Waste Vitrification Plant Startup Relative Risk Factor Summary.

Activity	Schedule	Cost	Success	Total
Waste retrieval	8.6	0.2	2.3	11.1
Pretreatment facilities	0.6	0.8	8.9	10.2
Hanford Waste Vitrification Plant	1.4	2.1	2.6	6.0
Tank Farms	0.0	0.5	0.3	0.8
Pretreatment technology	0.0	0.0	0.6	0.6
Waste sampling and characterization	0.0	0.0	0.2*	0.2*
Grout**	0.0	0.0	0.0	0.0**

*Impacts from waste sampling and characterization are reflected in affected activities (e.g., retrieval) and are greater than indicated by the relative risk factor.
**Grout is not a risk to HWVP startup because it has no interfacing activities with HWVP startup.

From Figure 4-14, the following conclusions are drawn. First, the HWVP startup model predicts a 0.5 probability of startup on or before FY 2004. This represents an increase in duration of 4 yr from the baseline case. The increases in duration are correspondingly smaller for the optimistic estimate only and most likely estimate only cases. The pessimistic estimate only case results in an increase of about 2½ yr beyond the expected value for the distributed case.

Figure 4-14. Cumulative Probability of Hanford Waste Vitrification Plant Startup Initiation Time (Date).



4.5.5.2 Program Costs to Hanford Waste Vitrification Plant Startup. The DST Program costs in unescalated FY 1991 dollars were aggregated for the activities leading up to the hot startup of HWVP. Figure 4-15 provides a graph of the probability of HWVP model cost to startup. For comparison purposes, the point value results for the baseline, and the optimistic, most likely, and pessimistic estimate only cases are also presented.

From inspection of the figure, the following conclusions are drawn. First, projected mean value for the distributed case is about $2.8 billion. This exceeds the baseline case by about $1.1 billion. The optimistic case also exceeds the baseline case by about $0.7 billion. Second, the range of costs projected by the distributed case is about $2.7 billion to $3.0 billion, or about a 10 percent spread. The equivalent spread for the total program was about 18 percent. This difference in relative range of cost reflects greater certainty regarding the initial phase of the program leading up to initiation of vitrification of NCAW and greater uncertainty associated with maintenance of an NCAW feedstock to the HWVP and the subsequent wastes to be retrieved, pretreated, and processed.

4.5.5.3 Hanford Waste Vitrification Plant Startup Critical Path Analysis. Figure 4-16 illustrates the time-based critical path obtained by quantification of the HWVP startup model. The model had a single critical path. The critical elements on the path are all related to obtaining NCAW feedstock for the HWVP. The HWVP startup model does not show either the B Plant modifications or the design and construction of HWVP as critical path items.

Figure 4-15. Cumulative Probability of Hanford Waste Vitrification Plant Startup Initiation Cost.

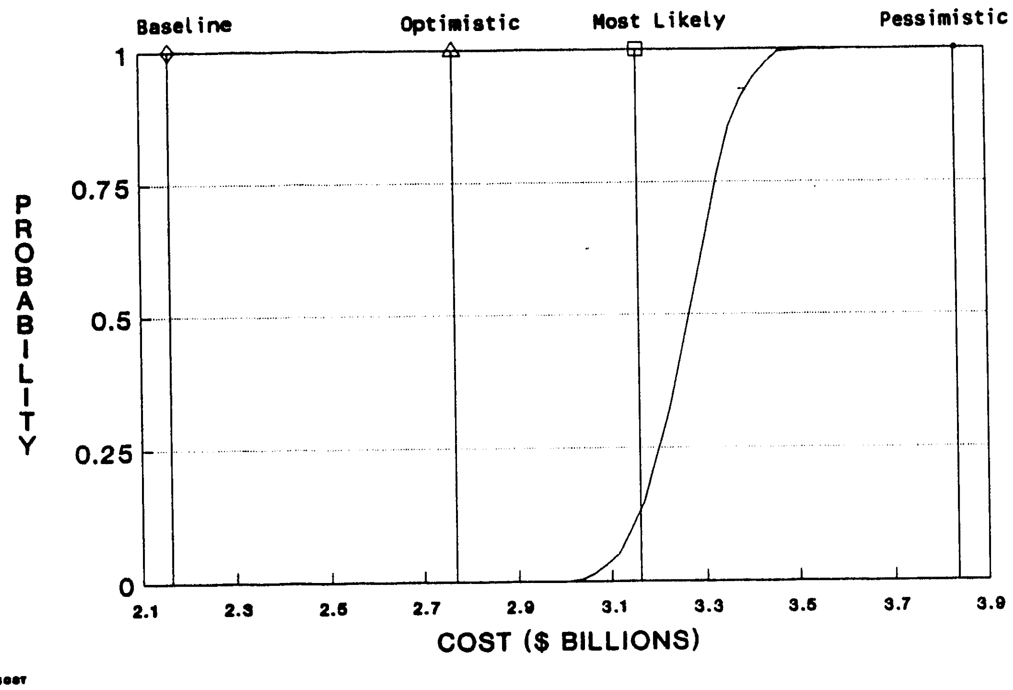
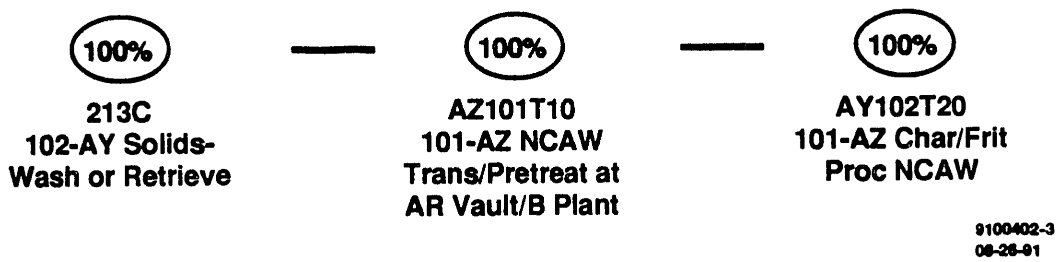


Figure 4-16. Time Critical Path for Hanford Waste Vitrification Plant Startup.



4.5.6 Sensitivity Analyses

4.5.6.1 Overview of Sensitivity Analyses. A powerful application of network modeling is the capability to vary the parameters and assumptions built into the model to test hypothesis and evaluate alternative scenarios. The DST model and the subsidiary model for HWVP startup were utilized to examine a set of general strategies for mitigating those uncertainties having the greatest influence on cost and schedule. Three general strategies were evaluated. Because specific alternatives to some of the present program elements are being developed, only general assumptions could be made regarding activities. The first general strategy was assumed to shorten the durations of selected activities in the DST Program. The second general strategy involved examining a subset of activities with shortened durations for the HWVP startup. A third evaluation looked at the construction time for the HWVP.

Additional discussion of this subject is provided in WHC-EP-0427, *Hanford Waste Vitrification Systems Risk Assessment - Final Report Supporting Information* (Miller et al. 1991).

4.5.6.2 Double-Shell Tank Program Mitigation Analysis. The intent of the mitigation analysis for the DST Program was to examine the effects of shortening the duration of selected activities on the cost and schedule of completing the DST Program. The mean value for the distributed case, as was previously discussed, projects a potential slippage of the program completion date from FY 2009 (top-level schedule) to FY 2016.

Evaluation of the preceding DST model results provided groupings of those activities most affecting the DST Program completion due either to uncertainties associated with durations or delays associated with funding constraints precluding activity initiation. Those groups of activities that potentially could, by mitigation, result in significant reduction in the DST Program schedule, in order of significance, are as follows:

- CC pretreatment operations
- Retrieval operations
- Waste characterization activities
- Pretreatment technology development
- Tank Farms activities
- B Plant and HWVP activities.

New durations were developed for these groups of activities by the DST Working Group. The assumption was made that sufficient resources were to be made available. Table 4-14 lists the input data generated for the DST model. An optimistic, most likely, and pessimistic value was provided for each activity. These values were then used as input data for a series of model simulations.

The results of the runs are given in Table 4-15. The results for the previously discussed distributed case are provided for purposes of comparison.

Table 4-14. Double-Shell Tank Program Group Mitigation Data. (sheet 1 of 2)

Activity group activity	Group mitigation data (duration)		
	O	ML	P
Concentrated complexant pretreatment operat'ons			
AN102T1, CC Pretreatment Opns - B Plant	1.83	1.83	1.83
AN106T2, CC Operations (Continued)	1.09	1.09	1.09
Retrieval Activities			
213A, W-151 101AZ Retr Sys. Proc. Test	4.00	5.50	6.50
213B, W-148 4-Pump Retr Sys. Eng. & Proc.	6.10	6.10	7.10
213C, 102-AY Solids Wash or Retrieve	6.00	7.00	9.00
213D, NCRW Retrieval Process Test Prep	3.50	4.00	6.00
213D0024, CC Process Test West Area	0.60	0.75	2.25
213E, CC East Retr Process Test Prep	Chg to	Start	FY93
213E0024, CC Process Test East Area	0.75	0.75	1.80
213F, CC West Retr Process Test Prep	5.50	6.50	8.50
213F0024, CC Process Test West Area	0.80	1.30	3.30
215H0A, Small-Scale NCRW Retr System	5.10	5.60	7.60
215H0C, Small-Scale CC Solids Retr	7.00	8.00	10.0
215H0E, Small-Scale PFP Solids Retr	5.80	6.80	8.80
AN102RSA, CC East Retr System	3.50	4.20	6.20
AN102RSB, CC East Petr System (Cont)	3.26	3.26	4.30
AN103RSA, NCRW Retr System	3.50	4.00	6.00
AN103RSB, NCRW Retr System (Cont)	3.00	3.25	5.25
SY101RSA, CC West Retr System	3.00	3.57	5.50
SY101RSB, CC West Retr System (Cont)	2.80	3.26	5.30
Waste characterization activities			
212CE01C, Core and Characterization (CC) FY91	0.92	1.42	2.42
212CE02C, Characterize Remaining Cores (CC)	4.50	5.00	6.00
212CE06N, Characterize Remaining Cores (NCRW)	4.59	4.59	5.59
Pretreatment technology - Pilot-plant relative activities			
215C0011, TRUEX Pilot Plant NCRW Scale Test	0.70	0.76	2.00
215C0013, TRUEX Pilot Plant CC Scale Test	0.60	0.75	1.00
215C0015, TRUEX Pilot Plant PFP Scale Test	0.60	0.77	1.00
215D0013, Pilot Plant Redesign and Minor Mods - PFP Solids	0.25	0.25	0.50
215D0015, Pilot Plant Redesign and Minor Mods - CC TRUEX	0.50	0.50	1.00

Table 4-14. Double-Shell Tank Program Group Mitigation Data. (sheet 2 of 2)

Activity group activity	Group mitigation data (duration)		
	O	ML	P
Tank Farm Activities			
75TF04, Tank Farm Documentation Upgrades	5.00	6.00	8.00
75TF01, Tank Farm Capital Upgrades	5.00	6.00	8.00
75TF02, Tank Farm Major Maint Upgrades	4.00	5.00	7.00
75TF03, Tank Farm Opns and Admin Upgrades	4.00	5.00	7.00
75030, 3-030 DST Vent Upgrades	2.75	3.08	5.08
75SY101S, 101SY Safety Issue Resolution	2.00	3.00	6.00
75SY103S, 103SY Safety Issue Resolution	1.00	1.50	6.00
HWVP and B Plant Activities			
134161, W-161 TRU Monitor	2.81	2.81	4.81
134700, NCAW Jumper Const	3.76	3.76	5.67
412231A, Waste Form Development	6.00	6.00	7.00
1373001, PFP Process Mods (Cont)	3.17	3.82	5.00

O = Optimistic ML = Most likely P = Pessimistic

CC = Complexant concentrate
DST = Double-shell tank
FY = Fiscal year
NCAW = Neutralized current acid waste
NCRW = Neutralized cladding removal waste
PFP = Plutonium Finishing Plant
TRUEX = Transuranic extraction

Table 4-15. Double-Shell Tank Program Group Mitigation Results.

Model run description	Program completion date	Cost ($billions)
Fully distributed run	February 2016	6.26
CC pretreatment operations mitigated	August 2014	6.08
Retrieval activities mitigated	August 2013	5.98
Characterization activities mitigated	July 2012	5.82
Pretreatment technology (pilot plant) activities mitigated	May 2012	5.78
Tank Farm activities mitigated	March 2012	5.72
HWVP and B Plant activities mitigated	February 2012	5.72
Optimistic case	February 2011	5.12

CC = Complexant concentrate
HWVP = Hanford Waste Vitrification Plant

For each group of activities mitigated, a resultant schedule and cost reduction is listed. If all groups of activities are mitigated, a schedule reduction of about 4 yr is projected. An associated cost reduction of almost $1 billion is projected. However, the input cost data were not altered to reflect the costs, if any, of mitigation. When such cost adjustments become possible as a result of the current DST Program redefinition effort, inclusion of costs of mitigation would permit trade-off analyses. One valuable result would be the capability to evaluate incremental increases in funding for specific activities against the resultant reductions, if any, in DST Program cost due to reduction in program duration. Another valuable result would be the capability to simulate the DST Program with a number of alternate strategies built-in to the model. This would provide a means of comparing the relative impacts of the alternatives in terms of program cost, program duration, and likelihood of program success.

4.5.6.3 Hanford Waste Vitrification Plant Startup Mitigation Analysis. Activity groupings and reduced activity durations were also developed as input for the HWVP startup model. The revised activity duration data are presented in Table 4-16. As discussed previously, a mean value of FY 2004 was projected for the HWVP startup. This is compared to the mitigation run results in Table 4-17. Mitigation of retrieval activities provides the maximum projected benefit. The projected incremental benefits from subsequently mitigating Tank Farm activities and then, in addition, HWVP and B Plant, are small.

Table 4-16. Hanford Waste Vitrification Plant Startup Mitigation Data.

Activity group activity	Group mitigation data (duration)		
	O	ML	P
Retrieval Activities			
213A, W-151 101AZ Retr Sys Proc. Test	4.00	5.50	6.50
213B, W-148 4-Pump Retr Sys Eng & Proc	6.10	6.10	7.10
213C, 102-AY Solids Wash or Retr	6.00	7.00	9.00
Tank Farm Activities			
75TF04, Tank Farm Documentation Upgrades	5.00	6.00	8.00
75TF01, Tank Farm Capital Upgrades	5.00	6.00	8.00
75TF02, Tank Farm Major Maint Upgrades	4.00	5.00	7.00
751F03, Tank Farm Opns and Admin Upgrades	4.00	5.00	7.00
75030, 3-030 DST Vent Upgrades	2.75	3.08	5.08
HWVP and B Plant Activities			
134161, W-161 TRU Monitor	2.81	2.81	4.81
134700, NCAW Jumper Const	3.76	3.76	5.67
412231A, Waste Form Development	6.00	6.00	7.00

O = Optimistic ML = Most likely P = Pessimistic

DST = Double-shell tank
HWVP = Hanford Waste Vitrification Plant
NCAW = Neutralized current acid waste
TRU = Transuranic extraction

Table 4-17. Hanford Waste Vitrification Plant Startup Mitigation Results.

Model run description	Program completion date	Cost ($ billions)
Fully distributed run	March 2004	3.26
Retrieval activities mitigated	April 2002	3.14
Tank Farm activities mitigated	January 2002	3.08
HWVP and B Plant activities mitigated	December 2001	3.07
Baseline	December 1999	2.13

HWVP = Hanford Waste Vitrification Plant

Again, for comparison purposes, the DST Program base case value is provided. As was mentioned earlier, no incremental cost was included for mitigating the groups of activities.

4.6 SIGNIFICANT RISKS AND MITIGATING STRATEGIES

The following activities or groups of activities represent areas of significant risk to the DSTWD program. These results reflect the findings from the computer modelling, as well as the judgments of the Risk Assessment Team. The activities are listed from highest to lowest risk based on the RRF developed in Section 4.5.

4.6.1 Retrieval

Relative Risk Factor: 16.9

Potential Program Impact: Delay in program completion.

Key Uncertainties: Development and implementation of waste retrieval systems consistently fall on the critical path schedule. The substantial variation in physical properties of the four waste types and lack of detailed characterization data on these physical properties; the uncertain condition of tank components; extensive equipment removal, and replacement in retrieval tanks; time required for laboratory development work; competition for construction resources and lay-down space; and questions regarding mixer pump effectiveness all add to the potential delay of retrieval activities.

Mitigating Strategies:

- Expedite funding and resources for retrieval activities necessary to support the startup of HWVP.
- Expedite activities required to support retrieval process testing. Of particular importance is the timely acquisition of permits for installation, operation, and disposal of required equipment, assessment of in-tank component conditions, and waste characterization.
- Reassess constraints to the retrieval system design to identify those that might be eliminated.
- Revise the program approach and/or priorities such that retrieval is removed from the program critical path for follow-on waste types after the initial feed to HWVP.

4.6.2 Pretreatment Facilities

Relative Risk Factor: 15.8

Potential Program Impact: The currently defined program does not succeed, resulting in need for new facility with substantial schedule delay and cost increase.

Key Uncertainties:

- The B Plant may not comply with current DOE Orders and environmental requirements, including, but not limited to, those associated with double containment. Compliance has not been demonstrated to the satisfaction of the DOE or regulatory authorities and will not be finalized until Ecology approves the RCRA Part B permit.
- The B Plant may not accommodate TRUEX and oxidation process equipment with sufficient capacity to ensure that post-NCAW can be processed at a rate that will support program schedule milestones.
- The cost and schedule impacts from disposal of large amounts of radioactive solid waste (i.e., old or replaced equipment) from B Plant could be substantial.
- Required studies must be completed to demonstrate compliance with DOE Orders and regulatory requirements. These studies (for example, a B Plant structural and emergency power requirements analysis, closed-loop cooling, etc.) may result in the need for additional, currently undefined, modifications of B Plant.

- The B Plant piping may not be compatible with corrosive solutions generated during pretreatment with the TRUEX process, requiring embedded pipe replacement.

Mitigating Strategies:

- Expedite DOE and Ecology review and determination on a study to demonstrate B Plant compliance with "double-containment" requirements.
- Expedite studies and activities needed to update the B Plant SAR and obtain required permits.
- Modify B Plant as necessary to comply with current regulatory requirements, based on the results of B Plant compliance reviews.
- Develop pretreatment options that do not require the use of B Plant or AR Vault as a fall-back position.
- Evaluate modification or replacement of selected B Plant piping with corrosion-resistant material.
- Investigate methods of avoiding the generation of corrosive solutions during pretreatment operations.
- Expedite the development of disposal/burial plans for radioactive solid waste (old equipment) generated by B Plant upgrades and modification.

4.6.3 Pretreatment Process Technology Development

Relative Risk Factor: 8.2

Potential Program Impacts: Delay in program completion.

Key Uncertainties:

- Acid dissolution and TRUEX process have only been demonstrated in laboratory-scale tests. Scaling to pilot- or full-scale could result in changes in the design and delays in implementing the processes.
- Organic destruction process development is in its infancy; process and facility requirements are not well defined.
- There is a lack of waste characterization data.
- The schedule for implementing TRUEX in B Plant may be overly optimistic.
- Processing rates for CC wastes may be substantially longer than previously assumed.

Mitigating Strategies:

- Develop a contingency plan for pretreatment processes that includes the following:
  - Alternate approaches to test the TRUEX process
  - Investigation of alternate, full-back techniques for TRUEX
  - Beginning development of alternate processes.
- Reassess the schedule for the TRUEX pilot plant based on the results of the contingency plan for development of pretreatment processes.
- Investigate permitting issues relating to installation of the TRUEX pilot plant in the WESF and selected B Plant processing cells.
- Reexaminate CC waste processing rates and process requirements to minimize the schedule duration for pretreating this waste.

4.6.4 Hanford Waste Vitrification Plant

Relative Risk Factor: 7.8

Potential Program Impact: Delay in program completion. Increased program cost. Failure of the HWVP to achieve hot operations by December 1999.

Key Uncertainties:

- Continuity of feed to HWVP
- Construction, cost, and schedule concerns associated with a large nuclear facility
- Timely resolution of startup and operations' problems identified by DWPF, such as hydrogen generation in the waste feed formating process
- Timely identification of feed composition for the post-NCAWs
- Timely identification of repository and waste form acceptance requirements
- Timely identification of solid waste handling requirements
- Lack of acceptance of the supplemental environmental analysis for the facility.

Mitigating Strategies:

- Evaluate alternate wastes that require only simple pretreatment processes, such as sludge washing and ion exchange, to minimize HWVP downtime caused by lack of feed.
- Place an increased emphasis on obtaining an approved WAPS for HWVP.
- Accelerate activities required to support current HWVP design, construction, and hot operations' schedules.
- Delay HWVP design, construction, and hot operation.

4.6.5 Tank Farm Upgrades and Resolution of Tank Safety Issues

Relative Risk Factor: 2.9

Potential Program Impacts:

- Delay of sampling and characterization activities
- Delay of retrieval activities
- Potential lack of required tank space.

Key Uncertainties:

- Flammable gas generation in the DSTs
- Ability to resolve safety-related material and design deficiencies
- Availability of resources for timely completion of required upgrades
- Adequacy of current Tank Farm systems and components to support the program without upgrade
- Conflicts with other Tank Farm activities
- Additional modifications that may be required to comply with as yet unidentified requirements (undefined scope).

Mitigating Strategies:

- Expeditiously resolve tank safety issues. Coordinate issue resolution with plans to retrieve and pretreat the wastes.
- Accelerate currently defined tank sampling and characterization activities.

- Develop a detailed integrated Tank Farm and DST processing schedule that identifies all significant interfaces.
- Proceed with construction of new tanks.
- Accelerate implementation of a Tank Farm upgrade program plan.

4.6.6 Waste Sampling and Characterization

Relative Risk Factor: 2.8

NOTE: The method used to quantify risks understates the magnitude of the risk related to characterization. The impacts of delays in sampling and analysis and the resultant uncertainties in the treatment process designs due to waste compositional uncertainties are measured mostly with the affected activities, such as retrieval, and not as a risk to characterization.

Potential Program Impact: Delay in program completion.

Key Uncertainties:

- Uncertain waste compositional variability for post-NCAWs
- Availability of adequate sampling and laboratory resources
- Timely resolution of tank safety issues
- Competing priorities for sampling.

Mitigating Strategies:

- Establish estimates of the waste composition variability for each waste type using process flowsheets and existing sample data. Correlate process and sample data to establish a range of variability.
- Review each of the process designs for retrieval, pretreatment, and vitrification against the waste composition uncertainties to revise sampling needs and update process design requirements.
- Provide funding and resources required to ensure rapid resolution of tank safety issues, such as flammable gas generation.
- Complete the efforts to prioritize sampling and analysis of all Hanford Site tank wastes.
- Assess analytical needs and construct new capabilities at the Hanford Site, or pursue the use of alternate analytical facilities. This may be a possible target for privatization.

- Add additional sampling capability, specifically, accelerate acquisition of a third sample truck (currently not planned until FY 1994).

- Consider buying an entire spare truck. Experience has shown high failure rates for sampling equipment. Therefore, adequate spare parts and a trained maintenance staff must be available to support an aggressive sample schedule.

- Develop more effective designs for weather screens and provide additional weather screens to allow sampling during inclement weather.

4.6.7 Grout

Relative Risk Factor: 1.6

Potential Program Impact: Delay in grout activities and the possible need to pretreat selected tanks may result in a lack of required tank space and subsequent delay of the program.

Key Uncertainties:

- Lack of waste characterization data

- Establishment of a grout formulation that meets performance requirements with acceptably low heat of hydration

- Structural and leachability performance of the asphalt concrete diffusion barrier added to the vault

- Timely completion of grout-supporting activities (FSAR and environmental permits)

- The need to pretreat DSS and DSSF so that hazardous wastes do not violate land disposal restrictions

- Acceptance of the performance assessment

- Results of a petition by Washington and Oregon States to the NRC that would require tank wastes to be treated to remove the largest technically achievable amount of radioactivity before grouting.

Mitigating Strategies:

- Accelerate resolution of issues related to grout formulation and performance assessment.

- Accelerate waste characterization.

- Pretreat DSS and DSSF tanks.

- Lower waste loading in grout vaults (at the expense of additional vaults).
- Build additional DSTs.

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5.0 SINGLE-SHELL TANK PROGRAM ASSESSMENT

The final disposal of the Hanford Site double-shell tank (DST) and single-shell tank (SST) waste and the ultimate closure of the single-shell Tank Farms was addressed in DOE/EIS-0113, *Final Environmental Impact Statement: Disposal of Hanford Defense High-Level, Transuranic, and Tank Wastes, Hanford Site, Richland, Washington* (HDW-EIS) (DOE 1987), and the resulting Record of Decision (ROD) (DOE 1988). The ROD identified vitrification and grout as the preferred alternatives for the DST waste but recommended continued storage of the SST waste until additional development and evaluation associated with the SSTs can be performed as follows.

- Radioactive and hazardous waste constituents will be characterized.
- Barrier performance will be demonstrated by both instrumented field tests and modeling.
- The need and methods to improve the stability of the waste form will be determined, and destruction or stabilization alternatives for hazardous constituents will be evaluated.
- Methods for retrieving, processing, and disposing of this waste will be evaluated.

It was further stated in the ROD that the development and evaluation activities are to be completed before development of a supplemental environmental impact statement (SEIS), which will determine the preferred alternative for final disposition of the SST systems. Furthermore, the ROD states that the Hanford Waste Vitrification Plant (HWVP), in addition to vitrifying the DST waste, will be designed with sufficient flexibility to accommodate all SST waste should the decision be made to recover this waste. Thus, the purpose of the SST assessment, as part of the Risk Assessment, is to review candidate HWVP processing scenarios for the SST wastes and identify any significant uncertainties that could impact the HWVP design or schedule if the decision is made to use HWVP for vitrification of the SST wastes.

5.1 METHODOLOGY

The objective of the SST assessment for this Risk Assessment was to identify any significant uncertainties in the HWVP design or schedule that could potentially limit the ability of the HWVP to vitrify a portion, or all, of the SST wastes should this decision be made.

The approach taken in this assessment is outlined below.

1. A reference schedule that considers the availability of the HWVP and closure of the SSTs within the schedule defined in the *Hanford Federal Facility Agreement and Consent Order* (also known as the Tri-Party Agreement) (Ecology 1990) was established for processing the SST wastes in the HWVP.

2. Three SST waste retrieval scenarios and two pretreatment scenarios were evaluated to define bounding cases in terms of the waste volumes and waste compositions to be vitrified from the SST wastes.

3. Key technical issues associated with the potential vitrification of the SST wastes were identified and evaluated. These technical issues were identified based on chemical and radiochemical differences between the DST and SST wastes.

Existing information and studies have been used to the extent possible to complete this assessment. A significant amount of information has been obtained from analyses for the closure of the SSTs.

5.2 MAJOR ACTIVITY ASSESSMENT

5.2.1 Process Bases for Assessment

The process bases for the SST risk assessment considered three tank retrieval cases and two waste pretreatment approaches to establish bounding cases for HWVP processing and remediation of the SSTs. The three tank retrieval cases considered the retrieval of 22, 75, and 149 tanks. The two cases for pretreatment of the SST wastes included a sludge-wash only process (referred to as sludge wash) and a solids dissolution and transuranic extraction (TRUEX) process (referred to as TRUEX). Table 5-1 summarizes the bounding cases evaluated in terms of number of SSTs retrieved, estimated number of glass canisters to be produced in the HWVP, and estimated HWVP vitrification campaign length. Figure 5-1 summarizes the major process steps involved in pretreating the SST wastes in the sludge wash and TRUEX processing options.

The sludge wash and TRUEX options selected for the purpose of this study provide bounding cases in terms of the number of glass canisters produced. The sludge-wash pretreatment process involves dissolution of the water-soluble chemical and radiochemical components from the waste. Radionuclides present in the wash solutions, principally ^{137}Cs, ^{99}Tc, and soluble ^{90}Sr and plutonium, are removed in sorption processes. The wash solution is solidified, after treatment, as a low-level waste (LLW). The TRUEX pretreatment process involves the same initial sludge-washing processes. In addition, the water-insoluble sludge is dissolved in acid, and the ^{90}Sr, ^{137}Cs, plutonium, and uranium are then removed from the dissolver solution. This approach results in a minimum of solids being transferred to the HWVP and will therefore result in a minimum number of canisters being produced. The LLW streams produced from these two pretreatment cases will have similar radiochemical inventories.

The HWVP Project feed compositions from the sludge wash and TRUEX process flowsheets for the three SST retrieval cases are summarized in Table 5-2. This table compares (for the major chemical components) the major differences between the current HWVP feed specification limit and the estimated HWVP feed composition resulting from the specified SST waste pretreatment scenarios.

Table 5-1. Bounding Cases for Single-Shell Tank Waste Retrieval and Vitrification in the Hanford Waste Vitrification Plant.

Single-shell tanks retrieved	Percent single-shell tank transuranic inventory	Volume of retrieved waste[a] in m^3 (Mgal)	Number of glass canisters produced	Years of HWVP operation
22	75	3,800 (10)	10,000[b] 2,000[c]	30 6
75	95	9,100 (24)	20,000[b] 5,000[c]	60 15
149	100	1,400,000 (37)	34,000[b] 10,000[c]	100 30

[a]Volume of waste currently stored in single-shell tanks.
[b]Sludge waste pretreatment.
[c]Transuranic extraction waste pretreatment.

HWVP = Hanford Waste Vitrification Plant

5.2.2 Definition of Reference Schedule

The development of the options to complete the remediation of the SSTs is being studied by Westinghouse Hanford Company (Westinghouse Hanford). The SST closure options will be evaluated and a preferred approach identified in an SEIS. For the purpose of this Risk Assessment, a reference schedule that incorporated two major assumptions was developed.

1. The closure of the SSTs will be completed within the schedule established by the Tri-Party Agreement.

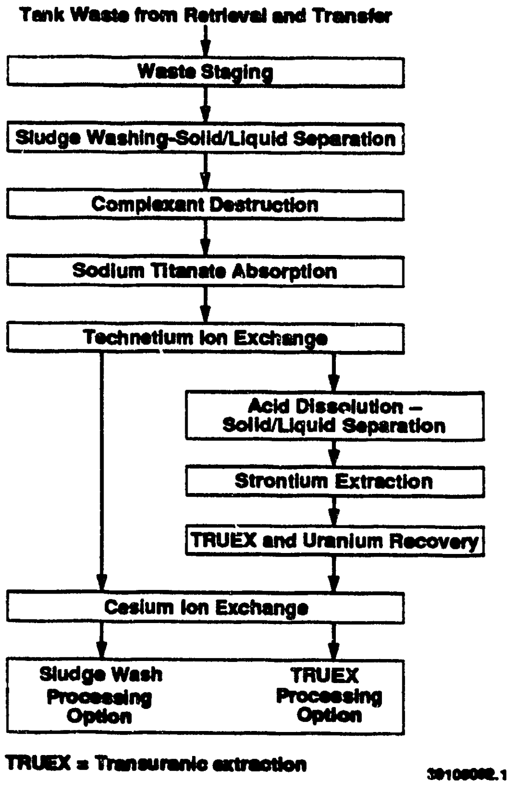
2. The range of process options, selected for vitrification of the SST wastes, will correspond to the bounding process bases established by an SST systems engineering study and listed in Figure 5-1.

The Risk Assessment reference schedule for remediation of the SSTs is shown in Figure 5-2. This schedule was developed for the Risk Assessment and does not necessarily represent the baseline SST remediation schedule. The schedule demonstrates an approach to integrate the DST and SST remediation schedules and assumes the following.

1. The initiation of the SEIS for the SSTs begins in 1991 and proceeds in parallel with SST waste characterization activities. Complete characterization of each of the 149 tanks is not required for completion of the SEIS. An approach will be developed in the EIS to determine the specific remedial action for each of the 149 tanks based on its radiochemical and hazardous material content.

2. The SEIS and closure plan for the SST will be completed before the design of the retrieval and pretreatment facilities needed for the remediation of the SSTs. Retrieval and pretreatment of at least 22 SSTs is assumed. Approval of the closure plan is not required to initiate retrieval operations.

Figure 5-1. Pretreatment Process Options for Single-Shell Tank Waste Processing.



3. Permitting actions by the Washington State Department of Ecology (Ecology), in compliance with the *Resource Conservation and Recovery Act of 1976* (RCRA), can be completed in parallel with the design of facilities needed for retrieval and pretreatment as is the approach used for the HWVP Project.

4. Construction of retrieval and pretreatment facilities can begin with issuance of the RCRA permit.

The reference schedule also ensures the completion of key Tri-Party Agreement milestones associated with the remediation of the SSTs as follows.

- Initiate a full-scale demonstration of waste retrieval technology (October 1997).
- Complete the analyses of at least two complete core samples from each SST (September 1998).
- Initiate a full-scale Tank Farm demonstration project (June 2004).
- Complete the closure of all 149 SSTs (June 2018).

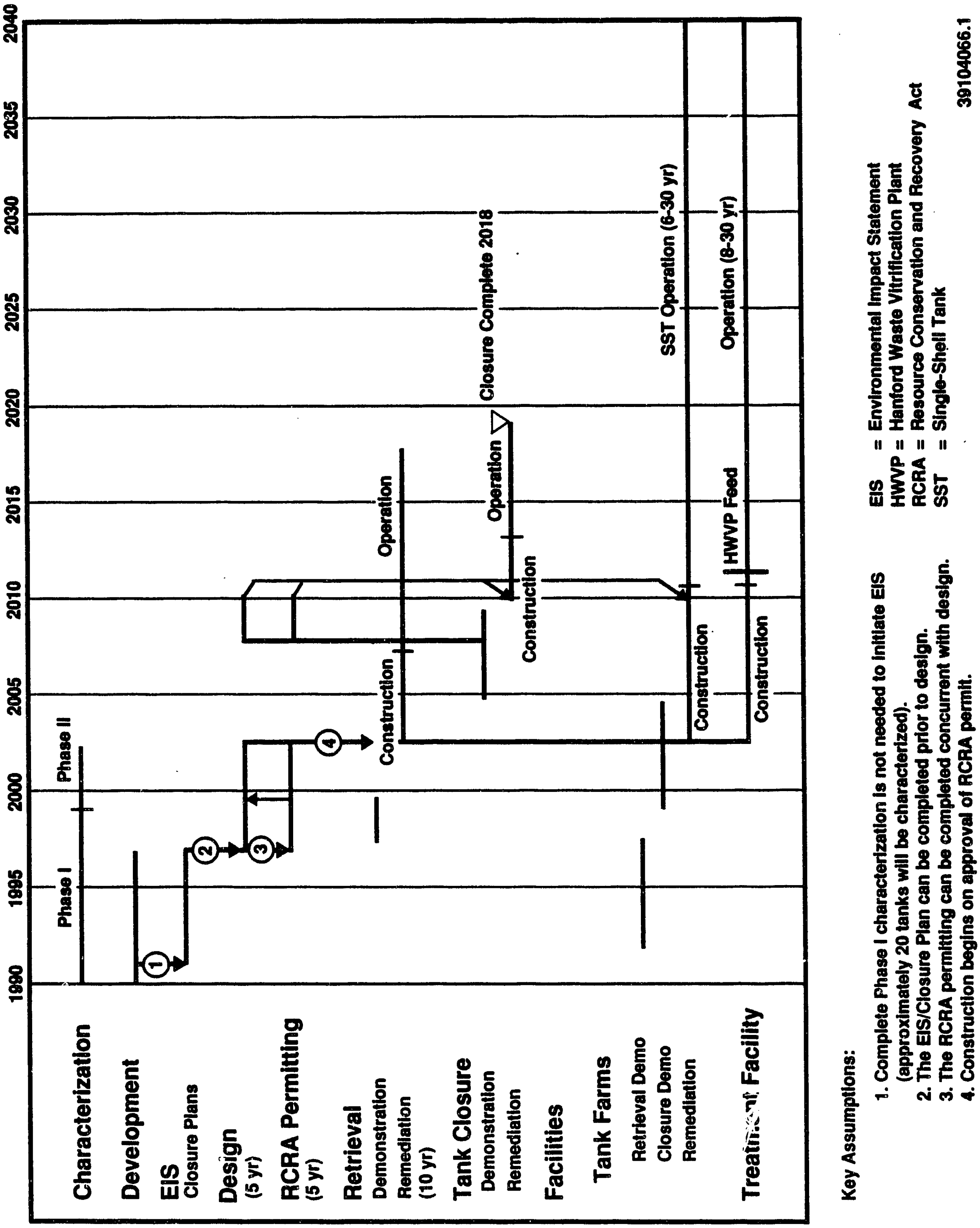
Table 5-2. Estimated Hanford Waste Vitrification Plant Waste Compositions from the Single-Shell Tank Processing Flowsheets.[a]

Oxides (wt%)	HWVP limit% (wt%)	Partitioning flowsheet					
		Sludge wash tanks retrieved			Transuranic extraction tanks retrieved		
		149	75	22	149	75	22
Na_2O	22	8.2	8.6	10.3	11.0	9.5	10.4
Al_2O_3	26[b]	28.4	31.1	34.1	27.4	24.9	30.4
CeO_2	--	2.0	1.7	1.5	0.7	0.6	0.8
Cr_2O_3	2	0.9	1.7	1.2	0.3	0.5	0.6
CdO	10	0.0	0.0	0.0	0.0	0.0	0.0
Fe_2O_3	60	7.2	11.2	11.1	5.1	8.0	6.2
SrO	--	0.3	0.4	0.4	1.0	1.4	2.3
Bi_2O_5	--	1.7	0.8	1.1	0.6	0.3	0.6
CaO	20	1.4	2.1	0.2	0.5	0.7	0.1
ThO_2	--	0.1	0.1	0.1	0.4	0.4	0.4
U_3O_8	32	10.6	11.4	8.0	4.6	4.8	5.4
HgO	--	7.001	7.001	7.001	7.001	7.001	7.001
MnO_2	20	1.3	2.2	3.5	0.4	0.7	1.9
ZrO_2	40	2.3	4.1	6.9	0.8	1.3	3.7
NiO	8	1.6	2.7	0.1	5.4	8.8	0.6
WO_3	--	0.1	0.1	0.1	0.0	0.0	0.1
TiO_2	4	0.9	1.4	1.4	3.2	4.7	7.5
La_2O_3	8	0.5	0.6	0.7	1.6	1.9	3.7
P_2O_5	4	23.5	10.8	15.1	8.0	3.5	8.0
SiO_2	--	6.8	5.8	3.1	23.3	19.2	16.3
CL^-	0.3	0.0	0.0	0.0	0.0	0.0	0.0
F^-	6.9	0.3	0.2	0.3	0.1	0.1	0.2
TOC	--	0.1	0.2	0.2	0.0	0.1	0.1
(CN)C	--	0.8	1.3	0.1	2.7	4.3	0.3
T(O+CN)C	--	0.9	1.5	0.3	2.7	4.4	0.4
Mt Oxides	--	13,987	7,016	3,709	4,089	2,128	701
$Ni_2Fe(CN)_6$ (Mt)	--	500	420	10	500	420	10
Radionuclides plutonium (kg) americium (kg) cesium-137 (Ci) strontium-90 (Ci)		382 8 1.2E+07 4.7E+07	356 8 6.0E+06 4.0E+07	234 7 5.9E+06 3.6E+07	377 7 8.8E+08 4.1E+09	353 7 6.0E+06 4.0E+07	232 6 5.9E+06 3.5E+07

[a]Based on HDW-EIS inventory and track radioactive components distribution.
[b]Shaded areas represent estimated chemical compositions that exceed current Hanford Waste Vitrification Plant glass specification limits.

HDW-EIS = Hanford Defense Waste-Environmental Impact Statement
HWVP = Hanford Waste Vitrification Plant
TOC = Total organic carbon

Figure 5-2. Reference Single-Shell Tank Closure Schedule for the Hanford Waste Vitrification Plant Risk Assessment.



5.2.3 Environmental and Regulatory Documentation Requirements

The environmental requirements and schedule for the potential integration of the SST and DST remediation schedules were identified in Section 5.2.2. The implementation of the required environmental documentation for the closure of SSTs will follow this sequence:

- *National Environmental Policy Act of 1969* (NEPA)
- Design/permit application and closure plan preparation/*State Environmental Policy Act* (SEPA)
- Final permit issuance
- Construction/procurement
- Operating permit issuance
- Operation
- Post-closure permit.

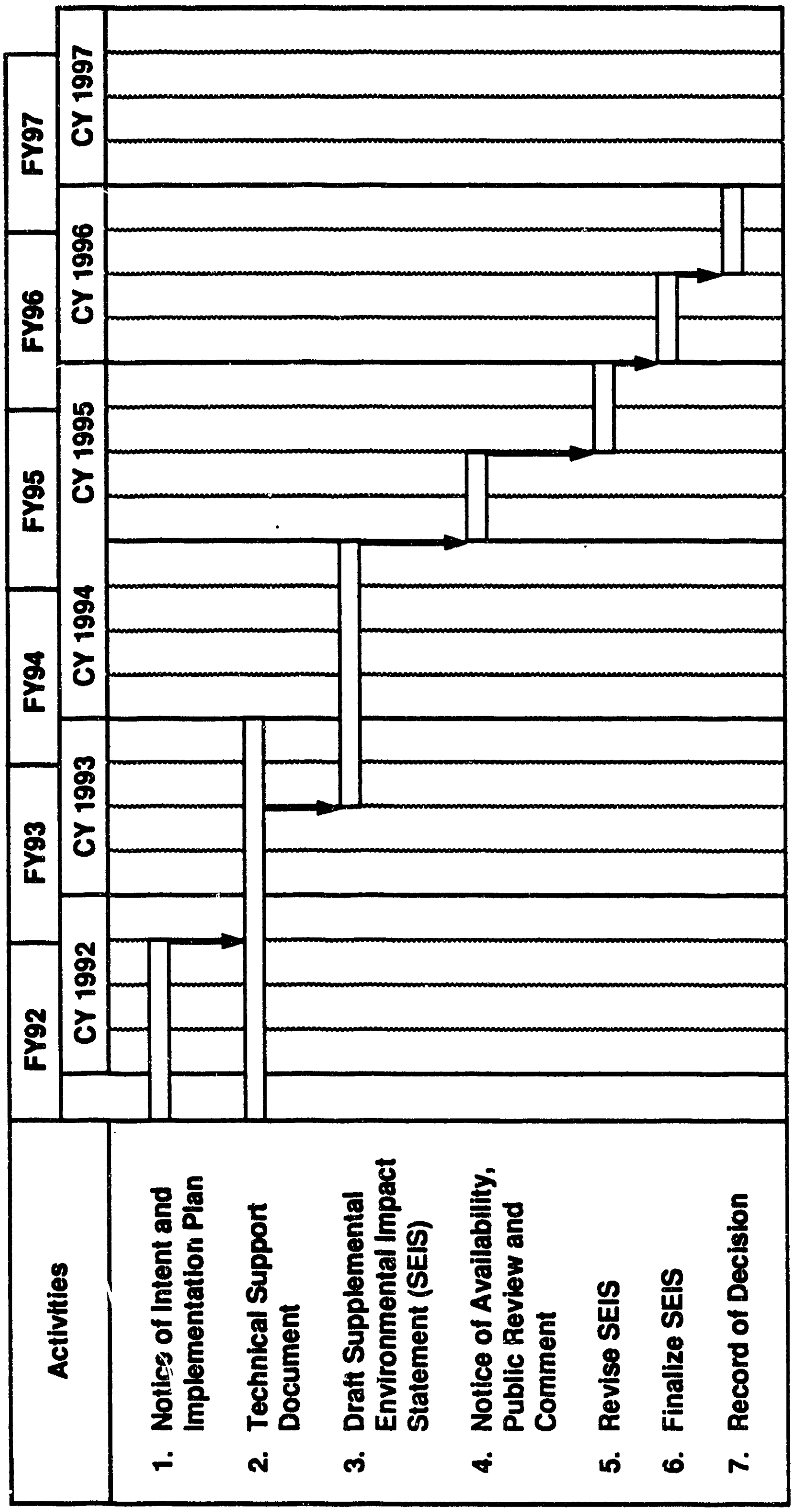
The NEPA documentation must be prepared to determine the environmental impacts of reasonable alternatives for the final disposal of the SST waste and closure of the tanks, ancillary equipment, and contaminated soils. A proposed accelerated schedule for the NEPA documentation, from the preparation of a Notice of Intent (NOI) in fiscal year 1992 through issuance of a final ROD at the end of calendar year 1996, is shown in Figure 5-3. This proposed schedule has been accelerated to fulfill the Tri-Party Agreement milestone for closure of the SSTs and reflects parallel efforts for preparation of the NOI coinciding with the technical support document.

Because of efforts to accelerate the SST SEIS, the proposed scope of the SEIS will need to change from the original scope identified in the HDW-EIS ROD. The proposed scope now includes treatment, storage, and final disposal of the waste contained within the SSTs instead of a closure decision on a tank-by-tank basis. Resources and technical activities will require acceleration to support this accelerated schedule.

Design, permit, closure plan preparation, and SEPA checklists can be initiated once an ROD has been published. The approach for obtaining the permits will depend on the magnitude of effort for the closure of the SSTs. If the efforts conclude with leaving the SST waste in place or simple retrieval, as part of closure, interim status expansion should be requested from Ecology. This would allow the closure of the SSTs without the generation of a Part B permit. A closure plan and post-closure permit then would be pursued. A generic schedule for the dangerous waste permit is shown in Figure 5-4. The post-closure permit application would require full characterization of any waste that is to be left in place after closure.

Treatment of the retrieved waste or in-situ treatment would require a dangerous waste permit (Part B) and full characterization of the waste that is

Figure 5-3. Proposed Single-Shell Tank--Supplemental Environmental Impact Statement Accelerated Schedule for Tri-Party Agreement Compliance.



Assumptions
1. Technical Database frozen December 31, 1993
2. This schedule does not reflect impacts from integration of the single-shell tank disposal program and the tank safety program.

CY = Calender Year FY = Fiscal Year

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Figure 5-4. Generic Dangerous Waste Permit Process for a New Facility. (sheet 1 of 3)

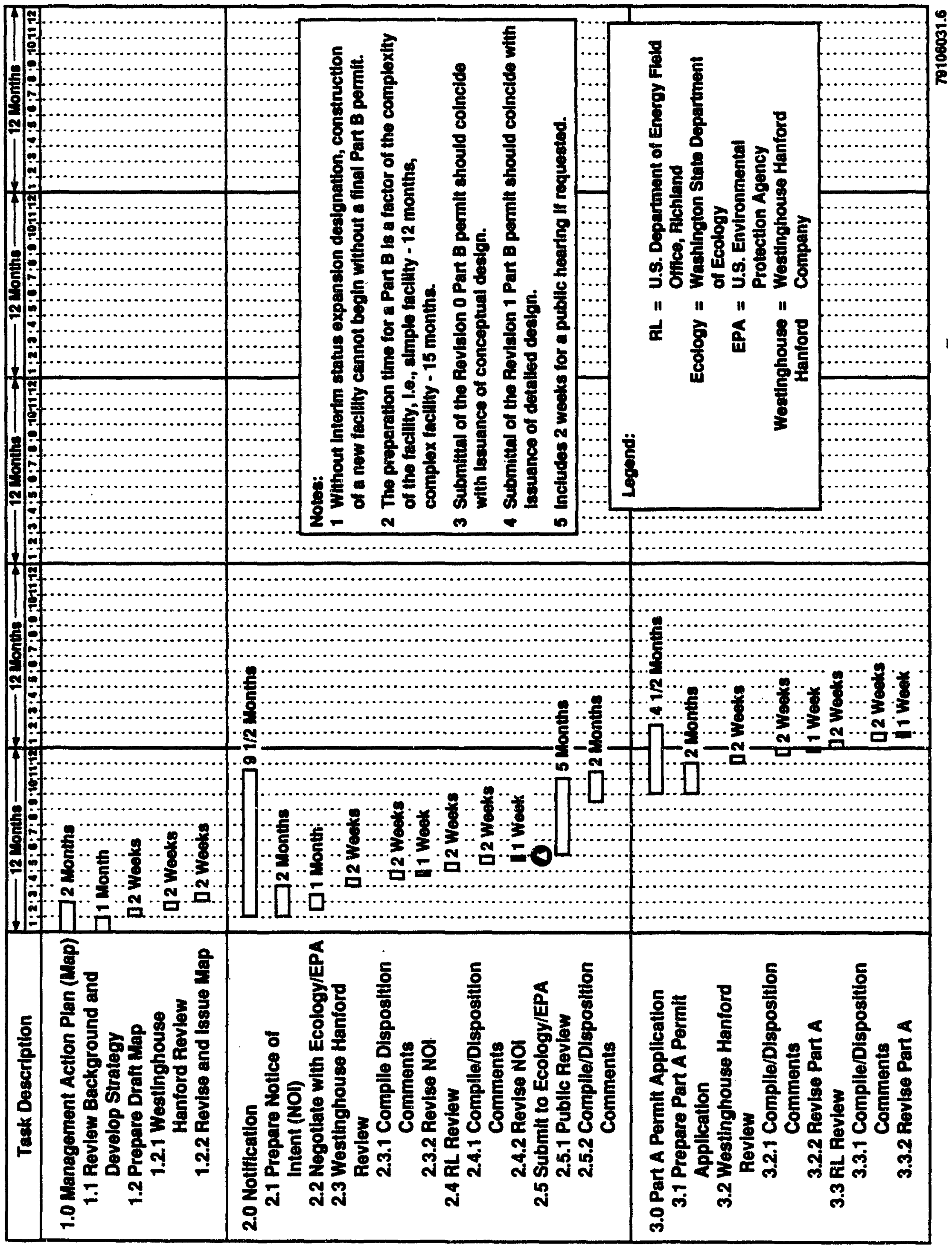


Figure 5-4. Generic Dangerous Waste Permit Process for a New Facility. (sheet 2 of 3)

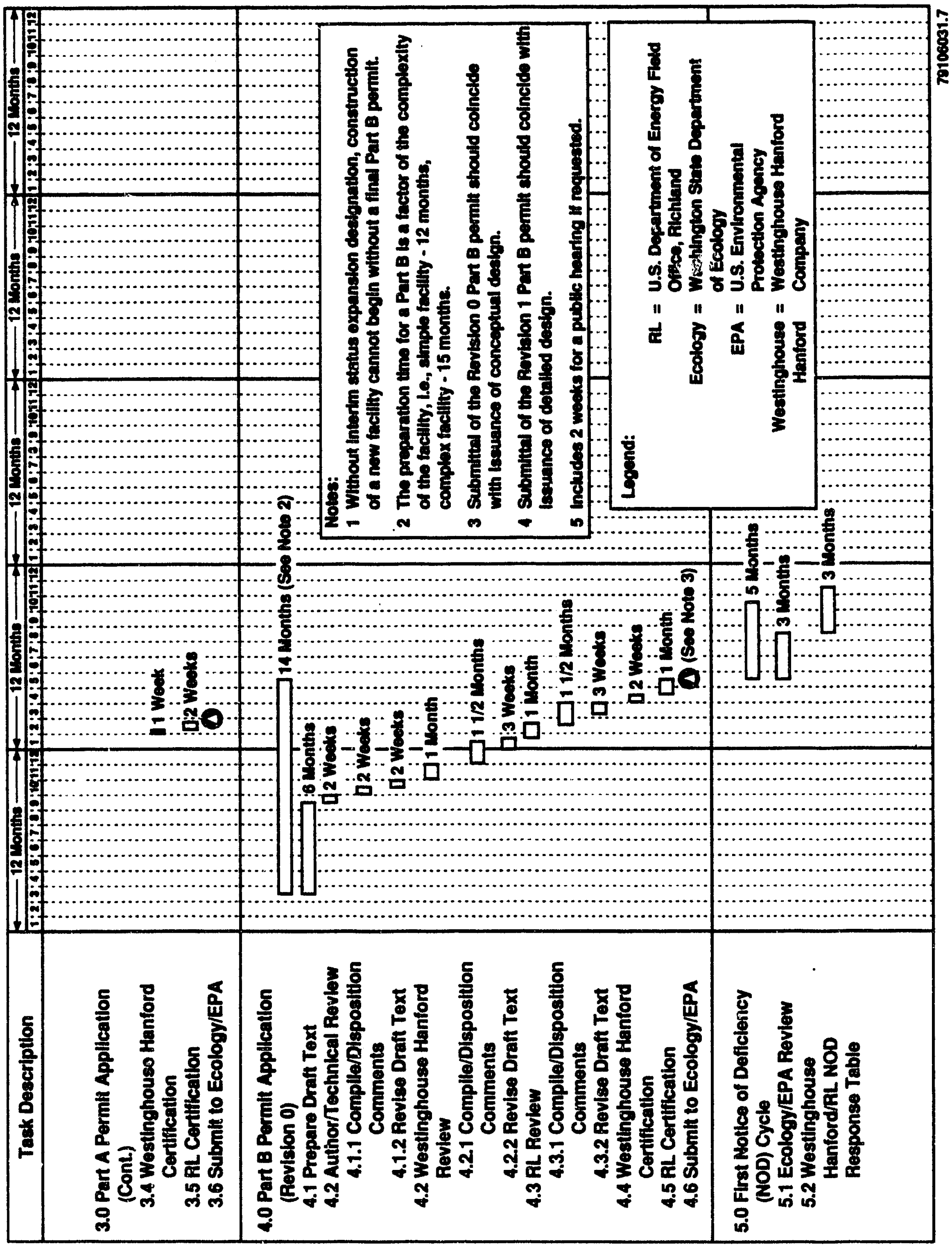
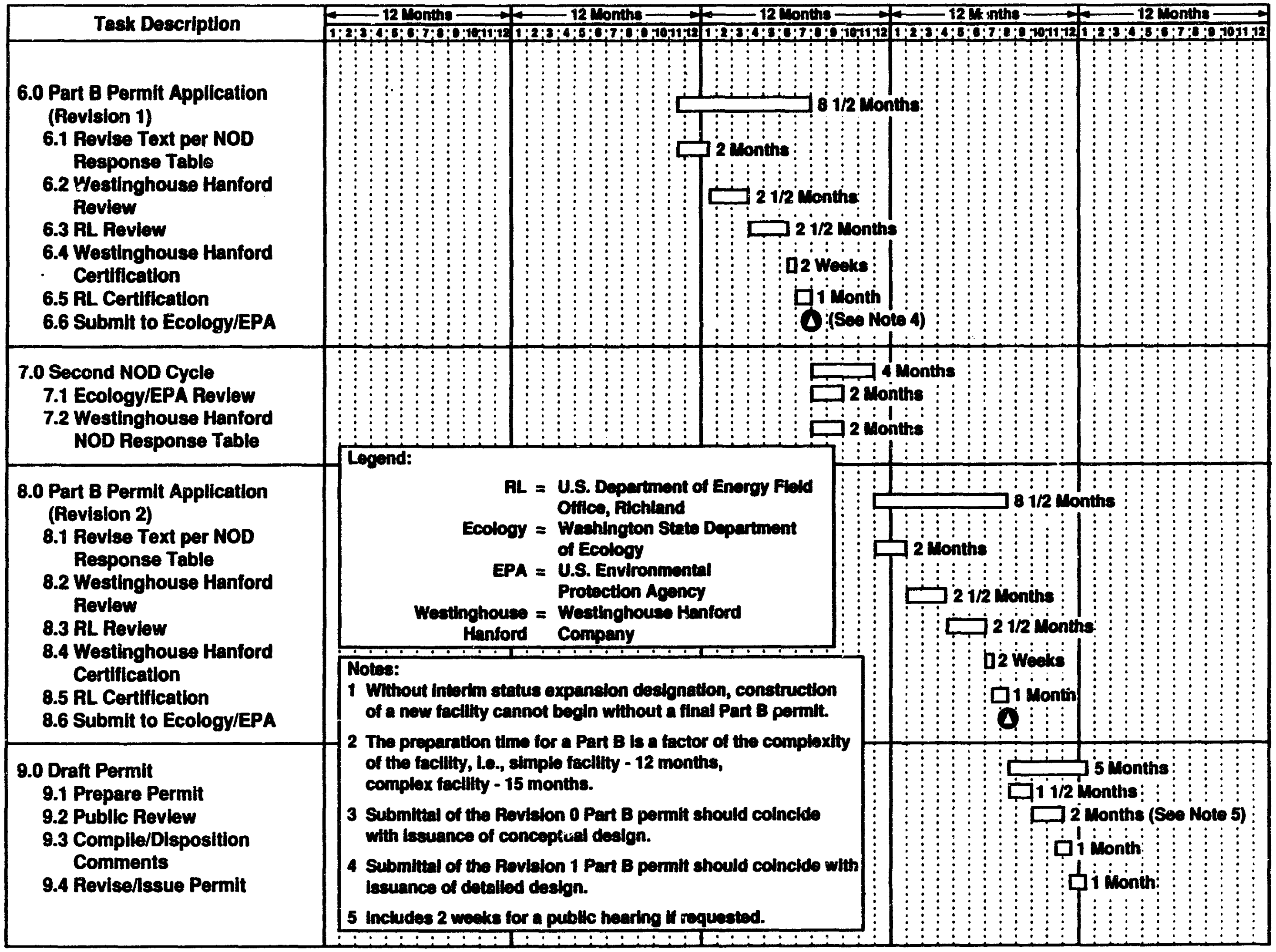


Figure 5-4. Generic Dangerous Waste Permit Process for a New Facility. (sheet 3 of 3)



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to be treated. For retrieval, this would be different from the original SST waste depending on the method of retrieval (i.e., sluicing or slurping will dilute the waste).

Recent discussions with Ecology have identified an approach for the RCRA permit where Ecology would be involved at the conceptual design stage of a new facility. This would allow the resolution of environmental issues during the definitive design stage. With this approach, submittal of a revised permit application at the completion of definitive design should result in a permit application with little or no outstanding issues. Approximately 12 to 15 months (after completion of definitive design) still would be required to obtain the final permit. This amount of time would be required for the drafting of the final permit and the required public review and comment period. This approach shortens the design and permit cycle from more than 10 yr to 6 yr.

Construction, and in some cases, procurement, cannot start until the final permits are issued with the exception of interim status expansion and/or specific agency approval to construct. A complete design is normally required to be submitted with the final permit applications. Once the final permits are issued, construction can begin within any negotiated bounds set forth in the permits. The involvement of the federal and state agencies during construction will depend on the negotiations conducted during the permit preparation. Review of any changes, assessments, certifications, and validations may be used as "hold points" for agency involvement during construction.

The operating permits may require updating of the final permits to incorporate any unforeseen design changes made during construction. The method and extent of the changes will vary for the specific permit involved and will be subject to negotiations with the appropriate regulating agency. Demonstration testing and/or reports may be required before actual operation begins.

Operation can begin once any prerequisites identified in the permit have been fulfilled. Periodic operating reports will be required and identified in the permits. All the environmental permits will require periodic renewal for long-term operation.

The post-closure permit will identify any requirements to be conducted during the post-closure period, which is 30 yr. The time frame and requirements for the closure period will be negotiated with Ecology based on the final waste form that is remaining after closure.

All environmental regulations are subject to change. This assessment is an accurate interpretation of environmental regulations in effect at the time this report is being prepared. Long-term activities, such as SST retrieval, will be affected by the changing regulatory environment. Environmental statute regulations are reauthorized approximately every 4 yr. During reauthorization, Congress may substantially modify the statute. For example, major changes to air pollution control and permitting are expected as a result of the *Clean Air Act Amendments of 1990*. Both RCRA and the *Clean Water Act of 1977* are expected to undergo reauthorization in the next Congressional session, and they are expected to undergo significant modification and result in more stringent standards being imposed on industry.

5.2.4 Technical Assessment of Potential Impacts to the Hanford Waste Vitrification Plant

Characterization of the SSTs is ongoing. Information used from the track radioactive components (TRAC), information prepared for the HDW-EIS, and core samples were used to establish a waste composition baseline for the SSTs for the purpose of this Risk Assessment.

The technical uncertainties associated with processing of the SST wastes in the HWVP result from chemical and radiochemical differences that exist between the SST and DST wastes. These chemical differences are displayed in Table 5-2. Although there are several chemical components in the SST wastes that exceed the current concentration limits of the HWVP, the components that have potentially the greatest impact on the vitrification system are phosphorus pentoxide (P_2O_5), cyanide, mercury, and total organic carbon (TOC). The remaining components, such as aluminum, which exceed HWVP specifications, will not unfavorably impact the vitrification process. Phosphate can unfavorably affect the processibility and durability of the glass waste form. Cyanides and organic materials are potential safety concerns. Cyanide and mercury can unfavorably affect process performance and impact the offgas system design. The relatively high fissile material content and ^{99}Tc of the SST wastes can potentially impact process safety and emission abatement performance, respectively. Thus, technical assessments were completed that focused on identification and assessment of the following issues:

- Fissile material content of the SST wastes, particularly for the TRUEX flowsheet
- Vitrification of ferrocyanide-containing feeds
- Vitrification of high phosphate-containing feeds and the potential issues with acceptance of a phosphate glass waste form
- Vitrification offgas abatement for mercury, hydrogen, cyanide, and ^{99}Tc.

The assessment of those technical issues are summarized in the following sections.

5.2.4.1 Fissile Material Content of the Single-Shell Tanks. The original criticality assessment for the HWVP Preliminary Safety Analysis Report (PSAR) (Herborn et al. 1991) evaluated the criticality safety for processing a blend of neutralized current acid waste (NCAW) and neutralized cladding removal waste (NCRW) in HWVP. This analysis showed that a plutonium concentration of approximately 4 g plutonium/L settled solids [equivalent to a plutonium to total feed oxides ratio of 0.65 (would be K-infinity = 0.93)] could be safely processed. However, this limit was based on an assumed "worst case" chemical concentration for the NCAW/NCRW mixture in which neutron capture in iron, nickel, and chromium was accounted for. As such, this limit is valid for only specific concentration ranges of iron, nickel, and chromium, and it is not applicable to other waste types such as complexant concentrate, Plutonium Finishing Plant, or SST solids.

In 1990, work was initiated to recalculate a limiting-plutonium concentration value for criticality safety in HWVP. The objective in this reanalysis was to find a plutonium limit value applicable to all waste feed types, whereas before, the limit value was specifically based on a single composition for NCAW. This recent analysis proposes a safe concentration limit of 0.7 g plutonium/L, applicable to slurries or solids anywhere in the HWVP process with no limitations on accumulated mass or geometry. This limit corresponds to a K-infinity value of 0.95 for the simplified worst-case stream composition--fissile material, sand [silicon dioxide (SiO_2)] spheres at 75 percent of theoretical density), and water. In the derivation of this limit, neutron capture in inert waste solids is modeled as though the solids were SiO_2--a material having the lowest thermal absorption cross-section of all the expected major waste oxides. Thus, the choice of SiO_2 to represent all waste solids depicts a conservative basis that is applicable to all waste feed types.

The projected concentration values for plutonium in pretreated SST waste solids as an HWVP feed for the 22-tank retrieval case are 0.031 wt% on the average and 0.11 wt% at a maximum. These plutonium/oxides ratios can be used to estimate the plutonium concentration (g ^{239}Pu/L) in the settled slurry receipt and adjustment tank (SRAT) solids or in the melter cold cap. It is assumed in this analysis that all plutonium is ^{239}Pu. It is necessary to apply a density factor for settled solids or cold cap solids to estimate these concentrations. Experimentally measured density values will be "waste-type specific." Therefore, the following bounding assumptions have been made:

- The bulk density of settled sludges in the SRAT cannot exceed 75 percent of the most dense major single hydroxide component, FeO(OH)--0.75 x 4.28 = 3.21 g/mL

- The bulk density of cold-cap oxides (without frit addition) cannot exceed 75 percent of zirconium oxide (ZrO_2), the most dense major single oxide component--0.75 x 5.6 = 4.2 g/mL

- The bulk density of cold-cap oxides (with frit addition) cannot exceed that of typical glass (2.8 g/mL).

Using these density values and concentration values for plutonium in pretreated solids, several possible concentrations for plutonium in settled sludges and cold-cap solids have been calculated and are summarized in Table 5-3. Note that for plutonium concentrations in the melter, two assumptions are considered: (1) waste feed is transferred and concentrated to near dryness in the melter <u>without</u> the normal addition of frit (frit omission error), and (2) a normal waste-frit mixture (25 wt% waste oxides) is transferred and concentrated in the melter.

The resulting estimates (Table 5-3) for the concentration of plutonium in settled solids or melter cold cap when processing "average" SST waste range from 0.22 to 1.3 g (^{239}Pu/L)--values that exceed the conservative limit of 0.7 g Pu/L but that would not likely exceed an SST waste-specific limit, which is based on the guaranteed presence of neutron absorbers such as iron, nickel, chromium, or uranium. Table 5-3 also provides estimated values for maximum feed plutonium levels ranging from 0.77 to 4.6 g ^{239}Pu/L. Comparison of these

Table 5-3. Plutonium Concentration Values in Hanford Waste Vitrification Plant Solids Derived from Single-Shell Tank Waste (22-Tank Case).[a]

Solids type and location	Assumed settled solids maximum density (g/mL)	Calculated plutonium concentration in settled solids (g ^{239}Pu/L of solids)	
		Average	Maximum
Hydroxide solids settled in slurry receipt and adjustment tank	1.4[b] 3.2[c]	0.43 0.99	1.5 3.5
Oxide solids in melter cold cap if frit omission error is made	2.8[d] 4.2[e]	0.87 1.3	3.1 4.6
Oxide solids in melter cold cap with normal frit additions[f]	2.8[d]	0.22	0.77

[a]Basis: Average ^{239}Pu in pretreated solids = 0.00031 g ^{239}Pu/g total oxides
Maximum ^{239}Pu in pretreated solids = 0.0011 g ^{239}Pu/g total oxides.
[b]Measured on sample of washed solids slurry (but not necessarily typical of single-shell tank solids).
[c]75 percent of theoretical density of FeOOH.
[d]Cap density assumed equal to typical glass.
[e]75 percent of theoretical density of ZrO_2.
[f]25 wt% waste oxides loading in glass.

maximum settled plutonium concentration values to the concentration limit of 4 g Pu/L for NCAW calculated in the original PSAR suggests that even with the development of an SST waste-specific plutonium limit, enough margin of safety may not exist to permit pretreatment and HWVP operations as planned. The problem predicted here is the result of four separate and possibly overly conservative assumptions.

1. The density of cold-cap solids (without frit addition) could be as great as 4.2 g/mL.

2. The neutron absorption of all solids is characterized by the low cross-section of silica.

3. The maximum plutonium concentration in pretreated SST feed varies from the average proportionate to the plutonium inventory variance among the 22 tanks before pretreatment.

4. The addition of frit to melter feed (at proper ratio) cannot be guaranteed in routine operation.

To increase the margin between the predicted maximum plutonium concentration and the limit concentration, test data need to be examined that would allow the solids density assumption to be lowered to something less than 4.2 g/mL. However, it is doubtful that this approach could improve the margin of safety by more than a factor of two, if even that much. It is likely the second assumption (i.e., the characterization of all solids as silica) also will need to be reconsidered. Perhaps the neutron absorption properties of iron could be accounted for in future criticality analyses (iron having about 15 times greater cross-section than silicon); then concentration control could be specified on the basis of a maximum plutonium/iron ratio. For waste types low in iron, an alternate system based on a plutonium/^{238}U ratio may be workable.

Further improvements in the margin of safety also could be gained during pretreatment operations. Here, the separated and concentrated transuranic stream, if of low enough volume, could be accumulated as necessary to blend its plutonium content evenly with the undissolved SST solids, thereby maintaining a nearly constant plutonium to total oxide ratio in each tank of HWVP feed (i.e., maximum values from assumption Number 3 above could be significantly reduced). Finally, the safety margin can be improved by a factor of two if HWVP controls were put in place to guarantee the addition of frit to each melter feed batch.

Considering the adjustments to assumptions and relatively simple modifications to pretreatment and HWVP operations that can be made, it should be possible to create a criticality safety system and philosophy for HWVP that will permit SST waste to be vitrified without significant impact. A margin of safety of five or greater (ratio of criticality plutonium concentration limit in settled solids or cold cap to the expected plutonium concentration) should be attainable. Thus, the "risk" to the HWVP design due to the issue of fissile material content in SST wastes is judged to be very low.

5.2.4.2 Vitrification of Ferrocyanide-Containing Feeds. There are significant quantities of ferrocyanide in 24 of the 149 SSTs. Pure mixtures of molten nitrite/nitrate and ferrocyanide salts are known to react exothermally above 230 °C (446 °F) and explosively at temperatures above 340 °C (644 °F) (Burger et al. 1991). The cesium nickel ferrocyanide chemical form is extremely stable and expected to remain in the high-level waste (HLW) fraction during TRUEX processing and sludge-wash processing. Thus, the ferrocyanide is anticipated to be a component of the HWVP feed. Thus, the possibility that ferrocyanide introduced with the SST HLW could react rapidly and in sufficient quantities to have adverse effects in the HWVP must be evaluated.

The nitrate/nitrite:ferrocyanide reactions of concern (Burger et al. 1991) are of the type shown in Eqs. 1 and 2:

$$Cs_2NiFe(CN)_6 + 6NaNO_3 + 6H_2O = 2CsOH + 6NaOH + Ni(OH)_2 + Fe(OH)_2 + 6CO_2 + 6N_2. \tag{1}$$

$$Cs_2NiFe(CN)_6 + 10NaNO_2 + 8H_2O = 2CsOH + 10NaOH + Ni(OH)_2 + Fe(OH)_2 + 6CO_2 + 6N_2. \tag{2}$$

The calculated enthalpies of reaction are -2490 and -2925 kJ, respectively. The maximum efficiency of the reactions should occur at the stoichiometric ratio of the reactants, which is 1 mol of nitrate or 5/3-mol of nitrite per mole of CN^-. Explosion test results reported by Burger et al. (1991) tended to confirm that the maximum force reactions occur at stoichiometry.

The melter is the first location in the HWVP where temperatures can conceivably approach the temperatures required for the reaction of nitrite/nitrate and ferrocyanide; thus, the analysis emphasized behavior in the melter, particularly the cold cap, which offers the potential for ferrocyanide accumulations. Using very conservative assumptions (i.e., waste from tank 104-BY vitrified without blending and a 16-cm (6.3 in.) depth of cold cap containing unreacted ferrocyanide), the maximum amount of ferrocyanide possible in the melter is 254 g-mol, or 54 kg. For a maximum reaction potential, it must be assumed that the cold cap also contains 254(6) = 1,524 g-mol nitrate.

Analyses were performed that showed that an explosive reaction of the maximum credible inventory of 254 and 1,524 mol of ferrocyanide and nitrate, respectively, in the cold cap, can be accommodated by the design of the HWVP melter. The maximum energy released if the 254 g-mol of ferrocyanide reacted stoichiometrically with NO_x compounds would be about 2 x 10^5 kcal. This is equivalent to 0.16 kg (0.36 lb) of trinitrotoluene (TNT). The maximum incident pressure on the melter lid from a 0.16 kg (0.36 lb) TNT charge centered on the molten glass would be about 200 lbf/in^2 (Grelecki 1983). This pressure has been shown in a previous explosion hazards analysis (Hutcherson et al. 1983) to be well within the stress limits of the melter shell. The previous analysis also indicated the pressure would cause expulsion of glass from the overflow but the quantity would not be expected to overflow the canister. The quantity of glass would probably be less than 0.057 m^3 (2 ft^3) because of the short duration of the pressurization and the high viscosity of the glass.

A deflagration of the ferrocyanide could theoretically produce 3,053 g-mol of combustion gas. If this quantity of gas is generated in a short time (seconds), the pressure increase in the plenum could exceed 400 lbf/in^2. The differential volume of gas would be greater than 85.5 m^3 (3,000 ft^3). The free volume in the melter plenum is about 2.85 m^3 (100 ft^3). A pressure of 400 lbf/in^2 would exceed typical safety factors for design but would not exceed the yield strength of the vessel. This pressure could only exist under stoichiometric conditions and without significant quantities of gas leaving the vessel. The maximum pressure calculated from deflagration is very conservative, and a typical safety factor for material stress would be unnecessary for this evaluation. The vessel should not yield even under a worst-case evaluation of potential pressure.

Furthermore, dilution and the thermal gradient in the cold cap will act to ensure that the effects of ferrocyanide reactions in the cold cap are inconsequential during normal HWVP operation. The amount of diluents (non-nitrate portions of the waste plus the glass frit) always will be at least four times larger than the amount of ferrocyanide to nitrite/nitrate reactants in the cold cap and usually orders of magnitude larger. Dilution alone will usually preclude explosions. The thermal gradient in the cold cap, from

100 °C (212 °F) at the top to approximately 1000 °C (1832 °F) at the bottom, will prevent accumulations of ferrocyanide because the ferrocyanide will react continuously as it reaches approximately 230 °C (446 °F).

Preliminary evaluations indicate that the risk associated with processing the ferrocyanide in SST HLW through the HWVP is low. However, this should be reexamined if vitrification of the SST waste occurs.

5.2.4.3 Vitrification of Phosphate-Containing Feeds. The maximum limit for P_2O_5 in HWVP glasses has been set at 1 wt%, or 4 wt% in the HLW, assuming a 25 wt% waste loading in the glass. This avoids the accumulation of phosphate containing second phase, which tends to collect at the melt surface and severely lower the processing rate in the melter. Although estimates of the P_2O_5 concentration in SST HLW vary depending on the waste-handling scenario (i.e., combination of number of tanks retrieved and pretreatments that are assumed), in almost all cases the concentration is well above that currently acceptable for the HWVP.

The HWVP criterion could be met by dilution, i.e., reduction of the waste loading of SST HLW, but that would increase the number of canisters going to the repository by as much as a factor of six. Alternatives to this undesirable solution must be sought.

The magnitude of the phosphate concentration problem is shown in Table 5-4. Two possible methods of solving the problem were considered in this assessment: (1) determine if the HWVP P_2O_5 limit can be relaxed, and (2) examine the impact of converting the HWVP to the production of lead-iron-phosphate (LIP) glass, which would have no P_2O_5 limit.

Even small amounts of P_2O_5 (less than 0.5 wt%) are apparently immiscible in silicate melts on the molecular scale. It is coalescence of the immiscible phases into droplets that creates the problem of a mass transfer limiting "scum" in the melter. The presence of calcium and, to a lesser extent, rare earths, promotes droplet formation.

There is a possibility that the 1 wt% HWVP limit is unduly conservative and that glasses containing considerably higher concentrations of P_2O_5 can be processed through the HWVP, if the calcium oxide (CaO) concentrations are carefully controlled. For example, glasses containing 4.58, 3.8, and 3.14 wt% P_2O_5, but no CaO, have been successfully processed in Pacific Northwest Laboratory (PNL) test melters. It is unlikely that rare earth concentrations can reach significant concentrations in SST HLW, so they should be of no concern.

The LIP glasses were invented at Oak Ridge National Laboratory (ORNL) in 1984, but their testing has not progressed beyond the laboratory. However, there is considerable experience with other kinds of phosphate glass, including 13 months of processing actual radioactive waste in the U.S.S.R, that is pertinent to the assessment. From the processing standpoint, it may be concluded that there is a moderate risk involved in shifting to LIP glass in the HWVP. Process control requirements would probably be at least as stringent as for borosilicate glass, possibly more so, but should be manageable. A new melter, with tin dioxide or molybdenum electrodes, and perhaps

Table 5-4. Anticipated Phosphorus Pentoxide Concentrations in Single-Shell Tank High-Level Waste Feed to the Hanford Waste Vitrification Plant.

Tanks retrieved	Partitioning flowsheet	Phosphorus pentoxide concentration in glass (wt%)	Canisters to repository*
149	Sludge wash	5.8	34,000
75	Sludge wash	2.7	20,000
22	Sludge wash	3.5	10,000
149	TRUEX	2.2	10,000
75	TRUEX	0.97	5,000
22	TRUEX	2.0	2,000

*Waste loading = 25 wt%.

TRUEX = Transuranic extraction

different refractories, would be required. A different glass-pouring system that guaranteed fast cooling of the glass to minimize secondary phase formation would almost certainly be necessary.

Obtaining repository acceptance may be expected to be the more risky and time-consuming aspect of shifting to LIP glass. The risk can be reduced by ensuring that the LIP glass sent to the repository is not devitrified. Adoption of an alternate waste form in which glass beads are formed and incorporated in a matrix would be one way of providing such assurance, but that approach would require major modifications to the HWVP, or a new facility. There is little doubt that vitrified LIP glass could meet all the specifications being established for borosilicate glass. Nevertheless, there is a concern that the repository acceptance process may be very time consuming and costly. There is a risk, probably slight but not discountable, that acceptance of LIP glass would not be obtained even after a major effort of many years. It may be concluded that while it is conceptually possible to convert the HWVP to the production of a phosphate glass, e.g., LIP glass, such a conversion should be considered only as a last resort.

Raising the P_2O_5 limits in the glass to 2.5 wt%, or preferably to 3.5 wt%, should make it possible to process TRUEX-pretreated SST HLW in the existing HWVP without modification of the reference TRUEX pretreatment flowsheets. The HWVP P_2O_5 limit can be raised to 2.5 wt% with low to moderate risk, and up to about 3.5 wt% with moderate to high risk. There is a small risk that the quality of the glass product would be compromised, but almost all concerns are associated with potential adverse effects on melter operation. Fortunately, the concentrations of calcium and rare earths in SST wastes are very low. It will be necessary to establish that the concentration of these constituents, and perhaps some others, can be controlled at the required levels in the SST HLW going to the HWVP.

5.2.4.4 Vitrification Offgas Assessment. The projected HWVP feeds from the SSTs will have concentrations of mercury, cyanide, ^{99}Tc, and organic materials that may exceed the concentrations of the DST wastes. Thus, the presence of these components in the HWVP feed preparation and offgas systems was reviewed to identify any significant impact.

The components of mercury, ^{99}Tc, and cyanide are listed as "Hazardous Air Pollutants" under the *Clean Air Act Amendments of 1990*, Section 112. However, the release limits for these components have not been determined by the U.S. Environmental Protection Agency or the states but will most likely exist before the HWVP begins vitrifying the SST wastes.

The total quantity of mercury in the SSTs is approximately 3,600 kg (7,940 lb). The mercury coming to the HWVP will be reduced to the elemental form by formic acid addition to the SRAT. Previous feed preparation testing has shown the majority of the mercury is suspended in the slurry as small droplets. This is why the Defense Waste Processing Facility (DWPF) refluxes the condensate from the SRAT after formic acid addition. The mercury is removed by boiling the tank and condensing the overheads in a mercury separator tank. The HWVP design does not have a separator tank. However, the HWVP has two operating options to process the mercury-containing feeds. The first would return the SRAT condensate to the SRAT, which may promote mercury settling. The second option would be to direct the condensate to the slurry mix evaporator condensate tank (SMECT). The SMECT solution would be relatively free of suspended solids, acidic, and normally unagitated. This condition would cause some of the mercury to dissolve and allow large quantities of the mercury to settle to the bottom. The mercury could be allowed to collect in the tank or be suspended by agitation and sent to a recycle system. Even if a separator tank or modification to the SRAT were required, this still does not represent a significant impact to the HWVP design.

The first operating option for the SRAT would return the mercury to the tank. Because the SRAT is agitated, most of the mercury would be carried on the slurry mix evaporator (SME). The SME is also boiled for a significant period of time to reduce the water volume. If there are significant quantities of mercury in the waste, the boiling of the contents would reduce the mercury content significantly. The overheads from the SME are normally condensed and routed to the SMECT. Therefore, for the first or second option, the majority of the mercury will eventually end up in the SMECT.

Some mercury will remain in the feed preparation equipment and eventually be fed to the melter. The mercury that is fed to the melter will volatilize from the melter, and the majority will flow to the submerged bed scrubber (SBS). The mercury entering the SBS could collect in the receiver tank, be pumped to the recycle system, and a small quantity would leave in the vent exhaust. The majority of mercury collected in the SBS would be insoluble and in the form of mercuric chloride. The redox state and temperature in the melter plenum can change the ratio of soluble to insoluble mercury from 0.1 to 3. Under typical operating conditions, the ratio would be 0.2. It also should be noted that the mercury compounds comprise the majority of the suspended solids in the melter condensate for previous small-scale tests. This addition to the recycle system may affect the operation of the filtration recycle system. However, it is not expected to change the equipment requirements.

The air leaving the SBS has a design outlet temperature of 51.7 °C (125 °F). Tests on similar scrubbing devices indicate the exhaust air will be saturated with mercury vapor. To meet emission requirements from the plant, the melter exhaust air probably will have to be cooled below 7.2 °C (45 °F) before it is mixed with other offgas systems. These requirements would be similar to DWPF requirements, and equipment could be added at a later date to ensure adequate emission abatement performance. The HWVP would need to maintain the SBS outlet temperature below 7.2 °C (45 °F) or add a condenser as in the DWPF flowsheet, which operates with a refrigerated coolant to ensure emission requirements can be met.

The chemistry of technetium in high-temperature solidification processes is found to be quite similar to that of ruthenium [ORNL-5562, Lammertz et al. (1985)]. This element can be volatilized as either a heptaoxide or oxy-acid. The volatile oxide melts at 120 °C (248 °F), boils at 310 °C (590 °F), and exerts a vapor pressure of 0.1 torr at 100 °C (212 °F). Consequently, volatilization of technetium during vitrification can be appreciable. Technetium was found to be the most penetrating of the effluents generated at the PAMELA Vitrification Plant in Belgium. This fact suggests some degree of gas-phase transport of technetium effluent through the offgas system of the plant.

However, the waste processed at the PAMELA Vitrification Plant was highly oxidizing, which is conducive as well as necessary for forming the +7 oxidation state of technetium that is characteristic of all its volatile compounds. Reductant added to calciner feed has been shown to significantly reduce technetium volatility (Lammertz et al. 1985). Because the reference HWVP process utilizes a formated feed stream, no significant technetium volatility is expected to accompany vitrification. This expectation has not been verified experimentally. However, because technetium is adjacent to ruthenium in the same transition series of the periodic table, the chemical behavior of these elements should be strongly linked. Because ruthenium volatility has been shown to be effectively suppressed by the formate in the reference HWVP feed, no process volatility losses for technetium have been projected for the HWVP. Indeed, plant emission calculations performed in support of the HWVP permit applications have assumed all process sources of technetium effluent to be primarily aerosol generators.

Because the emission abatement capabilities at the HWVP are more than adequate for dealing with highly penetrating aerosols, the only significant impact of increased technetium content in HWVP feeds will be on the secondary waste streams generated by the plant. Because these waste streams are to be solidified as an LLW, a significant environmental impact is not anticipated.

The species of organic compounds in the SSTs are not well known, and the effects of radiation and chemical interaction may have altered their chemical form. Therefore, it is not possible to estimate the specific releases of controlled organic compounds. Concentrations of organic material as TOC are presented in Table 5-2. However, data from melter tests with plenum heat as proposed in HWVP operations indicate the majority of organic materials that are fed to the melter are destroyed in the plenum because of the high temperature. Specific organic materials may survive in small quantities and may be an emission problem if they have very low release limits. This is unlikely based on typical organic materials expected in the tanks. In addition, the organic materials remaining in the tanks and making it through the pretreatment process are not likely to have high vapor pressures. The most likely release of organic materials may be in the waste concentrating process where organic materials with high vapor pressures could escape. These releases could be controlled by the existing SBS. The operating temperature of the SBS could be controlled to a lower temperature to minimize releases of organic materials. The lower temperature also may be a requirement to control mercury emissions.

The cyanide compounds in the feed coming from SSTs may create gaseous cyanide compounds in the melter offgas (MOG). Cyanide compounds are listed as hazardous air pollutants. However, no emissions guidelines have been set. The conservative assumption is to express all the cyanide in the form of hydrogen cyanide (HCN). The National Institute for Occupational Safety and Health has set ambient air-quality standards for HCN of 5 p/M (4 mg/m^3). Assuming there is no cyanide offgas abatement capability in the HWVP and the HWVP stack air flow is 3,400 m^3/min (120,000 ft^3/min), the maximum quantity of HCN that could be in the melter feed stream would be 1 wt%.

The maximum quantity of cyanide as HCN that could be delivered to the melter after pretreatment is about 3 wt%. This is based on the pretreatment options that would yield the highest cyanide concentrations from tank 104-BY and allow vitrifying with a 25 wt% waste loading in the glass. The cyanide is expected to quantitatively oxidize in the melter due to the high temperatures of the glass and in the plenum. This oxidation would occur similar to the organic compounds that have oxidized during simulated melter tests at the Savannah River Site and PNL. Significant oxidation is probable and would mean that 3 wt% HCN could probably be processed in the HWVP without affecting air emissions.

In summary, there does not appear to be any significant emission abatement issues with the potential vitrification of the SST waste. Some process modifications, such as operating the SBS and offgas chillers at lower temperatures, may be required to mitigate any potential abnormal release of aerosols from the HWVP MOG system.

5.3 RISK ANALYSIS APPROACH

The approach to quantify risks for the SST assessment involves the use of a risk matrix. "Risk" is defined as a function of the probability the uncertainty will occur, and the consequence that would result from realization of the uncertainty. The risk matrix is shown in Table 5-5. The probability ranges are high, medium, and low and are summarized as follows:

High probability - Substantial expectation the uncertainty will occur (greater than 75 percent)

Medium probability - Uncertain or moderate expectation the uncertainty will occur (25 to 75 percent)

Low probability - Limited expectation that the uncertainty will occur (less than 25 percent).

Table 5-5. Risk Matrix.

Probability	Consequences		
	Major	Moderate	Minor
High	High risk	Moderate risk	Low risk
Medium	High risk	Moderate risk	Low risk
Low	Moderate risk	Low risk	Low risk

The consequences associated with the uncertainty are manifested as schedule and cost impacts to the HWVP Program and are divided into major, moderate, and minor categories, as follows:

Major consequence - Schedule delay in program greater than 1 yr <u>or</u> cost increase greater than $100 million

Moderate consequence - Schedule delay in program of 3 to 12 months <u>or</u> cost increase of $20 million to $100 million

Minor consequence - Schedule delay less than 3 months <u>or</u> cost increase less than $20 million.

The process for ranking the risk associated with the identified uncertainties used a group review and evaluation process. The results of this semi-quantitative ranking were then subjected to interval reviews by Westinghouse Hanford and PNL management.

5.4 ASSESSMENT OF RISKS TO THE HANFORD WASTE VITRIFICATION PLANT FROM THE SINGLE-SHELL TANK REMEDIATION PROGRAM

The uncertainties from the potential vitrification of the SST wastes have been aggregated into four basic categories as follows:

1. DST/SST feed continuity to the HWVP
2. Availability of DST space to support SST retrieval and processing (see Section 7.0)
3. Ability to produce acceptable borosilicate glass from the SST wastes
4. Potential design impacts to the HWVP to vitrify the SST wastes.

Those uncertainties and their associated risks are summarized in the following subsections.

5.4.1 Double-Shell Tank/Single-Shell Tank Feed Continuity to the Hanford Waste Vitrification Plant

Uncertainty Description--The SST closure schedule under the current Tri-Party Agreement approach assumes that the SEIS will be completed after the SST wastes have been characterized and technology has been developed and demonstrated for SST barrier performance, waste-form stability, destruction or stabilization of hazardous constituents, and methods developed for retrieval, processing, and disposal of the SST wastes. Furthermore, the current environmental and regulatory approach assumes the following:

- The SSTs are completely characterized before the SEIS can be initiated
- Design of new SST pretreatment and retrieval facilities is initiated only after the EIS/closure plan are approved
- The RCRA permitting process is initiated at 80 percent design completion
- Construction of the pretreatment and retrieval facilities is allowed only after approval of the RCRA permit.

With these constraints, the closure of the SST would not be complete until the year 2030 (as shown in Figure 5-5), and feed to the HWVP would not be available until 2022 to 2024. This situation then would result in a potential feed gap to the HWVP of 10 to 15 yr between the DST and SST programs based on completing vitrification of DST wastes by approximately 2009.

Consequence--The consequences from a potential 10- to 15-yr gap between the Double-Shell and Single-Shell Tank Vitrification Program are judged major. The HWVP standby costs are estimated to be approximately $50 million to $70 million/yr in current year program dollars; HWVP restart costs also will be high after this significant shut-down period. In addition, the potential to vitrify the SST wastes in the HWVP may be jeopardized because the design life of the HWVP may be significantly exceeded.

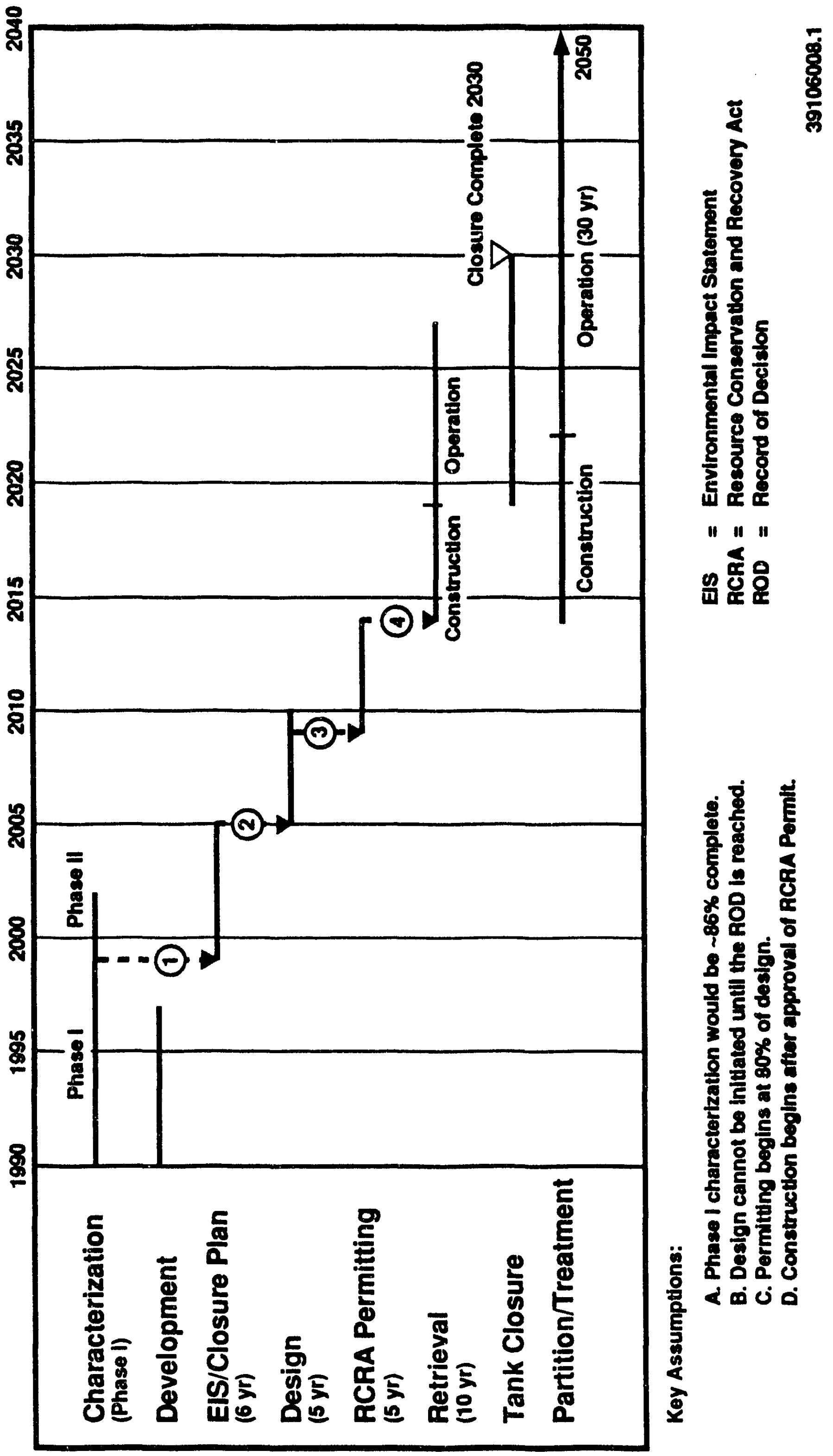
Probability--There is a high probability that there will be a significant gap in feed continuity between the completion of the Double-Shell Tank Vitrification Program and the start of SST vitrification operations under the current SST Program approach.

Risk--There is a high risk that there will be a significant interruption in HWVP operations between the DST and SST Programs under the current program approach.

Mitigating Strategies--The three basic strategies for mitigating the risk associated with the potential HWVP feed gap between the DST and SST vitrification campaign are as follows.

1. Accelerate the activities for completion for remediation of the SSTs by initiating the SEIS before completing SST characterization.

Figure 5-5. Single-Shell Tank Closure--Conservative Planning Case Assuming Current Program Approach.



Complete the design and construction of facilities needed for remediation of the SST wastes in parallel with the EIS/closure plan and RCRA permitting process.

2. Accept the potential consequences of an extended outage in the HWVP.

3. Delay the operation of the HWVP for up to 10 yr.

The second two options are unacceptable from an HWVP Project perspective. Therefore, an approach needs to be developed both from the standpoint of ensuring an efficient DST and SST vitrification mission and completing SST closure by the year 2018 to accelerate the SEIS for the SST closure. It is recommended that the SST SEIS be accelerated from its original schedule to support issuance of an ROD by 1996.

5.4.2 Availability of Double-Shell Tank to Support Single-Shell Tank Retrieval

Uncertainty Description--Based on DST volume projections summarized in Section 7.0, additional DSTs will be needed to support the retrieval and pretreatment of the SSTs. The number of additional DSTs will depend on the following:

- The number of SSTs retrieved
- Timely completion of the DST program
- The capacity of the SST waste pretreatment facility
- The retrieval schedule for the SSTs.

Consequence--The consequences for the unavailability of additional DSTs to support SST closure are that the closure of the SSTs by the year 2018 as stated in the SEIS may not be possible. In addition, feed availability to the HWVP from the SSTs may be interrupted for several years depending on the SST waste pretreatment approach. These consequences are considered major.

Probability--There is a high probability that there will be an insufficient number of DSTs to support the retrieval and processing of the SSTs. Up to a total of 53 DSTs will be needed to support the 2018 closure of the SST assuming that all 149 SSTs are to be retrieved. The funding, design, permitting, and construction of additional DSTs within a schedule to support continuous HWVP operations and closure of the single-shell Tank Farms will be difficult to achieve.

Risk--There is a high risk that closure of the SSTs by the year 2018 is not possible.

Mitigating Strategies--There is a potential that up to a total of 53 DSTs will be required to support the retrieval and immobilization of the SSTs. The number of DST tanks is dependent on the following: the number of SSTs retrieved; the rate at which the SST waste is pretreated, vitrified, and grouted; and the schedule for waste retrieval and closure date for the single-shell Tank Farms. A trade-off study that considers these factors and others to achieve an optimum schedule for the remediation of the SSTs should be conducted. Plans should be put in place to construct a limited number of additional DSTs. At this time, four additional DSTs are planned and four more are under consideration. In addition, reuse of the aging waste tanks after retrieval should be studied.

5.4.3 Production of Borosilicate Glass From Single-Shell Tank Wastes

Uncertainty Description--The HWVP has established a phosphate concentration limit of 1 wt% in the HWVP borosilicate glass. This concentration limit is based on experience with borosilicate glasses that showed high phosphate concentrations can unfavorably affect the performance of the HWVP melter and durability of the borosilicate glass waste form.

Consequences--The consequences from an unfavorable impact to HWVP operations and waste form qualification are major. The HWVP melter processing rate may be substantially reduced due to high phosphate levels that will significantly increase the SST vitrification campaign and the number of glass canisters produced. The high phosphate concentration could result in borosilicate glass that does not meet durability requirements as defined in the waste acceptance specifications (WAS). The consequences are potentially manifested as both a schedule increase in operations and cost increase in waste form development and qualification.

Probability--The probability is low that there will be a significant impact to HWVP operations from the phosphate concentration in the SST wastes. The TRUEX processing of the SST wastes will yield a P_2O_5 concentration of 1 to 2.2 wt% depending on the number of SSTs retrieved. The HWVP limit for P_2O_5 can be increased beyond its 1 wt% limit to potentially 2.5 wt% with no significant unfavorable impact to the HWVP provided that the calcium and rare-earth concentrations in the glass are limited.

Risk--The risk is moderate that the phosphate concentration in the SSTs can unfavorably impact the HWVP production schedule.

Mitigating Strategies--To mitigate the unfavorable effects of the SST vitrification program on the HWVP due to a relatively high phosphate concentration, the following work should be completed.

- Complete a development program for the potential SST borosilicate glass waste form to test and evaluate glass formulations with relatively high P_2O_5 concentration to ensure that revised HWVP WAS's can be met.

- Develop a modified HWVP melter that can process borosilicate glasses at a higher rate should the glass-melting rate be limited by phosphate concentrations in the HWVP feed.

5.4.4 Hanford Waste Vitrification Plant Design Impacts to Process Single-Shell Tank Wastes

Uncertainty Description--The chemical and radiochemical differences between the DST and SST wastes and pretreatment approaches may impact the current HWVP process or facility design.

Consequence--The consequences to the HWVP in terms of needed additional equipment to process the SST wastes or HWVP facility changes to support this equipment is considered moderate. These modifications, if required, appear to result in a moderate impact to the HWVP.

Probability--The probability that significant technical issues exist that cannot be resolved and that are associated with the processing of the SST wastes, which impact the HWVP design, is considered low. Key chemical and radiochemical differences between the DST and SST wastes have been identified and evaluated. These include the following:

- Fissile material concentration and its impact on HWVP operations
- Ferrocyanide concentration and its impact on the safety of operations
- Offgas abatement issues associated with mercury, ^{99}Tc, and organic materials in the SST wastes.

A review of these issues showed that the impacts to the HWVP from these components are minor. However, additional engineering work and development testing will be required to verify these conclusions.

Risk--There is a low risk that the processing of the SST wastes will result in a significant design change to the HWVP. There does not appear to be a significant consequence associated with the HWVP design.

Mitigating Strategies--Although the risk to the HWVP design is low in terms of processing the SST wastes, the potential impacts should be reassessed as the SST wastes are more fully characterized and a decision is made concerning the retrieval of the SST wastes.

5.5 SUMMARY OF RISKS TO THE HANFORD WASTE VITRIFICATION PLANT

The risks to the HWVP design configuration and operations schedule from the potential vitrification processing of the SSTs are summarized in Table 5-6. During the conduct of this assessment, no significant technical risks that impact the HWVP design were identified. Risks associated with the production of a borosilicate glass containing significant concentrations of phosphate are judged to be moderate. The risks to the HWVP associated with the ability to programmatically integrate the DST and SST programs because of the current programmatic and regulatory approach are judged high. In addition, the unavailability of additional DSTs to support remediation of the SSTs is programmatic and determined to be high; although there is adequate time to build additional DSTs.

Table 5-6. Summary of Risks to the Hanford Waste Vitrification Plant.

Uncertainty	Classification	Risk category
DST/SST feed continuity to HWVP	Programmatic/ regulatory	High
Availability of DSTs to support SST retrieval and pretreatment schedule	Programmatic	High
Production of borosilicate glass from SST wastes	Technical/ regulatory	Moderate
HWVP design impacts to process SST wastes	Technical	Low

DST = Double-shell tank
HWVP = Hanford Waste Vitrification Plant
SST = Single-shell tan

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6.0 VITRIFICATION OF CESIUM AND STRONTIUM CAPSULES

6.1 BACKGROUND

The Record of Decision (ROD) (DOE 1988) on the final Environmental Impact Statement, Hanford Defense Waste-Environmental Impact Statement (DOE 1987a), states:

> "Encapsulated cesium and strontium wastes will continue to be stored safely until such time as a geologic repository is ready to receive this waste for disposal. Prior to shipment to a geologic repository, these wastes will be packaged in accordance with repository waste acceptance specifications."

The overpacking concept will not comply with the statutory requirements for chemical and phase stability defined by Title 10, Code of Federal Regulations (CFR), Section 60.135(a)(2), or chemical compatibility defined by 10 CFR 60.135(a)(1) (NRC 1991). Thus, it will not be possible to dispose of the overpacked cesium and strontium capsules without obtaining a waiver for at least these two repository disposal requirements. Uncertainty about the acceptability of overpacked capsules and the high cost of repository disposal per canister (496 canisters would be required at a repository cost of $174 million) suggest that other disposal alternatives be considered.

Recently, the vitrification of cesium and strontium salts in the Hanford Waste Vitrification Plant (HWVP) was identified as a possible alternative to overpacking. As a result of these events, and before the initiation of this Risk Assessment, the Projects Technical Support Office performed a feasibility study to determine if any significant technical issues preclude vitrification. Further, the study compared this vitrification scenario with alternatives of indefinite storage and the ROD position of overpacking the capsules for disposal in a geologic repository. Recently, the HWVP Project reevaluated the cell wall shielding criteria and determined that the current degree of shielding is sufficient for processing cesium and strontium contained within the capsules.

A feasibility study for the processing of the Hanford Site's cesium and strontium isotopic resources in HWVP concluded that it was technically feasible to blend the cesium chloride and strontium fluoride (SrF_2) encapsulated salts with neutralized current acid waste (NCAW) or complexant concentrate (CC) waste feed streams and process the waste through the HWVP. Similarly, the study determined that it was technically feasible to remove the halides (chlorine and fluorine) and blend the resulting cesium nitrate ($CsNO_3$) and strontium carbonate ($SrCO_3$) with the NCAW or CC waste feed streams. Treating the cesium and strontium salts to remove halides results in the generation of a hazardous waste (silver chloride) for disposal and would require the installation of an offgas treatment system for hydrogen fluoride resulting in higher costs than the direct-blending concept. Rough-order-of-magnitude cost estimates showed that blending the cesium and strontium salts with the waste or removing the halides before blending with NCAW or CC waste are the least-cost alternatives.

The study also considered the feasibility of vitrifying capsule contents as a standalone HWVP mission. While technically feasible, the production and repository disposal costs for approximately 133 additional canisters make this option less attractive than the blending options. Nonetheless, all vitrification scenarios resulted in lower estimated costs than either the long-term storage option or overpacking the capsules for disposal in a geologic repository.

6.2 CESIUM AND STRONTIUM VITRIFICATION SCENARIOS

Beginning with the information in the aforementioned feasibility study, the risk assessment team identified the uncertainties and evaluated the risks related to dismantling the capsules and vitrifying the contents under the following scenarios:

- Blending with NCAW
- Blending with CC waste
- Standalone HWVP mission.

[NOTE: The NCAW and CC wastes are first-cycle raffinates from the plutonium-uranium extraction (PUREX) process. Although CC waste has been reprocessed to remove cesium and strontium, both wastes are high-level wastes (HLW) by U.S. Nuclear Regulatory Commission definition. The neutralized cladding removal waste (NCRW) and Plutonium Finishing Plant (PFP) waste are transuranic (TRU) wastes and as such may be acceptable for disposal in the Waste Isolation Pilot Plant (WIPP). Consideration was not given to blending cesium and strontium with TRU wastes because doing so would preclude disposal in the WIPP. Additional *National Environmental Policy Act of 1969* (NEPA) documentation may be required before NCRW and PFP wastes can be sent to WIPP.]

A discussion of uncertainties together with strategies for mitigating the potential consequences follows the scenario descriptions.

6.2.1 Blending with Neutralized Current Acid Waste

In this scenario, the cesium and strontium capsules would be dismantled in the Waste Encapsulation and Storage Facility (WESF), which is adjacent, and connected by pipeline, to B Plant. Cesium chloride will be dissolved in water and the solution blended with the high-level fraction of pretreated NCAW in B Plant for transfer to the HWVP feed tank(s). Strontium fluoride, which is almost insoluble in water, will be crushed and mixed with sufficient water to permit transfer to B Plant for blending with pretreated NCAW as a slurry. The capsules will be processed concurrently with the pretreatment of NCAW (scheduled from January 1997 to July 1999) to minimize the potential for a "tank bump." [The double-shell tanks (DST) are normally maintained at a negative pressure to minimize the potential for radionuclide release. Heat of decay is theorized as generating pockets of vapor or steam in settled sludges.

A "tank bump" occurs when a pocket of vapor is vented to the void space in the tank resulting in a momentary positive tank pressure.] In addition, the dismantling of the capsules and blending of the salts must be completed in a timely manner so as not to delay the characterization of pretreated waste as the basis for frit procurement.

6.2.2 Blending with Complexant Concentrate Waste

This scenario differs from the first scenario only in that cesium and strontium salts will be dissolved or crushed and slurried and then transferred to tanks containing the high-level/TRU fraction of pretreated CC waste. The baseline schedule shows CC waste pretreatment occurring from May 2004 to April 2007, and the capsule processing would be accomplished concurrently.

6.2.3 Standalone Hanford Waste Vitrification Plant Mission

This scenario differs from the first scenario only in that capsule processing would be accomplished to allow vitrification as a standalone HWVP mission. This could occur in an effort to minimize HWVP standby time while awaiting pretreated feed (i.e., between vitrification of NCAW and NCRW or between PFP and CC wastes) or if circumstances preclude blending with either NCAW or CC waste. For instance, priority WESF missions such as the transuranic extraction pilot-plant and melter bench-scale testing could preclude processing capsules for blending with NCAW or CC waste.

6.3 UNCERTAINTIES, CONSEQUENCES, AND MITIGATING STRATEGIES

This subsection identifies the uncertainties associated with the previously described scenarios. Each uncertainty presents a potential consequence with some probability of occurrence. The product of consequence and probability is the risk associated with a given uncertainty. For the purpose of discussion in this subsection, the magnitude of risk was determined using the risk analysis approach presented in Section 5.3.

6.3.1 Uncertainties Common to all Scenarios

6.3.1.1 Uncertainty. The WESF stores only HLW and as such is not currently permitted as a dangerous waste treatment, storage, and/or disposal unit. The WESF is dependent on the adjacent B Plant for liquid radioactive waste transfer, liquid effluent treatment and disposal, solid-waste handling, and lag storage for processed capsule contents. There is an uncertainty as to whether the cesium and strontium salts would be classified as a mixed (radioactive and hazardous) waste when removed from the capsules. It is thought that salts may contain some impurities (i.e., lead and cadmium), which are regulated under the Dangerous Waste Regulations [*Washington Administrative Code* 173-303 (Ecology 1991)]. It is not known if the concentration of these metals is sufficient to trigger the regulations. Further testing will determine the status of the capsules under the regulations.

When Congress enacted the *Resource Conservation and Recovery Act of 1976* (RCRA), there was recognition that certain radioactive materials were already regulated under the *Atomic Energy Act of 1954* (AEA). Consequently, these materials were excluded from regulation as solid waste, and hence hazardous waste, under the provisions of the RCRA. The AEA (Chapter 2, Section 11.e) defines by-product material as "(1) any radioactive material (except special nuclear material) yielded in or made radioactive by exposure to the radiation incident to the process of producing or utilizing special nuclear material, and ... " Cesium and strontium that are yielded in the process of producing special nuclear materials both qualify as by-product material under the AEA. Although by-product material is excluded from regulation under the RCRA [see 40 CFR 261 (EPA 1990)], mixtures consisting of by-product material [as defined in the AEA, Chapter 2, Section 11.e (1)] and hazardous wastes are not. Such radioactive mixed waste is subject to regulation under both the AEA and the RCRA. The Federal Register, Vol. 52 (84) (DOE 1987b), states "[f]or purposes of determining the applicability of RCRA to any radioactive waste substance owned or produced by DOE...the words "any radioactive material"... refer only to the actual radionuclides dispersed or suspended in the waste substance. The nonradioactive hazardous component of the waste substance will be subject to regulation under the Resource Conservation and Recovery Act."

The current position on cesium and strontium capsules is that source, special nuclear, or by-product material as defined by the AEA, including stable decay products existing solely from the transformation of such material, is not subject to regulation by the RCRA, but rather is subject to AEA authority. The issue of potential regulatory authority over stable decay products is being addressed at a national level by a tank group for government-owned, contractor-operated issues. Given the unfavorable determination that the cesium and strontium salts are a mixed waste, there is an uncertainty regarding the permitting of the WESF as a dangerous waste facility.

Consequences: A determination that the cesium and strontium salts are a mixed waste and the inability to obtain a permit for the WESF and/or B Plant would require a new facility be identified for dismantling capsules.

Mitigating Strategy: The removal of cesium and strontium salts from the capsule, and if necessary the processing of the capsule wastes, could be accomplished in the HWVP. One of the lay-down areas would have to be modified to provide the necessary capabilities. Lay-down space would have to be identified elsewhere in the facility or the HWVP would have to be extended. To duplicate facilities and equipment available in the WESF, modification to the HWVP would have to include the following: shielded windows (two), remote camera, cell lining and cover blocks, in-cell lighting, process steam water and air services, sump jet and regulated drain to the decontamination treatment tank, double-encased process lines (two) to the slurry receipt and adjustment tank (SRAT), and stainless steel vessels (three) together with necessary agitators, transfer jets, and piping. In addition, changes to the plant ventilation and filtration systems may be needed to prevent dispersion of cesium chloride and to address cesium volatility in the melter.

In using the HWVP for capsule processing, the blending of processed capsule wastes with pretreated waste feed streams would be accomplished in the SRAT, bypassing B Plant, the HWVP feed storage tanks, and the receipt and lag storage tank (RLST). Bypassing the HWVP feed storage tank avoids increasing the probability of a "tank bump."

The processing of capsule wastes would be concurrent with the processing of the waste type selected for blending to minimize the quantity of cesium and strontium stored in the HWVP. Characterization data from the pretreated HWVP feed stream would have to be adjusted to account for the subsequent addition of cesium and/or strontium salts. The specification for frit procurement would have to be similarly adjusted.

Impact: The minimum cost for modifying the HWVP to process cesium and strontium capsules is $13 million. If the Vitrification Building is lengthened to provide additional lay-down area, the cost is estimated to be $3.9 million/m ($1.2 million/ft). Total costs will exceed $20 million.

Probability: There is a low probability that the capsules will be classified as a mixed waste.

Risk: The low probability that the capsules will be classified as a mixed waste, combined with a moderate consequence, identifies this uncertainty as a low risk.

6.3.1.2 Uncertainty. As presently planned, the RLST in the HWVP is not maintainable and is to be fabricated of American Iron and Steel Institute (AISI) 316 stainless steel, which is known to be subject to stress corrosion cracking in the presence of halides. The uncertainty is whether the cesium and strontium salts can be processed without damage to the RLST or the internal tank components.

Consequences: There is a possibility of premature failure of the RLST. Replacement costs would be in the range of $10 million to $50 million and would result in a 2-yr HWVP standby at a cost of $150 million.

Mitigating Strategy 1: Dismantle the capsules in the HWVP and blend the contents with NCAW in the SRAT as described in Subsection 6.3.1.1.

Mitigating Strategy 2: Change the material of construction from AISI 316 stainless steel to Hastelloy™ or similar alloy, which is better suited to the processing of halides.

Impact: Substitution of Hastelloy could increase RLST costs by as much as $10 million.

Probability: There is a medium probability that dissolved cesium salts would have an adverse impact on the RLST fabricated from stainless steel. The SrF_2 salts, which are in slurry form rather than solubilized, are not likely to affect the RLST.

™Hastelloy is a trademark of the Cabot Corporation.

Risk: The medium probability of an adverse impact to the RLST, combined with consequences of premature RLST failure, suggests the basis for a substantial risk. The low to moderate costs to implement a mitigating strategy result in a low to moderate risk determination for this uncertainty.

6.3.1.3 Uncertainty. Strontium fluoride is practically insoluble in water. As such, the compound has to be crushed into a powder and mixed with a sufficient volume of water to be transferred as a slurry. There is an uncertainty as to whether the slurry transfer will result in increased potential for transfer line plugging.

Consequence: Plugging of a transfer line between the WESF and HWVP could result in HWVP standby while the line is either cleared or possibly replaced. The HWVP standby costs are estimated to be $6 million/month. The time required to clear or replace a plugged transfer line could range from 1 to 12 months.

Mitigating Strategy: Install a dedicated transfer line from the WESF/ B Plant complex to the HWVP for handling the waste from the cesium and strontium capsules.

Impact: Transfer line construction costs are estimated to be $5.5 million (approximately $3,300/m or $1,000/ft).

Probability: Virtually all transfers of DST wastes will be slurries. The transfer of slurries is a standard operating procedure at the Hanford Site. Some plugging of the long [i.e., 11-km (7-mi)], cross-site transfer lines has occurred during past operations. Relatively short transfers between B Plant and HWVP, however, present a low probability. As a general rule, it is advisable to have a redundant transfer line (which is relatively low cost) to ensure continuous operation of a relatively high-cost facility like the HWVP.

Risk: Low probability and the availability of a relatively low-cost mitigating strategy result in this uncertainty being considered a low risk.

6.3.2 Uncertainty to Blending with Neutralized Current Acid Waste

Uncertainty: The NCAW is stored in aging waste tanks equipped with air-lift circulators to minimize heat build-up in settled solids due to radionuclide decay. The uncertainty is whether the additional heat of decay due to blending of capsule contents would significantly increase the risk of a "tank bump."

Consequence: Capsule contents cannot be blended with NCAW resulting in 4 to 8 yr of additional storage.

Mitigating Strategy: The capsule contents could be blended with CC waste or vitrified as a standalone HWVP mission.

Impact: There may be additional storage costs of $26 million to $52 million. Canister vitrification and disposal costs are estimated to be $66.5 million in 1991 dollars.

Probability: This is a moderate probability, pending the results of ongoing studies.

Risk: This is a moderate probability combined with a moderate consequence resulting in a moderate risk.

6.3.3 Uncertainty Related to Blending with Complexant Concentrate Waste

Uncertainty: The CC waste has not been fully characterized. There is concern that some unknown constituent could preclude blending of cesium and strontium salts with CC waste.

Consequence: There may be a deferral of capsule processing.

Mitigating Strategy: The capsules could be processed as a standalone HWVP mission.

Impact: There may be 4 yr of added storage costs for the capsules at a cost of $26 million, and a 2-yr extension of the B Plant mission at a cost of $60 million.

Probability: The probability is low--the CC waste results from processing of PUREX first-cycle raffinates to remove the cesium and strontium that are presently encapsuled.

Risk: The low probability, combined with moderate consequences, results in a low to moderate risk.

6.3.4 Uncertainties Related to Capsule Vitrification as a Standalone Hanford Waste Vitrification Plant Mission

No uncertainties have been identified other than those listed in Subsection 6.3.1.

6.4 DISCUSSION OF SUBSTANTIAL RISKS

Within the risk assessment criteria described in Section 6.3, none of the uncertainties associated with the vitrification of capsule wastes were determined to be high risks to the baseline program. The two most significant risks to the base scenarios (program baseline alternatives are described in Section 6.2) are as follows:

(1) The increased possibility of a "tank bump" occurring as a result of blending cesium and strontium with pretreated NCAW in the HWVP feed tanks (aging waste DSTs)

(2) The potential adverse impact of halides on the RLST.

Both of these risks could be mitigated by modifying the HWVP to receive and dismantle the capsules.

6.4.1 Recommendations

The development of a supplemental environmental impact statement should be initiated to reassess disposal methods for the cesium and strontium capsules. Given a decision to vitrify the capsule contents, a possible location for dismantling operations is the WESF where the capsules are currently stored. Regulatory considerations could require the use of another facility, such as the HWVP, for this function. There is need for a focused effort to determine the regulatory status of the capsule contents.

In light of some potential advantages in processing capsule wastes in the HWVP, more detailed studies should be performed to accomplish the following.

- Define the extent of required HWVP modifications, including a determination of the impact of halides on equipment. Develop a recommendation as to the need to remove halides from capsule wastes.

- Identify the potential impacts of blending capsule waste with the pretreated waste feed stream in the SRAT. The current premise is that the total contents of an HWVP feed tank be characterized as the basis for frit procurement. The study should determine if the addition of capsule waste would impact the frit procurement specification. If the frit procurement specification requires adjustment, the study must determine if the unavailability of capsule waste for blending would impact HWVP operations (i.e., if the frit specification has to be adjusted because of the addition of capsule wastes, will the frit be adequate for HWVP operations if capsule processing is interrupted?).

- Evaluate the impact of heat of decay on the total number of canisters required to vitrify capsule wastes as a standalone mission. The feasibility study for processing capsule waste identified rates of heat generation in the range of 2,000 W/canister. This study should develop a recommended limit for heat generation based on the potential for extended storage in the HWVP.

- Given a determination that capsule wastes should be blended with the pretreated waste stream in the HWVP feed tank, determine the impact of capsule wastes on the probability of a "tank bump."

Other topics that should be studied include dispersability of cesium chloride and the potential impacts on the plant ventilation and high-efficiency particulate air filtration systems. Cesium volatility in the melter, and the impacts resulting therefrom, also should be studied.

6.5 REFERENCES

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7.0 DOUBLE-SHELL TANK SPACE UTILIZATION ASSESSMENT

Pretreatment operations associated with the existing double-shell tank (DST) wastes and the potential retrieval and pretreatment operations associated with single-shell tanks (SST) suggest that there may be inadequate DST space to support Waste Management Operations. Thus, waste volume projections were examined for several retrieval and pretreatment scenarios involving both the DSTs and SSTs to identify any impacts to the current DST waste Tank Farm capacity.

7.1 DOUBLE-SHELL TANK PROGRAM REQUIREMENTS

The availability of DST space is impacted by the potential future operations of the Plutonium-Uranium Extraction (PUREX) Plant to process the remaining N Reactor fuel, and the potential delays in completion of the grout campaigns to solidify the double-shell slurry (DSS) and double-shell slurry feed (DSSF) wastes. These potential impacts are assessed below.

The DST waste volume projections for the baseline schedule are summarized in Figure 7-1 for two cases. The first case assumes PUREX is restarted to process the remainder of the N Reactor fuel during the time period 1995-1999; in a second case, PUREX operations are not resumed. As can be observed from Figure 7-1, the potential operation of PUREX does not significantly affect the availability of the DSTs to support the baseline schedule for pretreatment and vitrification. The increase in DST space needs in 2006 is due to the pretreatment of the complexant concentrate (CC) waste. The CC waste will be diluted from its stored volume of approximately 1,800 m^3 (4.8 million gal) to more than 5,670 m^3 (15 million gal) during the pretreatment campaign for transuranic extraction (TRUEX) operations. Furthermore, it is assumed that once the waste from the aging waste tanks is retrieved, these tanks will be retired from service.

The impact to DST space availability was also examined for two different grout processing campaign schedules. The first case considered a 19-month delay in the start of DSS/DSSF grouting operation from 1991 to January 1993. The second case considered an indefinite delay in the grouting of the DSS/DSSF wastes. The projection also assumed that a third Liquid Effluent Retention Facility module would be ready by fiscal year (FY) 1994; four 3,800-m^3 (four 1-million gal) tanks would be available in September 1999; and B Plant pretreatment operations would be initiated in FY 1999. The 19-month grout delay case assumes that seven grout vaults will be filled through 1994 and 20 grout vaults will be filled between 1994 and 1998.

The tank volume projection results for the 19-month grout campaign delay case are summarized in Figure 7-2. As is shown in Figure 7-2, at least a 22,800-m^3 (6-million gal) capacity is available in the double-shell Tank Farms at all times. These results show that the DST baseline schedule will not be impacted.

Figure 7-1. Hanford Site Double-Shell Tank Waste Volume Projection for the Case 2 Double-Shell Tank Baseline Schedule.

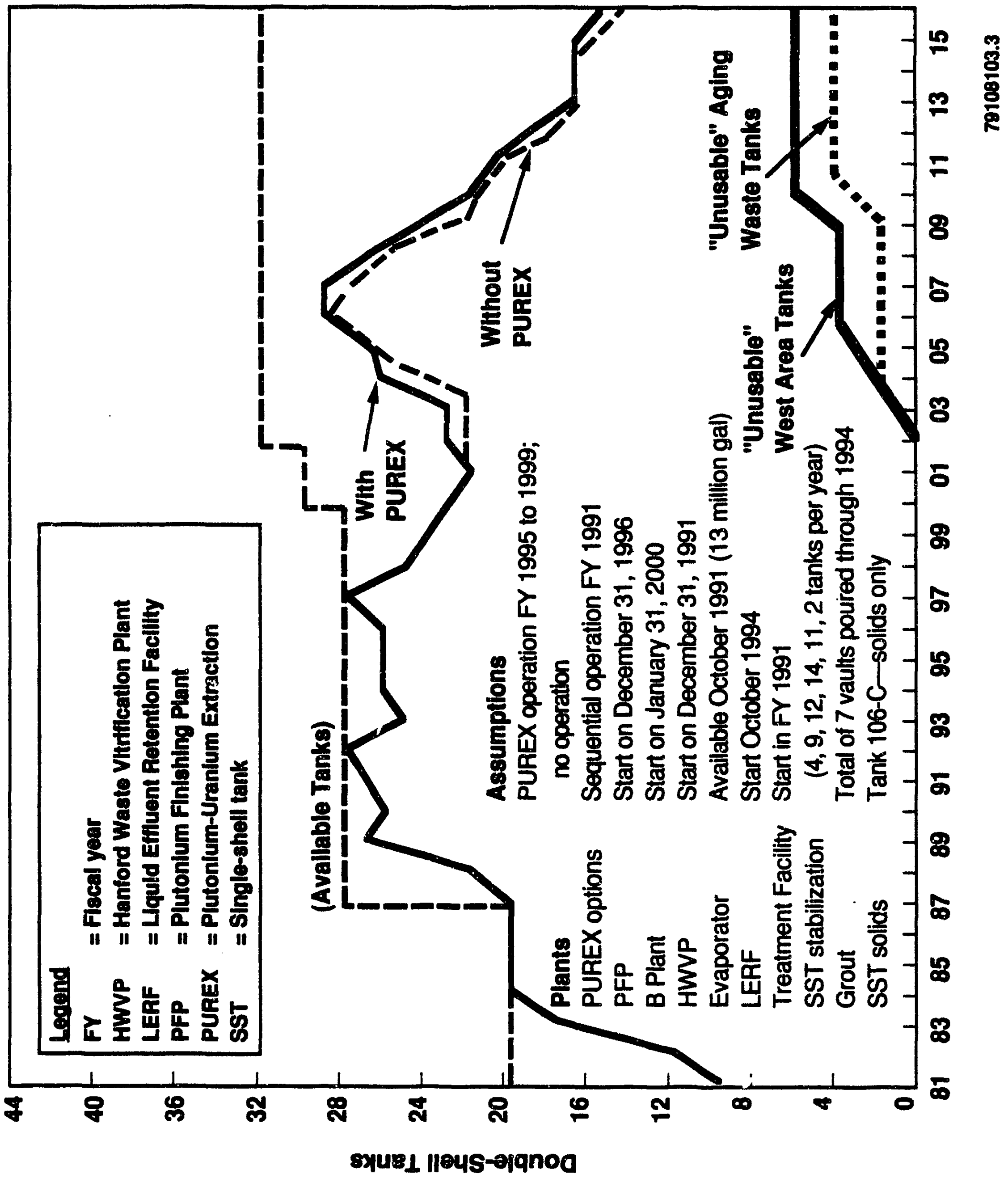
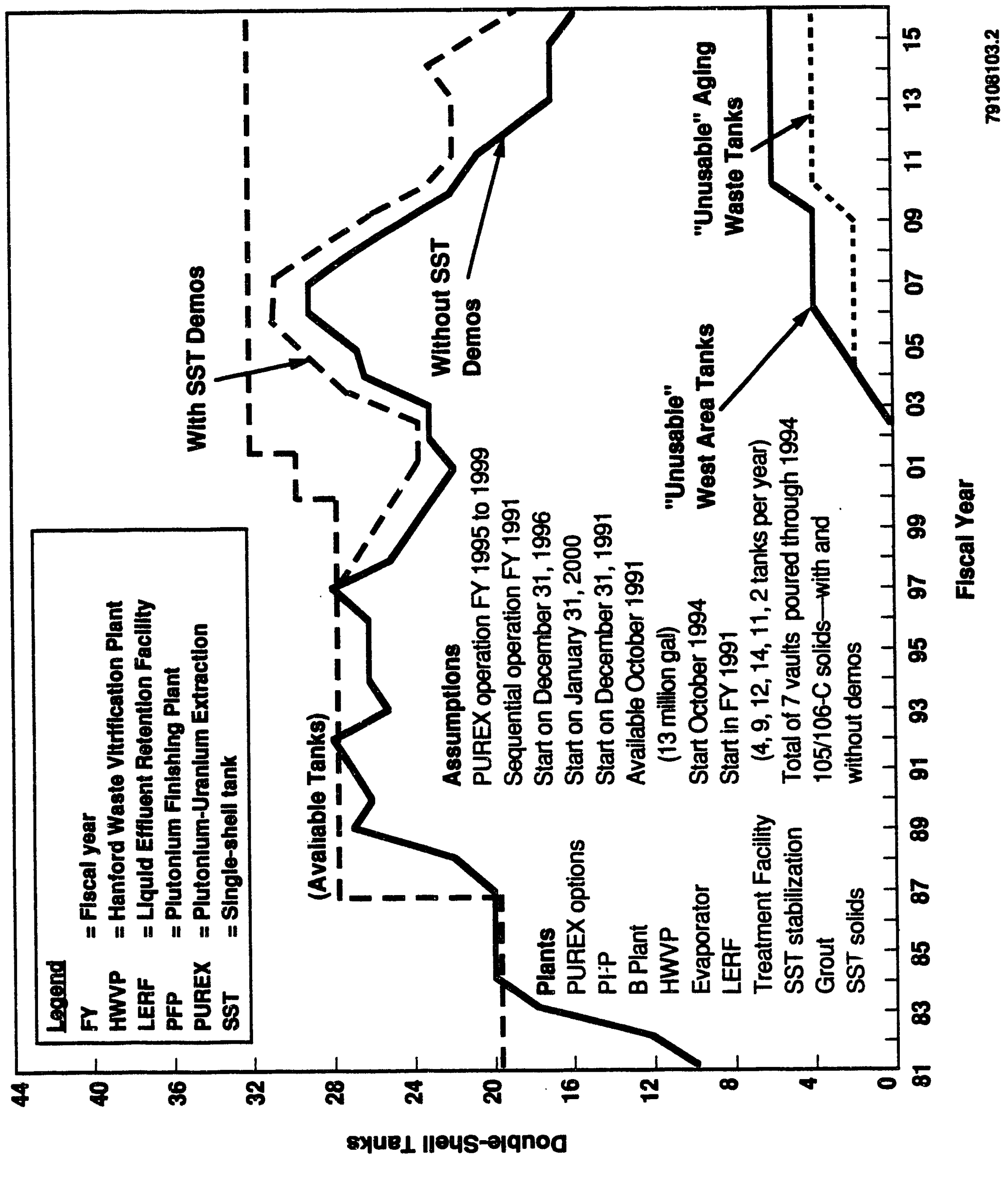


Figure 7-2. Double-Shell Tank Volume Projection Assuming a Nineteen-Month Delay in Grouting the Double-Shell Slurry/ Double-Shell Slurry Feed Wastes.



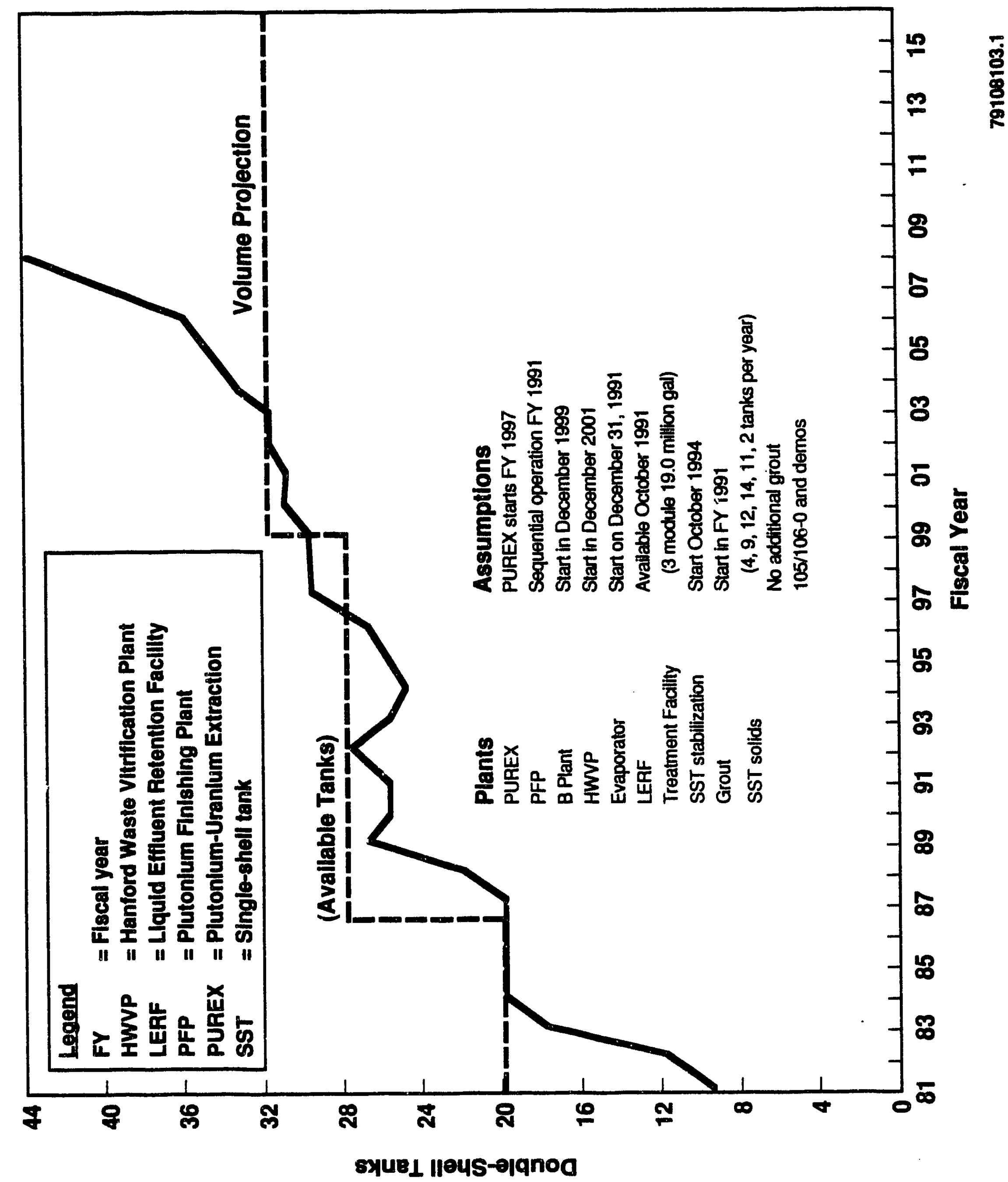
The case in which grouting operations are delayed indefinitely has a substantial impact on the baseline vitrification schedule. Pretreatment operations associated with the neutralized current acid waste (NCAW), neutralized cladding removal waste, Plutonium Finishing Plant, and CC wastes cannot be conducted because of limited tank space availability (Figure 7-3). Contingency measures to allow partial pretreatment operations are not acceptable alternatives. These include operation of the Tank Farm without a spare or contingency tank and the postponement of SST solids retrieval efforts until additional DSTs are constructed. The completion of seven grout vaults by the year FY 1996 would provide sufficient space to match tank space needs through the year 2002. Completion of the DST pretreatment and vitrification mission is therefore not possible on a timely schedule unless the DSS/DSSF wastes can be grouted or a greater number of additional DSTs constructed beyond the four DSTs already planned.

7.2 SINGLE-SHELL TANK REMEDIATION PROGRAM

Retrieval and pretreatment of the SSTs before disposal are being examined as part of an SST systems engineering study. A decision to retrieve the SSTs, other than tank 106-C, has not been made at this time. Thus, the potential need for DSTs to support remediation of the SSTs is based on potential retrieval scenarios for the SSTs. In order to establish bounding cases for additional tank space requirements, the following assumptions are used.

- Schedule and process integration
  - Pretreatment of DST waste will be complete by 2004.
  - Vitrification of DST wastes in the Hanford Waste Vitrification Plant (HWVP) will be complete by 2009.
- Retrieval operations
  - SST waste is retrieved during a 10-yr period (2006 to 2016).
  - Waste is diluted by three parts water, one part waste during retrieval operations.
  - Cross-site transfer will require one DST in the 200 West Area to collect and stage waste for transfer.
- Waste pretreatment operations
  - Waste partitioning will require two DSTs to serve as retrieval and lag storage tanks.
  - Pretreatment of the SST wastes will be completed using a TRUEX process over a 10-yr period.
- Low-level waste treatment
  - Low-level waste (LLW) treatment will be by a grout process sized to remain current with the waste partitioning operation.

Figure 7-3. Double-Shell Tank Volume Projection Assuming an Indefinite Delay in Grouting of the Double-Shell Slurry/ Double-Shell Slurry Feed Wastes.



- Feed to the LLW treatment facility will be from a set of 3,800 m^3 (1 million gal) DSTs that are dedicated to grout feed characterization. Characterization of the feed and validation of the grout formulation requires 6 months to complete. Thus, two characterization tanks are required for every 7,200 m^3 (2 million gal) of feed to be grouted in a year. The characterization tanks are devoted to grout characterization. One additional tank is needed to serve as a process feed tank.

- High-level waste treatment
  - The HWVP glass formulation assumes the following.
    - The HWVP reference glass formulation (derived from the NCAW formulation) is 25 wt% waste oxide [i.e., 21,300 Mt (46,860 ton) glass].
    - Phosphate limited glass--The HWVP borosilicate glass formulation is limited to 1 wt% phosphorus pentoxide being in the HWVP feed [i.e., 33,100 Mt (72,820 ton) of glass would be made].
  - The HWVP will produce 2.4 Mt (2.64 ton) of glass per operating day and will operate 256 days/yr.
  - Each vitrification campaign will last 24 months; at the end of each vitrification campaign, a 6-month maintenance outage will be performed to replace the melter.
  - Lag storage is required to sample HWVP feed and to order frit.
    - For the first SST feed batch, the HWVP feed storage volumes assume a 30-month storage time.
      - Twelve months lead time for sampling a full tank and obtaining results.
      - Eighteen months lead time for ordering frit once sample results are available.
    - For subsequent tanks of SST feed, the tanks are sampled and analyzed such that there is no schedule impact to HWVP operations.

The estimates of the number of DSTs needed to support the potential remediation of the SSTs are summarized in Table 7-1. These results consider two retrieval cases and two schedule cases, which illustrate sensitivity to tank volume needs. The retrieval cases consider the retrieval of 22 and 149 tanks. The schedule cases assume an accelerated environmental impact statement (EIS), which allows retrieval and pretreatment operations to commence simultaneously in the year 2006, and a second case also assumes an accelerated EIS in which retrieval begins in 2006 and pretreatment begins in 2008.

Table 7-1. Estimation of Double-Shell Tank Requirements for Single-Shell Tank Waste Retrieval Cases.

Tank function	Case 1 schedule Accelerated EIS, retrieval, and pretreatment begin in 2006		Case 2 schedule Accelerated EIS, retrieval begins in 2006; pretreatment begins in 2008	
	22 tanks retrieved	149 tanks retrieved	22 tanks retrieved	149 tanks* retrieved
Retrieval	2	2	2	2
Receipt/lag storage	2	2	2	2
Retrieval/lag storage	0	0	11	24
HWVP lag storage	2	12	2	12
HWVP feed	2	2	2	2
LLW receipt	1	3	3	3
LLW characterization	6	7	6	7
Grout feed	1	1	1	1
DST total	16	29	29	53

*Adapted from WHC-EP-0405-1, Table 2.4 (Boomer 1991).
DST = Double-shell tank
EIS = Environmental Impact Statement
HWVP = Hanford Waste Vitrification Plant
LLW = Low-level waste

These results show that the number of additional DSTs depends on the schedule for completion of the EIS assuming SST closure by the year 2018. Only cases in which the EIS is accelerated are considered because the tank needs to comply with the *Hanford Federal Facility Agreement and Consent Order* (also known as the Tri-Party Agreement) (Ecology 1990) milestone closure date of 2018, and the Record of Decision (DOE 1988) date of 2004 on DOE/EIS-0113, *Final Environmental Impact Statement: Disposal of Hanford Defense High-Level, Transuranic, and Tank Wastes, Hanford Site, Richland, Washington* (HDW-EIS) (DOE 1987), results in the need for an unreasonable volume of DST storage capacity. The double-shell Tank Farms currently have 28 tanks.

At the time of initiation of retrieval of the SSTs (assumed to be 2006), only three of the DSTs may be available for reuse because of the age of the existing tanks. However, four other DSTs planned for construction in the late 1990's will be available, bringing the total of potentially available DSTs to seven. Assuming these seven tanks will be available for use, at least 22 additional DSTs could be required to support complete retrieval of all 149 SSTs under the Case 1 assumptions, and 46 additional DSTs under Case 2. For the retrieval of 22 SSTs, nine additional DSTs are projected to be needed under Case 1 assumptions, and 22 additional DSTs are projected to be needed under Case 2 assumptions. The need for additional DSTs to support the potential retrieval of the SSTs is dependent on the retrieval and pretreatment schedules for the SSTs.

The number of additional DSTs to support retrieval of the SSTs can be minimized if the schedule for completion of the SST closure EIS is accelerated and SST retrieval and pretreatment facilities are constructed at an earlier date than that currently planned. In addition, consideration could be given to delaying the closure date for the SSTs beyond 2018 if a decision is made to retrieve all 149 SSTs. The impacts to the HWVP also should be considered in this examination.

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APPENDIX A

SUPPLEMENTAL RISK ANALYSIS RESULTS

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APPENDIX A

SUPPLEMENTAL RISK ANALYSIS RESULTS

This appendix presents a discussion of the risk analysis details not included in the main document and the results of several supplemental risk analyses performed to support the Risk Assessment.

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APPENDIX A

SUPPLEMENTAL RISK ANALYSIS RESULTS

A.1 RISK ASSESSMENT MODEL INPUT DATA

Each of the 210 activities listed in Table A-1 represents a task or grouping of tasks from the top-level schedule (Figure 4-4). The listing is a condensation of data taken from the Risk Assessment Report Forms [WHC-EP-0427 (Miller et al. 1991)]. The data resulted from the double-shell tank team assessment of the probability, time, and cost uncertainties associated with each activity. This information was the basis for the Venture Evaluation and Review Technique (VERT) analysis of the program.

The table is sorted on the facility/function column, which groups the activities into the following categories: characterization, grout, Hanford Waste Vitrification Plant, pretreatment facilities, retrieval, pretreatment technology, and Tank Farms.

The "MDL#" column provides the activity number for the task that can be referenced back to the top-level schedule. The time (in years) and cost (in thousands of dollars) required to complete the task is specified in terms of optimistic, pessimistic, most likely, and baseline estimates. A zero in the baseline column indicated that no formal estimate had been prepared for that scope of work. Delta calculations for the cost and schedule parameters are included in the listing for comparison purposes. These delta values were used in the calculation of the cost and schedule relative risk factors (RRF) discussed in Section A.9 of this appendix.

The "Funding Constr't FY Start" column identifies activities that have funding-constrained start dates or are constrained for other reasons. The start of the activity will be delayed to the fiscal year indicated.

A.2 CRITICAL COST ACTIVITY RISK RANKING LIST

Table A-2 lists program activities that have non-zero value cost RRFs. The activities are listed in descending cost relative risk factor (RRF_c) order. Discussion of the methodology used in establishing the RRF_c values is provided in Section A.9.

A.3 SCHEDULE/TIME RELATIVE RISK FACTOR RANKING LIST

Table A-3 lists the program activities that have non-zero value schedule RRFs. The activities are listed in descending schedule relative risk factor (RRF_s) order. Discussion of the methodology used in establishing the RRF_s values is provided in Section A.9.

Table A-1. Hanford Waste Vitrification Systems Risk Assessment Model Input Data. (sheet 1 of 5)

	ACTIVITY TITLE	FAC./ FUNCT.	MDL #	FUNDING CONSTR'T FY START	PROB.	SCHEDULE (YEARS) OPT.	PESM.	MST LK.	DELTA (ML-BL)	BSLN	DELTA (P-ML)	COST-CALCULATED ($000) OPT.	PESM.	MST LK.	DELTA (ML-BL)	BSLN	DELTA (P-ML)
1	CORE & CHARACTERIZATION (CC) FY91	CHAR	212CE01C	N/A	0.98	0.92	3.92	2.92	1.99	0.93	1.00	2892	3192	3092	2124	968	100
2	CHARACTERIZATION OF REMAINING CORES (CC)	CHAR	212CE02C	N/A	0.80	6.00	7.00	6.00	1.00	5.00	1.00	11300	12800	11800	8704	3096	1000
3	CORE SAMPLE AND CHARACTERIZE NCAW FY91	CHAR	212CE03N	N/A	0.98	0.58	0.58	0.58	0.00	0.58	0.00	1800	1800	1800	1014	786	0
4	CORE SAMPLE AND CHARACTERIZE REMAINING CORE	CHAR	212CE04N	N/A	0.98	2.58	4.58	2.58	0.99	1.59	2.00	9080	9840	9080	8118	962	760
5	2ND CORE AND CHARACTERIZATION NCRW (FY92)	CHAR	212CE05N	N/A	0.98	0.54	0.54	0.54	0.00	0.54	0.00	900	900	900	379	521	0
6	CHARACTERIZATION OF REMAINING CORES (NCRW)	CHAR	212CE06N	N/A	0.98	5.59	6.59	5.59	1.00	4.59	1.00	9500	11000	10000	7710	2290	1000
7	CORE SAMPLE AND CHARACTERIZATION (PFP) FY91	CHAR	212CE07P	FY93	0.98	0.58	0.58	0.58	-0.01	0.59	0.00	900	900	900	520	380	0
8	CHARACTERIZATION OF REMAINING CORES (PFP)	CHAR	212CE08P	N/A	0.98	4.60	5.60	4.60	1.00	3.60	1.00	5700	6400	5900	4000	1900	500
9	CHARACTERIZE GROUT DSSF & DSS	CHAR	212CE09D	FY92	0.98	4.10	5.10	4.10	0.00	4.10	1.00	1100	1300	1200	1137	63	100
10	DEVELOP/VERIFY GROUT FORMULATIONS	GRT	53G02	N/A	1.00	1.17	2.00	1.58	-3.19	4.77	0.42	1500	2700	2100	2100	0	600
11	TYPE 2 READINESS REVIEW (GROUT)	GRT	53G05	N/A	1.00	1.00	1.42	1.08	0.25	0.83	0.34	1000	1700	1300	-1300	2600	400
12	GROUT PERFORMANCE ASSESSMENT	GRT	53G07	N/A	1.00	0.83	2.00	1.25	0.42	0.83	0.75	500	1500	500	500	0	1000
13	GROUT PART B PERMIT	GRT	53G08	N/A	1.00	1.42	2.08	1.67	0.84	0.83	0.41	350	500	400	-400	800	100
14	GROUT SAFETY ANALYSIS REPORT (FSAR)	GRT	53G09	N/A	1.00	1.75	2.25	1.83	0.24	1.59	0.42	2800	3600	2800	-7000	9800	800
15	GROUT FACILITY MODIFICATIONS	GRT	53G10	N/A	1.00	1.92	2.08	2.00	-3.02	5.02	0.08	500	1000	700	-244873	245573	300
16	W-062 GROUT FEED TANK MODS	GRT	75062	N/A	1.00	1.08	1.08	1.08	0.00	1.08	0.00	1100	1100	1100	1100	0	0
17	B-340B GROUT FEED TANK MODS	GRT	75340	N/A	1.00	0.17	0.18	0.17	-0.17	0.34	0.01	10	20	15	15	0	5
18	GROUT DSS/DSSF OPERATIONS	GRT	AP000	N/A	0.87	5.25	7.00	5.50	2.00	3.50	1.50	233200	255200	244200	244200	0	11000
19	GROUT NCAW OPERATIONS	GRT	AP001	N/A	0.87	1.67	2.25	1.92	0.92	1.00	0.33	31800	34800	33300	33300	0	1500
20	GROUT NCRW OPERATIONS	GRT	AP002	N/A	0.87	2.17	2.92	2.42	0.42	2.00	0.50	21200	23200	22200	22200	0	1000
21	GROUT PFP OPERATIONS	GRT	AP003	N/A	0.87	3.42	4.58	3.67	2.59	1.08	0.91	10600	11600	11100	11100	0	500
22	GROUT CC OPERATIONS	GRT	AP004	N/A	0.87	2.92	3.92	3.17	0.25	2.92	0.75	159000	174000	166500	166500	0	7500
23	COMPLETE POST NCAW PROCESS DEVELOPMENT	HWVP	41000030	N/A	0.99	3.50	4.00	3.50	-0.27	3.77	0.50	7000	8000	7000	7000	0	1000
24	PERFORM CONSTRUCTION/ATP/CAT	HWVP	41000130	N/A	0.99	5.00	9.00	7.00	-0.02	7.02	2.00	669278	1034336	851807	104699	747108	182529
25	DESIGN SUFFICIENT TO START CONSTRUCTION	HWVP	4110110	N/A	1.00	0.33	0.50	0.33	-0.09	0.42	0.17	1143	1143	1143	0	1143	0
26	HWVP DETAILED DESIGN TITLE II	HWVP	4113104	N/A	0.99	3.00	4.00	3.00	0.24	2.76	1.00	113628	119608	143530	23922	119608	-23922
27	MONITOR DWPF LESSONS LEARNED	HWVP	4121010	N/A	0.99	6.98	8.91	7.75	-0.02	7.77	1.16	698	891	775	775	0	116
28	DESIGN AND CONSTRUCTION-EXCHANGE	HWVP	4121020	N/A	0.99	2.99	3.99	2.99	2.99	N/A	1.00	5941	7928	5941	3954	1987	1987
29	WASTE FORM DEVELOPMENT	HWVP	4122310	N/A	0.99	6.00	8.00	6.00	-0.11	6.11	2.00	91068	116924	91068	14768	76300	25856
30	WASTE FORM DEVELOPMENT	HWVP	412231A	N/A	0.99	6.00	8.00	6.00	0.00	6.00	2.00	90066	115588	90066	88986	1080	25522
31	FEED PROCESSING DEVELOPMENT	HWVP	4122320	N/A	1.00	3.00	3.00	3.00	-0.02	3.02	0.00	1017	1017	1017	0	1017	0
32	TRANSFER TECH TO DESIGN	HWVP	4122340	N/A	0.99	4.00	5.00	4.00	1.24	2.76	1.00	7908	9885	7908	1	7907	1977
33	PERFORM WFQ TESTING	HWVP	4122530	N/A	0.99	0.33	1.00	0.50	0.00	0.50	0.50	13611	41245	20623	20623	0	20623
34	ANALYZE AND INTEGRATE TECHNOLOGY	HWVP	4123210	N/A	0.99	7.75	9.00	7.75	-0.03	7.78	1.25	18368	21330	18368	68	18300	2963
35	ISSUE/APPROVE WQR	HWVP	4125110	N/A	0.99	0.08	0.75	0.25	0.25	N/A	0.50	1752	16425	5475	5475	0	10950
36	PERFORM PREOPERATIONAL TESTING	HWVP	4133070	N/A	0.99	2.50	4.17	2.92	-0.08	3.00	1.25	88264	130676	98930	24816	74114	31746
37	WHC INSPECT AND ACCEPT CONSTRUCTION	HWVP	4133333	N/A	0.98	0.08	1.00	0.08	-3.42	3.50	0.92	48	600	48	-2	50	552
38	PREPARE FINAL WASTE COMPLIANCE PLAN	HWVP	41750010	N/A	0.70	0.67	1.00	0.67	-0.08	0.75	0.33	280	418	280	1	279	138
39	INPUT COMPOSITION REQUIREMENT-NCRW FRIT PRO	HWVP	41CC1	N/A	0.99	1.50	2.00	1.50	0.00	1.50	0.50	2198	2930	2198	2198	N/A	733
40	INPUT COMPOSITION REQUIREMENT-PFP FRIT PROC	HWVP	41CC2	N/A	0.99	0.50	1.00	0.50	-1.00	1.50	0.50	733	1465	733	733	N/A	733
41	INPUT COMPOSITION REQUIREMENT-CC FRIT PROC	HWVP	41CC3	N/A	0.99	1.50	2.00	1.50	0.00	1.50	0.50	2198	2930	2198	2198	N/A	733
42	RECEIVE ACCEPTABLE FRIT FOR TESTING	HWVP	41DD1	N/A	0.99	1.00	2.00	1.50	0.00	1.50	0.50	950	1150	1000	0	1000	150
43	RECEIVE ACCEPTABLE FRIT FOR HOT STARTUP	HWVP	41DD2	N/A	0.99	1.00	2.00	1.50	-0.10	1.60	0.50	200	400	300	300	0	100
44	INPUT DESIGN POST NCAW FEED SPECS	HWVP	41F1A	N/A	1.00	5.00	5.83	5.58	5.57	0.01	0.25	15000	17490	16740	16740	0	750
45	PERFORM COLD TEST READINESS REVIEW	HWVP	41II1	N/A	0.99	0.83	1.25	1.00	0.00	1.00	0.25	1098	1654	1323	1323	N/A	331

Table A-1. Hanford Waste Vitrification Systems Risk Assessment Model Input Data. (sheet 2 of 5)

	ACTIVITY TITLE	FAC./ FUNCT.	MDL #	FUNDING CONSTR'T FY START	PROB.	SCHEDULE (YEARS) OPT.	SCHEDULE (YEARS) PESM.	SCHEDULE (YEARS) MST LK.	DELTA (ML-BL)	BSLN	DELTA (P-ML)	COST-CALCULATED ($000) OPT.	COST-CALCULATED ($000) PESM.	COST-CALCULATED ($000) MST LK.	DELTA (ML-BL)	BSLN	DELTA (P-ML)
46	DOE HQ KEY DECISION #3 APPROVAL TO START CONST	HWVP	41MD0004	N/A	0.99	0.08	1.00	0.08	0.00	0.08	0.92	48	600	48	-2	50	552
47	DOE RL APPROVE PSAR	HWVP	41MD0156	N/A	0.99	0.42	1.00	0.42	0.42	N/A	0.58	1122	2671	1122	9	1113	1549
48	APPROVE FSAR	HWVP	41MD0157	N/A	0.99	7.50	8.33	7.75	7.75	N/A	0.58	2538	2538	2538	2538	0	0
49	ECOLOGY ISSUE RCRA PART B/CAA PERMIT	HWVP	41MD0469	N/A	0.99	0.75	2.17	0.75	0.75	N/A	1.42	2040	5902	2040	-3	2043	3862
50	ISSUE REVISED RCRA PART B PERMIT	HWVP	41MD0531	N/A	0.99	0.50	1.50	1.00	-2.26	3.26	0.50	245	734	489	489	0	245
51	PERFORM HOT OPS READINESS REVIEW	HWVP	41MW0050	N/A	1.00	3.08	3.58	3.17	1.91	1.26	0.41	8633	10035	8886	8886	0	1149
52	INITIATE HWVP HOT OPERATIONS	HWVP	41MW0053	N/A	0.99	0.08	0.25	0.08	0.08	N/A	0.17	6187	19334	6187	6187	0	13147
53	PERFORM OPERATIONAL TESTING	HWVP	41MW0532	N/A	0.99	0.75	1.30	0.92	-0.08	1.00	0.38	77356	134083	94890	94890	0	39194
54	PROCURE EQUIPMENT IN TIME	HWVP	41W1	N/A	0.99	7.00	8.00	7.00	-0.10	7.10	1.00	196970	240256	208919	0	208919	31337
55	INPUT COMPOSITION REQUIREMENT-NCAW FRIT PRO	HWVP	41Z1	N/A	0.99	0.50	1.00	0.50	-0.17	0.67	0.50	1465	2930	1465	0	1465	1465
56	NCRW FRIT-HWVP	HWVP	AN101T20	N/A	0.99	1.00	2.00	1.50	0.00	1.50	0.50	950	1150	1000	1000	0	150
57	NCRW OPERATIONS-HWVP	HWVP	AN101T21	N/A	0.95	0.83	1.50	1.08	-0.01	1.09	0.42	77729	129543	97063	97063	0	32480
58	CC FRIT-HWVP	HWVP	AW101T24	N/A	0.99	0.50	1.00	0.75	-0.50	1.25	0.25	475	575	500	500	0	75
59	CC OPERATIONS - HWVP	HWVP	AW101T25	N/A	0.95	0.85	1.25	1.05	0.01	1.04	0.20	45627	60971	53299	53299	0	7672
60	CC FRIT-HWVP (CONT)	HWVP	AW101T26	N/A	1.00	0.50	1.00	0.75	-0.50	1.25	0.25	475	575	500	500	0	75
61	CC OPERATIONS - HWVP (CONT)	HWVP	AW101T27	N/A	1.00	0.85	1.25	1.05	0.01	1.04	0.20	45627	60971	53299	53299	0	7672
62	PFP FRIT-HWVP	HWVP	AW103T2	N/A	0.99	1.00	2.00	1.50	0.00	1.50	0.50	950	1150	1000	1000	0	150
63	PFP OPERATIONS-HWVP	HWVP	AW103T20	N/A	0.95	0.30	0.60	0.30	-0.03	0.33	0.30	27267	50367	27267	27267	0	23100
64	102-AY CHAR/FRIT PROC NCAW	HWVP	AY102T20	N/A	0.99	1.00	2.00	1.50	0.00	1.50	0.50	950	1150	1000	1000	0	150
65	102-AY NCAW SOLIDS TRANS/VITRIFY AT HWVP	HWVP	AY102T21	N/A	0.98	1.00	2.25	1.25	0.00	1.25	1.00	89834	186502	109168	109168	0	77334
66	101-AZ CHAR/FRIT PROC NCAW	HWVP	AZ101T20	N/A	0.99	1.00	2.00	1.50	0.00	1.50	0.50	950	1150	1000	1000	0	150
67	101-AZ NCAW SOLIDS TRANS/VITRIFY AT HWVP	HWVP	AZ101T21	N/A	0.99	0.58	1.25	0.67	0.00	0.67	0.58	52993	104583	59923	59923	0	44660
68	REPLACE MELTER #1/TEST & STARTUP	HWVP	MELTER1	N/A	0.99	0.50	2.00	1.00	0.00	1.00	1.00	51167	167168	89834	89834	0	77334
69	REPLACE MELTER #2/TEST & STARTUP	HWVP	MELTER2	N/A	0.99	0.50	2.00	1.00	0.00	1.00	1.00	51167	167168	89834	89834	0	77334
70	B PLANT READINESS REVIEW-WHC/DOE	PTFAC	130101	N/A	0.98	0.38	0.48	0.42	-0.99	1.41	0.06	190	240	210	-1600	1810	30
71	B PLANT SYSTEM OPERABILITY TESTING	PTFAC	1310	N/A	0.98	4.17	4.67	4.17	-0.16	4.33	0.50	8000	8000	8000	-5387	13387	0
72	B PLANT FACILITY SAR	PTFAC	132210	N/A	0.98	3.00	6.00	4.00	-0.01	4.01	2.00	5700	5700	5700	2597	3103	0
73	B PLANT ADMINISTRATIVE MANUAL UPGRD	PTFAC	13233	N/A	1.00	0.50	1.50	1.00	0.95	0.05	0.50	250	750	500	500	0	250
74	B PLANT TRAINING	PTFAC	13243010	FY92	0.99	0.67	2.00	1.00	-3.92	4.92	1.00	150	420	210	-5015	5225	210
75	W-003 CHEM SEWER ENVIRONMENTAL UPGRD	PTFAC	133003	N/A	1.00	1.33	2.00	1.33	-0.15	1.48	0.67	1108	1700	1108	990	118	592
76	W-004 B PLANT AMU UPGRD	PTFAC	133004	N/A	0.99	1.17	2.42	1.42	0.48	0.94	1.00	875	1675	875	800	75	800
77	W-007 B PLANT PROCESS CONDENSATE FAC	PTFAC	133007	N/A	0.99	1.00	3.92	2.92	-0.26	3.18	1.00	2000	15200	14700	13245	1455	500
78	W-008 B PLANT CHEM SEWER NEUTRALIZATION	PTFAC	133008	N/A	1.00	0.19	0.25	0.21	-0.04	0.25	0.04	1131	1200	1131	1007	124	69
79	W-010 B PLANT ENVIRONMENTAL COMPLIANCE	PTFAC	133010	N/A	0.99	1.00	2.00	1.42	-0.20	1.62	0.58	3500	4500	3500	2234	1266	1000
80	W-024 B PLANT RAD EFFLUENT AND CONTAINMENT UP	PTFAC	133024	N/A	0.70	2.50	6.00	4.33	-0.10	4.43	1.67	1200	57000	18000	14339	3661	39000
81	W-098 HAZARD WASTE STORAGE	PTFAC	133098	N/A	1.00	0.00	3.75	3.75	0.53	3.22	0.00	500	750	750	309	441	0
82	W-107 BCS TREATMENT CENRIC	PTFAC	133107	N/A	1.00	2.50	3.50	2.75	-0.24	2.99	0.75	1650	4000	2134	1626	508	1866
83	W-108 BCE TREATMENT FACILITY	PTFAC	133108	N/A	0.99	0.00	3.50	2.75	-0.24	2.99	0.75	1000	5000	1200	-245	1445	3800
84	CLEAN WATER ACT-BCE	PTFAC	133200	N/A	0.98	3.00	5.00	4.00	2.85	1.15	1.00	600	1000	800	800	0	200
85	CLEAN WATER ACT-BCP	PTFAC	133201	N/A	0.98	3.00	5.00	4.00	2.85	1.15	1.00	600	1000	800	800	0	200
86	CLEAN WATER ACT-BCS	PTFAC	133202	FY92	0.98	3.00	5.00	4.00	2.85	1.15	1.00	600	1000	800	800	0	200
87	CLEAN WATER ACT-CBC	PTFAC	133203	N/A	0.98	3.00	5.00	4.00	2.85	1.15	1.00	600	1000	800	800	0	200
88	CLEAN WATER ACT-PROJECT W-107	PTFAC	133300	FY92	0.98	1.33	2.67	1.33	0.58	0.75	1.34	450	900	450	450	0	450
89	CLEAN WATER-PROJECT W-098	PTFAC	133310	FY92	0.98	1.33	2.67	1.33	0.58	0.75	1.34	150	302	150	150	0	151
90	CLEAN AIR ACT-NCAW PROCESSING	PTFAC	133320	N/A	0.98	1.33	2.67	1.33	1.19	0.14	1.34	150	302	150	150	0	151

Table A-1. Hanford Waste Vitrification Systems Risk Assessment Model Input Data. (sheet 3 of 5)

	ACTIVITY TITLE	FAC./ FUNCT.	MDL #	FUNDING CONSTR'T FY START	PROB.	SCHEDULE (YEARS) OPT.	PESM.	MST LK.	DELTA (ML-BL)	BSLN	DELTA (P-ML)	COST-CALCULATED ($000) OPT.	PESM.	MST LK.	DELTA (ML-BL)	BSLN	DELTA (P-ML)
91	B-PLANT PART B APPLICATION	PTFAC	1339000	FY92	0.70	2.00	3.00	2.50	1.50	1.00	0.50	3500	3500	3500	1590	1910	0
92	B PLANT INTERIM STATUS ACTIONS BIS/BPL	PTFAC	133901	N/A	1.00	1.28	1.63	1.42	0.00	1.42	0.21	50	50	50	50	0	0
93	B PLANT TANK INTEGRITY ASSESSMENT	PTFAC	133903	N/A	0.98	1.50	4.50	2.50	1.00	1.50	2.00	4400	4900	4400	4400	0	500
94	W-002 CANYON CRANE REPLACEMENT	PTFAC	134002	N/A	0.98	5.33	6.33	5.33	0.79	4.54	1.00	10400	12600	12600	10159	2441	0
95	W-040 CELL 18 CESIUM IX COL	PTFAC	134040	N/A	1.00	1.50	3.50	1.50	-0.32	1.82	2.00	747	927	777	303	474	150
96	W-056 IIWC/PHPF PC VALVE PH I	PTFAC	134056	N/A	0.99	2.50	3.92	2.92	-0.26	3.18	1.00	1200	1500	1200	70	1130	300
97	W-059 CAT I VENTILATION UPGRD	PTFAC	134059	N/A	0.99	4.33	5.17	4.83	-0.20	5.03	0.34	24200	26000	24200	22459	1741	1800
98	W-065 WH/IX/SD PROCESS CONTRL VALVE	PTFAC	134065	N/A	0.99	2.50	3.92	2.92	-0.10	3.02	1.00	1200	1500	1200	551	649	300
99	W-077 CT/CS PROCESS CONTROL VALVE UPGRD	PTFAC	134077	N/A	0.98	2.50	3.92	2.92	-0.10	3.02	1.00	1200	1500	1200	507	693	300
100	W-103 ON DECK SAMPLING IMPROVEMENT	PTFAC	134103	N/A	0.99	2.50	5.00	2.50	-0.17	2.67	2.50	2000	5000	2000	2000	0	3000
101	W-159 CT/CS INSTRUMENT UPGRD	PTFAC	134159	N/A	0.99	2.50	3.58	2.58	-0.14	2.72	1.00	1200	1500	1200	1200	0	300
102	W-161 TRU MONITOR	PTFAC	134161	FY92	0.70	4.33	6.06	4.67	1.86	2.81	1.41	421	632	505	505	0	127
103	W-161 TRU MONITOR CONTINUED	PTFAC	1341611	N/A	1.00	1.35	1.72	1.50	0.10	1.40	0.22	675	860	750	750	0	110
104	W-162 IX MECHANICAL EQUIPMENT UPGRD	PTFAC	134162	N/A	0.99	2.50	3.50	3.00	0.63	2.37	0.50	860	1200	860	860	0	340
105	W-163 CELL DRAINAGE AND VESSEL VENT INSTRUMEN	PTFAC	134163	N/A	1.00	1.50	2.50	1.50	-1.06	2.56	1.00	266	500	266	266	0	234
106	NCAW JUMPER CONSTRUCTION	PTFAC	134700	N/A	1.00	4.67	6.67	5.67	1.91	3.76	1.00	150	250	200	-1749	1949	50
107	W-027 271B HVAC UPGRD	PTFAC	136027	N/A	0.99	2.50	5.00	3.50	0.26	3.24	1.50	2500	5000	3500	2837	663	1500
108	W-102 GALLERY EXHAUST VENT	PTFAC	136102	N/A	0.98	3.08	3.93	3.42	-0.11	3.53	0.51	200	700	492	-1444	1936	208
109	W-104 B PLANT OPS SUPPORT BUILDING	PTFAC	136104	N/A	0.99	3.60	4.60	4.00	-0.02	4.02	0.60	1200	1200	1200	840	360	0
110	W-160 IN CELL AND HPT LEAK DETECTION	PTFAC	136160	N/A	0.99	2.00	6.00	3.83	-0.35	4.18	2.17	980	1380	1150	1150	0	230
111	W-168 B PLANT FILTER SYSTEM TIE-IN	PTFAC	136168	N/A	0.99	0.33	1.33	0.83	0.32	0.51	0.50	250	350	300	300	0	50
112	CAM UPGRD-B PLANT ENVIRONMENTAL	PTFAC	136220	N/A	1.00	1.25	2.00	1.50	-0.80	2.30	0.50	250	250	250	250	0	0
113	RADIATION AREA MONITOR	PTFAC	136230	N/A	1.00	0.58	3.00	2.83	2.27	0.56	0.17	200	200	200	200	0	0
114	B-PLANT CANYON EXHAUST FILTER SYSTEMS	PTFAC	136250	N/A	1.00	3.17	3.67	3.67	1.51	2.16	0.00	2240	2240	2240	1344	896	0
115	W-094 291B FILTER INSTRUMENTATION UPGRD	PTFAC	1362501	N/A	1.00	0.82	0.84	0.83	-1.10	1.93	0.01	410	420	415	415	0	5
116	B-625 SAND FILTER VENT DUCT	PTFAC	136260	N/A	1.00	0.50	0.60	0.50	-0.35	0.85	0.10	100	100	100	100	0	0
117	SEISMIC ANALYSIS-B PLANT	PTFAC	136431	N/A	0.99	2.50	6.00	3.50	0.83	2.67	2.50	1000	2000	1500	634	866	500
118	W-128 B PLANT CELL CLEANOUT	PTFAC	137128	N/A	0.98	5.00	10.00	7.00	-0.65	7.65	3.00	26000	78000	39000	39000	0	39000
119	W-095 NCRW PROCESS MODIFICATIONS-B PLANT	PTFAC	137200	FY93	0.98	7.12	7.14	7.13	-0.03	7.16	0.01	192410	252050	251837	251837	0	213
120	W-095 NCRW PROCESS MODIFICATIONS (CONT)	PTFAC	1372001	N/A	0.98	2.87	2.89	2.88	-0.02	2.90	0.01	78590	102950	102836	102836	0	114
121	PFP PROCESS MODIFICATIONS-B PLANT	PTFAC	137300	N/A	0.98	4.17	6.42	5.17	-0.26	5.43	1.25	13200	13200	13200	13200	0	0
122	PFP PROCESS MODIFICATIONS (CONT)/STARTUP	PTFAC	1373001	N/A	0.98	3.17	5.42	4.17	0.35	3.82	1.25	10800	10800	10800	10800	0	0
123	W-096 CC/OXIDATION MODIFICATIONS-B PLANT	PTFAC	137400	FY94	0.98	5.55	7.10	6.17	-0.01	6.18	0.93	13920	13920	13920	13920	0	0
124	W-096 CC/OXIDATION MODIFICATIONS (CONT)/STARTU	PTFAC	1374001	N/A	0.98	3.90	4.98	4.33	-0.04	4.37	0.65	10080	10080	10080	10080	0	0
125	AR VLT OPS/WFQ SOLIDS WASHING	PTFAC	24400000	N/A	0.99	0.25	1.00	0.50	0.27	0.23	0.50	300	1000	500	500	0	500
126	AR VLT READINESS REVIEW (WHC & DOE)	PTFAC	2440001	N/A	1.00	1.17	3.00	2.00	0.85	1.15	1.00	1200	3000	2000	1845	155	1000
127	AR VLT SYSTEM OPERABILITY TESTING	PTFAC	24400013	FY92	0.99	3.25	6.25	4.33	0.06	4.27	1.92	10800	41700	14400	14400	0	27300
128	W-091 AR VLT COMPRESSOR UPGRD	PTFAC	244091	N/A	1.00	0.22	0.29	0.25	-0.03	0.28	0.04	180	180	180	0	180	0
129	W-110 AR VLT TRANSFER LINE AND DIESEL FUEL	PTFAC	244110	N/A	0.98	3.33	4.33	3.83	0.08	3.75	0.50	2000	4000	2000	2000	0	2000
130	W-111 AR VLT SEAL POT AND VESSEL VENT	PTFAC	244111	N/A	0.98	3.33	6.00	3.83	0.45	3.38	2.17	1700	4200	2000	2000	0	2200
131	W-135 AR VLT SLUDGE WASHING PROCESS MODS	PTFAC	244135	N/A	0.98	3.42	6.25	4.00	0.61	3.39	2.25	2200	4200	2200	2200	0	2000
132	W-136 AR VLT SLUDGE WASHING CONTROL ROOM MO	PTFAC	244136	N/A	0.98	2.83	4.58	3.67	0.82	2.85	0.91	2000	4200	2400	2400	0	1800
133	AR VLT SAR	PTFAC	244207	FY92	0.99	2.48	3.16	2.75	-0.01	2.76	0.41	2480	3160	2750	1112	1638	410
134	AR VLT-FACILITY DESCRIPTION MANUAL	PTFAC	2442135	FY93	0.99	0.50	2.00	1.00	0.59	0.41	1.00	120	480	240	222	18	240
135	AR VLT ENVIRONMENTAL PERMITTING	PTFAC	24422800	N/A	0.70	2.00	3.00	2.00	0.01	1.99	1.00	2000	2500	2000	1951	49	500

Table A-1. Hanford Waste Vitrification Systems Risk Assessment Model Input Data. (sheet 4 of 5)

	ACTIVITY TITLE	FAC./ FUNCT.	MDL #	FUNDING CONSTR'T FY START	PROB.	SCHEDULE (YEARS) OPT.	PESM.	MST LK.	DELTA (ML-BL)	BSLN	DELTA (P-ML)	COST-CALCULATED ($000) OPT.	PESM.	MST LK.	DELTA (ML-BL)	BSLN	DELTA (P-ML)
136	AR VLT ENVIRONMENTAL ANALYSIS	PTFAC	244235	FY92	0.99	0.50	1.50	1.00	0.01	0.99	0.50	60	180	120	-180	300	60
137	AR VLT TRAINING	PTFAC	2442356	FY94	0.99	0.67	2.00	1.00	0.42	0.58	1.00	150	420	210	184	26	210
138	AR VLT TANK INTEGRITY ASSESSMENT	PTFAC	24424	FY92	0.99	0.50	1.00	0.67	0.21	[illegible]	0.33	140	140	140	139	1	0
139	AR VLT SEISMIC ANALYSIS	PTFAC	244253	N/A	0.99	0.50	1.00	0.75	-0.49	1.24	0.25	250	300	300	224	76	0
140	AR VLT CANYON CRANE INSPECTION/UPGRD	PTFAC	24430241	FY92	0.98	1.92	4.00	2.00	1.00	1.00	2.00	100	1000	300	113	187	700
141	AR VLT NEW CANYON EQUIPMENT	PTFAC	2443031	FY92	0.99	1.05	1.35	1.17	0.05	1.12	0.18	250	250	250	191	59	0
142	CC PRETREATMENT OPERATIONS-B PLANT	PTFAC	AN102T1	N/A	0.95	2.40	3.20	2.50	0.67	1.83	0.70	24000	32000	25000	25000	0	7000
143	CC PRETREAMENT OPERATIONS (CONT)	PTFAC	AN106T2	N/A	1.00	2.40	3.20	2.50	1.41	1.09	0.70	24000	32000	25000	25000	0	7000
144	PFP PRETREATMENT OPERATIONS-B PLANT	PTFAC	AW101T2	N/A	0.95	1.00	1.25	1.09	0.00	1.09	0.16	15000	20000	17000	17000	0	3000
145	NCRW PRETREATMENT OPERATIONS-B PLANT	PTFAC	AW103T1	N/A	0.95	1.80	2.21	2.00	0.00	2.00	0.21	18000	24000	20000	20000	0	4000
146	101-AZ NCAW TRANS/PRETREAT AT AR VLT/B PLANT	PTFAC	AZ101T10	N/A	0.99	1.42	1.82	1.58	-0.01	1.59	0.24	14200	18200	15800	15800	0	2400
147	102-AZ NCAW TRANS/PRETREAT AT AR VLT/B PLANT	PTFAC	AZ102T10	N/A	0.99	0.90	1.15	1.00	0.00	1.00	0.15	9000	11500	10000	10000	0	1500
148	GROUT FEED SPEC	PTFAC	NEWGRT	N/A	1.00	0	0	0	0.16	N/A	0.00	10	20	15	15	0	5
149	W-151 101AZ RETRIEVAL SYS PROCESS TEST	RTRVL	213A	N/A	0.99	6.00	8.50	7.50	3.50	4.00	1.00	26000	38800	34700	34700	0	4100
150	NCAW TANK 101-AZ PROCESS TEST	RTRVL	213A1088	N/A	0.50	0.70	1.20	0.70	0.01	0.69	0.50	2000	3400	2000	210	1790	1400
151	W-148 NCAW 4 PUMP RETRIEVAL SYSTEM ENG & PROC	RTRVL	213B	N/A	0.99	7.30	9.30	7.30	1.20	6.10	2.00	4000	4670	4000	-2640	6640	670
152	W-148 NCAW 4 PUMP RETRIEVAL SYSTEM INSTALLATI	RTRVL	213B-1	N/A	0.99	2.00	3.00	2.00	2.00	N/A	1.00	4000	6000	4000	4000	N/A	2000
153	102-AY SOLIDS-WASH OR RETRIEVE	RTRVL	213C	N/A	0.95	8.80	11.80	9.80	3.95	5.85	2.00	27000	35700	30700	9528	21172	5000
154	NCRW RETRIEVAL PROCESS TEST PREPARATIONS	RTRVL	213D	FY93	0.98	5.00	8.00	6.00	0.98	5.02	2.00	23000	36200	28700	9923	18777	7500
155	NCRW PROCESS TEST	RTRVL	213D0024	N/A	0.90	0.80	3.80	1.80	1.05	0.75	2.00	1500	7100	3400	2650	750	3700
156	CC EAST RETRIEVAL PROCESS TEST PREPARATIONS	RTRVL	213E	FY94	0.99	7.00	10.00	8.00	-0.04	8.04	2.00	24000	34100	28700	12033	16667	5400
157	CC PROCESS TEST EAST AREA PROCESS TEST	RTRVL	213E0024	N/A	0.70	0.80	3.80	1.80	1.05	0.75	2.00	1500	7100	3400	2650	750	3700
158	CC WEST RETRIEVAL PROCESS TEST PREPARATIONS	RTRVL	213F	FY93	0.99	6.00	9.00	7.00	0.98	6.02	2.00	24000	35500	29100	10337	18763	6400
159	CC PROCESS TEST WEST AREA	RTRVL	213F0024	N/A	0.98	0.30	3.80	1.80	0.96	0.84	2.00	1500	7100	3400	2650	750	3700
160	SMALL SCALE NCRW RETRIEVAL SYSTEM	RTRVL	215H0A	N/A	0.70	6.60	9.60	7.60	3.97	3.63	2.00	7000	11500	9800	9260	540	1700
161	SMALL SCALE CC SUPERNATE TRANSFER SYSTEM	RTRVL	215H0B	FY95	0.99	3.00	6.00	4.00	2.15	1.85	2.00	6000	12800	9600	9600	0	3200
162	SMALL SCALE CC SOLIDS RETRIEVAL SYSTEM	RTRVL	215H0C	N/A	0.98	9.60	12.60	10.60	6.33	4.27	2.00	9000	13300	11800	11800	0	1500
163	SMALL SCALE PFP SOLIDS RETRIEVAL SYSTEM	RTRVL	215H0E	N/A	0.98	7.80	10.80	8.80	3.62	5.18	2.00	22000	30800	26200	23950	2250	4600
164	W-028 AGING WASTE TRANSFER LINES	RTRVL	75028	N/A	0.99	3.30	4.00	3.30	0.00	3.30	0.70	15000	17500	15000	13885	1115	2500
165	W-066 AZ TANK FARM ELECTRICAL UPGRADE	RTRVL	75066	N/A	0.99	3.00	4.00	3.00	2.00	1.00	1.00	900	1200	900	-200	1100	300
166	W-106 TWREHO	RTRVL	75106	N/A	1.00	1.80	2.40	1.80	0.88	0.92	0.60	300	370	300	300	0	70
167	CC EAST RETRIEVAL SYSTEM	RTRVL	AN102RSA	FY98	0.99	4.20	7.20	5.20	1.02	4.18	2.00	800	1400	1000	-2980	3980	400
168	CC EAST RETRIEVAL SYSTEM (CONT)	RTRVL	AN102RSB	N/A	1.00	3.30	6.30	4.30	1.04	3.26	2.00	31200	60700	45800	32680	13120	14900
169	DSSF RETRIEVAL SYSTEMS	RTRVL	AW101RS0	N/A	0.95	10.30	13.30	11.30	2.77	8.53	2.00	48000	69600	62100	48240	13860	7500
170	NCRW RETRIEVAL SYSTEM	RTRVL	AW103RSA	FY95	0.99	3.50	6.50	4.50	0.98	3.52	2.00	400	700	500	-820	1320	200
171	NCRW RETRIEVAL SYSTEM (CONT)	RTRVL	AW103RSB	N/A	1.00	3.20	6.20	4.20	0.95	3.25	2.00	15600	31100	22900	16340	6560	8200
172	102-AZ NCAW RETRIEVAL SYSTEM	RTRVL	AZ102RS0	N/A	0.99	7.40	9.40	8.90	1.87	7.03	0.50	16000	20800	19600	16320	3280	1200
173	CC WEST RETRIEVAL SYSTEM	RTRVL	SY101RSA	N/A	0.99	3.50	6.50	4.50	0.93	3.57	2.00	400	700	500	-820	1320	200
174	CC WEST RETRIEVAL SYSTEM (CONT)	RTRVL	SY101RSB	N/A	1.00	3.30	6.30	4.30	1.04	3.26	2.00	15600	30400	22900	20640	2260	7500
175	PFP RETRIEVAL SYSTEM	RTRVL	SY102RS0	FY94	0.95	7.00	10.00	8.00	0.97	7.03	2.00	16000	25000	21300	17820	3480	3700
176	ION EXCHANGE TECHNOLOGY	TECH	214A0	N/A	0.90	0.92	3.58	2.08	0.85	1.23	1.50	85	1105	1105	1018	87	0
177	DRAFT FINAL FLOWSHEET FOR AR VAULT/B PLANT	TECH	214A0305	N/A	0.99	0.50	0.50	0.50	-0.01	0.51	0.00	100	150	150	150	0	0
178	ENG EVAL OF FLOC OPT TEST	TECH	214A0310	FY92	0.99	0.50	1.25	0.83	0.33	0.50	0.42	120	180	120	-16	136	60
179	ENG EVAL FOR PH CONTROL	TECH	214A0320	FY92	0.99	0.50	1.25	0.83	0.04	0.79	0.42	174	255	174	3	171	81
180	TRU MONITOR-HOT PROTOTYPE	TECH	214A1	N/A	0.80	3.50	5.50	4.50	0.68	3.82	1.00	1663	2613	2138	1769	369	475

Table A-1. Hanford Waste Vitrification Systems Risk Assessment Model Input Data. (sheet 5 of 5)

				FUNDING		SCHEDULE (YEARS)						COST-CALCULATED ($000)					
	ACTIVITY TITLE	FAC./ FUNCT.	MDL #	CONSTR'T FY START	PROB.	OPT.	PESM.	MST LK.	DELTA (ML-BL)	BSLN	DELTA (P-ML)	OPT.	PESM.	MST LK.	DELTA (ML-BL)	BSLN	DELTA (P-ML)
181	TRUEX PROCESS DEVELOPEMENT	TECH	215A01	N/A	0.80	2.25	5.67	4.67	-0.23	4.90	1.00	4210	5700	5200	4425	775	500
182	CC PROCESS DEVELOPMENT-PHASE I	TECH	215A021	N/A	0.90	0.92	1.67	1.17	0.17	1.00	0.50	725	725	725	725	0	0
183	CC PROCESS DEVELOPMENT- PHASE II	TECH	215A022	N/A	1.00	3.50	4.17	4.17	-0.59	4.76	0.00	1850	4450	2225	2225	0	2225
184	W-153 TRUEX PILOT PLANT	TECH	215B	N/A	0.99	5.25	7.25	6.25	0.58	5.67	1.00	25000	100000	35000	27460	7540	65000
185	TRUEX PILOT PLANT SCALE TEST WITH NCRW	TECH	215C0011	N/A	0.80	0.75	2.50	1.00	0.24	0.76	1.50	750	1500	1000	250	750	500
186	TRUEX PILOT PLANT SCALE TEST WITH CC WASTE	TECH	215C0013	N/A	0.80	0.75	1.00	1.00	0.26	0.74	0.00	750	1500	1000	20	980	500
187	TRUEX PILOT PLANT SCALE TEST WITH PFP WASTE	TECH	215C0015	N/A	0.80	0.75	1.00	1.00	0.23	0.77	0.00	750	1500	1000	250	750	500
188	TRUEX PILOT PLANT SCALE TEST WITH CC SOLIDS	TECH	215C0017	N/A	0.80	0.75	1.00	1.00	0.25	0.75	0.00	750	1500	1000	250	750	500
189	FINAL FLOWSHEET NCRW TRUEX	TECH	215C052	N/A	0.99	0.50	0.51	0.50	0.00	0.50	0.01	100	102	100	0	100	2
190	FINAL FLOWSHEET CC TRUEX	TECH	215C0525	N/A	0.99	0.50	0.51	0.50	0.00	0.50	0.01	100	102	100	0	100	2
191	FINAL CC DISSOLUTION FLOWSHEET	TECH	215C0526	N/A	0.99	0.50	0.51	0.50	0.00	0.50	0.01	100	102	100	0	100	2
192	FINAL FLOWSHEET PFP TRUEX	TECH	215C0528	N/A	0.99	0.50	0.51	0.50	0.00	0.50	0.01	100	102	100	100	0	2
193	PILOT PLANT REDESIGN & MINOR MODS-PFP SOLIDS	TECH	215D0013	N/A	1.00	0.25	1.25	1.00	0.76	0.24	0.25	100	3000	1000	900	100	2000
194	PILOT PLANT REDESIGN & MINOR MODS-CC TRUEX	TECH	215D0015	N/A	1.00	0.50	1.25	1.00	0.49	0.51	0.25	100	3000	1000	850	150	2000
195	PILOT PLANT REDESIGN AND MINOR MODS-CC SOLIDS	TECH	215D0019	N/A	1.00	0.25	1.25	1.00	0.75	0.25	0.25	100	3000	1000	950	50	2000
196	OXIDATION PILOT PLANT	TECH	215E	N/A	0.99	4.00	4.72	4.00	-0.02	4.02	0.72	14465	16989	14465	7115	7350	2524
197	CC ORGANIC DEST PILOT PLANT HOT TESTS	TECH	215F0013	N/A	0.99	0.75	0.88	0.75	0.00	0.75	0.13	2712	3167	2712	1962	750	455
198	CC ORGANIC DESTRUCTION PILOT PLANT COLD TESTS	TECH	215F0014	N/A	0.70	0.67	0.79	0.67	-1.00	1.67	0.12	2423	2844	2423	2423	0	421
199	FINAL FLOWSHEET CC ORGANIC DESTRUCTION	TECH	215F0528	N/A	0.99	0.50	0.52	0.50	0.02	0.48	0.02	90	94	90	-10	100	4
200	W-30 DST STORAGE VENT UPGRD	TKFRM	75030	N/A	1.00	2.75	7.08	3.08	-0.25	3.33	4.00	22200	33100	24600	23150	1450	8500
201	W-058 CROSS SITE TRANSFER LINE	TKFRM	75058	N/A	1.00	2.67	2.92	2.67	-3.25	5.92	0.25	48975	50115	48975	22975	26000	1140
202	103/104/105-AN SAFETY ISSUE RESOLUTION	TKFRM	75AN103S	N/A	0.90	1.00	2.00	1.50	1.49	0.01	0.50	2500	3500	3000	3000	0	500
203	101-SY SAFETY ISSUE RESOLUTION	TKFRM	75SY101S	N/A	0.90	2.00	11.00	3.00	0.96	2.04	8.00	12000	30000	14000	14000	0	16000
204	103-SY SAFETY ISSUE RESOLUTION	TKFRM	75SY103S	N/A	0.90	1.00	9.50	1.50	1.50	N/A	8.00	2500	11000	3000	3000	0	8000
205	TANK FARMS CAPITAL UPGRD	TKFRM	75TF01	N/A	0.98	6.00	9.00	7.00	7.00	N/A	2.00	455400	538200	483000	483000	0	55200
206	TANK FARMS MAJOR MAINTENANCE UPGRD	TKFRM	75TF02	N/A	0.99	6.00	9.00	7.00	7.00	N/A	2.00	56568	66852	59996	59996	0	6856
207	TANK FARMS OPERATIONS AND ADMINISTRATIVE UPG	TKFRM	75TF03	N/A	0.99	6.00	9.00	7.00	7.00	N/A	2.00	66942	79113	70999	70999	0	8114
208	TANK FARMS DOCUMENTATION UPGRD	TKFRM	75TF04	N/A	0.99	5.00	9.00	7.00	6.99	0.01	2.00	22000	26800	24400	24400	0	2400
209	AVAILABLE EAST AREA HOLDING TANK-CC TRANSFER	TKFRM	SY101T	N/A	1.00	1.80	2.30	2.08	-0.01	2.09	0.22	1248	1378	1321	1321	0	57
210	AVAILABLE EAST AREA HOLDING TANK-PFP TRANSFER	TKFRM	SY102T	N/A	1.00	1.80	2.30	2.00	0.00	2.00	0.30	1248	1378	1300	1300	0	78

LEGEND/DEFINITIONS:

FAC./FUNCT. - FACILITY / FUNCTION
GRT - GROUT
PTFAC - PRETREATMENT FACILITIES
CHAR - CHARACTERIZATION
HWVP - HANFORD WASTE VITRIFICATION PLANT
RTRVL - RETRIEVAL
TKFRM - TANK FARMS
TECH - PRETREATMENT TECHNOLOGY
MDL# - ACTIVITY # USED IN RISK ANALYSIS MODEL
PROB - PROBABILITY OF SUCCESS
OPT - OPTIMISTIC
PESM - PESSIMISTIC

MST LK - MOST LIKELY
BSLN - BASELINE
DELTA - DIFFERENCE BETWEEN VALUES IN ( )
(ML-BL) - (MOST LIKELY - BASELINE)
(P-ML) - (PESSIMISTIC - MOST LIKELY)

Table A-2. Cost Relative Risk Factor Ranking List. (sheet 1 of 3)

	ACTIVITY TITLE	FAC./ FUNCT.	DELTA COST	COST RRF RANKING
1	PERFORM CONSTRUCTION/ATP/CAT	HWVP	182529	0.91
2	WASTE FORM DEVELOPMENT	HWVP	88986	0.44
3	REPLACE MELTER #1/TEST & STARTUP	HWVP	77334	0.39
4	102-AY NCAW SOLIDS TRANS/VITRIFY AT HWVP	HWVP	77334	0.39
5	REPLACE MELTER #2/TEST & STARTUP	HWVP	77334	0.39
6	W-153 TRUEX PILOT PLANT	TECH	65000	0.33
7	TANK FARMS CAPITAL UPGRD	TKFRM	55200	0.28
8	DSSF RETRIEVAL SYSTEMS	RTRVL	48240	0.24
9	101-AZ PNCAW SOLIDS TRANS/VITRIFY AT HWVP	HWVP	44660	0.22
10	PERFORM OPERATIONAL TESTING	HWVP	39194	0.20
11	W-024 B PLANT RAD EFFLUENT AND CONTAINMENT UPG	PTFAC	39000	0.20
12	W-128 B PLANT CELL CLEANOUT	PTFAC	39000	0.20
13	CC EAST RETRIEVAL SYSTEM (CONT)	RTRVL	32680	0.16
14	NCRW OPERATIONS-HWVP	HWVP	32480	0.16
15	PERFORM PREOPERATIONAL TESTING	HWVP	31746	0.16
16	PROCURE EQUIPMENT IN TIME	HWVP	31337	0.16
17	AR VLT SYSTEM OPERABILITY TESTING	PTFAC	27300	0.14
18	WASTE FORM DEVELOPMENT	HWVP	25856	0.13
19	SMALL SCALE PFP SOLIDS RETRIEVAL SYSTEM	RTRVL	23950	0.12
20	HWVP DETAILED DESIGN TITLE II	HWVP	23922	0.12
21	W-30 DST STORAGE VENT UPGRD	TKFRM	23150	0.12
22	PFP OPERATIONS-HWVP	HWVP	23100	0.12
23	W-058 CROSS SITE TRANSFER LINE	TKFRM	22975	0.11
24	W-059 CAT I VENTILATION UPGRD	PTFAC	22459	0.11
25	CC WEST RETRIEVAL SYSTEM (CONT)	RTRVL	20640	0.10
26	PERFORM WFQ TESTING	HWVP	20623	0.10
27	PFP RETRIEVAL SYSTEM	RTRVL	17820	0.09
28	NCRW RETRIEVAL SYSTEM (CONT)	RTRVL	16340	0.08
29	102-AZ NCAW RETRIEVAL SYSTEM	RTRVL	16320	0.08
30	101-SY SAFETY ISSUE RESOLUTION	TKFRM	16000	0.08
31	W-028 AGING WASTE TRANSFER LINES	RTRVL	13885	0.07
32	W-007 B PLANT PROCESS CONDENSATE FAC	PTFAC	13245	0.07
33	INITIATE HWVP HOT OPERATIONS	HWVP	13147	0.07
34	CC EAST RETRIEVAL PROCESS TEST PREPARATIONS	RTRVL	12033	0.06
35	GROUT DSS/DSSF OPERATIONS	GRT	11000	0.06
36	ISSUE/APPROVE WQR	HWVP	10950	0.05
37	CC WEST RETRIEVAL PROCESS TEST PREPARATIONS	RTRVL	10337	0.05
38	W-002 CANYON CRANE REPLACEMENT	PTFAC	10159	0.05
39	NCRW RETRIEVAL PROCESS TEST PREPARATIONS	RTRVL	9923	0.05
40	102-AY SOLIDS-WASH OR RETRIEVE	RTRVL	9528	0.05
41	SMALL SCALE NCRW RETRIEVAL SYSTEM	RTRVL	9260	0.05
42	CHARACTERIZATION OF REMAINING CORES (CC)	CHAR	8704	0.04
43	CORE SAMPLE AND CHARACTERIZE REMAINING CORES N	CHAR	8118	0.04
44	TANK FARMS OPERATIONS AND ADMINISTRATIVE UPGRD	TKFRM	8114	0.04
45	103-SY SAFETY ISSUE RESOLUTION	TKFRM	8000	0.04
46	CHARACTERIZATION OF REMAINING CORES (NCRW)	CHAR	7710	0.04
48	CC OPERATIONS - HWVP (CONT)	HWVP	7672	0.04

Table A-2. Cost Relative Risk Factor Ranking List. (sheet 2 of 3)

	ACTIVITY TITLE	FAC./ FUNCT.	DELTA COST	COST RRF RANKING
49	GROUT CC OPERATIONS	GRT	7500	0.04
50	OXIDATION PILOT PLANT	TECH	7115	0.04
51	CC PRETREATMENT OPERATIONS-B PLANT	PTFAC	7000	0.04
52	CC PRETREAMENT OPERATIONS (CONT)	PTFAC	7000	0.04
53	TANK FARMS MAJOR MAINTENANCE UPGRD	TKFRM	6856	0.03
54	TRUEX PROCESS DEVELOPEMENT	TECH	4425	0.02
55	W-151 101AZ RETRIEVAL SYS PROCESS TEST	RTRVL	4100	0.02
56	CHARACTERIZATION OF REMAINING CORES (PFP)	CHAR	4000	0.02
57	NCRW PRETREATMENT OPERATIONS-B PLANT	PTFAC	4000	0.02
58	DESIGN AND CONSTRUCTION-EXCHANGE	HWVP	3954	0.02
59	ECOLOGY ISSUE RCRA PART B/CAA PERMIT	HWVP	3862	0.02
60	W-108 BCE TREATMENT FACILITY	PTFAC	3800	0.02
61	NCRW PROCESS TEST	RTRVL	3700	0.02
62	CC PROCESS TEST WEST AREA	RTRVL	3700	0.02
63	CC PROCESS TEST EAST AREA PROCESS TEST	RTRVL	3700	0.02
64	SMALL SCALE CC SUPERNATE TRANSFER SYSTEM	RTRVL	3200	0.02
65	PFP PRETREATMENT OPERATIONS-B PLANT	PTFAC	3000	0.02
66	W-103 ON DECK SAMPLING IMPROVEMENT	PTFAC	3000	0.02
67	ANALYZE AND INTEGRATE TECHNOLOGY	HWVP	2963	0.01
68	W-027 271B HVAC UPGRD	PTFAC	2837	0.01
69	B PLANT FACILITY SAR	PTFAC	2597	0.01
70	101-AZ NCAW TRANS/PRETREAT AT AR VLT/B PLANT	PTFAC	2400	0.01
71	TANK FARMS DOCUMENTATION UPGRD	TKFRM	2400	0.01
72	W-010 B PLANT ENVIRONMENTAL COMPLIANCE	PTFAC	2234	0.01
73	CC PROCESS DEVELOPMENT- PHASE II	TECH	2225	0.01
74	W-111 AR VLT SEAL POT AND VESSEL VENT	PTFAC	2200	0.01
75	CORE & CHARACTERIZATION (CC) FY91	CHAR	2124	0.01
76	W-135 AR VLT SLUDGE WASHING PROCESS MODS	PTFAC	2000	0.01
77	W-110 AR VLT TRANSFER LINE AND DIESEL FUEL	PTFAC	2000	0.01
78	W-148 NCAW 4 PUMP RETRIEVAL SYSTEM INSTALLATIO	RTRVL	2000	0.01
79	PILOT PLANT REDESIGN & MINOR MODS-PFP SOLIDS	TECH	2000	0.01
80	PILOT PLANT REDESIGN AND MINOR MODS-CC SOLIDS	TECH	2000	0.01
81	PILOT PLANT REDESIGN & MINOR MODS-CC TRUEX	TECH	2000	0.01
82	TRANSFER TECH TO DESIGN	HWVP	1977	0.01
83	CC ORGANIC DEST PILOT PLANT HOT TESTS	TECH	1962	0.01
84	AR VLT ENVIRONMENTAL PERMITTING	PTFAC	1951	0.01
85	W-107 BCS TREATMENT CENRIC	PTFAC	1866	0.01
86	AR VLT READINESS REVIEW (WHC & DOE)	PTFAC	1845	0.01
87	W-136 AR VLT SLUDGE WASHING CONTROL ROOM MODS	PTFAC	1800	0.01
88	TRU MONITOR-HOT PROTOTYPE	TECH	1769	0.01
89	B-PLANT PART B APPLICATION	PTFAC	1590	0.01
90	DOE RL APPROVE PSAR	HWVP	1549	0.01
91	GROUT NCAW OPERATIONS	GRT	1500	0.01
92	102-AZ NCAW TRANS/PRETREAT AT AR VLT/B PLANT	PTFAC	1500	0.01
93	SMALL SCALE CC SOLIDS RETRIEVAL SYSTEM	RTRVL	1500	0.01
94	INPUT COMPOSITION REQUIREMENT-NCAW FRIT PRO	HWVP	1465	0.01
95	NCAW TANK 101-AZ PROCESS TEST	RTRVL	1400	0.01

Table A-2. Cost Relative Risk Factor Ranking List. (sheet 3 of 3)

	ACTIVITY TITLE	FAC./ FUNCT.	DELTA COST	COST RRF RANKING
96	B-PLANT CANYON EXHAUST FILTER SYSTEMS	PTFAC	1344	0.01
97	PERFORM HOT OPS READINESS REVIEW	HWVP	1149	0.01
98	CHARACTERIZE GROUT DSSF & DSS	CHAR	1137	0.01
99	AR VLT SAR	PTFAC	1112	0.01
100	ION EXCHANGE TECHNOLOGY	TECH	1018	0.01
101	CORE SAMPLE AND CHARACTERIZE NCAW FY91	CHAR	1014	0.01
102	W-008 B PLANT CHEM SEWER NEUTRALIZATION	PTFAC	1007	0.01
103	GROUT PERFORMANCE ASSESSMENT	GRT	1000	0.01
104	GROUT NCRW OPERATIONS	GRT	1000	0.01
105	COMPLETE POST NCAW PROCESS DEVELOPMENT	HWVP	1000	0.01

Table A-3. Schedule/Time Relative Risk Factor Ranking List.

	ACTIVITY TITLE	FAC./ FUNCT.	CRITICAL PATH FREQ	DELTA TIME	TIME RRF RANKING
1	CC PRETREAMENT OPERATIONS (CONT)	PTFAC	0.9990	1.41	2.82
2	NCRW RETRIEVAL SYSTEM (CONT)	RTRVL	0.3890	2.00	1.56
3	NCRW RETRIEVAL PROCESS TEST PREPARATIONS	RTRVL	0.3790	2.00	1.52
4	NCRW PROCESS TEST	RTRVL	0.3790	2.00	1.52
5	CC EAST RETRIEVAL SYSTEM (CONT)	RTRVL	0.3390	2.00	1.36
6	CC PRETREATMENT OPERATIONS-B PLANT	PTFAC	0.9640	0.70	1.35
7	CC EAST RETRIEVAL PROCESS TEST PREPARATIONS	RTRVL	0.3020	2.00	1.21
8	CC PROCESS TEST EAST AREA PROCESS TEST	RTRVL	0.3020	2.00	1.21
9	CORE & CHARACTERIZATION (CC) FY91	CHAR	0.1580	1.99	0.63
10	SMALL SCALE NCRW RETRIEVAL SYSTEM	RTRVL	0.0730	3.97	0.58
11	101-SY SAFETY ISSUE RESOLUTION	TKFRM	0.0270	8.00	0.43
12	CC OPERATIONS - HWVP (CONT)	HWVP	1.0000	0.20	0.40
13	PFP PROCESS MODIFICATIONS-B PLANT	PTFAC	0.1440	1.25	0.36
14	CHARACTERIZATION OF REMAINING CORES (CC)	CHAR	0.1580	1.00	0.32
15	TRUEX PILOT PLANT SCALE TEST WITH NCRW	TECH	0.0730	1.50	0.22
16	PFP PRETREATMENT OPERATIONS-B PLANT	PTFAC	0.5320	0.16	0.17
17	NCRW PRETREATMENT OPERATIONS-B PLANT	PTFAC	0.3890	0.21	0.16
18	PILOT PLANT REDESIGN & MINOR MODS-CC TRUEX	TECH	0.1580	0.49	0.15
19	CC EAST RETRIEVAL SYSTEM	RTRVL	0.0370	2.00	0.15
20	CC WEST RETRIEVAL SYSTEM (CONT)	RTRVL	0.0350	2.00	0.14
21	PILOT PLANT REDESIGN & MINOR MODS-PFP SOLIDS	TECH	0.0900	0.76	0.14
22	CC WEST RETRIEVAL SYSTEM	RTRVL	0.0330	2.00	0.13
23	W-096 CC/OXIDATION MODIFICATIONS (CONT)/STARTU	PTFAC	0.0930	0.65	0.12
24	TRUEX PILOT PLANT SCALE TEST WITH PFP WASTE	TECH	0.2320	0.23	0.11
25	TRUEX PILOT PLANT SCALE TEST WITH CC WASTE	TECH	0.1420	0.26	0.07
26	SMALL SCALE CC SOLIDS RETRIEVAL SYSTEM	RTRVL	0.0050	6.33	0.06
27	TRUEX PILOT PLANT SCALE TEST WITH CC SOLIDS	TECH	0.0930	0.25	0.05
28	NCRW RETRIEVAL SYSTEM	RTRVL	0.0100	2.00	0.04
29	AVAILABLE EAST AREA HOLDING TANK-CC TRANSFER	TKFRM	0.0350	0.22	0.02
30	CC WEST RETRIEVAL PROCESS TEST PREPARATIONS	RTRVL	0.0020	2.00	0.01
31	CC PROCESS TEST WEST AREA	RTRVL	0.0020	2.00	0.01
32	103/104/105-AN SAFETY ISSUE RESOLUTION	TKFRM	0.0060	0.50	0.01

A.4 PROBABILITY RELATIVE RISK FACTOR RANKING LIST

Table A-4 lists the program activities that have non-zero value probability RRFs. The activities are listed in descending probability relative risk factor (RRF_p) order. Discussion of the methodology used in establishing the RRF_p values is provided in Section A.9.

A.5 INTEGRATED RELATIVE RISK FACTOR RANKING LIST

Table A-5 groups program activities into major program activities (characterization, retrieval, etc.) and sums the integrated RRFs for each of these areas. The major activities are listed in decreasing RRF order. The activities within each major activity are also listed in decreasing RRF order.

A.6 HANFORD WASTE VITRIFICATION PLANT HOT STARTUP INTEGRATED RELATIVE RISK FACTOR RANKING LIST

Table A-6 lists the program activities that have non-zero value integrated RRFs that support the hot startup of HWVP. The table lists activities in descending RRF order.

A.7 PROGRAM FUNCTIONAL AREA COST BREAKDOWN

Table A-7 provides a breakdown of the mean program costs by functional area to provide a perspective of how the probable costs are spread across the entire program.

A.8 SPECIAL CASE CRITICAL PATH ANALYSIS

In addition to the primary critical path analysis discussed in Section 4.5.3.3, several special case time critical path analyses were performed. These supplementary critical path analyses included: (1) the baseline schedule, (2) the optimistic estimate schedule case, (3) the most likely estimate schedule case, and (4) the pessimistic estimate schedule case. In each of these special critical path analyses, the schedule duration range for each activity was replaced with a single duration equal to the baseline optimistic, most likely, or pessimistic duration estimates, respectively. Because only a single duration is provided in these special critical path analyses, a single 100 percent probable critical path through the model network results. These four special case critical paths are depicted in Figures A-1 through A-4, respectively.

Table A-4. Probability Relative Risk Factor Ranking List.
(sheet 1 of 3)

	ACTIVITY TITLE	FAC./ FUNCT.	ACTIVITY START YEAR	PROB. OF SUCCESS	PROB. RRF RANKING
1	PREPARE FINAL WASTE COMPLIANCE PLAN	HWVP	1991.00	0.70	1.50
2	W-024 B PLANT RAD EFFLUENT AND CONTAINMENT UPG	PTFAC	1991.00	0.70	1.50
3	SMALL SCALE NCRW RETRIEVAL SYSTEM	RTRVL	1991.00	0.70	1.50
4	B-PLANT PART B APPLICATION	PTFAC	1992.00	0.70	1.45
5	W-161 TRU MONITOR	PTFAC	1992.00	0.70	1.45
6	AR VLT ENVIRONMENTAL PERMITTING	PTFAC	1992.71	0.70	1.41
7	CC ORGANIC DESTRUCTION PILOT PLANT COLD TESTS	TECH	1999.38	0.70	1.05
8	TRU MONITOR-HOT PROTOTYPE	TECH	1991.00	0.80	1.00
9	TRUEX PROCESS DEVELOPEMENT	TECH	1991.00	0.80	1.00
10	CHARACTERIZATION OF REMAINING CORES (CC)	CHAR	1993.54	0.80	0.91
11	CC PROCESS TEST EAST AREA PROCESS TEST	RTRVL	2002.37	0.70	0.89
12	TRUEX PILOT PLANT SCALE TEST WITH NCRW	TECH	1998.93	0.80	0.72
13	TRUEX PILOT PLANT SCALE TEST WITH CC WASTE	TECH	2000.97	0.80	0.64
14	TRUEX PILOT PLANT SCALE TEST WITH PFP WASTE	TECH	2001.93	0.80	0.61
15	TRUEX PILOT PLANT SCALE TEST WITH CC SOLIDS	TECH	2002.91	0.80	0.57
16	GROUT DSS/DSSF OPERATIONS	GRT	1996.55	0.87	0.52
17	CC PROCESS DEVELOPMENT-PHASE I	TECH	1991.00	0.90	0.50
18	ION EXCHANGE TECHNOLOGY	TECH	1991.00	0.90	0.50
19	103/104/105-AN SAFETY ISSUE RESOLUTION	TKFRM	1991.00	0.90	0.50
20	101-SY SAFETY ISSUE RESOLUTION	TKFRM	1991.00	0.90	0.50
21	103-SY SAFETY ISSUE RESOLUTION	TKFRM	1991.00	0.90	0.50
22	GROUT NCAW OPERATIONS	GRT	2003.83	0.87	0.35
23	NCRW PROCESS TEST	RTRVL	1999.39	0.90	0.35
24	GROUT NCRW OPERATIONS	GRT	2008.19	0.87	0.25
25	102-AY SOLIDS-WASH OR RETRIEVE	RTRVL	1991.00	0.95	0.25
26	DSSF RETRIEVAL SYSTEMS	RTRVL	1991.00	0.95	0.25
27	GROUT PFP OPERATIONS	GRT	2009.58	0.87	0.22
28	PFP RETRIEVAL SYSTEM	RTRVL	2002.30	0.95	0.15
29	GROUT CC OPERATIONS	GRT	2012.72	0.87	0.15
30	NCRW PRETREATMENT OPERATIONS-B PLANT	PTFAC	2006.17	0.95	0.11
31	CORE SAMPLE AND CHARACTERIZE NCAW FY91	CHAR	1991.00	0.98	0.10
32	2ND CORE AND CHARACTERIZATION NCRW (FY92)	CHAR	1991.00	0.98	0.10
33	CORE & CHARACTERIZATION (CC) FY91	CHAR	1991.00	0.98	0.10
34	CLEAN WATER ACT-BCP	PTFAC	1991.00	0.98	0.10
35	PFP PROCESS MODIFICATIONS-B PLANT	PTFAC	1991.00	0.98	0.10
36	CLEAN WATER ACT-BCE	PTFAC	1991.00	0.98	0.10
37	W-136 AR VLT SLUDGE WASHING CONTROL ROOM MODS	PTFAC	1991.00	0.98	0.10
38	CLEAN AIR ACT-NCAW PROCESSING	PTFAC	1991.00	0.98	0.10
39	B PLANT FACILITY SAR	PTFAC	1991.00	0.98	0.10
40	W-110 AR VLT TRANSFER LINE AND DIESEL FUEL	PTFAC	1991.00	0.98	0.10
41	W-102 GALLERY EXHAUST VENT	PTFAC	1991.00	0.98	0.10
42	W-111 AR VLT SEAL POT AND VESSEL VENT	PTFAC	1991.00	0.98	0.10
43	CLEAN WATER ACT-CBC	PTFAC	1991.00	0.98	0.10
44	W-135 AR VLT SLUDGE WASHING PROCESS MODS	PTFAC	1991.00	0.98	0.10
45	B PLANT TANK INTEGRITY ASSESSMENT	PTFAC	1991.00	0.98	0.10
46	W-128 B PLANT CELL CLEANOUT	PTFAC	1991.00	0.98	0.10
47	W-002 CANYON CRANE REPLACEMENT	PTFAC	1991.00	0.98	0.10
48	B PLANT SYSTEM OPERABILITY TESTING	PTFAC	1991.00	0.98	0.10
49	SMALL SCALE CC SOLIDS RETRIEVAL SYSTEM	RTRVL	1991.00	0.98	0.10
50	SMALL SCALE PFP SOLIDS RETRIEVAL SYSTEM	RTRVL	1991.00	0.98	0.10
51	TANK FARMS CAPITAL UPGRD	TKFRM	1991.00	0.98	0.10
52	CHARACTERIZATION OF REMAINING CORES (NCRW)	CHAR	1991.54	0.98	0.10
53	CORE SAMPLE AND CHARACTERIZE REMAINING CORES N	CHAR	1991.58	0.98	0.10
54	CHARACTERIZE GROUT DSSF & DSS	CHAR	1992.00	0.98	0.10
55	CLEAN WATER-PROJECT W-098	PTFAC	1992.00	0.98	0.10
56	AR VLT CANYON CRANE INSPECTION/UPGRD	PTFAC	1992.00	0.98	0.10
57	CLEAN WATER ACT-BCS	PTFAC	1992.00	0.98	0.10
58	CLEAN WATER ACT-PROJECT W-107	PTFAC	1992.00	0.98	0.10
59	WHC INSPECT AND ACCEPT CONSTRUCTION	HWVP	1992.56	0.98	0.09
60	PFP PRETREATMENT OPERATIONS-B PLANT	PTFAC	2008.46	0.95	0.09
61	CORE SAMPLE AND CHARACTERIZATION (PFP) FY91	CHAR	1993.00	0.98	0.09
62	W-095 NCRW PROCESS MODIFICATIONS-B PLANT	PTFAC	1993.00	0.98	0.09
63	NCRW RETRIEVAL PROCESS TEST PREPARATIONS	RTRVL	1993.00	0.98	0.09

Table A-4. Probability Relative Risk Factor Ranking List.
(sheet 2 of 3)

	ACTIVITY TITLE	FAC./ FUNCT.	ACTIVITY START YEAR	PROB. OF SUCCESS	PROB. RRF RANKING
64	CHARACTERIZATION OF REMAINING CORES (PFP)	CHAR	1993.58	0.98	0.09
65	W-096 CC/OXIDATION MODIFICATIONS-B PLANT	PTFAC	1994.00	0.98	0.09
66	NCRW OPERATIONS-HWVP	HWVP	2009.71	0.95	0.08
67	CC PRETREATMENT OPERATIONS-B PLANT	PTFAC	2010.01	0.95	0.08
68	B PLANT READINESS REVIEW-WHC/DOE	PTFAC	1996.88	0.98	0.08
69	PFP OPERATIONS-HWVP	HWVP	2011.22	0.95	0.07
70	CC PROCESS TEST WEST AREA	RTRVL	2000.48	0.98	0.07
71	W-095 NCRW PROCESS MODIFICATIONS (CONT)	PTFAC	2000.84	0.98	0.06
72	PFP PROCESS MODIFICATIONS (CONT)/STARTUP	PTFAC	2003.35	0.98	0.06
73	CC OPERATIONS - HWVP	HWVP	2013.07	0.95	0.05
74	W-096 CC/OXIDATION MODIFICATIONS (CONT)/STARTU	PTFAC	2004.32	0.98	0.05
75	102-AY NCAW SOLIDS TRANS/VITRIFY AT HWVP	HWVP	2004.40	0.98	0.05
76	DOE RL APPROVE PSAR	HWVP	1991.00	0.99	0.05
77	ANALYZE AND INTEGRATE TECHNOLOGY	HWVP	1991.00	0.99	0.05
78	PROCURE EQUIPMENT IN TIME	HWVP	1991.00	0.99	0.05
79	DESIGN AND CONSTRUCTION-EXCHANGE	HWVP	1991.00	0.99	0.05
80	TRANSFER TECH TO DESIGN	HWVP	1991.00	0.99	0.05
81	MONITOR DWPF LESSONS LEARNED	HWVP	1991.00	0.99	0.05
82	APPROVE FSAR	HWVP	1991.00	0.99	0.05
83	PERFORM COLD TEST READINESS REVIEW	HWVP	1991.00	0.99	0.05
84	ISSUE REVISED RCRA PART B PERMIT	HWVP	1991.00	0.99	0.05
85	ECOLOGY ISSUE RCRA PART B/CAA PERMIT	HWVP	1991.00	0.99	0.05
86	HWVP DETAILED DESIGN TITLE II	HWVP	1991.00	0.99	0.05
87	WASTE FORM DEVELOPMENT	HWVP	1991.00	0.99	0.05
88	WASTE FORM DEVELOPMENT	HWVP	1991.00	0.99	0.05
89	W-159 CT/CS INSTRUMENT UPGRD	PTFAC	1991.00	0.99	0.05
90	W-168 B PLANT FILTER SYSTEM TIE-IN	PTFAC	1991.00	0.99	0.05
91	W-160 IN CELL AND HPT LEAK DETECTION	PTFAC	1991.00	0.99	0.05
92	W-103 ON DECK SAMPLING IMPROVEMENT	PTFAC	1991.00	0.99	0.05
93	W-162 IX MECHANICAL EQUIPMENT UPGRD	PTFAC	1991.00	0.99	0.05
94	SEISMIC ANALYSIS-B PLANT	PTFAC	1991.00	0.99	0.05
95	W-065 WH/IX/SD PROCESS CONTRL VALVE	PTFAC	1991.00	0.99	0.05
96	W-004 B PLANT AMU UPGRD	PTFAC	1991.00	0.99	0.05
97	W-059 CAT I VENTILATION UPGRD	PTFAC	1991.00	0.99	0.05
98	AR VLT SEISMIC ANALYSIS	PTFAC	1991.00	0.99	0.05
99	W-108 BCE TREATMENT FACILITY	PTFAC	1991.00	0.99	0.05
100	W-056 IIWC/PHPF PC VALVE PH I	PTFAC	1991.00	0.99	0.05
101	W-010 B PLANT ENVIRONMENTAL COMPLIANCE	PTFAC	1991.00	0.99	0.05
102	W-104 B PLANT OPS SUPPORT BUILDING	PTFAC	1991.00	0.99	0.05
103	W-027 271B HVAC UPGRD	PTFAC	1991.00	0.99	0.05
104	W-00[illegible] B PLANT PROCESS CONDENSATE FAC	PTFAC	1991.00	0.99	0.05
105	W-07[illegible] CT/CS PROCESS CONTROL VALVE UPGRD	PTFAC	1991.00	0.99	0.05
106	102-AZ NCAW RETRIEVAL SYSTEM	RTRVL	1991.00	0.99	0.05
107	W-028 AGING WASTE TRANSFER LINES	RTRVL	1991.00	0.99	0.05
108	W-148 NCAW 4 PUMP RETRIEVAL SYSTEM ENG & PROC	RTRVL	1991.00	0.99	0.05
109	W-151 101AZ RETRIEVAL SYS PROCESS TEST	RTRVL	1991.00	0.99	0.05
110	W-066 AZ TANK FARM ELECTRICAL UPGRADE	RTRVL	1991.00	0.99	0.05
111	W-153 TRUEX PILOT PLANT	TECH	1991.00	0.99	0.05
112	TANK FARMS DOCUMENTATION UPGRD	TKFRM	1991.00	0.99	0.05
113	TANK FARMS OPERATIONS AND ADMINISTRATIVE UPGRD	TKFRM	1991.00	0.99	0.05
114	TANK FARMS MAJOR MAINTENANCE UPGRD	TKFRM	1991.00	0.99	0.05
115	AR VLT SYSTEM OPERABILITY TESTING	PTFAC	1992.00	0.99	0.05
116	AR VLT SAR	PTFAC	1992.00	0.99	0.05
117	AR VLT ENVIRONMENTAL ANALYSIS	PTFAC	1992.00	0.99	0.05
118	AR VLT NEW CANYON EQUIPMENT	PTFAC	1992.00	0.99	0.05
119	B PLANT TRAINING	PTFAC	1992.00	0.99	0.05
120	AR VLT TANK INTEGRITY ASSESSMENT	PTFAC	1992.00	0.99	0.05
121	ENG EVAL OF FLOC OPT TEST	TECH	1992.00	0.99	0.05
122	ENG EVAL FOR PH CONTROL	TECH	1992.00	0.99	0.05
123	DOE HQ KEY DECISION #3 APPROVAL TO START CONST	HWVP	1992.20	0.99	0.05
124	PERFORM WFQ TESTING	HWVP	1992.56	0.99	0.05
125	PERFORM CONSTRUCTION/ATP/CAT	HWVP	1992.57	0.99	0.05
126	AR VLT-FACILITY DESCRIPTION MANUAL	PTFAC	1993.00	0.99	0.05
127	CC WEST RETRIEVAL PROCESS TEST PREPARATIONS	RTRVL	1993.00	0.99	0.05

Table A-4. Probability Relative Risk Factor Ranking List.
(sheet 3 of 3)

	ACTIVITY TITLE	FAC./ FUNCT.	ACTIVITY START YEAR	PROB. OF SUCCESS	PROB. RRF RANKING
128	DRAFT FINAL FLOWSHEET FOR AR VAULT/B PLANT	TECH	1993.20	0.99	0.05
129	OXIDATION PILOT PLANT	TECH	1993.54	0.99	0.05
130	AR VLT TRAINING	PTFAC	1994.00	0.99	0.04
131	CC EAST RETRIEVAL PROCESS TEST PREPARATIONS	RTRVL	1994.00	0.99	0.04
132	SMALL SCALE CC SUPERNATE TRANSFER SYSTEM	RTRVL	1995.00	0.99	0.04
133	NCRW RETRIEVAL SYSTEM	RTRVL	1995.00	0.99	0.04
134	PERFORM PREOPERATIONAL TESTING	HWVP	1995.27	0.99	0.04
135	COMPLETE POST NCAW PROCESS DEVELOPMENT	HWVP	1996.45	0.99	0.04
136	CC EAST RETRIEVAL SYSTEM	RTRVL	1998.00	0.99	0.04
137	W-148 NCAW 4 PUMP RETRIEVAL SYSTEM INSTALLATIO	RTRVL	1999.14	0.99	0.04
138	INPUT COMPOSITION REQUIREMENT-NCRW FRIT PROC	HWVP	2000.31	0.99	0.03
139	FINAL FLOWSHEET NCRW TRUEX	TECH	2000.32	0.99	0.03
140	CC ORGANIC DEST PILOT PLANT HOT TESTS	TECH	2000.34	0.99	0.03
141	AR VLT OPS/WFQ SOLIDS WASHING	PTFAC	2000.52	0.99	0.03
142	PERFORM OPERATIONAL TESTING	HWVP	2001.12	0.99	0.03
143	INPUT COMPOSITION REQUIREMENT-NCAW FRIT PRO	HWVP	2001.12	0.99	0.03
144	FINAL FLOWSHEET CC ORGANIC DESTRUCTION	TECH	2001.13	0.99	0.03
145	101-AZ NCAW TRANS/PRETREAT AT AR VLT/B PLANT	PTFAC	2001.16	0.99	0.03
146	RECEIVE ACCEPTABLE FRIT FOR HOT STARTUP	HWVP	2001.77	0.99	0.03
147	RECEIVE ACCEPTABLE FRIT FOR TESTING	HWVP	2001.79	0.99	0.03
148	FINAL FLOWSHEET CC TRUEX	TECH	2001.89	0.99	0.03
149	102-AY CHAR/FRIT PROC NCAW	HWVP	2002.76	0.99	0.03
150	102-AZ NCAW TRANS/PRETREAT AT AR VLT/B PLANT	PTFAC	2002.76	0.99	0.03
151	INPUT COMPOSITION REQUIREMENT-PFP FRIT PROC	HWVP	2002.85	0.99	0.03
152	FINAL FLOWSHEET PFP TRUEX	TECH	2002.86	0.99	0.03
153	CC WEST RETRIEVAL SYSTEM	RTRVL	2003.13	0.99	0.03
154	ISSUE/APPROVE WQR	HWVP	2003.31	0.99	0.03
155	INPUT COMPOSITION REQUIREMENT-CC FRIT PROC	HWVP	2003.82	0.99	0.03
156	FINAL CC DISSOLUTION FLOWSHEET	TECH	2003.82	0.99	0.03
157	101-AZ CHAR/FRIT PROC NCAW	HWVP	2003.83	0.99	0.03
158	INITIATE HWVP HOT OPERATIONS	HWVP	2004.26	0.99	0.03
159	101-AZ PNCAW SOLIDS TRANS/VITRIFY AT HWVP	HWVP	2005.98	0.99	0.02
160	REPLACE MELTER #1/TEST & STARTUP	HWVP	2006.82	0.99	0.02
161	NCRW FRIT-HWVP	HWVP	2008.18	0.99	0.02
162	PFP FRIT-HWVP	HWVP	2009.58	0.99	0.02
163	CC FRIT-HWVP	HWVP	2010.00	0.99	0.02
164	REPLACE MELTER #2/TEST & STARTUP	HWVP	2011.62	0.99	0.01

Table A-5. Integrated Relative Risk Factor Ranking List.
(sheet 1 of 8)

	ACTIVITY TITLE	FAC./ FUNCT.	TIME RRF RANKING	COST RRF RANKING	SUCCESS RRF RANKING	INTEGRATED RRF RANKING	ACTIVITY RRF RANKING
	RETRIEVAL						
1	CC PROCESS TEST EAST AREA PROCESS TEST	RTRVL	1.21	0.02	0.89	2.12	16.9
2	NCRW PROCESS TEST	RTRVL	1.52	0.02	0.35	1.88	
3	NCAW TANK 101-AZ PROCESS TEST	RTRVL	0.00	0.01	1.85	1.85	
4	NCRW RETRIEVAL PROCESS TEST PREPARATIONS	RTRVL	1.52	0.05	0.09	1.66	
5	NCRW RETRIEVAL SYSTEM (CONT)	RTRVL	1.56	0.08	0.00	1.64	
6	CC EAST RETRIEVAL SYSTEM (CONT)	RTRVL	1.36	0.16	0.00	1.52	
7	CC EAST RETRIEVAL PROCESS TEST PREPARATIONS	RTRVL	1.21	0.06	0.04	1.31	
8	DSSF RETRIEVAL SYSTEMS	RTRVL	0.00	0.24	0.25	0.49	
9	102-AY SOLIDS-WASH OR RETRIEVE	RTRVL	0.00	0.05	0.25	0.30	
10	CC WEST RETRIEVAL SYSTEM (CONT)	RTRVL	0.14	0.10	0.00	0.24	
11	PFP RETRIEVAL SYSTEM	RTRVL	0.00	0.09	0.15	0.24	
12	SMALL SCALE PFP SOLIDS RETRIEVAL SYSTEM	RTRVL	0.00	0.12	0.10	0.22	
13	CC EAST RETRIEVAL SYSTEM	RTRVL	0.15	0.00	0.04	0.19	
14	SMALL SCALE CC SOLIDS RETRIEVAL SYSTEM	RTRVL	0.06	0.01	0.10	0.17	
15	CC WEST RETRIEVAL SYSTEM	RTRVL	0.13	0.00	0.03	0.16	
16	102-AZ NCAW RETRIEVAL SYSTEM	RTRVL	0.00	0.08	0.05	0.13	
17	W-028 AGING WASTE TRANSFER LINES	RTRVL	0.00	0.07	0.05	0.12	
18	CC WEST RETRIEVAL PROCESS TEST PREPARATIONS	RTRVL	0.01	0.05	0.05	0.11	
19	CC PROCESS TEST WEST AREA	RTRVL	0.01	0.02	0.07	0.09	
20	NCRW RETRIEVAL SYSTEM	RTRVL	0.04	0.00	0.04	0.08	
21	W-151 101AZ RETRIEVAL SYS PROCESS TEST	RTRVL	0.00	0.02	0.05	0.07	
22	SMALL SCALE CC SUPERNATE TRANSFER SYSTEM	RTRVL	0.00	0.02	0.04	0.06	
23	W-148 NCAW 4 PUMP RETRIEVAL SYSTEM ENG & PROC	RTRVL	0.00	0.00	0.05	0.05	
24	W-066 AZ TANK FARM ELECTRICAL UPGRADE	RTRVL	0.00	0.00	0.05	0.05	
25	W-148 NCAW 4 PUMP RETRIEVAL SYSTEM INSTALLATIO	RTRVL	0.00	0.01	0.04	0.05	
26	W-106 TWREHO	RTRVL	0.00	0.00	0.00	0.00	
27	SMALL SCALE NCRW RETRIEVAL SYSTEM	RTRVL	0.58	0.05	1.50	2.13	
			9.5	1.3	6.1	16.9	

Table A-5. Integrated Relative Risk Factor Ranking List.
(sheet 2 of 8)

	ACTIVITY TITLE	FAC./ FUNCT.	TIME RRF RANKING	COST RRF RANKING	SUCCESS RRF RANKING	INTEGRATED RRF RANKING	ACTIVITY RRF RANKING
	PRETREATMENT FACILITIES						
28	CC PRETREAMENT OPERATIONS (CONT)	PTFAC	2.82	0.04	0.00	2.85	15.8
29	W-024 B PLANT RAD EFFLUENT AND CONTAINMENT UPG	PTFAC	0.00	0.20	1.50	1.70	
30	CC PRETREATMENT OPERATIONS-B PLANT	PTFAC	1.35	0.04	0.08	1.46	
31	B-PLANT PART B APPLICATION	PTFAC	0.00	0.01	1.45	1.45	
32	W-161 TRU MONITOR	PTFAC	0.00	0.00	1.45	1.45	
33	AR VLT ENVIRONMENTAL PERMITTING	PTFAC	0.00	0.01	1.41	1.42	
34	PFP PROCESS MODIFICATIONS-B PLANT	PTFAC	0.36	0.00	0.10	0.46	
35	NCRW PRETREATMENT OPERATIONS-B PLANT	PTFAC	0.16	0.02	0.11	0.30	
36	W-128 B PLANT CELL CLEANOUT	PTFAC	0.00	0.20	0.10	0.30	
37	PFP PRETREATMENT OPERATIONS-B PLANT	PTFAC	0.17	0.02	0.09	0.28	
38	AR VLT SYSTEM OPERABILITY TESTING	PTFAC	0.00	0.14	0.05	0.18	
89	W-096 CC/OXIDATION MODIFICATIONS (CONT)/STARTU	PTFAC	0.12	0.00	0.05	0.17	
40	W-059 CAT I VENTILATION UPGRD	PTFAC	0.00	0.11	0.05	0.16	
41	W-002 CANYON CRANE REPLACEMENT	PTFAC	0.00	0.05	0.10	0.15	
42	W-007 B PLANT PROCESS CONDENSATE FAC	PTFAC	0.00	0.07	0.05	0.12	
43	B PLANT FACILITY SAR	PTFAC	0.00	0.01	0.10	0.11	
44	W-111 AR VLT SEAL POT AND VESSEL VENT	PTFAC	0.00	0.01	0.10	0.11	
45	W-110 AR VLT TRANSFER LINE AND DIESEL FUEL	PTFAC	0.00	0.01	0.10	0.11	
46	W-135 AR VLT SLUDGE WASHING PROCESS MODS	PTFAC	0.00	0.01	0.10	0.11	
47	W-136 AR VLT SLUDGE WASHING CONTROL ROOM MODS	PTFAC	0.00	0.01	0.10	0.11	
48	B PLANT TANK INTEGRITY ASSESSMENT	PTFAC	0.00	0.00	0.10	0.10	
49	W-102 GALLERY EXHAUST VENT	PTFAC	0.00	0.00	0.10	0.10	
50	CLEAN WATER ACT-CBC	PTFAC	0.00	0.00	0.10	0.10	
51	CLEAN WATER ACT-BCP	PTFAC	0.00	0.00	0.10	0.10	
52	CLEAN WATER ACT-BCE	PTFAC	0.00	0.00	0.10	0.10	
53	CLEAN AIR ACT-NCAW PROCESSING	PTFAC	0.00	0.00	0.10	0.10	
54	B PLANT SYSTEM OPERABILITY TESTING	PTFAC	0.00	0.00	0.10	0.10	
55	AR VLT CANYON CRANE INSPECTION/UPGRD	PTFAC	0.00	0.00	0.10	0.10	
56	CLEAN WATER ACT-PROJECT W-107	PTFAC	0.00	0.00	0.10	0.10	

Table A-5. Integrated Relative Risk Factor Ranking List.
(sheet 3 of 8)

	ACTIVITY TITLE	FAC./ FUNCT.	TIME RRF RANKING	COST RRF RANKING	SUCCESS RRF RANKING	INTEGRATED RRF RANKING	ACTIVITY RRF RANKING
57	CLEAN WATER ACT-BCS	PTFAC	0.00	0.00	0.10	0.10	
58	CLEAN WATER-PROJECT W-098	PTFAC	0.00	0.00	0.10	0.10	
59	W-095 NCRW PROCESS MODIFICATIONS-B PLANT	PTFAC	0.00	0.00	0.09	0.09	
60	W-096 CC/OXIDATION MODIFICATIONS-B PLANT	PTFAC	0.00	0.00	0.09	0.09	
61	B PLANT READINESS REVIEW-WHC/DOE	PTFAC	0.00	0.00	0.08	0.08	
62	W-108 BCE TREATMENT FACILITY	PTFAC	0.00	0.02	0.05	0.07	
63	W-095 NCRW PROCESS MODIFICATIONS (CONT)	PTFAC	0.00	0.00	0.06	0.07	
64	W-103 ON DECK SAMPLING IMPROVEMENT	PTFAC	0.00	0.02	0.05	0.07	
65	W-027 271B HVAC UPGRD	PTFAC	0.00	0.01	0.05	0.06	
66	W-010 B PLANT ENVIRONMENTAL COMPLIANCE	PTFAC	0.00	0.01	0.05	0.06	
67	PFP PROCESS MODIFICATIONS (CONT)/STARTUP	PTFAC	0.00	0.00	0.06	0.06	
68	W-104 B PLANT OPS SUPPORT BUILDING	PTFAC	0.00	0.00	0.05	0.05	
69	W-004 B PLANT AMU UPGRD	PTFAC	0.00	0.00	0.05	0.05	
70	AR VLT SAR	PTFAC	0.00	0.01	0.05	0.05	
71	SEISMIC ANALYSIS-B PLANT	PTFAC	0.00	0.00	0.05	0.05	
72	W-065 WH/IX/SD PROCESS CONTRL VALVE	PTFAC	0.00	0.00	0.05	0.05	
73	W-077 CT/CS PROCESS CONTROL VALVE UPGRD	PTFAC	0.00	0.00	0.05	0.05	
74	W-162 IX MECHANICAL EQUIPMENT UPGRD	PTFAC	0.00	0.00	0.05	0.05	
75	W-159 CT/CS INSTRUMENT UPGRD	PTFAC	0.00	0.00	0.05	0.05	
76	W-056 IIWC/PHPF PC VALVE PH I	PTFAC	0.00	0.00	0.05	0.05	
77	W-160 IN CELL AND HPT LEAK DETECTION	PTFAC	0.00	0.00	0.05	0.05	
78	AR VLT SEISMIC ANALYSIS	PTFAC	0.00	0.00	0.05	0.05	
79	W-168 B PLANT FILTER SYSTEM TIE-IN	PTFAC	0.00	0.00	0.05	0.05	
80	B PLANT TRAINING	PTFAC	0.00	0.00	0.05	0.05	
81	AR VLT NEW CANYON EQUIPMENT	PTFAC	0.00	0.00	0.05	0.05	
82	AR VLT TANK INTEGRITY ASSESSMENT	PTFAC	0.00	0.00	0.05	0.05	
83	AR VLT ENVIRONMENTAL ANALYSIS	PTFAC	0.00	0.00	0.05	0.05	
84	AR VLT-FACILITY DESCRIPTION MANUAL	PTFAC	0.00	0.00	0.05	0.05	
85	AR VLT TRAINING	PTFAC	0.00	0.00	0.04	0.05	
86	101-AZ NCAW TRANS/PRETREAT AT AR VLT/B PLANT	PTFAC	0.00	0.01	0.03	0.04	
87	102-AZ NCAW TRANS/PRETREAT AT AR VLT/B PLANT	PTFAC	0.00	0.01	0.03	0.04	

Table A-5. Integrated Relative Risk Factor Ranking List. (sheet 4 of 8)

	ACTIVITY TITLE	FAC./ FUNCT.	TIME RRF RANKING	COST RRF RANKING	SUCCESS RRF RANKING	INTEGRATED RRF RANKING	ACTIVITY RRF RANKING
88	AR VLT OPS/WFQ SOLIDS WASHING	PTFAC	0.00	0.00	0.03	0.04	
89	W-107 BCS TREATMENT CENRIC	PTFAC	0.00	0.01	0.00	0.01	
90	AR VLT READINESS REVIEW (WHC & DOE)	PTFAC	0.00	0.01	0.00	0.01	
91	B-PLANT CANYON EXHAUST FILTER SYSTEMS	PTFAC	0.00	0.01	0.00	0.01	
92	W-008 B PLANT CHEM SEWER NEUTRALIZATION	PTFAC	0.00	0.01	0.00	0.01	
93	W-003 CHEM SEWER ENVIRONMENTAL UPGRD	PTFAC	0.00	0.00	0.00	0.00	
94	W-098 HAZARD WASTE STORAGE	PTFAC	0.00	0.00	0.00	0.00	
95	W-040 CELL 18 CESIUM IX COL	PTFAC	0.00	0.00	0.00	0.00	
96	B PLANT ADMINISTRATIVE MANUAL UPGRD	PTFAC	0.00	0.00	0.00	0.00	
97	W-163 CELL DRAINAGE AND VESSEL VENT INSTRUMENT	PTFAC	0.00	0.00	0.00	0.00	
98	W-161 TRU MONITOR CONTINUED	PTFAC	0.00	0.00	0.00	0.00	
99	NCAW JUMPER CONSTRUCTION	PTFAC	0.00	0.00	0.00	0.00	
100	W-094 291B FILTER INSTRUMENTATION UPGRD	PTFAC	0.00	0.00	0.00	0.00	
101	GROUT FEED SPEC	PTFAC	0.00	0.00	0.00	0.00	
102	B PLANT INTERIM STATUS ACTIONS BIS/BPL	PTFAC	0.00	0.00	0.00	0.00	
103	RADIATION AREA MONITOR	PTFAC	0.00	0.00	0.00	0.00	
104	W-091 AR VLT COMPRESSOR UPGRD	PTFAC	0.00	0.00	0.00	0.00	
105	B-625 SAND FILTER VENT DUCT	PTFAC	0.00	0.00	0.00	0.00	
106	CAM UPGRD-B PLANT ENVIRONMENTAL	PTFAC	0.00	0.00	0.00	0.00	
			5.0	1.1	9.7	15.8	
	PRETREATMENT TECHNOLOGY						
107	CC ORGANIC DESTRUCTION PILOT PLANT COLD TESTS	TECH	0.00	0.00	1.05	1.05	8.2
108	TRUEX PROCESS DEVELOPEMENT	TECH	0.00	0.02	1.00	1.02	
109	TRU MONITOR-HOT PROTOTYPE	TECH	0.00	0.01	1.00	1.01	
110	TRUEX PILOT PLANT SCALE TEST WITH NCRW	TECH	0.22	0.00	0.72	0.94	
111	TRUEX PILOT PLANT SCALE TEST WITH CC WASTE	TECH	0.07	0.00	0.64	0.72	
112	TRUEX PILOT PLANT SCALE TEST WITH PFP WASTE	TECH	0.11	0.00	0.61	0.72	
113	TRUEX PILOT PLANT SCALE TEST WITH CC SOLIDS	TECH	0.05	0.00	0.57	0.62	
114	ION EXCHANGE TECHNOLOGY	TECH	0.00	0.01	0.50	0.51	

Table A-5. Integrated Relative Risk Factor Ranking List.
(sheet 5 of 8)

ACTIVITY TITLE	FAC./ FUNCT.	TIME RRF RANKING	COST RRF RANKING	SUCCESS RRF RANKING	INTEGRATED RRF RANKING	ACTIVITY RRF RANKING
115 CC PROCESS DEVELOPMENT-PHASE I	TECH	0.00	0.00	0.50	0.50	
116 W-153 TRUEX PILOT PLANT	TECH	0.00	0.33	0.05	0.38	
117 PILOT PLANT REDESIGN & MINOR MODS-CC TRUEX	TECH	0.15	0.01	0.00	0.16	
118 PILOT PLANT REDESIGN & MINOR MODS-PFP SOLIDS	TECH	0.14	0.01	0.00	0.15	
119 OXIDATION PILOT PLANT	TECH	0.00	0.04	0.05	0.08	
120 ENG EVAL FOR PH CONTROL	TECH	0.00	0.00	0.05	0.05	
121 ENG EVAL OF FLOC OPT TEST	TECH	0.00	0.00	0.05	0.05	
122 DRAFT FINAL FLOWSHEET FOR AR VAULT/B PLANT	TECH	0.00	0.00	0.05	0.05	
123 CC ORGANIC DEST PILOT PLANT HOT TESTS	TECH	0.00	0.01	0.03	0.04	
124 FINAL FLOWSHEET NCRW TRUEX	TECH	0.00	0.00	0.03	0.03	
125 FINAL FLOWSHEET CC ORGANIC DESTRUCTION	TECH	0.00	0.00	0.03	0.03	
126 FINAL FLOWSHEET PFP TRUEX	TECH	0.00	0.00	0.03	0.03	
127 FINAL FLOWSHEET CC TRUEX	TECH	0.00	0.00	0.03	0.03	
128 FINAL CC DISSOLUTION FLOWSHEET	TECH	0.00	0.00	0.03	0.03	
129 CC PROCESS DEVELOPMENT- PHASE II	TECH	0.00	0.01	0.00	0.01	
130 PILOT PLANT REDESIGN AND MINOR MODS-CC SOLIDS	TECH	0.00	0.01	0.00	0.01	
		0.7	0.5	7.0	8.2	
HWVP						
131 PREPARE FINAL WASTE COMPLIANCE PLAN	HWVP	0.00	0.00	1.50	1.50	7.8
132 PERFORM CONSTRUCTION/ATP/CAT	HWVP	0.00	0.91	0.05	0.96	
133 WASTE FORM DEVELOPMENT	HWVP	0.00	0.44	0.05	0.49	
134 102-AY NCAW SOLIDS TRANS/VITRIFY AT HWVP	HWVP	0.00	0.39	0.05	0.44	
135 CC OPERATIONS - HWVP (CONT)	HWVP	0.40	0.04	0.00	0.44	
136 REPLACE MELTER #1/TEST & STARTUP	HWVP	0.00	0.39	0.02	0.41	
137 REPLACE MELTER #2/TEST & STARTUP	HWVP	0.00	0.39	0.01	0.40	
138 101-AZ PNCAW SOLIDS TRANS/VITRIFY AT HWVP	HWVP	0.00	0.22	0.02	0.25	
139 NCRW OPERATIONS-HWVP	HWVP	0.00	0.16	0.08	0.25	
140 PERFORM OPERATIONAL TESTING	HWVP	0.00	0.20	0.03	0.23	
141 PROCURE EQUIPMENT IN TIME	HWVP	0.00	0.16	0.05	0.21	

Table A-5. Integrated Relative Risk Factor Ranking List. (sheet 6 of 8)

	ACTIVITY TITLE	FAC./ FUNCT.	TIME RRF RANKING	COST RRF RANKING	SUCCESS RRF RANKING	INTEGRATED RRF RANKING	ACTIVITY RRF RANKING
142	PERFORM PREOPERATIONAL TESTING	HWVP	0.00	0.16	0.04	0.20	
143	PFP OPERATIONS-HWVP	HWVP	0.00	0.12	0.07	0.19	
144	WASTE FORM DEVELOPMENT	HWVP	0.00	0.13	0.05	0.18	
145	HWVP DETAILED DESIGN TITLE II	HWVP	0.00	0.12	0.05	0.17	
146	PERFORM WFQ TESTING	HWVP	0.00	0.10	0.05	0.15	
147	WHC INSPECT AND ACCEPT CONSTRUCTION	HWVP	0.00	0.00	0.09	0.10	
148	INITIATE HWVP HOT OPERATIONS	HWVP	0.00	0.07	0.03	0.09	
149	CC OPERATIONS - HWVP	HWVP	0.00	0.04	0.05	0.09	
150	ISSUE/APPROVE WQR	HWVP	0.00	0.05	0.03	0.08	
151	DESIGN AND CONSTRUCTION-EXCHANGE	HWVP	0.00	0.02	0.05	0.07	
152	ECOLOGY ISSUE RCRA PART B/CAA PERMIT	HWVP	0.00	0.02	0.05	0.07	
153	ANALYZE AND INTEGRATE TECHNOLOGY	HWVP	0.00	0.01	0.05	0.06	
154	TRANSFER TECH TO DESIGN	HWVP	0.00	0.01	0.05	0.06	
155	DOE RL APPROVE PSAR	HWVP	0.00	0.01	0.05	0.06	
156	PERFORM COLD TEST READINESS REVIEW	HWVP	0.00	0.00	0.05	0.05	
157	ISSUE REVISED RCRA PART B PERMIT	HWVP	0.00	0.00	0.05	0.05	
158	DOE HQ KEY DECISION #3 APPROVAL TO START CONST	HWVP	0.00	0.00	0.05	0.05	
159	MONITOR DWPF LESSONS LEARNED	HWVP	0.00	0.00	0.05	0.05	
160	APPROVE FSAR	HWVP	0.00	0.00	0.05	0.05	
161	COMPLETE POST NCAW PROCESS DEVELOPMENT	HWVP	0.00	0.01	0.04	0.05	
162	INPUT COMPOSITION REQUIREMENT-NCAW FRIT PRO	HWVP	0.00	0.01	0.03	0.04	
163	INPUT COMPOSITION REQUIREMENT-NCRW FRIT PROC	HWVP	0.00	0.00	0.03	0.04	
164	INPUT COMPOSITION REQUIREMENT-PFP FRIT PROC	HWVP	0.00	0.00	0.03	0.03	
165	RECEIVE ACCEPTABLE FRIT FOR TESTING	HWVP	0.00	0.00	0.03	0.03	
166	RECEIVE ACCEPTABLE FRIT FOR HOT STARTUP	HWVP	0.00	0.00	0.03	0.03	
167	INPUT COMPOSITION REQUIREMENT-CC FRIT PROC	HWVP	0.00	0.00	0.03	0.03	
168	102-AY CHAR/FRIT PROC NCAW	HWVP	0.00	0.00	0.03	0.03	
169	101-AZ CHAR/FRIT PROC NCAW	HWVP	0.00	0.00	0.03	0.03	
170	NCRW FRIT-HWVP	HWVP	0.00	0.00	0.02	0.02	
171	PFP FRIT-HWVP	HWVP	0.00	0.00	0.02	0.02	
172	CC FRIT-HWVP	HWVP	0.00	0.00	0.02	0.02	

Table A-5. Integrated Relative Risk Factor Ranking List.
(sheet 7 of 8)

	ACTIVITY TITLE	FAC./ FUNCT.	TIME RRF RANKING	COST RRF RANKING	SUCCESS RRF RANKING	INTEGRATED RRF RANKING	ACTIVITY RRF RANKING
173	PERFORM HOT OPS READINESS REVIEW	HWVP	0.00	0.01	0.00	0.01	
174	INPUT DESIGN POST NCAW FEED SPECS	HWVP	0.00	0.00	0.00	0.00	
175	CC FRIT-HWVP (CONT)	HWVP	0.00	0.00	0.00	0.00	
176	FEED PROCESSING DEVELOPMENT	HWVP	0.00	0.00	0.00	0.00	
177	DESIGN SUFFICIENT TO START CONSTRUCTION	HWVP	0.00	0.00	0.00	0.00	
			0.4	4.2	3.2	7.8	
	TANK FARMS						
178	101-SY SAFETY ISSUE RESOLUTION	TKFRM	0.43	0.08	0.50	1.01	2.9
179	103-SY SAFETY ISSUE RESOLUTION	TKFRM	0.00	0.04	0.50	0.54	
180	103/104/105-AN SAFETY ISSUE RESOLUTION	TKFRM	0.02	0.00	0.50	0.52	
181	TANK FARMS CAPITAL UPGRD	TKFRM	0.00	0.28	0.10	0.38	
182	W-30 DST STORAGE VENT UPGRD	TKFRM	0.00	0.12	0.00	0.12	
183	W-058 CROSS SITE TRANSFER LINE	TKFRM	0.00	0.11	0.00	0.11	
184	TANK FARMS OPERATIONS AND ADMINISTRATIVE UPGRD	TKFRM	0.00	0.04	0.05	0.09	
185	TANK FARMS MAJOR MAINTENANCE UPGRD	TKFRM	0.00	0.03	0.05	0.08	
186	TANK FARMS DOCUMENTATION UPGRD	TKFRM	0.00	0.01	0.05	0.06	
187	AVAILABLE EAST AREA HOLDING TANK-CC TRANSFER	TKFRM	0.02	0.00	0.00	0.02	
188	AVAILABLE EAST AREA HOLDING TANK-PFP TRANSFER	TKFRM	0.00	0.00	0.00	0.00	
			0.5	0.7	1.8	2.9	
	CHARACTERIZATION						
189	CORE & CHARACTERIZATION (CC) FY91	CHAR	0.63	0.01	0.10	0.74	2.8
190	CORE SAMPLE AND CHARACTERIZE REMAINING CORES N	CHAR	0.00	0.04	0.10	0.14	
191	CHARACTERIZATION OF REMAINING CORES (NCRW)	CHAR	0.00	0.04	0.10	0.14	
192	CHARACTERIZATION OF REMAINING CORES (PFP)	CHAR	0.00	0.02	0.09	0.11	
193	CORE SAMPLE AND CHARACTERIZE NCAW FY91	CHAR	0.00	0.01	0.10	0.11	
194	CHARACTERIZE GROUT DSSF & DSS	CHAR	0.00	0.01	0.10	0.10	
195	2ND CORE AND CHARACTERIZATION NCRW (FY92)	CHAR	0.00	0.00	0.10	0.10	

Table A-5. Integrated Relative Risk Factor Ranking List.
(sheet 8 of 8)

	ACTIVITY TITLE	FAC./ FUNCT.	TIME RRF RANKING	COST RRF RANKING	SUCCESS RRF RANKING	INTEGRATED RRF RANKING	ACTIVITY RRF RANKING
196	CORE SAMPLE AND CHARACTERIZATION (PFP) FY91	CHAR	0.00	0.00	0.09	0.10	
197	CHARACTERIZATION OF REMAINING CORES (CC)	CHAR	0.32	0.04	0.91	1.27	
			0.9	0.2	1.7	2.8	
	GROUT						
198	GROUT DSS/DSSF OPERATIONS	GRT	0.00	0.06	0.52	0.58	1.6
199	GROUT NCAW OPERATIONS	GRT	0.00	0.01	0.35	0.36	
200	GROUT NCRW OPERATIONS	GRT	0.00	0.01	0.25	0.26	
201	GROUT PFP OPERATIONS	GRT	0.00	0.00	0.22	0.22	
202	GROUT CC OPERATIONS	GRT	0.00	0.04	0.15	0.18	
203	GROUT PERFORMANCE ASSESSMENT	GRT	0.00	0.01	0.00	0.01	
204	GROUT SAFETY ANALYSIS REPORT (FSAR)	GRT	0.00	0.00	0.00	0.00	
205	DEVELOP/VERIFY GROUT FORMULATIONS	GRT	0.00	0.00	0.00	0.00	
206	TYPE 2 READINESS REVIEW (GROUT)	GRT	0.00	0.00	0.00	0.00	
207	GROUT FACILITY MODIFICATIONS	GRT	0.00	0.00	0.00	0.00	
208	GROUT PART B PERMIT	GRT	0.00	0.00	0.00	0.00	
209	B-340B GROUT FEED TANK MODS	GRT	0.00	0.00	0.00	0.00	
210	W-062 GROUT FEED TANK MODS	GRT	0.00	0.00	0.00	0.00	
			0.0	0.1	1.5	1.6	

Table A-6. Hanford Waste Vitrification Plant Hot Startup Integrated Relative Risk Factor Ranking List. (sheet 1 of 5)

	ACTIVITY TITLE	FAC./ FUNCT.	TIME RRF	COST RRF	SUCCESS RRF	INTEGRATED RRF	ACTIVITY RRF RANKING
	RETRIEVAL						
1	102-AY SOLIDS-WASH OR RETRIEVE	RTRVL	5.06	0.05	0.25	5.36	11.1
2	W-151 101AZ RETRIEVAL SYS PROCESS TEST	RTRVL	2.50	0.02	0.05	2.57	
3	NCAW TANK 101-AZ PROCESS TEST	RTRVL	0.36	0.01	1.85	2.21	
4	W-148 NCAW 4 PUMP RETRIEVAL SYSTEM INSTALLATIO	RTRVL	0.70	0.01	0.04	0.75	
5	W-028 AGING WASTE TRANSFER LINES	RTRVL	0.00	0.07	0.05	0.12	
6	W-148 NCAW 4 PUMP RETRIEVAL SYSTEM ENG & PROC	RTRVL	0.00	0.00	0.05	0.06	
7	W-066 AZ TANK FARM ELECTRICAL UPGRADE	RTRVL	0.00	0.00	0.05	0.05	
8	W-106 TWREHO	RTRVL	0.00	0.00	0.00	0.00	
			8.6	0.2	2.3	11.1	
	PRETREATMENT FACILITIES						
9	W-024 B PLANT RAD EFFLUENT AND CONTAINMENT UPG	PTFAC	0.00	0.20	1.50	1.70	10.2
10	B-PLANT PART B APPLICATION	PTFAC	0.00	0.01	1.45	1.45	
11	W-161 TRU MONITOR	PTFAC	0.00	0.00	1.45	1.45	
12	AR VLT ENVIRONMENTAL PERMITTING	PTFAC	0.00	0.01	1.41	1.42	
13	101-AZ NCAW TRANS/PRETREAT AT AR VLT/B PLANT	PTFAC	0.39	0.01	0.03	0.43	
14	AR VLT OPS/WFQ SOLIDS WASHING	PTFAC	0.19	0.00	0.03	0.22	
15	AR VLT SYSTEM OPERABILITY TESTING	PTFAC	0.00	0.14	0.05	0.18	
16	W-059 CAT I VENTILATION UPGRD	PTFAC	0.00	0.11	0.05	0.16	
17	W-002 CANYON CRANE REPLACEMENT	PTFAC	0.00	0.05	0.10	0.15	
18	W-007 B PLANT PROCESS CONDENSATE FAC	PTFAC	0.00	0.07	0.05	0.12	
19	B PLANT FACILITY SAR	PTFAC	0.00	0.01	0.10	0.11	
20	W-111 AR VLT SEAL POT AND VESSEL VENT	PTFAC	0.00	0.01	0.10	0.11	
21	W-135 AR VLT SLUDGE WASHING PROCESS MODS	PTFAC	0.00	0.01	0.10	0.11	
22	W-110 AR VLT TRANSFER LINE AND DIESEL FUEL	PTFAC	0.00	0.01	0.10	0.11	
23	W-136 AR VLT SLUDGE WASHING CONTROL ROOM MODS	PTFAC	0.00	0.01	0.10	0.11	
24	B PLANT TANK INTEGRITY ASSESSMENT	PTFAC	0.00	0.00	0.10	0.10	
25	W-102 GALLERY EXHAUST VENT	PTFAC	0.00	0.00	0.10	0.10	
26	CLEAN WATER ACT-BCP	PTFAC	0.00	0.00	0.10	0.10	

Table A-6. Hanford Waste Vitrification Plant Hot Startup Integrated Relative Risk Factor Ranking List. (sheet 2 of 5)

	ACTIVITY TITLE	FAC./ FUNCT.	TIME RRF	COST RRF	SUCCESS RRF	INTEGRATED RRF	ACTIVITY RRF RANKING
27	CLEAN WATER ACT-BCE	PTFAC	0.00	0.00	0.10	0.10	
28	CLEAN WATER ACT-CBC	PTFAC	0.00	0.00	0.10	0.10	
29	CLEAN AIR ACT-NCAW PROCESSING	PTFAC	0.00	0.00	0.10	0.10	
30	B PLANT SYSTEM OPERABILITY TESTING	PTFAC	0.00	0.00	0.10	0.10	
31	AR VLT CANYON CRANE INSPECTION/UPGRD	PTFAC	0.00	0.00	0.10	0.10	
32	CLEAN WATER ACT-PROJECT W-107	PTFAC	0.00	0.00	0.10	0.10	
33	CLEAN WATER ACT-BCS	PTFAC	0.00	0.00	0.10	0.10	
34	CLEAN WATER-PROJECT W-098	PTFAC	0.00	0.00	0.10	0.10	
35	B PLANT READINESS REVIEW-WHC/DOE	PTFAC	0.00	0.00	0.08	0.08	
36	W-108 BCE TREATMENT FACILITY	PTFAC	0.00	0.02	0.05	0.07	
37	W-103 ON DECK SAMPLING IMPROVEMENT	PTFAC	0.00	0.02	0.05	0.07	
38	W-027 271B HVAC UPGRD	PTFAC	0.00	0.01	0.05	0.06	
39	W-010 B PLANT ENVIRONMENTAL COMPLIANCE	PTFAC	0.00	0.01	0.05	0.06	
40	W-104 B PLANT OPS SUPPORT BUILDING	PTFAC	0.00	0.00	0.05	0.05	
41	W-004 B PLANT AMU UPGRD	PTFAC	0.00	0.00	0.05	0.05	
42	AR VLT SAR	PTFAC	0.00	0.01	0.05	0.05	
43	SEISMIC ANALYSIS-B PLANT	PTFAC	0.00	0.00	0.05	0.05	
44	W-065 WH/IX/SD PROCESS CONTRL VALVE	PTFAC	0.00	0.00	0.05	0.05	
45	W-077 CT/CS PROCESS CONTROL VALVE UPGRD	PTFAC	0.00	0.00	0.05	0.05	
46	W-162 IX MECHANICAL EQUIPMENT UPGRD	PTFAC	0.00	0.00	0.05	0.05	
47	W-056 IIWC/PHPF PC VALVE PH I	PTFAC	0.00	0.00	0.05	0.05	
48	W-159 CT/CS INSTRUMENT UPGRD	PTFAC	0.00	0.00	0.05	0.05	
49	W-160 IN CELL AND HPT LEAK DETECTION	PTFAC	0.00	0.00	0.05	0.05	
50	AR VLT SEISMIC ANALYSIS	PTFAC	0.00	0.00	0.05	0.05	
51	W-168 B PLANT FILTER SYSTEM TIE-IN	PTFAC	0.00	0.00	0.05	0.05	
52	B PLANT TRAINING	PTFAC	0.00	0.00	0.05	0.05	
53	AR VLT NEW CANYON EQUIPMENT	PTFAC	0.00	0.00	0.05	0.05	
54	AR VLT TANK INTEGRITY ASSESSMENT	PTFAC	0.00	0.00	0.05	0.05	
55	AR VLT ENVIRONMENTAL ANALYSIS	PTFAC	0.00	0.00	0.05	0.05	
56	AR VLT-FACILITY DESCRIPTION MANUAL	PTFAC	0.00	0.00	0.05	0.05	
57	AR VLT TRAINING	PTFAC	0.00	0.00	0.04	0.05	

Table A-6. Hanford Waste Vitrification Plant Hot Startup Integrated Relative Risk Factor Ranking List. (sheet 3 of 5)

ACTIVITY TITLE	FAC./ FUNCT.	TIME RRF	COST RRF	SUCCESS RRF	INTEGRATED RRF	ACTIVITY RRF RANKING
58 W-107 BCS TREATMENT CENRIC	PTFAC	0.00	0.01	0.00	0.01	
59 AR VLT READINESS REVIEW (WHC & DOE)	PTFAC	0.00	0.01	0.00	0.01	
60 B-PLANT CANYON EXHAUST FILTER SYSTEMS	PTFAC	0.00	0.01	0.00	0.01	
61 W-008 B PLANT CHEM SEWER NEUTRALIZATION	PTFAC	0.00	0.01	0.00	0.01	
62 W-003 CHEM SEWER ENVIRONMENTAL UPGRD	PTFAC	0.00	0.00	0.00	0.00	
63 W-098 HAZARD WASTE STORAGE	PTFAC	0.00	0.00	0.00	0.00	
64 W-040 CELL 18 CESIUM IX COL	PTFAC	0.00	0.00	0.00	0.00	
65 B PLANT ADMINISTRATIVE MANUAL UPGRD	PTFAC	0.00	0.00	0.00	0.00	
66 W-163 CELL DRAINAGE AND VESSEL VENT INSTRUMENT	PTFAC	0.00	0.00	0.00	0.00	
67 W-161 TRU MONITOR CONTINUED	PTFAC	0.00	0.00	0.00	0.00	
68 NCAW JUMPER CONSTRUCTION	PTFAC	0.00	0.00	0.00	0.00	
69 GROUT FEED SPEC	PTFAC	0.00	0.00	0.00	0.00	
70 W-094 291B FILTER INSTRUMENTATION UPGRD	PTFAC	0.00	0.00	0.00	0.00	
71 RADIATION AREA MONITOR	PTFAC	0.00	0.00	0.00	0.00	
72 B-625 SAND FILTER VENT DUCT	PTFAC	0.00	0.00	0.00	0.00	
73 B PLANT INTERIM STATUS ACTIONS BIS/BPL	PTFAC	0.00	0.00	0.00	0.00	
74 CAM UPGRD-B PLANT ENVIRONMENTAL	PTFAC	0.00	0.00	0.00	0.00	
75 W-091 AR VLT COMPRESSOR UPGRD	PTFAC	0.00	0.00	0.00	0.00	
		0.6	0.8	8.9	10.2	
HWVP						
76 PREPARE FINAL WASTE COMPLIANCE PLAN	HWVP	0.00	0.00	1.50	1.50	6.0
77 PERFORM CONSTRUCTION/ATP/CAT	HWVP	0.00	0.91	0.05	0.96	
78 102-AY CHAR/FRIT PROC NCAW	HWVP	0.81	0.00	0.03	0.84	
79 WASTE FORM DEVELOPMENT	HWVP	0.00	0.44	0.05	0.49	
80 ISSUE/APPROVE WQR	HWVP	0.18	0.05	0.03	0.26	
81 INPUT COMPOSITION REQUIREMENT-NCAW FRIT PRO	HWVP	0.19	0.01	0.03	0.23	
82 RECEIVE ACCEPTABLE FRIT FOR TESTING	HWVP	0.18	0.00	0.03	0.21	
83 PROCURE EQUIPMENT IN TIME	HWVP	0.00	0.16	0.05	0.21	
84 PERFORM PREOPERATIONAL TESTING	HWVP	0.00	0.16	0.04	0.20	

Table A-6. Hanford Waste Vitrification Plant Hot Startup Integrated Relative Risk Factor Ranking List. (sheet 4 of 5)

	ACTIVITY TITLE	FAC./ FUNCT.	TIME RRF	COST RRF	SUCCESS RRF	INTEGRATED RRF	ACTIVITY RRF RANKING
85	HWVP DETAILED DESIGN TITLE II	HWVP	0.00	0.12	0.05	0.17	
86	PERFORM WFQ TESTING	HWVP	0.00	0.10	0.05	0.15	
87	WHC INSPECT AND ACCEPT CONSTRUCTION	HWVP	0.00	0.00	0.09	0.10	
88	INITIATE HWVP HOT OPERATIONS	HWVP	0.00	0.07	0.03	0.09	
89	DESIGN AND CONSTRUCTION-EXCHANGE	HWVP	0.00	0.02	0.05	0.07	
90	ECOLOGY ISSUE RCRA PART B/CAA PERMIT	HWVP	0.00	0.02	0.05	0.07	
91	ANALYZE AND INTEGRATE TECHNOLOGY	HWVP	0.00	0.01	0.05	0.06	
92	TRANSFER TECH TO DESIGN	HWVP	0.00	0.01	0.05	0.06	
93	DOE RL APPROVE PSAR	HWVP	0.00	0.01	0.05	0.06	
94	PERFORM COLD TEST READINESS REVIEW	HWVP	0.00	0.00	0.05	0.05	
95	ISSUE REVISED RCRA PART B PERMIT	HWVP	0.00	0.00	0.05	0.05	
96	DOE HQ KEY DECISION #3 APPROVAL TO START CONST	HWVP	0.00	0.00	0.05	0.05	
97	MONITOR DWPF LESSONS LEARNED	HWVP	0.00	0.00	0.05	0.05	
98	APPROVE FSAR	HWVP	0.00	0.00	0.05	0.05	
99	RECEIVE ACCEPTABLE FRIT FOR HOT STARTUP	HWVP	0.01	0.00	0.03	0.04	
100	PERFORM HOT OPS READINESS REVIEW	HWVP	0.00	0.01	0.00	0.01	
101	FEED PROCESSING DEVELOPMENT	HWVP	0.00	0.00	0.00	0.00	
102	DESIGN SUFFICIENT TO START CONSTRUCTION	HWVP	0.00	0.00	0.00	0.00	
			1.4	2.1	2.6	6.0	
	TANK FARMS						
103	TANK FARMS CAPITAL UPGRD	TKFRM	0.00	0.28	0.10	0.38	0.7
104	W-30 DST STORAGE VENT UPGRD	TKFRM	0.01	0.12	0.00	0.12	
105	TANK FARMS OPERATIONS AND ADMINISTRATIVE UPGRD	TKFRM	0.00	0.04	0.05	0.09	
106	TANK FARMS MAJOR MAINTENANCE UPGRD	TKFRM	0.00	0.03	0.05	0.08	
107	TANK FARMS DOCUMENTATION UPGRD	TKFRM	0.00	0.01	0.05	0.06	
			0.0	0.5	0.3	0.7	

Table A-6. Hanford Waste Vitrification Plant Hot Startup Integrated Relative Risk Factor Ranking List. (sheet 5 of 5)

ACTIVITY TITLE	FAC./ FUNCT.	TIME RRF	COST RRF	SUCCESS RRF	INTEGRATED RRF	ACTIVITY RRF RANKING
PRETREATMENT TECHNOLOGY						
108 ION EXCHANGE TECHNOLOGY	TECH	0.00	0.01	0.50	0.51	0.6
109 ENG EVAL FOR PH CONTROL	TECH	0.00	0.00	0.05	0.05	
110 ENG EVAL OF FLOC OPT TEST	TECH	0.00	0.00	0.05	0.05	
111 DRAFT FINAL FLOWSHEET FOR AR VAULT/B PLANT	TECH	0.00	0.00	0.05	0.05	
		0.0	0.0	0.6	0.6	
CHARACTERIZATION						
112 CORE SAMPLE AND CHARACTERIZE REMAINING CORES N	CHAR	0.00	0.04	0.10	0.14	0.2
113 CORE SAMPLE AND CHARACTERIZE NCAW FY91	CHAR	0.00	0.01	0.10	0.11	
		0.0	0.0	0.2	0.2	
GROUT						
(GROUT activities do not affect the hot startup of HWVP)		0.0	0.0	0.0	0.0	0.0

Table A-7. Distributed Model Results--Program Functional Area Estimated Cost Breakdown.

Activity	Total cost ($M) (FY 1991 dollars
Characterization	45.3
Grout	489.8
HWVP	2,746.7
Pretreatment	1,223.1
Retrieval	453.9
Pretreatment technology	86.0
Tank Farms	752.5
Program management	434.6
Program Total	6,231.8

FY = Fiscal year
HWVP = Hanford Waste Vitrification Plant

A.9 RELATIVE RISK FACTOR ANALYSIS

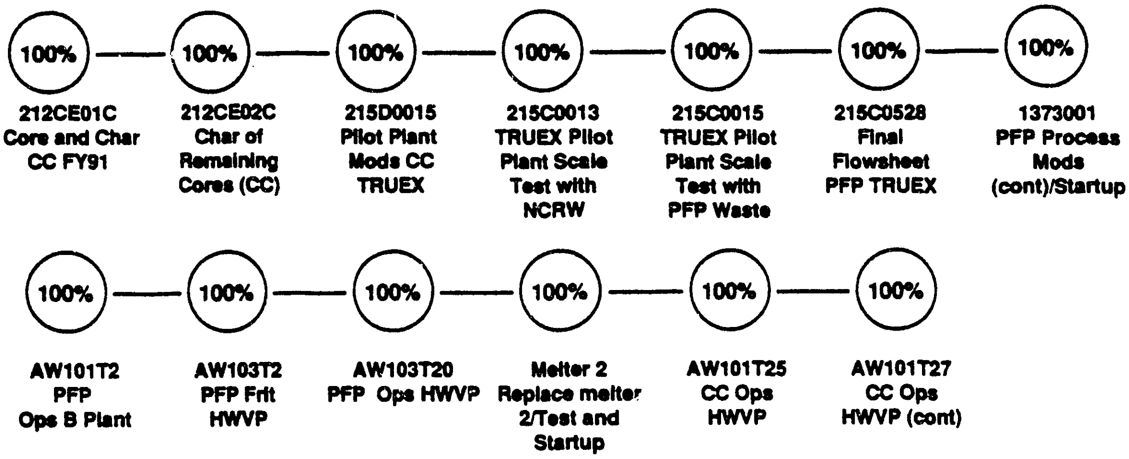
The analysis of the program risk resulting from an activity or grouping of activities must include all three risk factors (cost, schedule, and probability of success) to correctly assess the total programmatic risk. Review of only the cost, schedule, or probability risks individually can be a valuable analysis tool. Drawing programmatic conclusions based on these individual risk factors can, however, produce erroneous results and should be avoided.

The aggregation of cost, schedule, and probability of success risks for individual activities and major activity groupings utilized in this assessment was accomplished using the integrated RRF equation discussed in the following paragraphs. The purpose of the integrated RRF is to sum the three risk factors incorporating appropriate weighting and adjustment factors to produce a numeric evaluation of the relative risk represented by the activity or grouping of activities by which they can be ranked.

Examples of the RRF values resulting from several cost, schedule, and probability uncertainties are presented in Table A-8. A complete integrated RRF calculation is provided in this section.

It should be noted that an activity with a significant projected delay in its completion schedule does not necessarily have a significant schedule RRF. Only if the activity in question has some probability of being on the program critical path will it receive a schedule RRF rating. This can result in masking significant schedule uncertainties. If a program has the potential for a substantial schedule delay, sensitivity analyses like those discussed in Sections 4.5.6.2 and 4.5.6.3 are necessary to ensure significant schedule uncertainties are not masked.

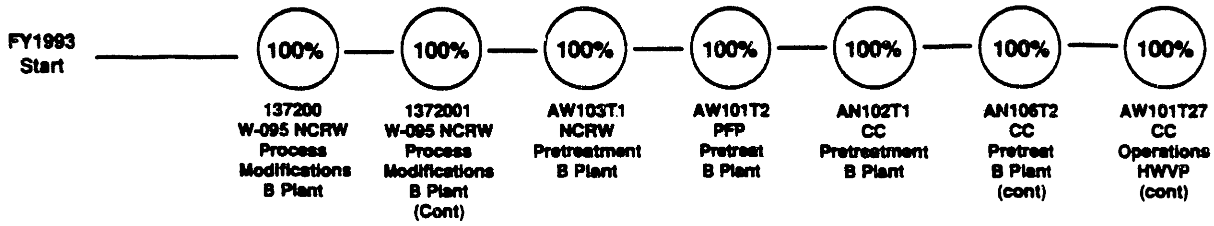
Figure A-1. Time Critical Path Baseline Case.



CC = Complexant Concentrate
HWVP = Hanford Waste Vitrification Plant
NCRW = Neutralized Cladding Removal Waste
PFP = Plutonium Finishing Plant

79108120.1

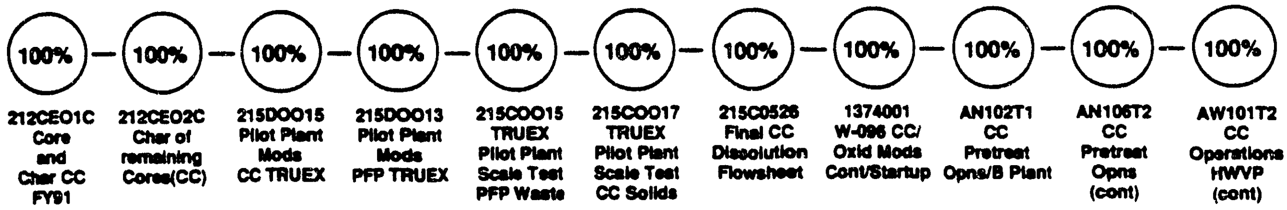
Figure A-2. Time Critical Path Optimistic Case.



CC = Complexant Concentrate
DSS = Double-Shell Slurry
DSSF = Double-Shell Slurry Feed
HWVP = Hanford Waste Vitrification Plant
NCRW = Neutralized Cladding Removal Waste
PFP = Plutonium Finishing Plant

79108120.2

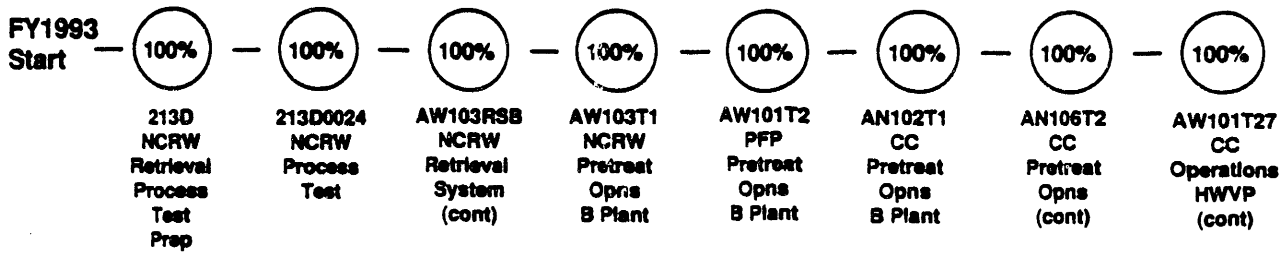
Figure A-3. Time Critical Path Most Likely Case.



CC = Complexant Concentrate
FY = Fiscal Year
HWVP = Hanford Waste Vitrification Plant
PFP = Plutonium Finishing Plant
TRUEX = Transuranic Extraction

79108120.3

Figure A-4. Time Critical Path Pessimistic Case.



CC = Complexant Concentrate
HWVP = Hanford Waste Vitrification Plant
NCRW = Neutralized Cladding Removal Waste
PFP = Plutonium Finishing Plant

79108120.4

Table A-8. Example of Relative Risk Factor Values.

Probability of Success Risk (sensitive to start date)	RRF value
• Activity starting now with 80% probability of success	1.0
• Same activity beginning 5 yr later	0.8
Schedule Risk (sensitive to critical path)	
• Activity with potential 1-yr delay and 50% on critical path	1.0
• Same activity 10% on critical path	0.2
Cost Risk	
• Activity with potential $200 million cost increase	1.0
• With $100 million cost increase	0.5

RRF = Relative risk factor

The RRF calculation equation (Eq. 1) is used to normalize the values of risk originating from the three types of uncertainty: (1) cost, (2) schedule duration, and (3) probability of success affecting program activities. The normalization of these three uncertainty types used the relationships similar to those established during the preparation of preliminary findings in December 1990. The lower limit values used in establishing a major consequence (cost and schedule duration) and a high probability activity (probability) used in developing the preliminary findings were used as the points in the uncertainty ranges at which the values were set equal. The actual values at which the uncertainties were equalized were: (1) cost = $100 million cost increase, (2) schedule = 1-yr schedule delay, and (3) probability = 80 percent probability of success for the activity.

Additional factors warrant consideration in establishing the ranking of risks of an activity. These include the following: (1) the potential impact an activity delay has on overhead costs and processing plant outages; (2) the frequency that the activity falls on the program's schedule critical path; and (3) the near- or long-term nature of a probability uncertainty, (i.e., the near-term probability problem is more significant than the long-term problem with the same probability rating because there is more time available to resolve the long-term probability uncertainty).

Consideration of these three additional factors has therefore been incorporated into the RRF calculation equation as discussed in the following paragraphs.

1. <u>Schedule Extension Impacts Factor</u>--The extension or delay of any program activity has the potential to extend the duration of the program.

Equation 1. Integrated Risk Ranking Factor Calculation.

The programmatic or integrated RRF (RRF_I) is calculated using the following equation:

$$RRF_I = RRF_S + RRF_C + RRF_P$$

where

RRF_I is the total programmatic, integrated RRF

RRF_S is the schedule RRF calculated as

$$RRF_S = K_S \cdot F_{CP} \cdot \text{Schedule Delta}$$

where

K_S is the constant 2.0 (see Item 1--Schedule Extension Factor discussion that follows)

F_{CP} is the critical path frequency of the activity (see Item 2--Critical Path Frequency Factor that follows)

Schedule delta is the larger of the following:

1. Pessimistic - most likely schedule duration
2. Most likely - baseline schedule duration*

RRF_C is the cost RRF calculated as

$$RRF_C = K_C \cdot \text{Cost Delta}$$

where

K_C is the constant 0.5 x 10^{-8}. [The 10^{-8} element of the constant equates $100 million (high consequence cost) to 1 yr (high consequence schedule). The 0.5 element is included to compensate for the lack of a percentage factor in the RRF_C calculation similar to the F_{CP} in the RRF_S calculation and the P_{SQ} in the RRF_P calculation. The 0.5 was selected as equivalent to a 50 percent or mid-point of the possible RRF_S and RRF_P percentage factors.]

Cost delta is the larger of the following:

1. Pessimistic - most likely activity cost
2. Most likely - baseline activity cost*

*This factor was not considered when a baseline value had not been established.

Equation 1. Integrated Risk Ranking Factor Calculation. (cont)

RRF_p is the probability RRF calculated as follows

$$RRF_P = K_P \cdot [1 - P_{(S)}] \cdot P_{SO}$$

where

K_p is the constant 5. This factor is required to numerically equate a high-risk probability to a high-consequence cost ($100 million) or schedule (1 yr).

P_s is the probability of success of the activity.

P_{so} is the probability schedule occurrence factor calculated as shown below (see Item 3--Near-Term Versus Long-Term Factor that follows).

$$P_{so} = 1 - \frac{\text{Years to activity start}}{\text{Program duration (years).}}$$

Extension of the program could cause the program to incur the additional program operating costs for the duration of the extension.

Annual costs for the total program excluding capital expenditures are in the $125-million to $150-million range.

Because a 1-yr extension of the duration of an activity (already defined as a major consequence) could have cost impacts to other program activities of the magnitude discussed above, additional weighing of the schedule RRF was deemed appropriate. A factor of 2 multiplier was selected to address the combined schedule delay impact and cost impact to other activities (potentially $100 million plus/yr).

2. The Critical Path Frequency Factor--For schedule impact activities, the frequency (percentage of the VERT model iterative calculations) with which the activity would fall on the program's critical path was included in the schedule RRF calculation. This factor addresses the fact that schedule extensions of non-critical path activities would be absorbed in float periods present in the program schedule.

3. Near-Term Versus Long-Term Factor--For probability impact activities, the near-term versus long-term factor is a factor that considered the time available to the program to take actions to

Relative Risk Factor Sample Calculation

The following sample calculation is provided to demonstrate the process. The calculation will be made on the "Test Activity" described below.

Test Activity Data

- Critical path frequency (F_{CP}) = 20 percent or 0.20 (The activity is on the program critical path this percentage of the time as determined by the VERT analysis.)
- Schedule delta
  - Pessimistic minus most likely schedule duration = 1.5 yr*
  - Most likely minus baseline schedule duration = 2.0 yr*
- Cost delta
  - Pessimistic minus most likely activity cost = $100,000K*
  - Most likely minus baseline activity cost = $2,000K*
- Probability of success = 80 percent or 0.80
- Years to activity start = 5 yr
- Program duration = 25.1 yr

Sample Calculation

$RRF_I = RRF_S + RRF_C + RRF_P = 0.6 + 0.5 + 0.8 = \underline{1.9}$

where

$RRF_S = K_S \cdot F_{CP} \cdot \text{Schedule delta}$

$= 2 \cdot (0.20) \cdot 2.0 = \underline{0.6}$

$RRF_C = K_C \cdot \text{Cost delta}$

$= 0.5 \cdot 10^{-8} \cdot (100{,}000{,}000) = \underline{0.5}$

$RRF_P = K_P \cdot [1 - P_{(S)}] \cdot [1 - \text{Yr to activity start/Program duration}]$

$= 5 \cdot [1 - 0.80] \cdot [1 - 5/25.1]$

$= 5 \cdot [0.20] \cdot [1 - 0.20] = \underline{0.80}$

*The calculation uses the larger of these two values.

improve the probability of success of an activity. This was accomplished by adding a multiplier to the probability RRF, which progressively reduced its weighing throughout the duration of the program.

A.10 PLANT STANDBY ANALYSIS

Data from the distributed model run and the critical path activity duration reduction sensitivity runs were further analyzed to determine B Plant and HWVP standby time during the total program duration. Table A-9 shows the results of this analysis.

Table A-9. Plant Standby Durations.

Plant	Standby time	
	Distributed run	Schedule durations mitigated - sensitivity analysis run
HWVP	3.75 yr	2.64 yr
B Plant	3.05 yr	1.69 yr

HWVP = Hanford Waste Vitrification Plant

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APPENDIX B

ASSESSMENT REVIEWS

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CONTENTS

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APPENDIX B

ASSESSMENT REVIEWS

B.1 B PLANT COMPLIANCE ASSESSMENT REVIEW

The B Plant Compliance Assessment Review was conducted to document any uncertainties caused by facility design deficiencies, which were identified during the DOE Order 6430.1A, *General Design Criteria* (DOE 1989), compliance assessment of this facility.

The results of this review were issued in April 1989, and documented the evaluation of B Plant compliance to DOE Order 6430.1A (draft dated 12/25/87) and to codes, standards, and regulations (CS&R) pertaining to radioactive waste management.

The goal of this review was to identify B Plant areas of noncompliance to DOE Orders and CS&Rs to permit reactivation of B Plant for a 20-yr mission. At the onset, it was determined that a detailed assessment of B Plant systems to DOE Order 6430.1A criteria would provide a sound basis for initial B Plant decisions, thus the review initially concentrated on DOE Order 6430.1A comparisons.

The compliance assessment was based on a B Plant classification as a radioactive liquid waste facility as defined by DOE 6430.1A, Section 1323. Furthermore, it is assumed that B Plant will not be a plutonium-handling facility based on DOE Order 6430.1A. The B Plant staff will install transuranic extraction equipment to reduce waste volumes sent to the Hanford Waste Vitrification Plant (HWVP) and to clean up waste streams--not for recovery of plutonium. An additional assumption initially made in the assessment was that the canyon ventilation and canyon building are the only safety class items required for B Plant operation. During the preparation of a final accident analysis and the resulting safety system selection by Westinghouse Hanford Company (Westinghouse Hanford), other candidate safety systems were identified. Although no final decision on safety class items was available, the comparison tables attempted to address safety class item issues on a case-by-case basis. Selection of safety class items has major impact on B Plant compliance to applicable CS&Rs.

In general, effort concentrated on assessments of the 221-B canyon building. Often the assessment was expanded to include surrounding B Plant facilities. For example, the heating, ventilating, and air conditioning (HVAC) assessment included the 291-B stack and associated facilities.

<u>Summary</u>--This report addressed approximately 610 selected criterion items, of which 73 were determined to be noncompliant. The compliance status of 36 issues is to be determined.

The major noncompliance issues identified are as follows.

1. It is not clear whether existing safety class structures, including the canyon (secondary confinement) and ventilation components,

retain confinement capability during and after a design basis earthquake (DBE).

2. The safety class stack ventilation and effluent monitoring systems do not have adequately qualified emergency power.

3. Modification to the exhaust stack, filter cells, and exhaust air tunnels may be needed to preclude unacceptable consequences during a DBE.

4. A fire protection analysis and subsequent facility modifications, if any, must be performed to ensure that B Plant is an "improved risk" facility.

5. The as low as reasonably achievable (ALARA) objectives can be enhanced in the areas of canyon sampling, steam system pressure relief, and operating gallery instrument dip-tube confinement.

6. The existing once-through process cooling system should be replaced to meet the requirements of closed-loop cooling systems specified by DOE Order 6430.1A for use in high-level radioactive liquid waste facilities.

7. Many of the candidate safety class instrumentation and control (I&C) systems do not meet the requirements of I&C safety class items including DBA resistance, redundancy, environmental qualification, and uninterruptible power supply (UPS) power.

<u>Other Issues Identified</u>--Other issues identified during the compliance assessment review included the following.

- The compliance assessment review concentrated on design issues to identify the necessary engineering projects and possible facility modifications to bring B Plant into compliance with the codes. Therefore, no detailed assessment table for administrative codes was prepared. However, there are administrative requirements that may directly affect the scope of engineering projects, including the following.

  - The final safety analysis report (FSAR) must be completed and approved before initial operation. Safety class items identified by the FSAR have a major impact on system design.

  - Seismic design shall be reviewed by a qualified, independent organization. Considerable seismic analysis is required to establish B Plant structural confinement adequacy.

  - Decommissioning issues must be addressed as specified in Section 1300-11 of DOE Order 6430.1A. These issues include design details consistent with program requirements of DOE Order 5820.2A, *Radioactive Waste Management* (DOE 1988a).

  - A comprehensive documentation system is required to properly facilitate quality assurance and future safety audits.

A document control and updating system approaching the requirement of ASME NQA-1-1989 (ASME 1989a) is necessary to ensure compliance to design criteria and safety requirements.

- The assessment of B Plant compliance to structural design criteria concentrated on canyon building 221-B because this was an area of potential major impact. The structure was built in the early 1940's so assessment of compliance to modern standards was made by comparison of modern standards to the *Uniform Building Code of 1940* (ICBO 1940), the assumed code of record for original construction. Several items, such as proper concrete pouring and forming procedures, could not be accurately assessed because adequate records do not exist to support this "after-the-fact" analysis.

- This compliance assessment was performed to DOE Order 6430.1A (draft dated 12/25/87), which has been superseded by DOE Order 6430.1A (dated 04/06/89) with some revision.

- Facility upgrade projects have been completed or planned since the compliance assessment was performed in 1989 and may require future assessment to meet DOE Order 6430.1A criteria for compliance.

In addition, *Independent Safety Evaluation Review of B Plant Viability Study* (Sprouse 1991), prepared by the Los Alamos Technical Associates, identified the following concerns.

- The B Plant final high-efficiency particulate air (HEPA) filters do not have the capability for inplace testing of each bank independently and without personnel entry into the plenum.

- Single-failure criterion for instrumentation and electrical power supply needs further evaluation.

- An additional evaluation of nonradioactive hazardous waste is recommended.

Significant Uncertainties Documented--The significant uncertainties documented for consideration in the risk assessment model as a result of this review are summarized below.

- The B Plant structure and confinement systems may not withstand a DBE.

- The B Plant once-through process cooling water system is less than adequate.

- The B Plant safety class systems are less than adequate.

- The B Plant FSAR for this operation has not been completed.

- The B Plant structural concrete integrity has not been verified.

- The B Plant compliance assessment did not address nonradioactive hazardous materials.
- The B Plant final HEPA filters do not have capability for inplace testing of individual banks.

B.2 244-AR VAULT COMPLIANCE ASSESSMENT REVIEW

The 244-AR Vault Compliance Assessment Review was conducted to document any uncertainties caused by facility design deficiencies, which were identified during the DOE Order 6430.1A compliance assessment of this facility.

The results of this review were issued in April 1989 and documented the evaluation of 244-AR Vault compliance to DOE Order 6430.1A (draft dated 12/25/87) and to CS&Rs pertaining to radioactive waste management.

The goal of this review was to identify 244-AR Vault areas of noncompliance to DOE Orders and CS&Rs to permit reactivation of 244-AR Vault for a 20-yr mission. At the onset, it was determined that a detailed assessment of 244-AR Vault systems to DOE Order 6430.1A criteria would provide a sound basis for initial 244-AR Vault decisions. Thus, this task initially concentrated on DOE Order 6430.1A comparisons.

The compliance assessment was based on a 244-AR Vault classification as a radioactive liquid waste facility as defined by DOE Order 6430.1A, Section 1323. Furthermore, it was assumed that the 244-AR Vault would not be a plutonium-handling facility. An additional assumption initially used in the assessment was that the ventilation systems and the 244-AR Vault structures are the only safety class items required for the 244-AR Vault operation. A final accident analysis and the resulting safety system selection was still being prepared by Westinghouse Hanford, and during the course of this work, other candidate safety systems were identified. Although no final decision on safety class items was available, the comparison tables attempted to address safety class item issues on a case-by-case basis. Selection of safety class items has major impact on 244-AR Vault compliance to applicable CS&Rs.

<u>Summary</u>--This report addressed approximately 670 selected criterion items, of which 95 were determined to be noncompliant. The compliance status of 94 issues is to be determined.

The major noncompliance issues identified are as follows.

1. It is not clear that the existing safety class structure and ventilation systems remain operational and retain confinement during and after credible DBAs.

2. The safety class ventilation systems and effluent monitoring systems do not have adequately qualified emergency power.

3. Fire protection analysis and subsequent facility modifications, if any, must be performed to ensure that the 244-AR Vault is an "improved risk" facility.

4. The ALARA objectives can be enhanced in the area of the control room/operating gallery due to the limited unallocated space and the contamination potential from the instrument tubes, jet gang valves, and chemical addition lines routed directly to incell tanks. Additional measures, such as providing floor drains, also should be considered.

5. Several areas concerning confinement issues require corrective action. The underground tanks, the offgas prefilter vault, and the buried offgas ventilation line prior to HEPA filtration need to be upgraded for additional containment and leak-detection capability.

6. A risk assessment should be performed with respect to the environmental impact associated with the concrete-encased, high-level waste transfer line. The concrete-encased transfer line should be upgraded with double-walled pipe with provisions for leak detection, collection, and transfer capabilities (if this assessment results in an unacceptable finding).

7. Many of the candidate safety class I&C systems do not meet the requirements of I&C safety class items including DBA resistance, redundancy, environmental qualification, and UPS power.

Other Issues Identified--Other issues identified during the compliance assessment review included the following.

- This task concentrated on design issues in order to identify the necessary engineering projects and possible facility modifications to bring the 244-AR Vault into compliance with the codes. Therefore, no detailed assessment table for administrative codes was prepared. However, there are administrative requirements that may directly affect the scope of engineering projects and these include the following.
  - The FSAR must be completed and approved before initial operation. Safety class items identified by the FSAR have a major impact on system design.
  - Seismic design shall be reviewed by a qualified, independent organization. Considerable seismic analysis is required to establish 244-AR Vault structural adequacy.
  - Decommissioning issues must be addressed as specified in Section 1300-11 of DOE Order 6430.1A. These issues include design details consistent with program requirements of DOE Order 5820.2A (DOE 1988a).
  - The drawings for the 244-AR Vault facility should be thoroughly reviewed and "as-built" for the current facility and system configurations.
- This compliance assessment was performed to DOE Order 6430.1A (draft dated 12/25/87), which has been superseded by DOE Order 6430.1A (dated 04/06/89) with some revision.

Significant Uncertainties Documented--The significant uncertainties documented for consideration in the risk assessment model as a result of this review are summarized below.

- The AR Vault structure and confinement systems may not withstand a DBE.

- The AR Vault emergency power system is less than adequate.
- The AR Vault confinement systems are less than adequate.
- The AR Vault concrete-encased transfer lines are less than adequate.
- The AR Vault safety class systems are less than adequate.
- The AR Vault FSAR for this operation has not been completed.
- The AR Vault facility drawings are not up to date.

B.3 HANFORD WASTE VITRIFICATION PLANT COMPLIANCE ASSESSMENT REVIEW

The Hanford Waste Vitrification Plant Compliance Assessment Review was conducted to document any uncertainties caused by facility design deficiencies, which were identified during the DOE Order 6430.1A compliance assessment of this facility.

This report compares design criteria, specifications, and preliminary design for the HWVP with applicable, safety-related criteria from DOE Order 6430.1A.

This report was issued in February 1991, and it documents the DOE Order 6430.1A compliance assessment by identifying safety-related criteria from the DOE Order 6430.1A applicable to HWVP, comparing these safety-related criteria with the preliminary HWVP design, and identifying specific areas of HWVP compliance and noncompliance.

The bases used in selecting criteria for the HWVP were identified from the HWVP preliminary design technical description report, other supporting documents, and the following technical assumptions.

- The HWVP is classified as a DOE "high" hazard facility.
- The HWVP is designated as a DOE "critical" facility.
- The HWVP operations are designated as a DOE "vital" program.
- The HWVP will not be a plutonium-handling facility.
- The HWVP is designated a "limited control facility" pertaining to criticality considerations.
- The HWVP will not include a safety-class cooling water system.
- The HWVP will not be a "Limited Access" area pertaining to security and will not store special nuclear materials.

The compliance assessment is based on the classification of the HWVP complex as a radioactive liquid waste facility (DOE Order 6430.1A, Section 1323), a radioactive solid waste facility (Section 1324), and a laboratory facility (including a hot laboratory) (Section 1325).

<u>Summary</u>--An overall assessment of the design of HWVP facilities indicates substantial compliance to DOE Order 6430.1A. The report addressed approximately 1,225 selected criterion items from DOE Order 6430.1A, of which only 86 were determined noncompliant. The compliance status of 258 issues is to be determined.

The major noncompliance issues identified are as follows.

1. Primary access to the DBE-qualified Vitrification Building is via non-qualified support facilities, which may not facilitate emergency response.

2. The HVAC design does not address removal of corrosive gases or particles from the analytical sample cells or the process cells. An additional study is recommended.

3. There are many noncompliances regarding fire protection systems. Significant areas of concern include the following:

   a. Fire barrier design is less than adequate

   b. Fire-suppression system coverage is less than adequate

   c. Fire-detection system coverage is less than adequate

   d. The DBE failure of SC-3 suppression systems may impact the SC-1 water supply

   e. Essentially, the fire protection design analysis appears less than adequate.

4. Command response times for cathode ray tubes are slower than required (i.e., 3 s versus 2 s).

5. Compressed gas cylinders are not properly isolated and ventilated as required.

6. The sanitary water system has cross-connections and piping tie-ins that are not permitted.

7. The sanitary sewer is not provided with the necessary sampling or monitoring capabilities.

8. The instrument air compressors are not appropriately specified as "non-lubricated" type.

9. Safety class electrical power is not specifically provided in compliance with DOE Order 6430.1A and IEEE 308-1980 (IEEE 1980).

10. Several rooms containing hazardous materials are not provided with the required multiple exits.

11. No provisions have been made for additional shielding, if required.

12. Only one personnel decontamination area is provided. This may be considered less than adequate.

13. Potential DBA failure of cell walls and cover blocks could impair safe shutdown capabilities.

14. The Canister Storage Building design does not provide for decontamination of the storage vault.

15. A human factors task analysis has not been performed and documented as required.

16. The provision and locations of change room facilities appear less than adequate.

17. Water collection systems are not adequately sized to contain fire-fighting runoff.

18. Life-cycle cost analyses have not been performed and documented as required.

19. The ALARA considerations and assessments have not been adequately documented.

20. A human factors engineering program plan has not been prepared, documented, or used as required.

21. A systems requirements analysis has not been prepared, documented, or used as required.

22. A communication system user requirements analysis has not been prepared or documented as required.

Other Issues Identified--Other issues identified during the compliance assessment review included the following.

- The melter, offgas system, and associated feed systems are classified as miscellaneous units as identified in WAC 173-303-680, "Miscellaneous Units" (Ecology 1991). As such, the Washington State Department of Ecology (Ecology) and the U.S. Environmental Protection Agency (EPA) will impose incinerator regulations, where applicable.

- Liquid discharges from HWVP are to be routed to an effluent treatment facility that does not currently exist.

Significant Uncertainties Documented--The significant uncertainties documented for consideration in the risk assessment model as result of this review and additional design evaluation are summarized below:

1. Glass melter, offgas system, and associated feed systems may be subject to incinerator regulations

2. Potentially radioactive liquid discharges from HWVP are routed to the 200 East Area effluent treatment facility, which does not currently exist

3. Labor strike during construction

4. Foundation construction delay due to unusual conditions

5. Weather-caused construction delays

6. Major construction accident

7. Major engineering errors

8. Major construction errors
9. Long-lead equipment delays
10. Steel dust from frit-blasting equipment may change glass characteristics
11. Production rate of facility does not meet functional design requirements
12. Melter feed nozzles plug with molten material
13. MOG line fills with foam and plugs
14. Melter drain nozzles plug with molten material
15. Life expectancy of lining material in melter
16. Line 112 between the slurry mix evaporator and melter feed tank may plug with frit
17. The slurry feed line may plug with solid glass frit
18. Melter drops contents on floor of melter cell
19. Receipt and lag storage tank agitator pump may not be large enough for receipt and lag storage tank
20. Pumps not being designed for proper head-losses in pipes
21. Pumps not being designed for the correct specific-gravity solution.

B.4 GROUT TREATMENT FACILITY COMPLIANCE ASSESSMENT REVIEW

The Grout Treatment Facility Compliance Assessment Review was conducted to document any uncertainties caused by facility design deficiencies, which were identified during the DOE Order 6430.1A compliance assessment of this facility.

This compliance review was issued in July 1990 and encompassed those facilities included in the Grout Treatment Facility (GTF). The GTF is designed to treat the low-level fraction of double-shell tank wastes from current and future Hanford Site operations and the low-level fraction of liquid wastes from future pretreatment of waste feed streams destined for the HWVP. The GTF comprises the following:

- Dry Materials Facility
- Liquid waste feed transfer system (FTS)
- Grout Processing Facility (GPF)
- Grout Waste Disposal Facility (GDF)
- Portable instrument house (PIH).

Design data of the GTF were reviewed for compliance with the requirements of DOE Order 6430.1A. The compliance review effort included the examination of design and procurement documentation in order to identify specific references to those codes and standards prescribed in DOE Order 6430.1A. In those instances where design documentation clearly indicated that the codes and standards required by DOE Order 6430.1A were specified in the design of the facility, the review noted that the facility complies with the DOE Order requirement. It should be noted that a detailed review of design documents to determine if the provisions of the required codes and standards were satisfied was not within the scope of this effort. In addition, the compliance review effort did not include design review or design verification. Compliance review is based on "as-specified" and not "as-built" component and structure data. Verification of as-built versus as-designed conditions was not within the scope of this effort.

<u>Summary</u>--The noncompliances by sub-facility are summarized below.

Noncompliance items for the GDF (vault) are as follows.

1. The vault ventilation system design does not maintain 7.6-mm (0.3-in.) water gauge negative pressure at all times. Currently, justification for this deviation is being pursued based on negligible dose consequences.

2. The vault seismic analysis does not fully address all applicable requirements of UCRL-15910 (Kennedy et al. 1989).

3. Shielding and environmental monitoring has not been adequately considered for protection of personnel during some maintenance and operations activities. Development of decontamination solutions is

in process to significantly lower exposure and dose consequences. Preliminary indications are that additional design modifications may be required.

4. Compliance with IEEE 242-1986 (IEEE 1986) has not been ascertained.

5. Effluent sampling systems must comply with ANSI N13.1-1969 (ANSI 1969). This standard was not referenced in the design.

Noncompliance items for the PIH are as follows.

1. The UPS provides both SC-2 and SC-3 loads. Electrical separation, isolation, and redundancy are not provided. Also, the UPS does not meet single-failure criteria, safe shutdown, environmental qualification, separation, etc.

Noncompliance items for the GPF are as follows.

1. The seismic design of the GPF is specified to conform to the Uniform Building Code rather than to the requirements of UCRL-15910, Section 4.2.3. One out of two confinement boundaries should be designed to maintain its integrity during and following an earthquake event unless otherwise demonstrated to be acceptable.

2. Ventilation exhaust outlets require two radiation monitoring systems, which should be classified as Safety Class 2, unless an analysis has been performed to justify a Safety Class 3 designation.

3. Shielding and environmental monitoring has not been adequately considered for protection of personnel during some maintenance and operations activities. Preliminary indications are that additional design modifications will be required.

4. Compliance with IEEE 242-1986 has not been ascertained.

5. The GPF computer control system does not comply with the single-failure criteria of DOE Order 6430.1A.

Noncompliance items for the FTS are as follows.

1. The FTS Safety Class 1 instrumentation systems do not comply with emergency power requirements; seismic, single-failure criteria; environmental qualification; separation; etc.

2. The FTS structure housing Safety Class 1 instrumentation is not designed to withstand design basis natural phenomena hazards.

General noncompliance items for the I&C system (safety and nonsafety) are as follows.

1. Air monitoring must comply with ANSI N13.1-1969. This standard was not referenced in the design.

2. Central readout of monitoring systems following a DBA is not ensured.

3. Remote manual initiation and control of safety functions is not achievable from the control room.

General noncompliance items for fire protection are as follows:

1. Use of less than 2-h fire-rated walls

2. Human factors do not meet recommendations of NFPA 80A-1987 (NFPA 1987)

3. Need two hydrants serving each building

4. Need primary and backup fire suppression capability (not all areas have even a single primary system).

Other Issues Identified--Other issues identified during the compliance assessment review include the following.

- Programmatic issues such as facility siting, ALARA, environmental (pollution control), human factors, and emergency preparedness were not addressed by this compliance assessment.

- Components such as process tanks, pumps, and heat exchangers were not addressed in this compliance assessment.

- The assessment of fire protection criteria is incomplete because an excessive number of the items were not evaluated due to a lack of design documentation. A reassessment of this section appears prudent.

- Many equipment items and components are not Underwriters Laboratory-listed, including Safety Class 1 seismic detection and monitoring components.

Significant Uncertainties Documented--The significant uncertainties documented for consideration in the risk assessment model as a result of this review are summarized as follows.

1. The GDF vault seismic analysis does not fully address all applicable portions of UCRL-15910.

2. The GDF vault shielding and environmental monitoring is less than adequate for specific maintenance and operations activities.

3. The GDF vault effluent sampling system is not designed in accordance with ANSI N13.1-1969.

4. The Grout Facility PIH electrical system is less than adequate.

5. The GPF was designed to Uniform Building Code criteria rather than to the seismic requirements of UCRL-15910.

6. The GPF gaseous effluent monitoring systems are less than adequate.

7. The GPF radiation shielding design is less than adequate for specific maintenance and operations activities.

8. The GPF computer control system does not comply with single-failure criteria.

9. The grout FTS SC-1 instrumentation system is less than adequate.

10. The grout FTS structure housing SC-1 instrumentation is not designed to withstand design basis natural phenomena hazards.

11. The fire protection systems of the grout facilities are less than adequate.

B.5 AGING WASTE FACILITY COMPLIANCE ASSESSMENT REVIEW

The Aging Waste Facility Compliance Assessment Review was conducted to document any uncertainties caused by facility design deficiencies, which were identified during the DOE Order 6430.1A compliance assessment of this facility.

The report was prepared to evaluate the Aging Waste Facility (AWF) safety-related structures, systems, equipment, and components for either compliance or noncompliance to selected portions of DOE Order 6430.1A in support of the development of an AWF safety analysis report (SAR).

The report was issued in April 1990, and contains pertinent safety-related design criteria from DOE Order 6430.1A that are applicable to the AWF.

This draft final report was submitted to Westinghouse Hanford for review and comments. A final report incorporating Westinghouse Hanford comments was not prepared due to funding considerations and still needs to be issued.

The compliance assessment is based on the classification of the AWF complex as a radioactive liquid waste facility as defined by Section 1323 of DOE Order 6430.1A.

Summary--Almost all the AWF assessment tables reflect a high degree of noncompliance to the selected design criteria from DOE Order 6430.1A. This is due to a large degree to the age of some of the facilities that are used in the AWF complex that were designed and constructed in the 1950's, 60's, and 70's. It is apparent that the AWFs, as currently configured, were compliant to the codes and standards of the time. However, as the criteria for safety-related system and environmental protection became more stringent over the past 10 yr or so, the AWF more or less stayed the same.

This report contains approximately 965 selected criterion items from DOE Order 6430.1A. Of this number, 401 were determined to be in complete compliance, 327 were in noncompliance, 211 were not applicable, and 118 were listed as to be determined, requiring additional documentation for evaluation.

The major noncompliance issues identified are as follows.

1. Wind analysis for aboveground structures is not documented.
2. Explosion protection/isolation for gasoline-powered equipment is not provided.
3. No seismic analysis for support/auxiliary system or structures was documented, including secondary tanks and transfer lines.
4. An independent review of seismic design was not documented.
5. Vibration analysis of foundations was not performed/documented.
6. Confinement systems were not designed to maintain integrity following all DBAs.

7. Adequate liquid effluent monitoring, retention, and diversion is not provided for all streams.

8. Facility transfer lines (i.e., pump-out lines and condensate tanks and lines) are not provided secondary confinement, leak detection, and inspection capabilities.

9. Valve, jumper, and pump "pits" are not adequately designed as enclosures to maintain confinement during normal operations.

10. None of the AWF safety class items are designed to the ASME *Boiler and Pressure Vessel Code* (ASME 1989b).

11. The primary tank ventilation system design does not incorporate the capability to remove volatile radionuclides or hazardous chemical vapors.

12. Support/auxiliary buildings are not provided with forced-air ventilation systems for contamination control or temperature control.

13. The primary tank ventilation system will not function after DBAs.

14. Confinement barriers do not incorporate decontamination capabilities for confinement barriers.

15. Solid-waste handling and storage areas are not provided confinement or ventilation.

16. Safety class systems and components were not typically designed as DBE-qualified or provided redundancy.

17. Direct-buried condensate and pump tanks are not permitted by DOE Order 5400.1, *General Environmental Protection Program* (DOE 1988b).

18. The potentially contaminated steam condensate and cooling water streams discharge to the soil column, a process that is no longer permitted.

19. A qualified source of emergency power is not provided. The UPS systems are not used.

20. The HEPA filters are not provided on primary tank or annulus inlet air pathways.

21. The HEPA filter systems do not comply with the requirements of ANSI N509-1989 (ANSI/ASME 1989).

22. The reliability and redundancy of the effluent monitoring system is less than adequate. Stacks are only provided with a single monitor.

23. The discharge stack for the ventilation system appears less than adequate in structural design and height.

24. Fire protection design analyses have not been performed for AWFs in accordance with DOE Order 5480.7 (DOE 1987).

25. The ventilation building structure may not maintain confinement during a design basis fire.

26. Fire hydrant coverage and water supply is less than adequate.

27. There are no fire detection or suppression systems provided for enclosures.

28. Safety class utility systems do not meet DBE qualifications.

29. Safety class cooling water is not provided.

30. Retention systems for industrial waste water are not provided.

31. The ALARA concepts are not uniformly imposed for routine activities or following DBAs.

32. Fixed shielding for personnel exposure reduction is less than adequate.

33. Personnel decontamination facilities are not provided at the AWF.

34. Separate men and women's change facilities are not provided at the AWF. The change facility does not provide adequate segregation of clothing or laundry.

35. The AWF SAR must be updated.

36. Asbestos materials were used in original design and construction.

37. The AWF was not designed with considerations for decontamination and decommissioning.

Other Issues Identified--Other issues identified during the compliance assessment review included the following.

- This is a draft report. The final report was not prepared.
- The SAR preparation has been postponed.

Significant Uncertainties Documented--The significant uncertainties documented for consideration in the risk assessment model as a result of this review are summarized as follows.

1. The AWF FSAR for this operation has not been completed.
2. The AWF seismic analyses are incomplete or nonexistent.
3. The AWF confinement systems may not survive DBAs.

4. The AWF liquid effluent retention, monitoring, and diversion capabilities are less than adequate.

5. The AWF support system transfer lines are less than adequate.

6. The AWF "pits" are not adequate as confinement enclosures.

7. The AWF primary tank ventilation will not survive DBAs.

8. The AWF emergency power system is less than adequate.

9. The AWF liquid effluent discharge to the soil column may not be allowed.

10. The AWF safety class systems and components are not seismically qualified.

11. The AWF HVAC stack monitor is less than adequate.

12. The AWF fire protection systems are less than adequate.

13. The AWF used asbestos materials in original design and construction.

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B.7 GLOSSARY

ABBREVIATIONS, ACRONYMS, AND INITIALISMS

ALARA	as low as reasonably achievable
ANSI	American National Standards Institute
ASME	American Society of Mechanical Engineers
AWF	aging waste facility
CS&R	codes, standards, and regulations
DBA	design basis accident
DBE	design basis earthquake
DOE	U.S. Department of Energy
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
FSAR	final safety analysis report
FTS	feed transfer system
GDF	Grout Waste Disposal Facility
GPF	Grout Processing Facility
GTF	Grout Treatment Facility
HEPA	high-efficiency particulate air
HVAC	heating, ventilating, and air conditioning
HWVP	Hanford Waste Vitrification Plant
I&C	instrumentation and control

IEEE	Institute of Electrical and Electronics Engineers
MOG	melter offgas
NFPA	National Fire Protection Association
PIH	portable instrument house
SAR	safety analysis report
UPS	uninterruptible power supply
Westinghouse Hanford	Westinghouse Hanford Company

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APPENDIX C

CHARACTERIZATION DATA

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APPENDIX C

CHARACTERIZATION DATA

C.1 CURRENT CONCENTRATION PROJECTIONS FOR WASTE TYPES TO BE VITRIFIED

Raw waste types that are slated to be pretreated and subsequently vitrified are neutralized current acid waste (NCAW), neutralized cladding removal waste (NCRW), Plutonium Finishing Plant (PFP), and complexant concentrate (CC). A general summary of the source, accumulation period, and characteristics for these four waste types is given in Table C-1. Current projections of the composition of these waste types for major and critical components are given in units of moles per liter or curies per liter in Table C-2. The following sections describe the sources and degree of uncertainty for these data.

C.1.1 Neutralized Current Acid Waste

The NCAW type, having been accumulated in two double-shell tanks with very little cross contamination from previous waste types, is the best characterized of the four waste types. The cation and anion data shown in Table C-2 are based on core samples of settled solids and associated supernatant liquids from tank 101-AZ. The range of concentrations accounts for: (1) variations in certain core sample results, and (2) the uncertain quantity of total solids in the tank. (Note that the uncertainty in tank solids volume is not unique to Hanford Site tanks. Other U.S. Department of Energy sites also suffer the same problem in their waste characterization.) For certain minor components such as the noble metals (palladium, rhodium, ruthenium), accurate analytical methods are not yet available. For the noble metal components, the composition has been derived from knowledge of N Reactor operating history and ORIGEN2 code calculations. There is no known mercury present in the NCAW. However, there is the potential that trace amounts of mercury could exist in the sludge heel in tank 102-AY, the presently planned feed tank for the HWVP. An analytical method for mercury is under development.

Curie-per-liter data for the listed critical radionuclides have been similarly derived from ORIGEN2 code calculations rather than from direct core sample measurements because accurate methods for counting ^{129}I are not yet available. In this case, a detailed composite of "ORIGEN2 calculations" has been made, accounting for the variations in fuel exposure and aging on every batch of N Reactor fuel processed through the plutonium-uranium extraction (PUREX) plant (1984 to present). The use of these detailed ORIGEN2 calculations for the definition of radionuclides in the NCAW tanks is further justified by the fact that comparisons to tank sample data check well. For example, the measured inventory of ^{137}Cs in tank 101-AZ agrees with the ORIGEN2 code prediction within 17 percent.

Similar core sample data and ORIGEN2 code projections are available for the second tank of accumulated NCAW (102-AZ) as it currently exists, partially filled. Future PUREX plant processing of the remaining N Reactor fuel backlog could add NCAW to tank 102-AZ, which may alter current compositions, depending

Table C-1. Double-Shell Tank Waste Types for Vitrification.

	NCAW	NCRW	PFP	CC
Source streams	PUREX first cycle raffinate (neutralized)	PUREX zirconium decladding stream (neutralized)	Z Plant (PFP) waste and T Plant (equipment decontamination)	B Plant (strontium recovery) raffinate
Accumulation period	FY 1984-1996	FY 1984-1996	FY 1982-2002	Essentially complete 1968-1975
Accumulation tanks	2 DSTs (with circulators and heat removal capability)	2 DSTs	1 DST	5 DSTs
Waste characteristics	Low solids slurry (solids partially settled); high heat; high activity; high fission products	Mostly settled solids (supernate liquids decanted for future grout disposal); low heat; TRU waste; some fission products	Mostly settled solids (supernate liquids decanted for future grout disposal); no heat; TRU waste	Slurry; organic complexant; TRU waste; some fission products; some settled solids
Current sources of tank waste composition data	PUREX flowsheet material balance Radionuclide inventory from reactor history Dip samples from tank Process samples from plant Core samples (three)	PUREX flowsheet material balance Core samples from tanks (five)	Z Plant flowsheet material balance Dip samples from tanks Core samples from tanks (two)	Dip samples from tanks Core samples from tanks (two)

CC = Complexant concentrate
DST = Double-shell tank
FY = Fiscal year
NCAW = Neutralized current acid waste
NCRW = Neutralized cladding removal waste
PFP = Plutonium Finishing Plant
PUREX = Plutonium-uranium extraction
TRU = Transuranic

Table C-2. Concentration of Major/Critical Components in Untreated Waste Types. (sheet 1 of 2)

Component	(g-mol/L)			
	Waste type			
	NCAW (tank 101-AZ)	NCRW	PFP	CC
Al	0.48 - 0.54	0.18	1.5	1.1
Ba	0.0003 - 0.0005	0.001	NM	NM
Ca	0.003 - 0.006	0.01	0.15	0.01
Cd	0.007 - 0.01	NM	0.008	NM
Cr	0.02	0.03	0.4	0.03
Fe	0.10 - 0.17	0.008	0.4	0.04
Hg	NM	NM	NM	NM
La	0.0009 - 0.002	0.003	0.003	0.002
Mn	0.006 - 0.01	0.0003	0.15	0.01
Mo	0.001	0.0001	0.001	0.003
Na	4.56 - 4.6	5.3	6.00	8.2
Nd	0.0008 - 0.001	0.001	(1)	(1)
Ni	0.004 - 0.007	0.002	0.01	0.005
Pd	0.0001	NM	NM	NM
Rh	0.0001	NM	NM	NM
Ru	0.0005	NM	NM	NM
Si	0.02 - 0.04	0.15	0.08	0.06
Ti	0.002 - 0.003	0.001	0.003	NM
U	0.004	0.02	0.01	NM
Zr	0.02 - 0.04	0.99	0.004	0.001
NH_3	NM	0.05	NM	NM
CO_3^{-3}	0.35 - 0.36	0.07	NM	NM
Cl^-	0.005	0.02	0.15	0.16
F^-	0.08	3.6	0.3	0.11
$NO_2^- + NO_3^-$	2.4	0.61	3.8	4.4
PO_4^{-3}	0.02	--	0.60	0.06
SO_4^{-2}	0.16	0.002	0.10	0.08

Table C-2. Concentration of Major/Critical Components in Untreated Waste Types. (sheet 2 of 2)

Component	(g-mol/L) Waste type			
	NCAW	NCRW	PFP	CC
(Ci/L)				
^{14}C	3 E-5	3 E-6	NM	NM
^{90}Sr	2 E-0	1.1 E-2	1.6 E-1	4.3 E-1
^{129}I	6 E-8	4.6 E-8	NM	4 E-7
^{137}Cs	2.4 E-0	6.6 E-2	1.3 E-1	3.4 E-1
^{239}Pu	5 E-4	4.7 E-4	1.1 E-2	1.3 E-4
^{241}Am	1 E-2	1 E-5	1.8 E-2	8.3 E-4

NOTE: Nd reported as La + Nd sum.

CC = Complexant concentrate
NCAW = Neutralized current acid waste
NCRW = Neutralized cladding removal waste
NM = Not measured
PFP = Plutonium Finishing Plant

on the mode of future PUREX operation. Fortunately, the ORIGEN2 code methodology permits such a future adjustment to tank radionuclide inventories to be accurately projected. The effect of future waste addition on tank chemical compositions is less easily predicted, but can be estimated from flowsheet calculations for the future PUREX operations.

C.1.2 Neutralized Cladding Removal Waste

Compositions of NCRW given in Table C-2 are derived from core samples of tank 103-AW, one of two tanks that have been used alternately to accumulate this cladding waste sludge. No ORIGEN2 code calculations have been used to augment the direct core sample data because it is difficult to accurately estimate the small fraction of fission products that have exited the PUREX process in the cladding waste stream. Thus, certain minor components, such as the noble metals, remain "not measured" pending the availability of analytical methods scheduled for completion in late 1991. This lack of noble metal data is not considered critical to the ongoing process development and plant design for HWVP because noble metal levels projected for NCAW are expected to be controlling.

Radionuclide concentrations are all derived from core sample analyses or analytical work done during the course of pretreatment process development testing with actual waste.

These data represent the average of five core segments taken to characterize the NCRW solids. Inspection of the zirconium, lanthanum, and plutonium concentrations in individual sections compares well with the known history of tank filling and PUREX plant operation, giving further confidence in the sampling technique and analytical data. For example, as shown in Figure C-1, the dramatic increase in lanthanum in the third core segment agrees in position and time with the beginning of rare earth additions to cladding waste in the PUREX process. Similarly, the temporary increase in the isotopic level of ^{240}Pu seen in core segment Number 2 agrees exactly with the period during which a block of high exposure fuel was processed in PUREX (August to December 1985).

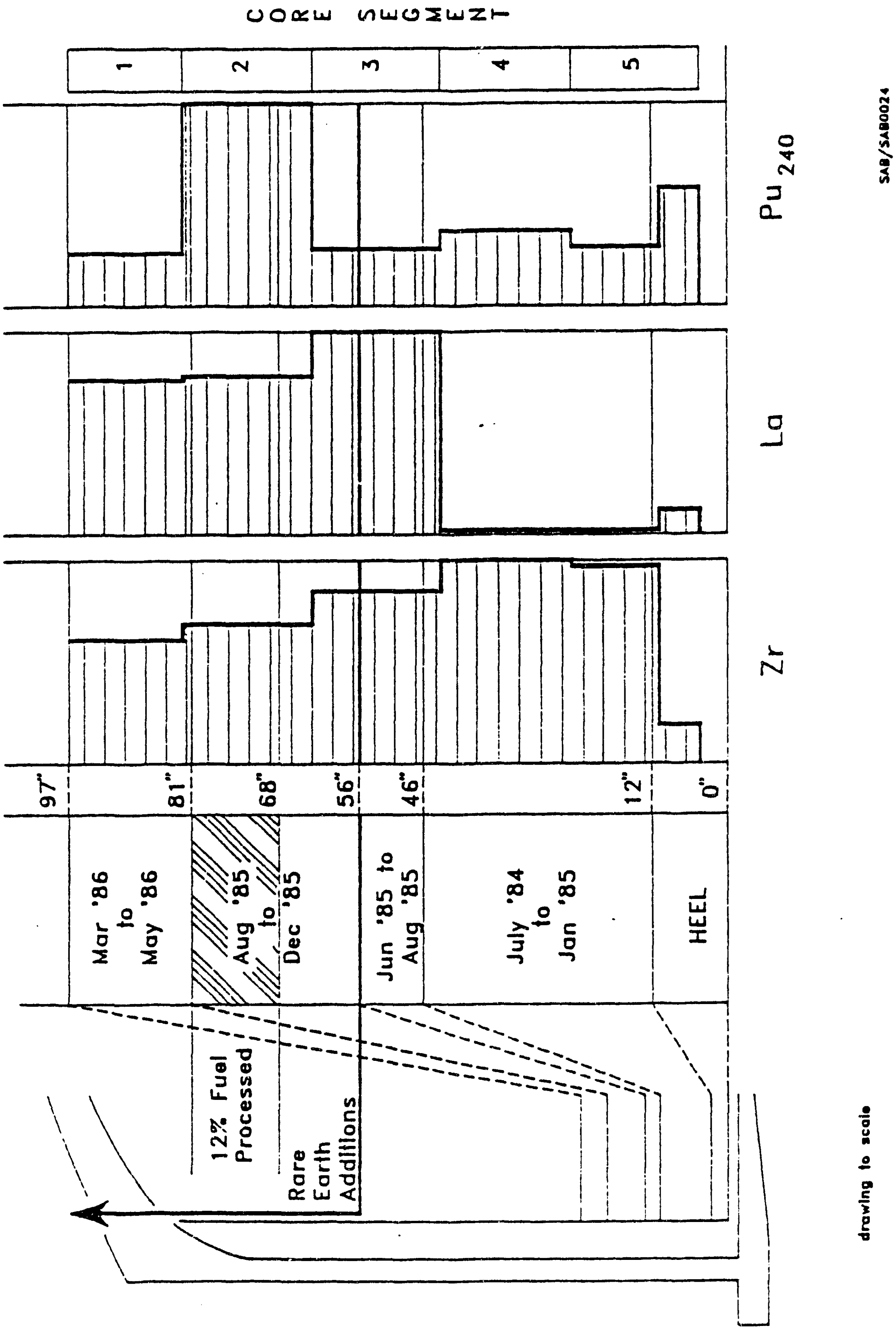
C.1.3 Plutonium Finishing Plant

The PFP waste type is mostly settled solids originating from PFP (Z Plant) operations and from equipment decontamination operations at T Plant. The cation, anion, and radionuclide compositions listed in Table C-2 have been derived from core samples (two), supplemented by data from previous dip samples and Z Plant material balance calculations. As is the case with the definition of the NCRW, noble metals have not been measured, pending availability of an accurate analytical method.

C.1.4 Complexant Concentrate

Cation, anion, and radionuclide concentrations listed for the CC waste type have been derived from limited core samples (two out of a total of five tanks), supplemented by earlier dip samples. Noble metals, if any are present, remain to be analyzed. Also, additional work will be required to characterize the speciation of organic complexants and decomposition products present in the CC waste. The CC waste is the least well characterized of the four types to be pretreated and vitrified. However, because the CC waste is to be processed last, more time is available to complete the needed characterization work.

Figure C-1. Neutralized Cladding Removal Waste Tank 105-AW Profile (Compositions Based on 1986 Core Sample).



APPENDIX D

AUTHORIZATION LETTER

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90048788

Department of Energy
Richland Operations Office
P.O. Box 550
Richland, Washington 99352

OCT 26 1990

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90-VDB-060

Mr. R. C. Nichols, President
Westinghouse Hanford Company
Richland, Washington

Dear Mr. Nichols:

HANFORD WASTE VITRIFICATION PROGRAM RISK ASSESSMENT

The currently incomplete knowledge regarding the contents of the high-level waste tanks indicates to DOE the need to conduct an assessment of the risks for proceeding with the planned Hanford vitrification program activities. By this letter, WHC is directed to immediately initiate a systems engineering risk analysis to evaluate the technical, safety, and regulatory uncertainties of all related elements of the vitrification program. WHC should target completion of this assessment in the May-June 1991 timeframe. To ensure that staff and management commitment is maintained for the duration of this assessment, WHC is strongly encouraged to establish a dedicated project team for this activity. Detailed guidance for this assessment is provided in the attached Purpose/Scope Statement. Any changes or modifications to the Statement, resulting from the ongoing DOE-HQ review, will be forwarded for your immediate attention.

Not Dedicated

I have informed the Washington Department of Ecology (Ecology) of DOE's intentions to conduct the subject assessment and have requested their active participation in the technical review of the assessment's findings. In your planning for the conduct of this assessment, please include appropriate lines of communication with Ecology through DOE to allow for exchange of information regarding interim/final assessment findings and overall assessment progress.

If you have any questions or comments regarding this transmittal, please contact Mr. Tom Davies of the Vitrification Project Office on 376-7924.

Sincerely,

John D. Wagoner
Manager

VPO:TLD

Attachment

cc w/attach: C. M. Cox, WHC
R. A. Smith, WHC
S. P. Cowan, EM-30

Attachment

PURPOSE/SCOPE STATEMENT FOR

HANFORD WASTE VITRIFICATION PROGRAM RISK ASSESSMENT

PURPOSE

A study will be performed to evaluate the uncertainties associated with the Hanford Waste Vitrification Program (Program) to quantify potential consequences and programmatic risks if construction of the Hanford Waste Vitrification Plant (HWVP) proceeds on the current schedule (July 1991). Technical, safety, and regulatory/environmental uncertainties will be assessed. The risks will address the viability of successfully completing the Program mission, including production performance, cost, and schedule implications. The results of the study will be the basis for a re-evaluation of the current Program planning.

SCOPE

All elements of the Program will be considered in this assessment, including waste characterization, retrieval from the storage tanks, pretreatment to separate the high and low level components of the waste, and vitrification of the high level waste fraction. Risks associated with the use of existing facilities for key elements of the Program will be included. Uncertainties will be identified separately for all Hanford tank waste inventories (Double Shell Tank wastes and Single Shell Tank wastes). The study will identify any decrease in risk related to the construction of HWVP as a result of increased experience from the startup and operation of other vitrification facilities, as well as from the progression of the Hanford Program. The study will also address risks associated with storage tank utilization as a function of time.

The study will examine the bases, planning, and status for waste characterization activities as a basis for pretreatment capabilities to meet HWVP feed requirements. Emphasis will be provided on how uncertainties (or unknowns) related to the waste content could potentially affect the viability of pretreatment processes. In addition, the complexity of the chemical processes, the maturity of the technology, the compliance of the current design criteria to existing DOE, national, and state requirements, the level of design definition, the capability to support safe and reliable facility operations, and the state of development of safety and environmental documentation (e.g., safety analyses reports, environmental permit applications, and NEPA documents) will be addressed.

The study will include a comparison of the high level waste vitrification programs and facilities at the Savannah River and Hanford Sites to assess impacts of uncertainties on the Hanford Program from problems identified at the Savannah River facilities. Program activities and facility design and operational features which have been or could be implemented to reduce uncertainties and risks will be identified. Areas where the Program should be examined for optimization will be defined for further evaluation.

To the maximum extent possible, the study will make use of existing documentation and previous or current assessments. For example, DOE's independent review team assessment of the pretreatment activities to be performed in October-November, 1990 will be used as a key element in the evaluation of the pretreatment program.

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POST-NCAW ACTIVITI

Group	Activity	Description	ES	EF
10	213.D	NCAW RETRIEVAL PROCESS TEST PREPARATIONS	1Oct90	28Sep95
	213.D.00.2463	NCAW PROCESS TEST	29Sep95	28Jun96
	213.F	CC WEST RETRIEVAL PROCESS TEST PREPARATIONS	1Oct90	26Sep96
	213.E	CC EAST RETRIEVAL PROCESS TEST PREPARATIONS	1Oct90	2Oct98
	213.F.00.2499	CC PROCESS TEST WEST AREA PROCESS TEST	27Sep96	30Jul97
	213.E.00.2481	CC PROCESS TEST EAST AREA PROCESS TEST	5Oct98	1Jul99
11	AW103RS05A	NCAW RETRIEVAL SYSTEM	1Apr93	2Oct96
	AW103RS05B	NCAW RETRIEVAL SYSTEM (CONTINUED)	1Jan97	31Mar00
	SY102RS09	PFP RETRIEVAL SYSTEM	1Apr92	1Apr99
	75SY101S1	101-SY SAFETY ISSUE RESOLUTION	1Oct90	12Oct92
	75058	W-058 CROSS-SITE TRANSFER LINE	1Oct90	31Aug95
	75SY103S1	103-SY SAFETY ISSUE RESOLUTION	2Oct90	2Oct90
	SY101RS09A	CC WEST RETRIEVAL SYSTEM	1Apr94	23Oct97
	AN102RS01A	CC EAST RETRIEVAL SYSTEM	1Apr96	30May00
	SY101RS09B	CC WEST RETRIEVAL SYSTEM (CONTINUED)	1Jan98	2Apr01
	AN102RS01B	CC EAST RETRIEVAL SYSTEM (CONTINUED)	31May00	29Aug03
	75340	B-340B GROUT FEED TANK MODS	1Oct90	31Jan91
	75062	W-062 GROUT FEED TANK MODS	1Oct90	31Oct91
	AN103AW101RS01	LLW RETRIEVAL SYSTEMS	1Oct90	31Mar99
	75AN103S1	DSS/DSSF 103/104/105-AN TANK SAFETY WATCH LIST	2Oct90	2Oct90
12	53G08	GROUT PART B PERMIT	1Oct90	31Jul91
	53G07	GROUT PERFORMANCE ASSESSMENT	1Oct90	31Jul91
	53G09	GROUT SAFETY ANALYSIS REPORT	1Oct90	30Apr92
	53G10	GROUT FACILITY MODS & VAULT CONSTRUCTION	1Oct90	29Sep95
	53G02	DEVELOP/VERIFY GROUT FORMULATIONS	31Jan91	31Oct95
	53G05	TYPE 2 READINESS REVIEW (GROUT)	2Sep91	30Jun92
	53G06	TYPE 3 READINESS REVIEW (GROUT)	2Sep91	31Dec92
	53G03	WASTE TRANSFER/TESTING CAMPAIGNS (GROUT)	2Dec91	31Jul95
	53G11	GROUT FILL VAULTS (M-01)	1Jan93	2Aug96
49	AN103AW101T	DSS/DSSF RETRIEVAL & TRANSFER TO GROUT FEED TANK	1Jun98	1Jul99
	AP000	GROUT DSS/DSSF OPERATIONS	1Jun98	31Dec01
	AN104AN105T	DSSF RETRIEVAL & TRANSFER TO GROUT FEED TANKS	3Apr00	31Dec01
	AP001	GROUT NCAW OPERATIONS	3Jul00	31Jul01
	AP002	GROUT NCAW OPERATIONS	1Oct02	27Sep04
	AP003	GROUT PFP OPERATIONS	3Jan05	28Feb06
	AP004	GROUT CC OPERATIONS	9May06	6Apr09
50	AN103T1	NCAW PRETREATMENT OPERATIONS - B PLANT	9Oct00	6Sep02
	SY102T	AVAILABLE EAST AREA HOLDING TANK - PFP TRANSFER	1Oct99	1Oct01
	AW101T2	PFP PRETREATMENT OPERATIONS - B PLANT	21Jan03	20Feb04
	SY101T	AVAILABLE EAST AREA HOLDING TANK - CC TRANSFER	2Sep02	30Sep04
	AN102T1	CC PRETREATMENT OPERATIONS - B PLANT	10May04	7Mar06
	AN106T2	CC PRETREATMENT OPERATIONS (CONTINUED)	8Mar06	9Apr07
51	AN101T20	NCAW FRIT - HWVP	9Sep02	5Mar04
	AN101T201	NCAW OPERATIONS - HWVP	8Mar04	6Apr05
	AW103T2	PFP FRIT - HWVP	23Feb04	19Aug05
	AW103T20	PFP OPERATIONS - HWVP	22Aug05	20Dec05
	AW101T204	CC FRIT - HWVP	30Jun05	28Dec07
	AW101T205	CC OPERATIONS - HWVP	21Dec06	19Jan09
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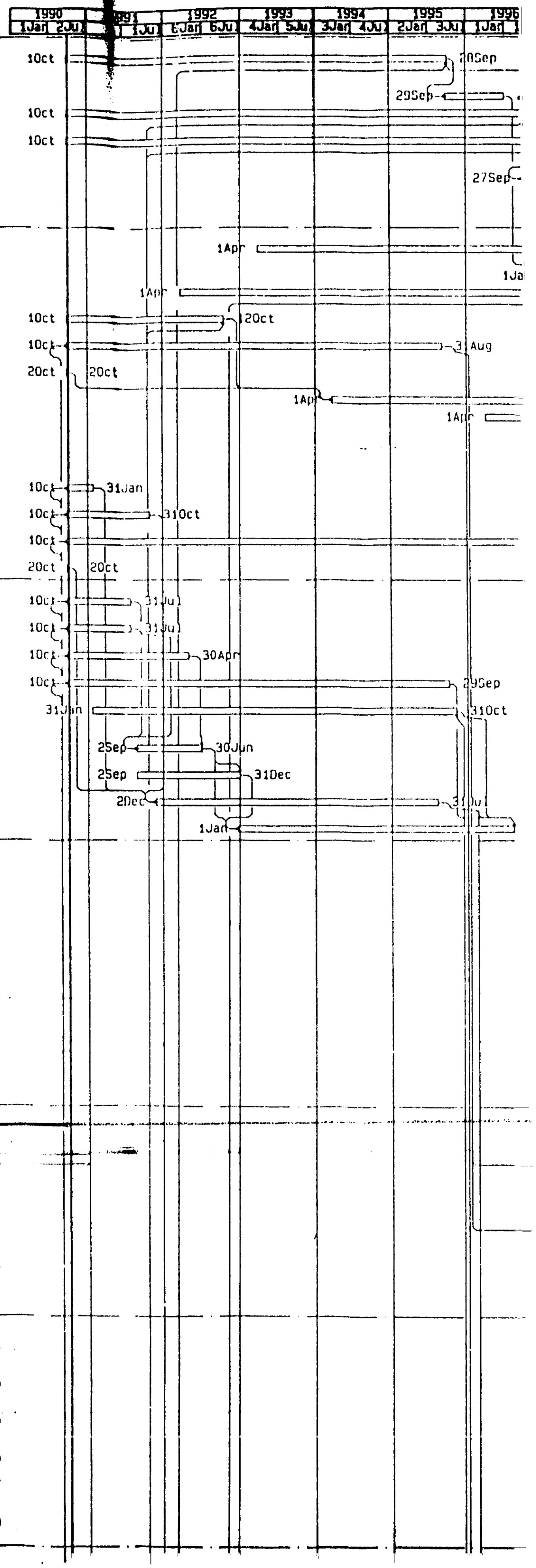

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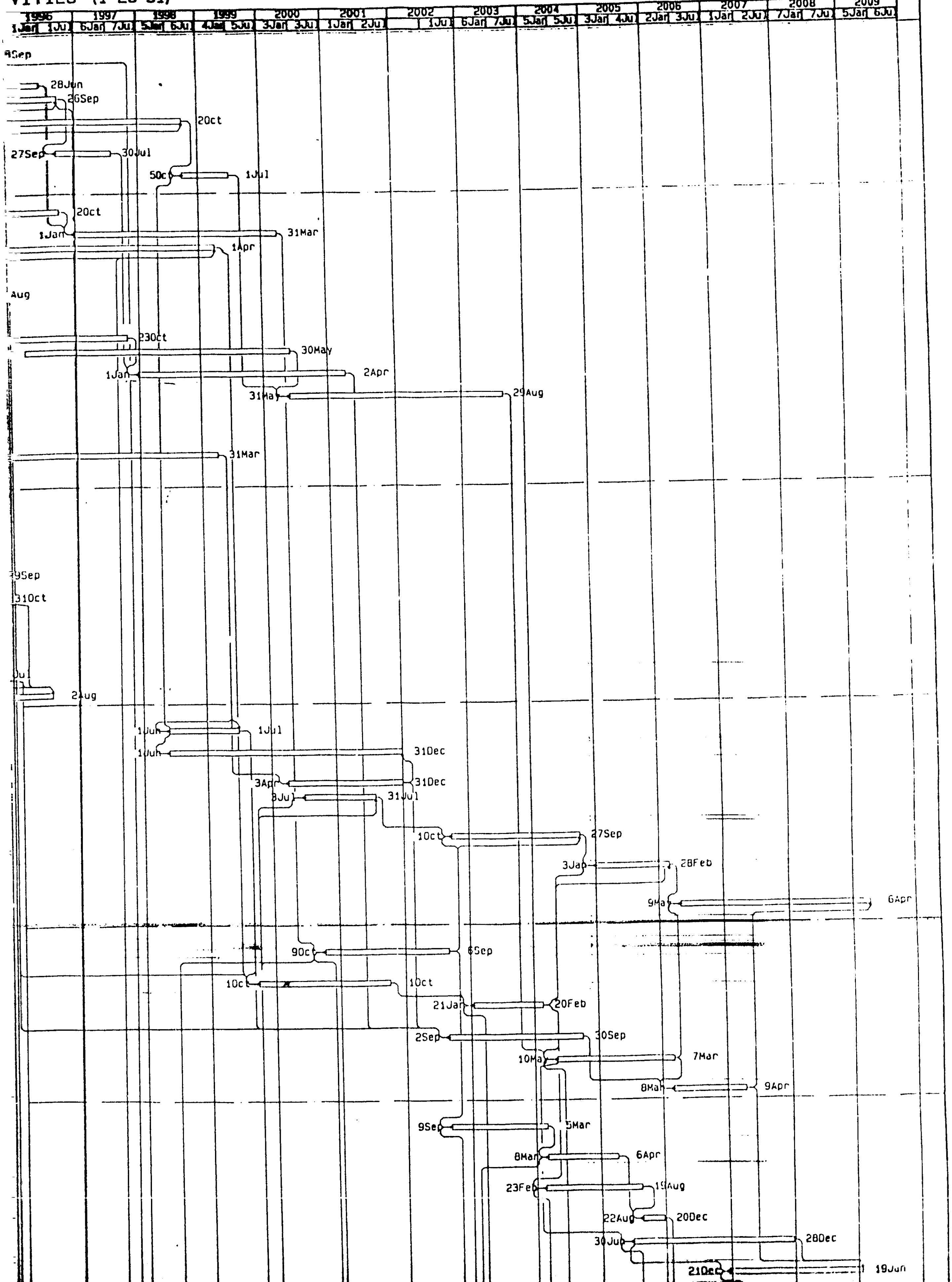

215.C.00.1361	TRUEX PILOT-PLANT SCALE TEST WITH NCAW	27May96	25Feb97
215.C.05.2886	FINAL FLOWSHEET NCAW TRUEX	26Feb97	25Aug97
215.H.0E	SMALL-SCALE PFP SOLIDS RETRIEVAL SYSTEM	1Oct90	27Nov95
215.D.00.1337	PILOT-PLANT REDESIGN & MINOR MODS - PFP TRUEX	16Sep97	9Dec97
215.C.00.1365	TRUEX PILOT-PLANT SCALE TEST WITH PFP WASTE	26Dec97	30Sep98
215.C.05.2888	FINAL FLOWSHEET PFP TRUEX	1Oct98	[illegible]pr99
215.A.021	CC PROCESS DEVELOPMENT - PHASE I	1Oct90	1Oct91
215.H.0B	SMALL-SCALE CC SUPERNATE TRANSFER SYSTEM	1Oct90	12May94
215.H.0C	SMALL-SCALE CC SOLIDS RETRIEVAL SYSTEM	1Oct90	30Dec94
215.E	OXIDATION PILOT PLANT	2Oct91	2Oct95
215.A.022	CC PROCESS DEVELOPMENT - PHASE II	31Dec91	26Sep96
215.F.00.1471	CC ORGANIC DESTRUCTION PILOT-PLANT COLD TESTS	3Oct95	30May97
215.D.00.1339	PILOT-PLANT REDESIGN & MINOR MODS - CC SOLIDS	27Sep96	27Dec96
215.D.00.1335	PILOT-PLANT REDESIGN & MINOR MODS - CC TRUEX	27Sep96	31Mar97
215.C.00.1363	TRUEX PILOT-PLANT SCALE TEST WITH CC WASTE	1Apr97	25Dec97
215.F.00.1473	CC ORGANIC DEST PILOT-PLANT HOT TESTS	2Jun97	27Feb98
215.C.05.2895	FINAL FLOWSHEET CC TRUEX	26Dec97	24Jun98
215.F.05.2890	FINAL FLOWSHEET CC ORGANIC DESTRUCTION	2Mar98	24Aug98
215.C.00.1367	TRUEX PILOT-PLANT SCALE TEST WITH CC SOLIDS	1Oct98	30Jun99
215.C.05.2896	FINAL CC DISSOLUTION FLOWSHEET	1Jul99	29Dec99
61			
137200	W-095 NCAW PROCESS MODIFICATIONS - B PLANT	1Oct90	17Nov97
137128	W-128 B PLANT CELL CLEANOUT	1Oct90	15May98
1372001	W-095 NCAW PROCESS MODIFICATIONS (CONTINUED)	18Nov97	6Oct00
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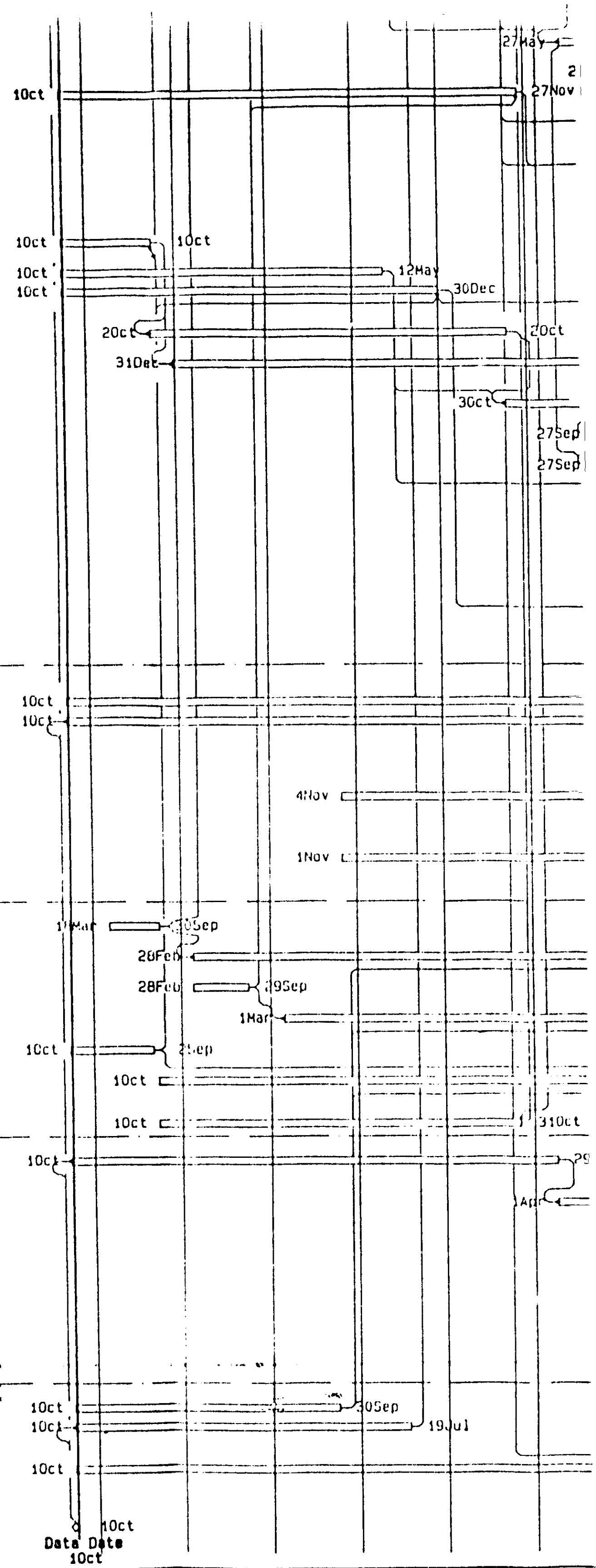
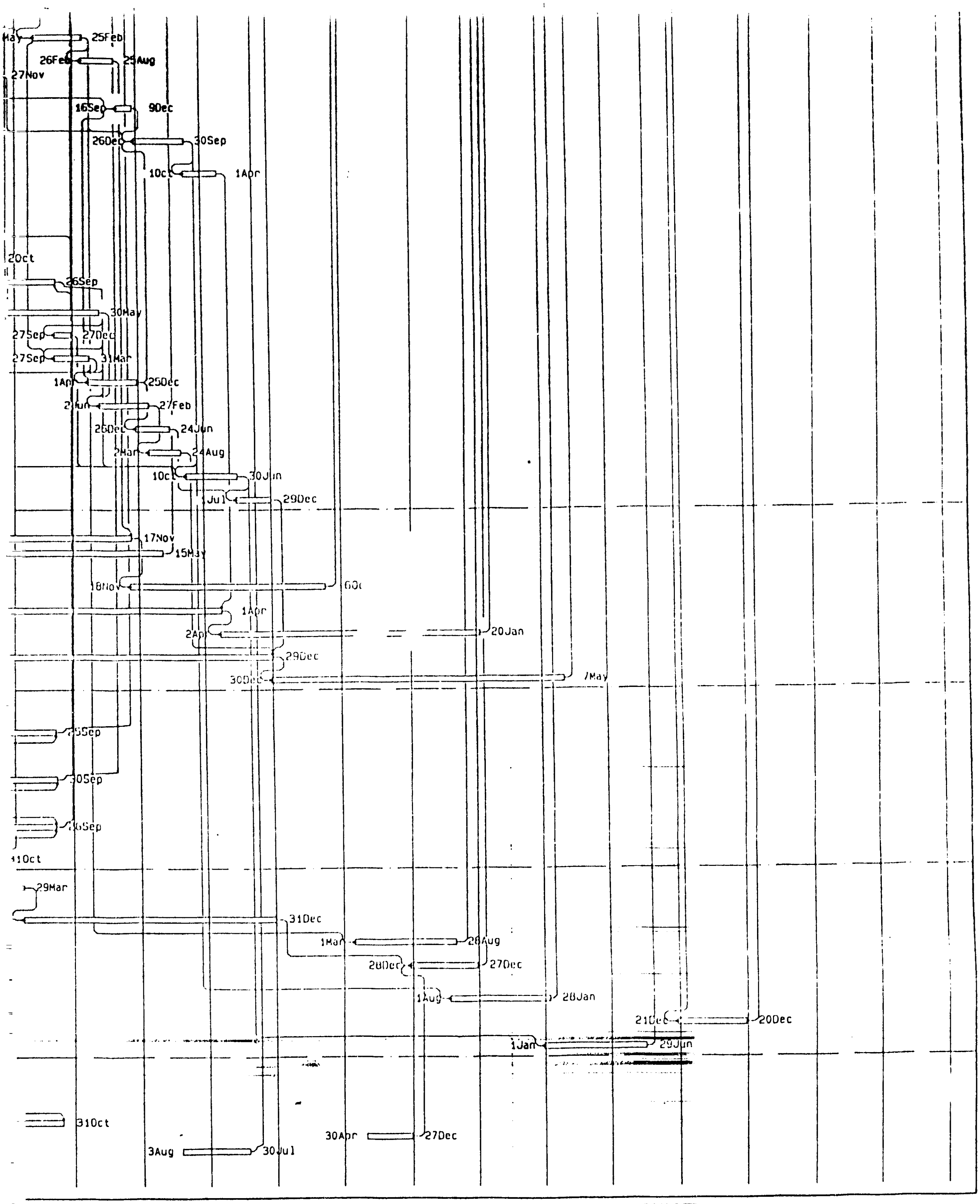
1373001	PFP PROCESS MODIFICATIONS (CONTINUED)	2Apr99	20Jan03
137400	W-096 CC/OXIDATION MODIFICATIONS - B PLANT	1Nov93	29Dec99
1374001	W-096 CC/OXIDATION MODIFICATIONS (CONTINUED)	30Dec99	7May04
7			
212.C.E05NCAW1	CORE AND CHARACTERIZATION (NCAW) FY91	18Mar91	30Sep91
212.C.E06NCAW2	CHARACTERIZATION OF REMAINING CORES (NCAW)	28Feb92	25Sep96
212.C.E07PFP1	CORE SAMPLE & CHARACTERIZATION (PFP) FY92	28Feb92	29Sep92
212.C.E08PFP2	CHARACTERIZATION OF REMAINING CORES (PFP)	1Mar93	30Sep96
212.C.E01CC1	CORE & CHARACTERIZATION (CC) FY91	1Oct90	2Sep91
212.C.E02CC2	CHARACTERIZATION OF REMAINING CORES (CC)	1Oct91	26Sep96
212.C.E09DSS1	CHARACTERIZE GROUT DSSF & DSS	1Oct91	31Oct95
9			
41F.1	INPUT POST-NCAW DESIGN FEED SPECS	1Oct90	29Mar96
410003014	COMPLETE POST-NCAW PROCESS DEVELOPMENT	1Apr96	31Dec99
41CC.1	INPUT COMPOSITION REQUIREMENT - NCAW FRIT PROC	1Mar01	28Aug02
MELTER1	REPLACE MELTER/TEST & STARTUP	28Dec01	27Dec02
41CC.2	INPUT COMPOSITION REQUIREMENT - PFP FRIT PROC	1Aug02	28Jan04
MELTER2	REPLACE MELTER/TEST & STARTUP	21Dec05	20Dec06
41CC.3	INPUT COMPOSITION REQUIREMENT - CC FRIT PROC	1Jan04	29Jun05
Activities Included By Selected Logic			
212.C.E11	DEVELOP METHODS FOR IMPROVED CORE SAMPLING	1Oct90	30Sep93
214A1	TRU MONITOR - HOT PILOT PLANT	1Oct90	19Jul94
4122310	WASTE FORM DEVELOPMENT	1Oct90	31Oct96
AZ101T2015	101-AZ PRE-NCAW SOLIDS TRANS/VITRIFY AT HWVP	30Apr01	27Dec01
AZ102T1001	102-AZ NCAW TRANS/PRETREAT AT AR VAULT/B PLANT	3Aug98	30Jul99
RISK1	START RISK ASSESSMENT NETWORK	1Oct90	1Oct90

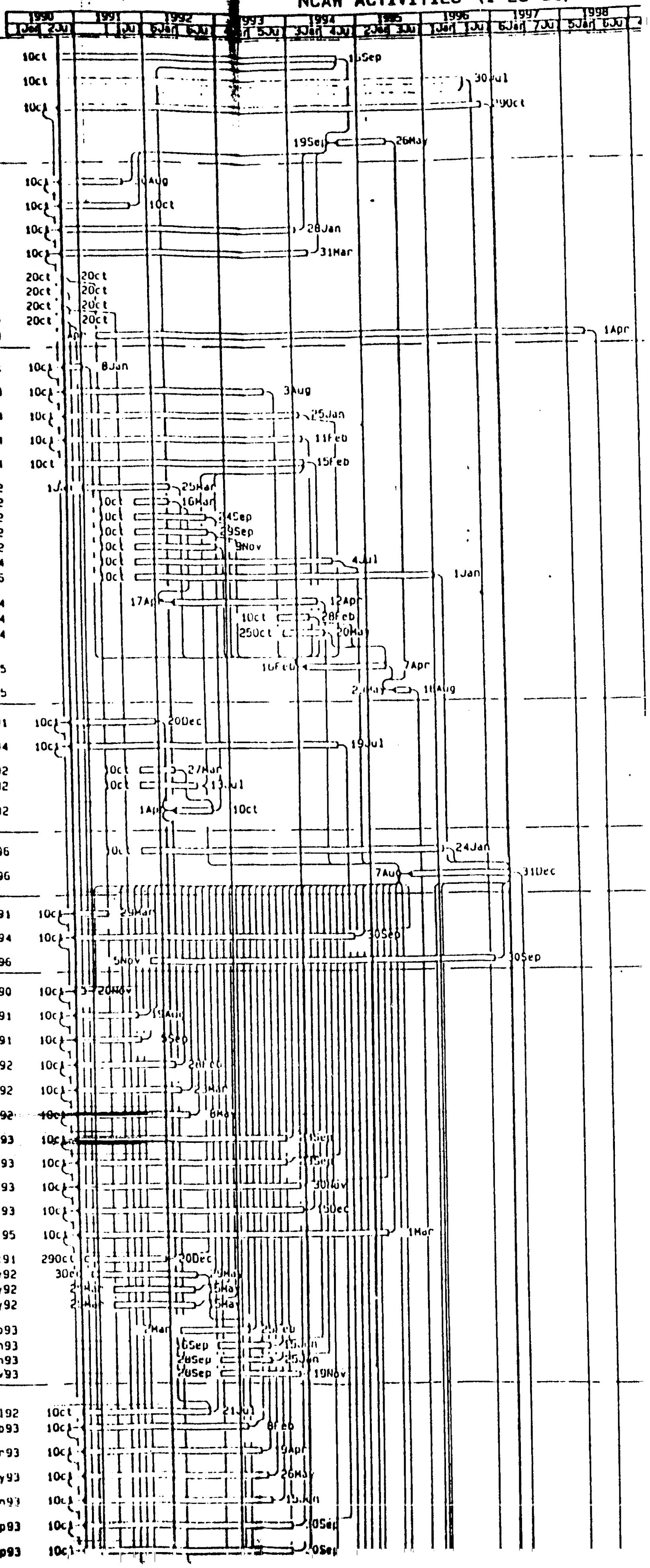


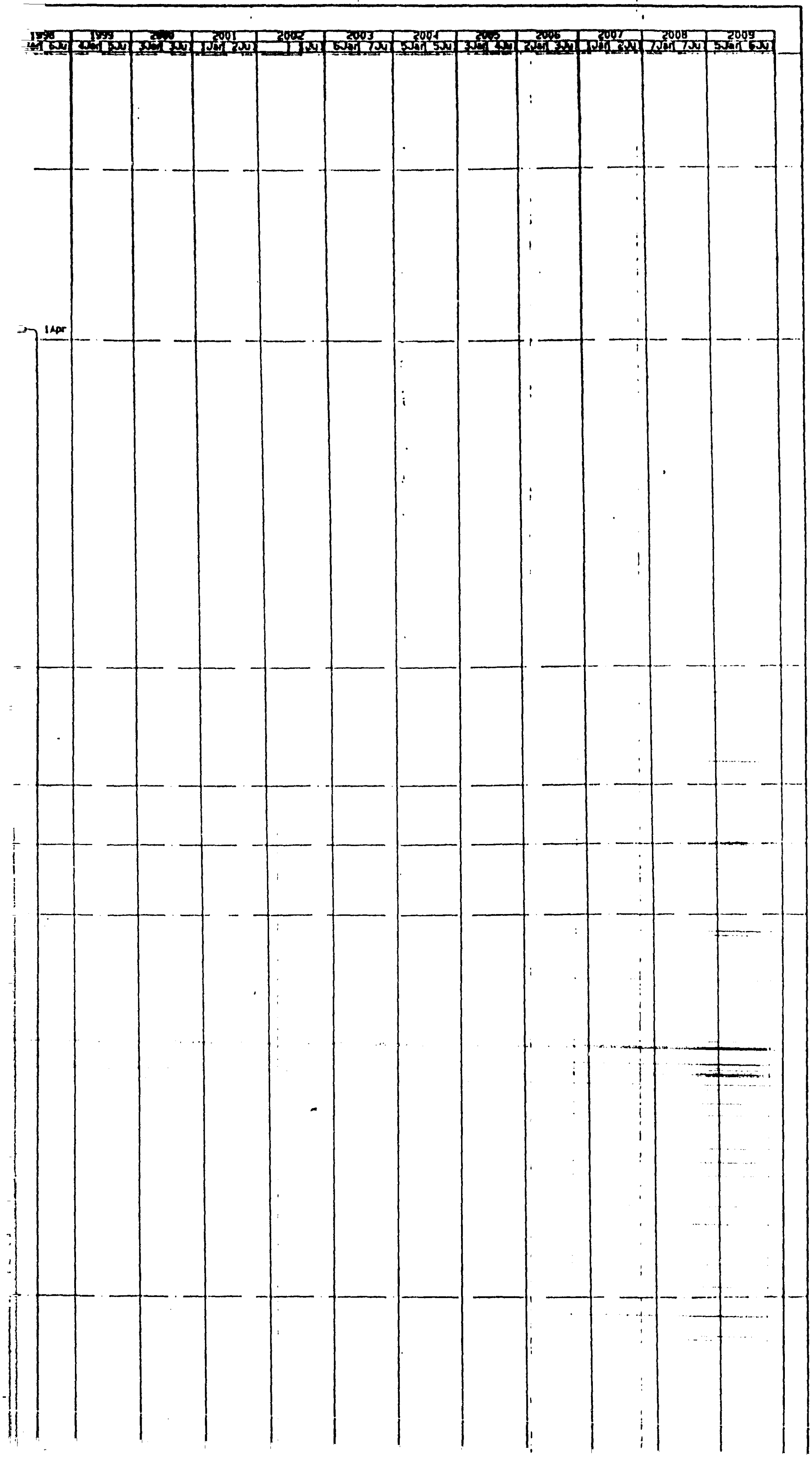


WHC-EP-0421 Figure 4-5. Top-Level Schedule--Post Neutralized Current Acid Waste.

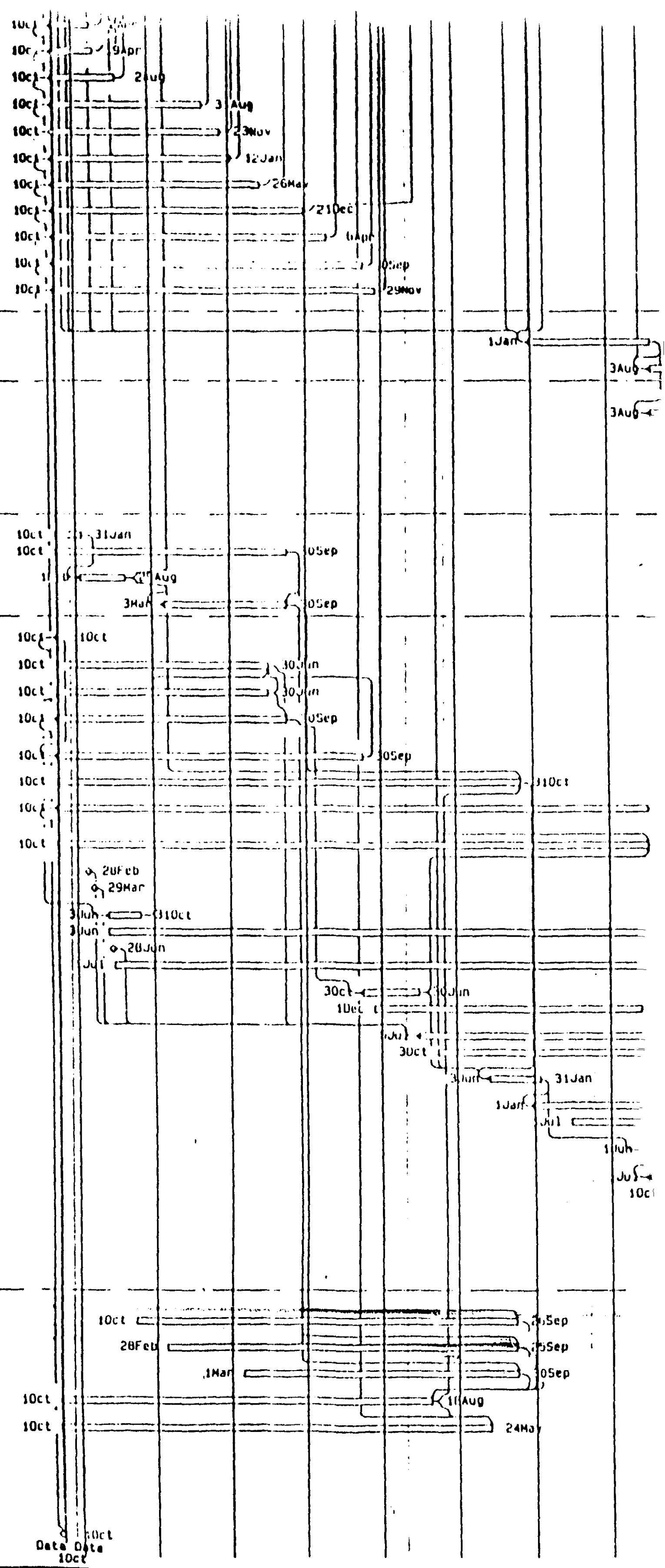
NCAW ACTIVITIES (1-28-91)

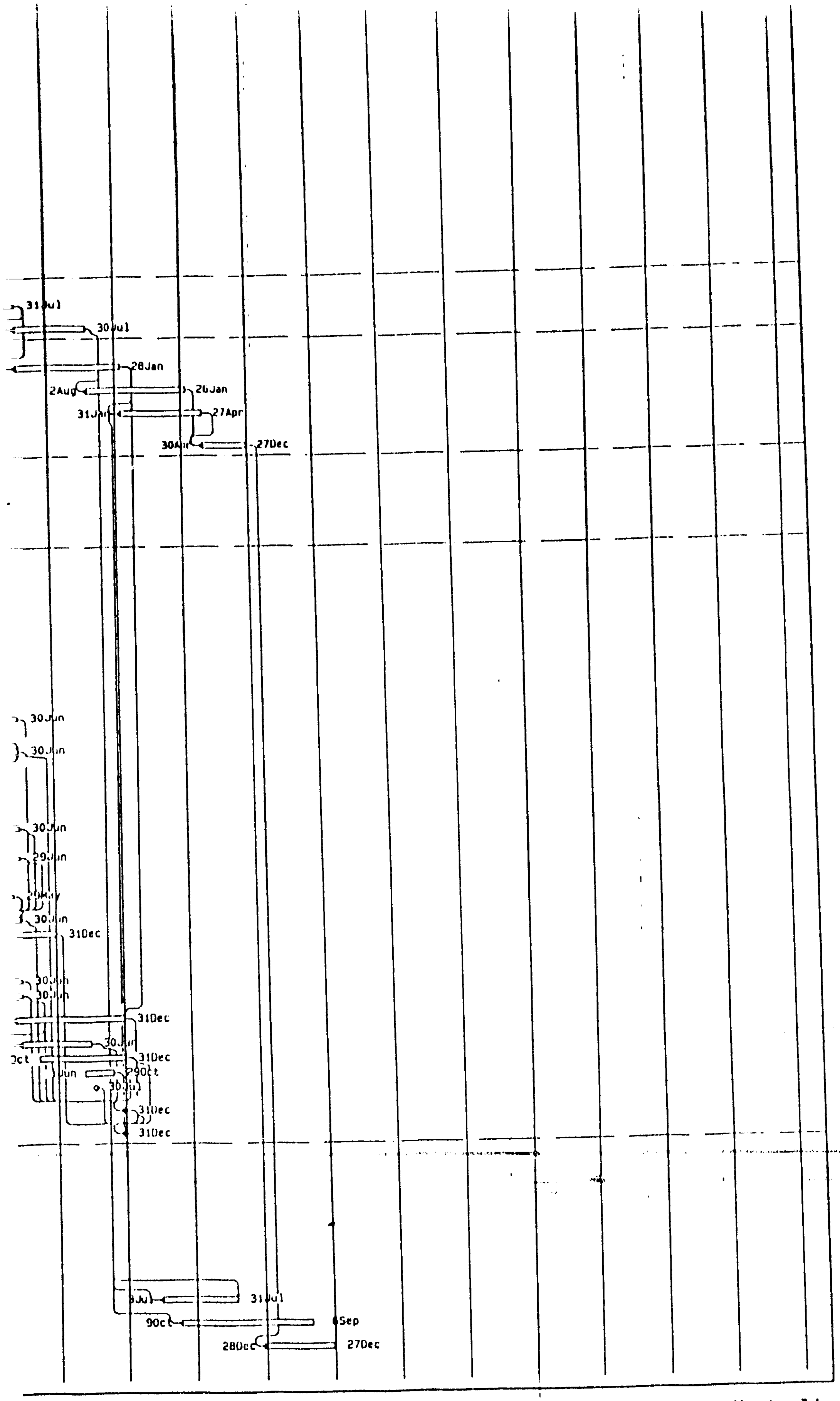
		ES	EF
10			
213.A	W-151 101-AZ RETRIEVAL SYSTEM PROCESS TEST	1Oct90	16Sep94
213.C	102-AY SOLIDS WASH RETRIEVAL	1Oct90	30Jul96
213.B	W-148 NCAW 4 PUMP RETRIEVAL SYSTEM MODS	1Oct90	29Oct96
213.A.10.0880	NCAW TANK 101-AZ PROCESS TEST	19Sep94	26May95
11			
75106	W-106 THREHO	1Oct90	30Aug91
75066	W-066 AZ TANK FARM ELECTRICAL UPGRADE	1Oct90	1Oct91
75028	W-028 AGING WASTE TRANSFER LINES	1Oct90	28Jan94
75030	W-030 DST STORAGE VENT UPGRADE	1Oct90	31Mar94
75TF01	TANK FARMS CAPITAL UPGRADES	2Oct90	2Oct90
75TF04	TANK FARMS DOCUMENTATION UPGRADES	2Oct90	2Oct90
75TF03	TANK FARMS OPERATIONS & ADMINISTRATIVE UPGRADES	2Oct90	2Oct90
75TF02	TANK FARMS MAJOR MAINTENANCE UPGRADES	2Oct90	2Oct90
AZ102RS05	102-AZ NCAW RETREIVAL SYSTEM	1Apr91	1Apr98
2			
244091	W-091 AR VLT COMPRESSOR UPGRADE	1Oct90	8Jan91
244136	W-136 AR VLT SLUDGE WASHING CONTROL ROOM MODS	1Oct90	3Aug93
244110	W-110 AR VLT TRANSFER LINE & DIESEL FUEL	1Oct90	25Jan94
244111	W-111 AR VLT SEAL POT & VESSEL VENT	1Oct90	11Feb94
244135	W-135 AR VLT SLUDGE WASHING PROCESS MODS	1Oct90	15Feb94
244253	AR VAULT SEISMIC ANALYSIS	1Jan91	25Mar92
24424	AR VAULT TANK INTEGRITY ASSESSMENT	1Oct91	16Mar92
244235	AR VAULT ENVIRONMENTAL ANALYSIS	1Oct91	24Sep92
244302414	AR VAULT CANYON CRANE INSPECTION/UPGRADE	1Oct91	29Sep92
2443031	AR VAULT NEW CANYON EQUIPMENT	1Oct91	9Nov92
244207	AR VAULT SAR	1Oct91	4Jul94
24400013	AR VAULT SYSTEM OPERABILITY TESTING	1Oct91	1Jan96
244228002	AR VAULT ENVIRONMENTAL PERMITTING	17Apr92	12Apr94
244213.5	AR VAULT - FACILITY DESCRIPTION MANUAL	1Oct93	28Feb94
244235.6	AR VAULT TRAINING	25Oct93	20May94
2440001	AR VAULT READINESS REVIEW	16Feb94	7Apr95
244000003	AR VAULT OPS/NFO SOLIDS WASHING	29May95	18Aug95
3			
214A0	ION EXCHANGE TECHNOLOGY	1Oct90	20Dec91
214A1	TRU MONITOR - HOT PILOT PLANT	1Oct90	19Jul94
214A0310	ENGR EVAL OF OPT B PRIME FLOC OPT TESTS	1Oct91	27Mar92
214A0320	ENG EVAL OF PH CONTROL	1Oct91	13Jul92
214A0305	DRAFT FINAL FLOWSHEET FOR AR VAULT/B PLANT	1Apr92	1Oct92
41			
1310	B PLANT SYSTEM OPERABILITY TESTING	1Oct91	24Jan96
130101	B PLANT READINESS REVIEW	7Aug95	31Dec96
42			
13233	B PLANT ADMINISTRATIVE MANUAL UPGRADES	1Oct90	29Mar91
132210	B PLANT FACILITY SAR	1Oct90	30Sep94
132430108	B PLANT TRAINING	5Nov91	30Sep96
43			
133320	CLEAN AIR ACT - NCAW PROCESSING	1Oct90	20Nov90
133008	W-008 B PLANT CHEM SEWER NEUTRALIZATION	1Oct90	19Aug91
133004	W-004 B PLANT AMU UPGRADE	1Oct90	5Sep91
133901	INTERIM STATUS ACTIONS BIS/OPL	1Oct90	28Feb92
133003	W-003 CHEM SEWER ENVIRONMENTAL UPGRADES	1Oct90	23Mar92
133010	W-010 B PLANT ENVIRONMENTAL COMPLIANCE UPGRADE	1Oct90	8May92
133107	W-107 BCS TREATMENT CENTRIC	1Oct90	23Sep93
133108	W-108 BCE TREATMENT FACILITY	1Oct90	23Sep93
133007	W-007 B PLANT PROCESS CONDENSATE FAC	1Oct90	30Nov93
133098	W-098 HAZARDOUS WASTE STORAGE	1Oct90	15Dec93
133024	W-024 B PLANT RAD EFFLUENT & CONTAINMENT UPGRADE	1Oct90	1Mar95
133201	CLEAN WATER ACT - UCP	29Oct90	20Dec91
133903	B PLANT TANK INTEGRITY ASSESSMENT	3Dec90	29May92
133203	CLEAN WATER ACT - CBC	25Mar91	15May92
133200	CLEAN WATER ACT - BCE	25Mar91	15May92
1339000	B PLANT PART B APPLICATION	2Mar92	25Feb93
133310	CLEAN AIR ACT - PROJECT W-098	16Sep92	15Jun93
133300	CLEAN AIR ACT - PROJECT W-107	28Sep92	25Jun93
133202	CLEAN WATER ACT - BCS	28Sep92	19Nov93
44			
134040	W-040 CELL 18 CESIUM IX COL	1Oct90	21Jul92
134162	W-162 IX MECHANICAL EQUIPMENT UPGRADE	1Oct90	8Feb93
134163	W-163 CELL DRAINAGE & VESSEL VENT INSTRUMENT UPG	1Oct90	19Apr93
134103	W-103 ONDECK SAMPLING IMPROVEMENT	1Oct90	26May93
134159	W-159 CT/CS INSTRUMENT UPGRADE	1Oct90	15Jun93
134077	W-077 CT/CS PROCESS CONTROL VALVE UPGRADE	1Oct90	30Sep93
134065	W-065 WH/IX/SD PROCESS CONTROL VALVE UPGRADE	1Oct90	30Sep93



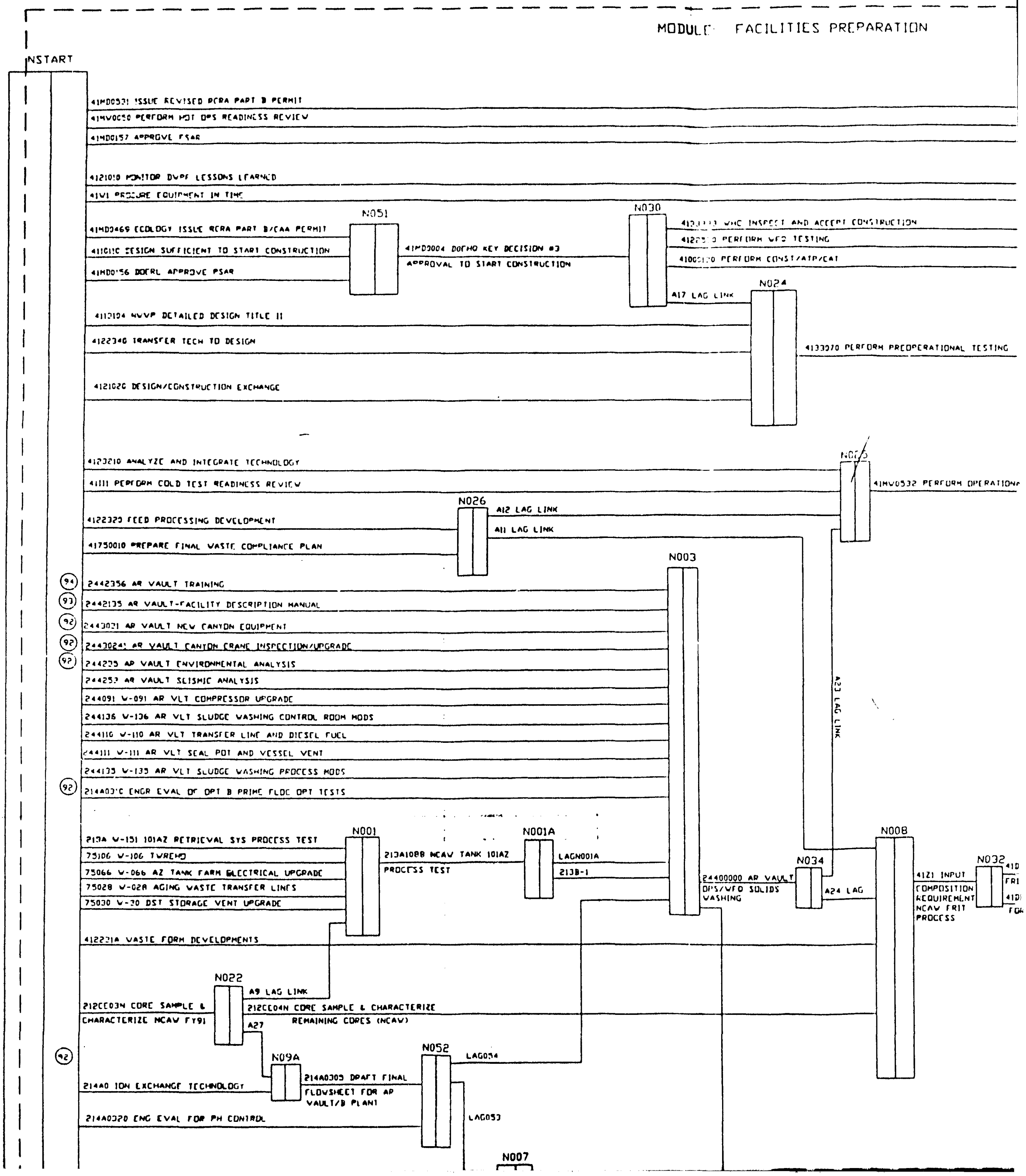

1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
6Jul
4Jan
5Jul
3Jan
3Jul
1Jan
2Jul
1Jul
6Jan
7Jul
5Jan
5Jul
3Jan
4Jul
2Jan
3Jul
1Jan
2Jul
7Jan
7Jul
5Jan
6Jul
1Apr

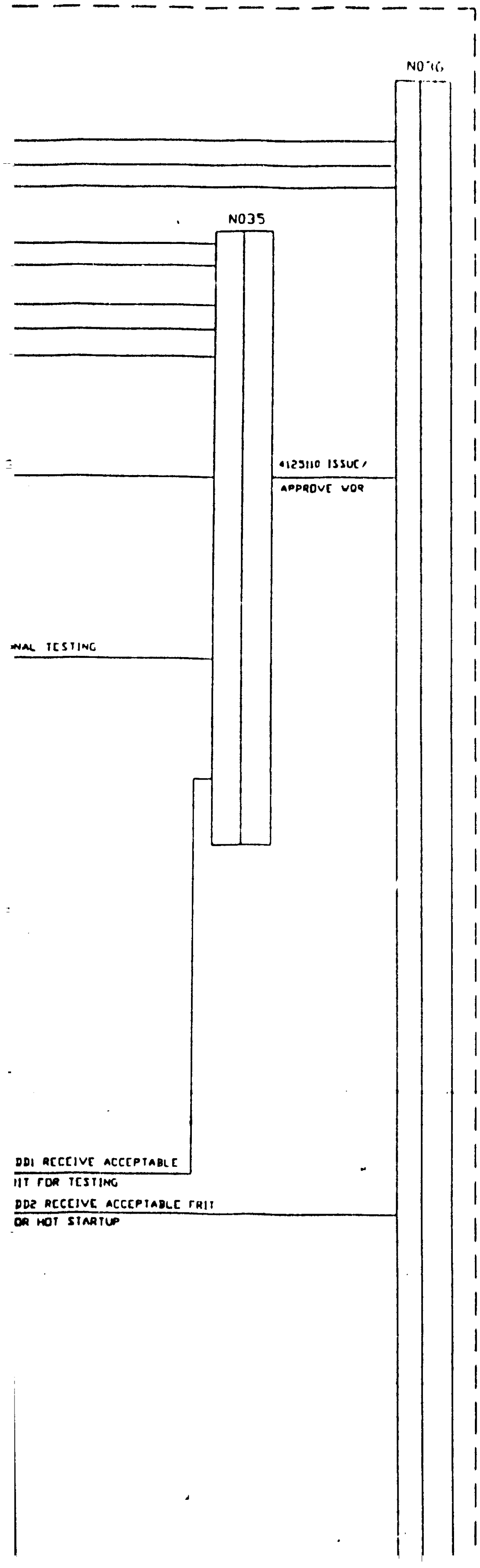
Activity ID	Description	Early Start	Early Finish
46			
136168	W-168 B PLANT FILTER SYSTEM TIE-IN	1Oct90	2Apr91
136230	RADIATION AREA MONITOR	1Oct90	19Apr91
136260	B-625 SAND FILTER VENT DUCT	1Oct90	2Aug91
1362501	W-094 291B FILTER INSTRUMENTATION UPGRADE	1Oct90	31Aug92
136250	B PLANT CANYON EXHAUST FILTER SYSTEMS	1Oct90	23Nov92
136220	CAM UPGRADE	1Oct90	12Jan93
136431	SEISMIC ANALYSIS	1Oct90	26May93
136027	W-027 271B HVAC UPGR	1Oct90	21Dec93
136102	W-102 GALLERY EXHAUST VENT	1Oct90	6Apr94
136104	W-104 B PLANT OPS SUPPORT BUILDING	1Oct90	30Sep94
136160	W-160 IN CELL & HPT LEAK DETECTION	1Oct90	29Nov94
50			
AZ101T1020	101-AZ NCAW TRANS/PRETREAT AT AR VAULT/B PLANT	1Jan97	31Jul98
AZ102T1001	102-AZ NCAW TRANS/PRETREAT AT AR VAULT/B PLANT	3Aug98	30Jul99
51			
AY102T2011	102-AY CHAR/FRIT PROC PRE-NCAW	3Aug98	28Jan00
AZ101T2011	101-AZ CHAR/FRIT PROC PRE-NCAW	2Aug99	26Jan01
AY102T2015	102-AY PRE-NCAW SOLIDS TRANS/VITRIFY AT HWVP	31Jan00	27Apr01
AZ101T2015	101-AZ PRE-NCAW SOLIDS TRANS/VITRIFY AT HWVP	30Apr01	27Dec01
7			
212.C.E10	DEVELOP IMPROVED METHOD FOR TRANSPORTING NCAW	1Oct90	31Jan91
212.C.E11	DEVELOP METHODS FOR IMPROVED CORE SAMPLING	1Oct90	30Sep93
212.C.E03NCAW1	CORE SAMPLE AND CHARACTERIZE (NCAW) FY91	1Feb91	29Aug91
212.C.E04NCAW2	CORE SAMPLE & CHARACTERIZE REMAINING CORES (NCAW	3Mar92	30Sep93
9			
41F1	INPUT DESIGN FEED SPECS	1Oct90	1Oct90
4113104	HWVP DETAILED DESIGN (TITLE II)	1Oct90	30Jun93
4121020	DESIGN/CONSTRUCTION EXCHANGE	1Oct90	30Jun93
4122320	FEED PROCESSING DEVELOPMENT	1Oct90	30Sep93
4122340	TRANSFER TECH TO DESIGN (APPLIED TECH HANDBOOK)	1Oct90	30Sep94
4122310	WASTE FORM DEVELOPMENT	1Oct90	31Oct96
4121010	MONITOR DWPF LESSONS LEARNED	1Oct90	30Jun98
4123210	ANALYZE & INTEGRATE TECHNOLOGY	1Oct90	30Jun98
41H0015GHRL	DOERL APPROVE PSAR	28Feb91	28Feb91
41H00004HHQ	DOEHQ KEY DECISION #3 APPROVAL TO START CONST	29Mar91	29Mar91
4110110	DESIGN SUFFICIENT TO START CONSTRUCTION	3Jun91	31Oct91
41M1	PROCURE EQUIPMENT IN TIME	3Jun91	30Jun98
41H00469HRL	ECOLOGY ISSUE RCRA PART B/CAA PERMIT	28Jun91	28Jun91
410001301	PERFORM CONSTRUCTION/ATP/CAT	1Jul91	29Jun98
417500102	PREPARE FINAL WASTE COMPLIANCE PLAN	3Oct94	30Jun95
4133333	WHC INSPECT & ACCEPT CONSTRUCTION	1Dec94	29May98
4133070	PERFORM PREOPERATIONAL TESTING	5Jul95	30Jun98
41H00531HRL	ISSUE REVISED RCRA PART B PERMIT	3Oct95	31Dec98
4..1	INPUT COMPOSITION REQUIREMENT - NCAW FRIT PROC	3Jun96	31Jan97
41D01	RECEIVE ACCEPTABLE FRIT FOR TESTING	1Jan97	30Jun98
41I11	PERFORM COLD TEST READINESS REVIEW	1Jul97	30Jun98
41D02	RECEIVE ACCEPTABLE FRIT FOR HOT STARTUP	1Jun98	31Dec99
41HW0532HRL	PERFORM OPERATIONAL TESTING	1Jul98	30Jun99
41HW0050HRL	PERFORM HOT OPS READINESS REVIEW	1Oct98	31Dec99
4122530	PERFORM WFQ TESTING	1Jun99	29Oct99
41H00157HRL	APPROVE FSAR	30Jul99	30Jul99
4125110	ISSUE/APPROVE WOR	31Dec99	31Dec99
41HW0053HHQ	INITIATE HWVP HOT OPERATIONS	31Dec99	31Dec99
Activities Included By Selected Logic			
212.C.E02CC2	CHARACTERIZATION OF REMAINING CORES (CC)	1Oct91	26Sep96
212.C.E06NCAW2	CHARACTERIZATION OF REMAINING CORES (NCAW)	28Feb92	25Sep96
212.C.E08PFP2	CHARACTERIZATION OF REMAINING CORES (PFP)	1Mar93	30Sep96
215.A.01	TRUEX PROCESS DEVELOPMENT	1Oct90	18Aug95
215.B	W-153 TRUEX PILOT PLANT	1Oct90	24May96
AP001	GROUT NCAW OPERATIONS	3Jul00	31Jul01
AW103T1	NCAW PRETREATMENT OPERATIONS - B PLANT	9Oct00	6Sep02
MELTER1	REPLACE MELTER/TEST & STARTUP	28Dec01	27Dec02
RISK1	START RISK ASSESSMENT NETWORK	1Oct90	1Oct90





WHC-EP-0421 Figure 4-4. Top-Level Schedule--Neutralized Current Acid Waste.

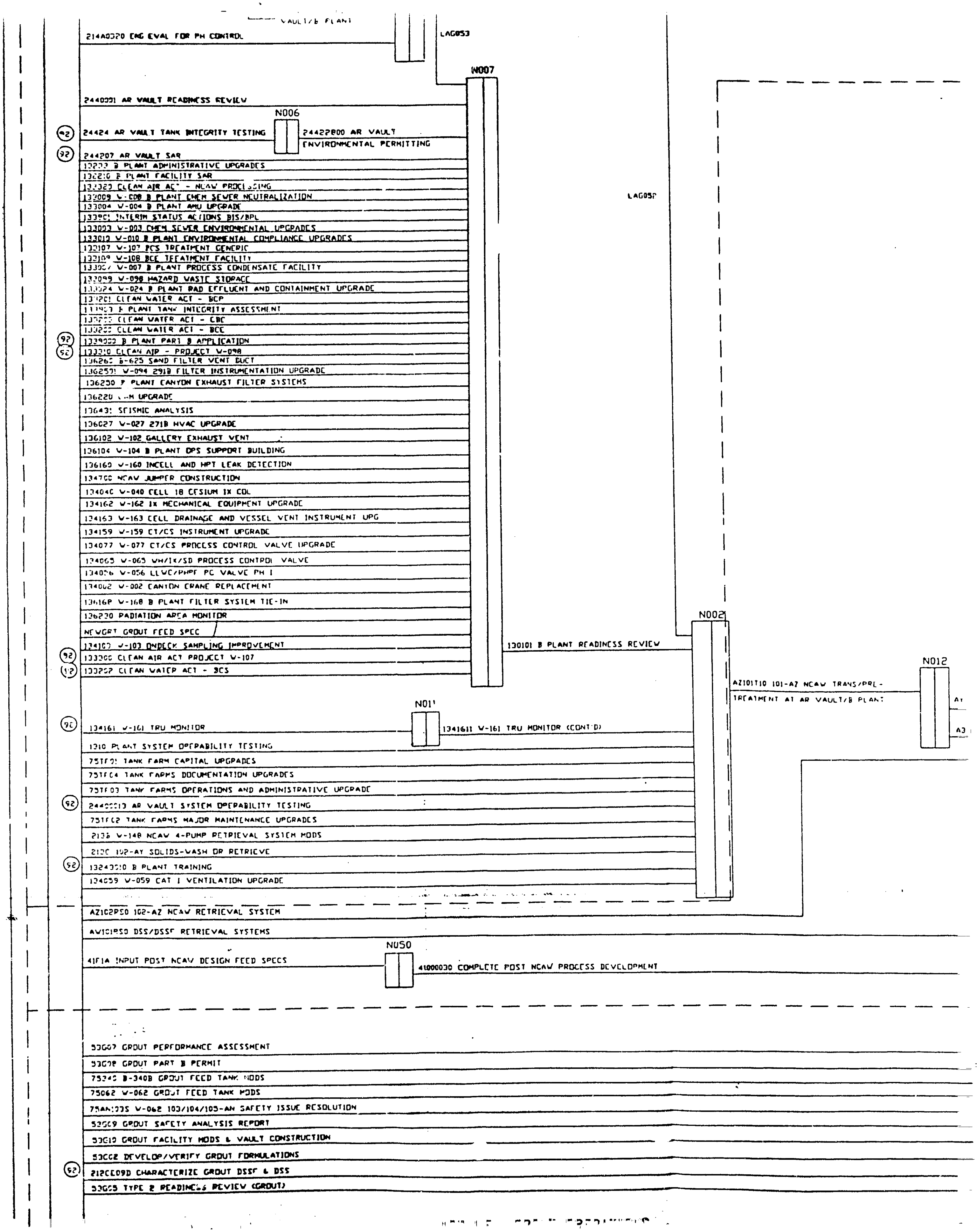

MODULE: FACILITIES PREPARATION
NSTART
41MD0531 ISSUE REVISED RCRA PART B PERMIT
41MV0050 PERFORM HOT OPS READINESS REVIEW
41MD0157 APPROVE FSAR
4121010 MONITOR DWPF LESSONS LEARNED
41V1 PROCURE EQUIPMENT IN TIME
41MD0469 ECOLOGY ISSUE RCRA PART B/CAA PERMIT
411011C DESIGN SUFFICIENT TO START CONSTRUCTION
41MD0156 DOERL APPROVE PSAR
N051
41MD0004 DOEHQ KEY DECISION #3
APPROVAL TO START CONSTRUCTION
N030
WHC INSPECT AND ACCEPT CONSTRUCTION
PERFORM VFO TESTING
PERFORM CONST/ATP/CAT
A17 LAG LINK
N024
4112104 NVVP DETAILED DESIGN TITLE II
4122340 TRANSFER TECH TO DESIGN
4133070 PERFORM PREOPERATIONAL TESTING
4121020 DESIGN/CONSTRUCTION EXCHANGE
4123210 ANALYZE AND INTEGRATE TECHNOLOGY
4111 PERFORM COLD TEST READINESS REVIEW
41MV0532 PERFORM OPERATIONA
N026
A12 LAG LINK
A11 LAG LINK
4122320 FEED PROCESSING DEVELOPMENT
41750010 PREPARE FINAL WASTE COMPLIANCE PLAN
N003
94
2442356 AR VAULT TRAINING
93
2442135 AR VAULT-FACILITY DESCRIPTION MANUAL
92
2443021 AR VAULT NEW CANYON EQUIPMENT
92
24430245 AR VAULT CANYON CRANE INSPECTION/UPGRADE
92
244225 AR VAULT ENVIRONMENTAL ANALYSIS
244253 AR VAULT SEISMIC ANALYSIS
244091 W-091 AR VLT COMPRESSOR UPGRADE
244136 W-136 AR VLT SLUDGE WASHING CONTROL ROOM MODS
244110 W-110 AR VLT TRANSFER LINE AND DIESEL FUEL
244111 W-111 AR VLT SEAL POT AND VESSEL VENT
244135 W-135 AR VLT SLUDGE WASHING PROCESS MODS
92
214A03C ENGR EVAL OF OPT B PRIME FLOC OPT TESTS
A23 LAG LINK
N001
213A W-151 101AZ RETRIEVAL SYS PROCESS TEST
75106 W-106 TWRFHD
75066 W-066 AZ TANK FARM ELECTRICAL UPGRADE
75028 W-028 AGING WASTE TRANSFER LINES
75030 W-30 DST STORAGE VENT UPGRADE
213A108B NCAW TANK 101AZ
PROCESS TEST
N001A
LAGN001A
213B-1
N034
24400000 AR VAULT
OPS/VFO SOLIDS
WASHING
A24 LAG
N008
4121 INPUT
COMPOSITION
REQUIREMENT
NCAW FRIT
PROCESS
N032
412221A WASTE FORM DEVELOPMENTS
N022
A9 LAG LINK
212CC03N CORE SAMPLE &
CHARACTERIZE NCAW FY91
212CC04N CORE SAMPLE & CHARACTERIZE
REMAINING CORES (NCAW)
A27
92
N09A
N052
LAG054
214A0 ION EXCHANGE TECHNOLOGY
214A0305 DRAFT FINAL
FLOWSHEET FOR AP
VAULT/B PLANT
214A0320 ENG EVAL FOR PH CONTROL
LAG053
N007



NCAW NETWORK

PREPARED BY SAIC

09 AUGUST 1991



VAULT/B PLANT
214A0320 ENG EVAL FOR PH CONTROL
LAG053
N007
244OO31 AR VAULT READINESS REVIEW
N006
24424 AR VAULT TANK INTEGRITY TESTING
24422800 AR VAULT ENVIRONMENTAL PERMITTING
244207 AR VAULT SAR
132033 B PLANT ADMINISTRATIVE UPGRADES
132210 B PLANT FACILITY SAR
132320 CLEAN AIR ACT - NCAW PROCESSING
133009 V-008 B PLANT CHEM SEWER NEUTRALIZATION
133004 V-004 B PLANT AMU UPGRADE
133901 INTERIM STATUS ACTIONS BIS/BPL
133003 V-003 CHEM SEWER ENVIRONMENTAL UPGRADES
133010 V-010 B PLANT ENVIRONMENTAL COMPLIANCE UPGRADES
133107 V-107 BCS TREATMENT GENERIC
133108 V-108 BCE TREATMENT FACILITY
133007 V-007 B PLANT PROCESS CONDENSATE FACILITY
133099 V-098 HAZARD WASTE STORAGE
133024 V-024 B PLANT RAD EFFLUENT AND CONTAINMENT UPGRADE
133201 CLEAN WATER ACT - BCP
133903 B PLANT TANK INTEGRITY ASSESSMENT
133203 CLEAN WATER ACT - CBC
133203 CLEAN WATER ACT - BCE
1339000 B PLANT PART B APPLICATION
133310 CLEAN AIR - PROJECT V-098
136265 B-625 SAND FILTER VENT DUCT
1362501 V-094 291B FILTER INSTRUMENTATION UPGRADE
136250 B PLANT CANYON EXHAUST FILTER SYSTEMS
136220 ...M UPGRADE
136431 SEISMIC ANALYSIS
136027 V-027 271B HVAC UPGRADE
136102 V-102 GALLERY EXHAUST VENT
136104 V-104 B PLANT OPS SUPPORT BUILDING
136160 V-160 INCELL AND HPT LEAK DETECTION
134700 NCAW JUMPER CONSTRUCTION
134040 V-040 CELL 18 CESIUM IX COL
134162 V-162 IX MECHANICAL EQUIPMENT UPGRADE
134163 V-163 CELL DRAINAGE AND VESSEL VENT INSTRUMENT UPG
134159 V-159 CT/CS INSTRUMENT UPGRADE
134077 V-077 CT/CS PROCESS CONTROL VALVE UPGRADE
134065 V-065 VH/IX/SD PROCESS CONTROL VALVE
134056 V-056 LLWC/PHPF PC VALVE PH I
134002 V-002 CANYON CRANE REPLACEMENT
136168 V-168 B PLANT FILTER SYSTEM TIE-IN
136230 RADIATION AREA MONITOR
NEWGRT GROUT FEED SPEC
134103 V-103 ONDECK SAMPLING IMPROVEMENT
133300 CLEAN AIR ACT PROJECT V-107
133202 CLEAN WATER ACT - BCS
LAG052
130101 B PLANT READINESS REVIEW
N002
N012
AZ101T10 101-AZ NCAW TRANS/PRE-TREATMENT AT AR VAULT/B PLANT
N011
134161 V-161 TRU MONITOR
1341611 V-161 TRU MONITOR (CONT'D)
1310 PLANT SYSTEM OPERABILITY TESTING
75TF01 TANK FARM CAPITAL UPGRADES
75TF04 TANK FARMS DOCUMENTATION UPGRADES
75TF03 TANK FARMS OPERATIONS AND ADMINISTRATIVE UPGRADE
24400010 AR VAULT SYSTEM OPERABILITY TESTING
75TF02 TANK FARMS MAJOR MAINTENANCE UPGRADES
2136 V-148 NCAW 4-PUMP RETRIEVAL SYSTEM MODS
2120 102-AY SOLIDS-WASH OR RETRIEVE
13240010 B PLANT TRAINING
134059 V-059 CAT I VENTILATION UPGRADE
AZ102RS0 102-AZ NCAW RETRIEVAL SYSTEM
AW101RS0 DSS/DSSF RETRIEVAL SYSTEMS
N050
41F1A INPUT POST NCAW DESIGN FEED SPECS
41000030 COMPLETE POST NCAW PROCESS DEVELOPMENT
53007 GROUT PERFORMANCE ASSESSMENT
53008 GROUT PART B PERMIT
75340 B-340B GROUT FEED TANK MODS
75062 V-062 GROUT FEED TANK MODS
75AN1035 V-062 103/104/105-AN SAFETY ISSUE RESOLUTION
53009 GROUT SAFETY ANALYSIS REPORT
53010 GROUT FACILITY MODS & VAULT CONSTRUCTION
53002 DEVELOP/VERIFY GROUT FORMULATIONS
212CE09D CHARACTERIZE GROUT DSSF & DSS
53005 TYPE 2 READINESS REVIEW (GROUT)

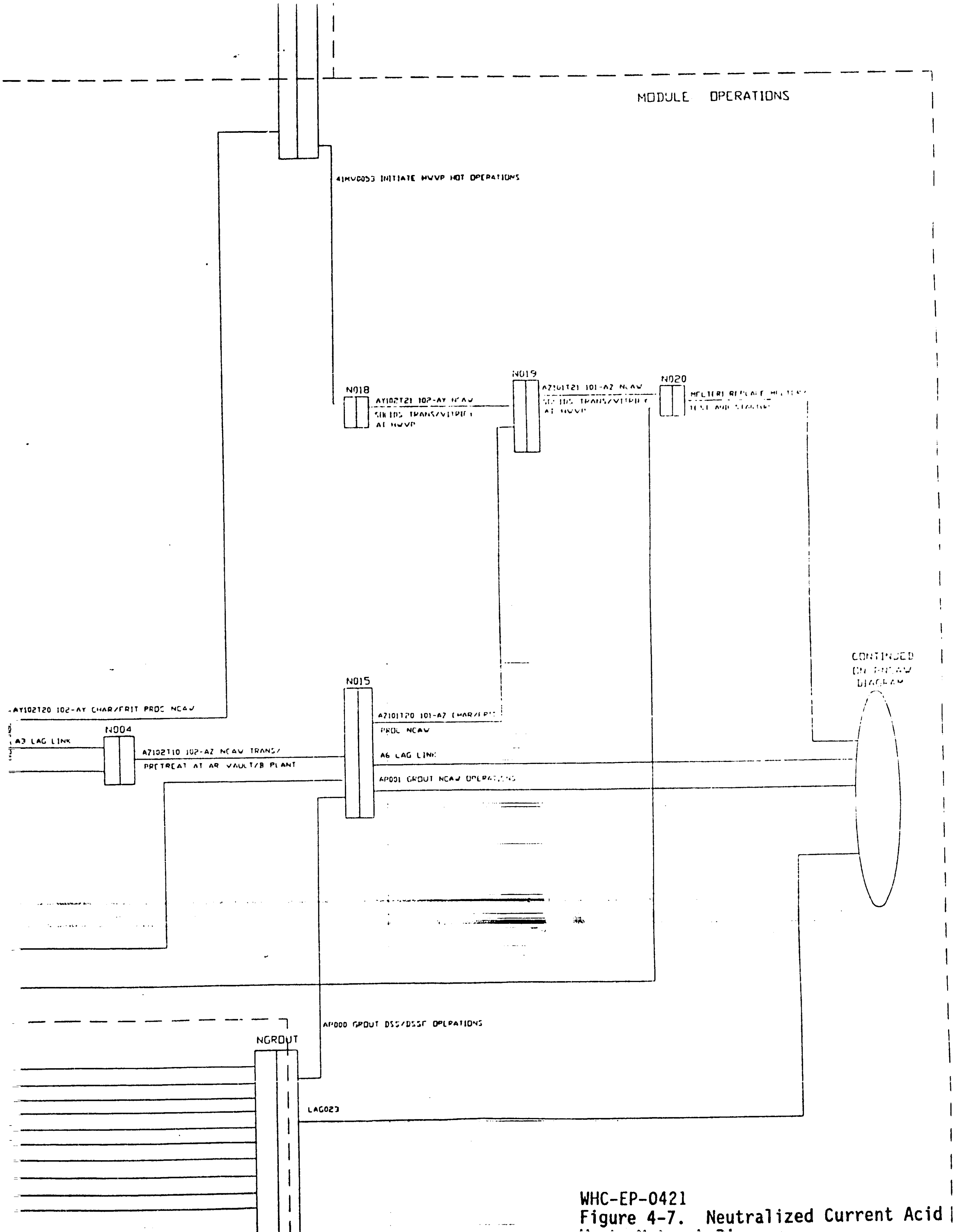


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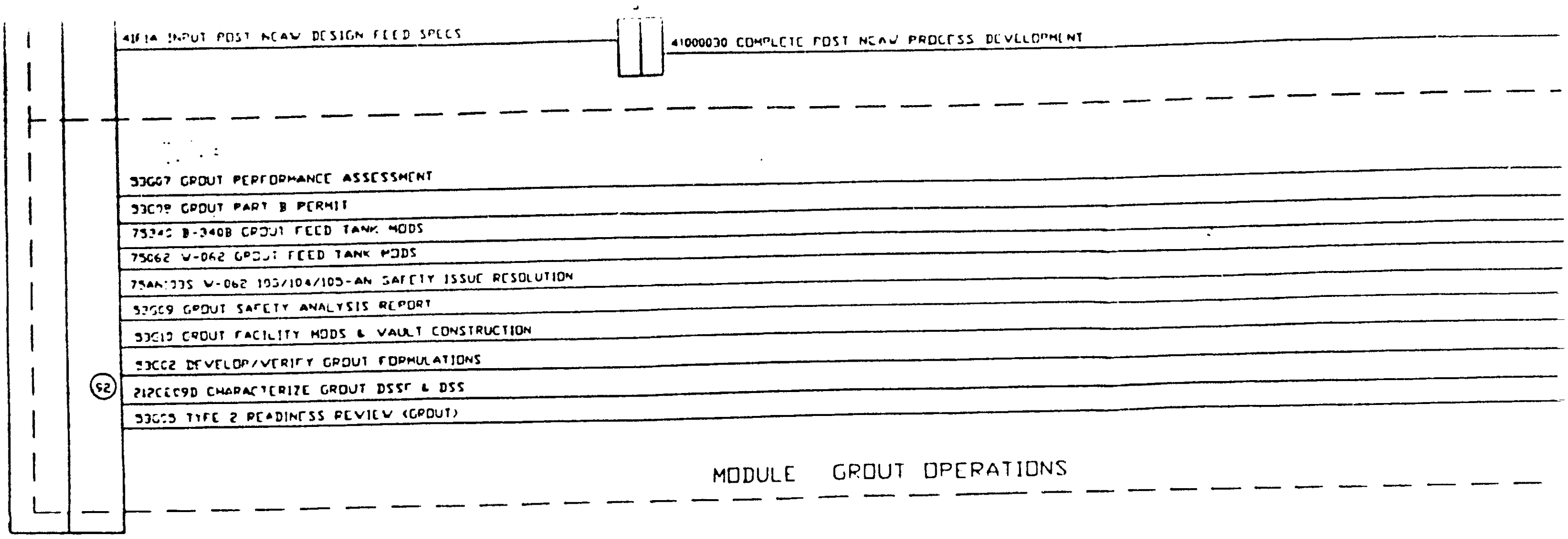
Figure 4-7. Neutralized Current Acid



41F1A INPUT POST NCAW DESIGN FEED SPECS
41000030 COMPLETE POST NCAW PROCESS DEVELOPMENT
53G07 GROUT PERFORMANCE ASSESSMENT
53C09 GROUT PART B PERMIT
75340 B-340B GROUT FEED TANK MODS
75062 W-062 GROUT FEED TANK MODS
75AN1035 W-062 103/104/105-AN SAFETY ISSUE RESOLUTION
53C09 GROUT SAFETY ANALYSIS REPORT
53C10 GROUT FACILITY MODS & VAULT CONSTRUCTION
53C02 DEVELOP/VERIFY GROUT FORMULATIONS
92
212CCC9D CHARACTERIZE GROUT DSSF & DSS
53C05 TYPE 2 READINESS REVIEW (GROUT)
MODULE GROUT OPERATIONS

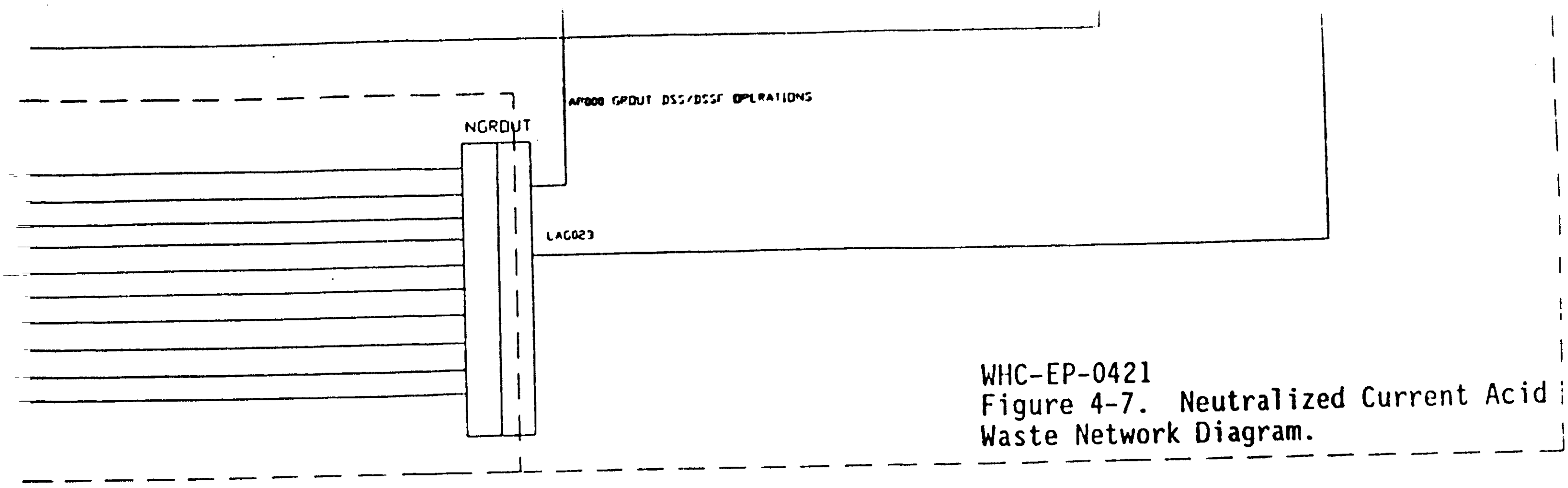


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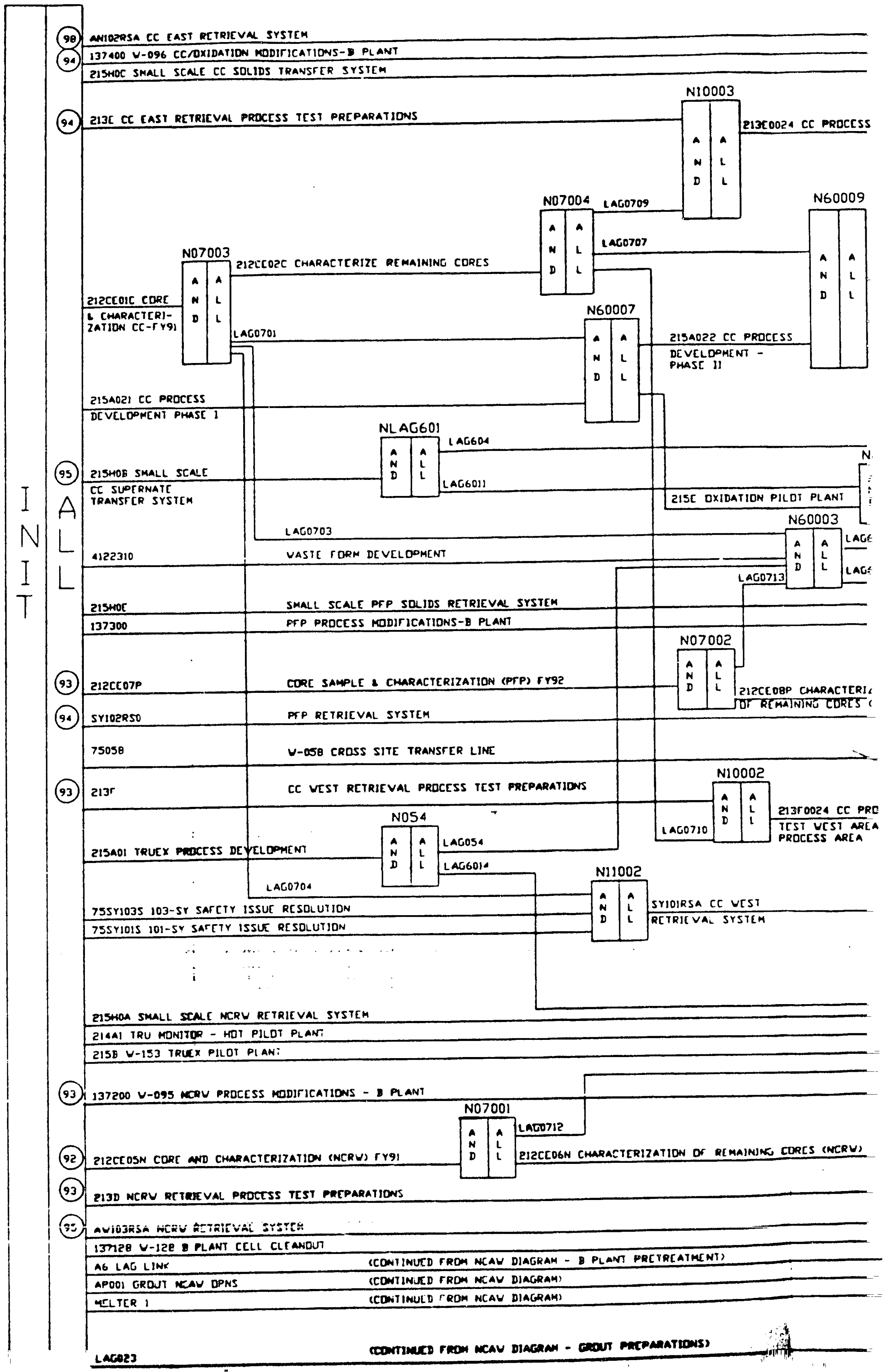
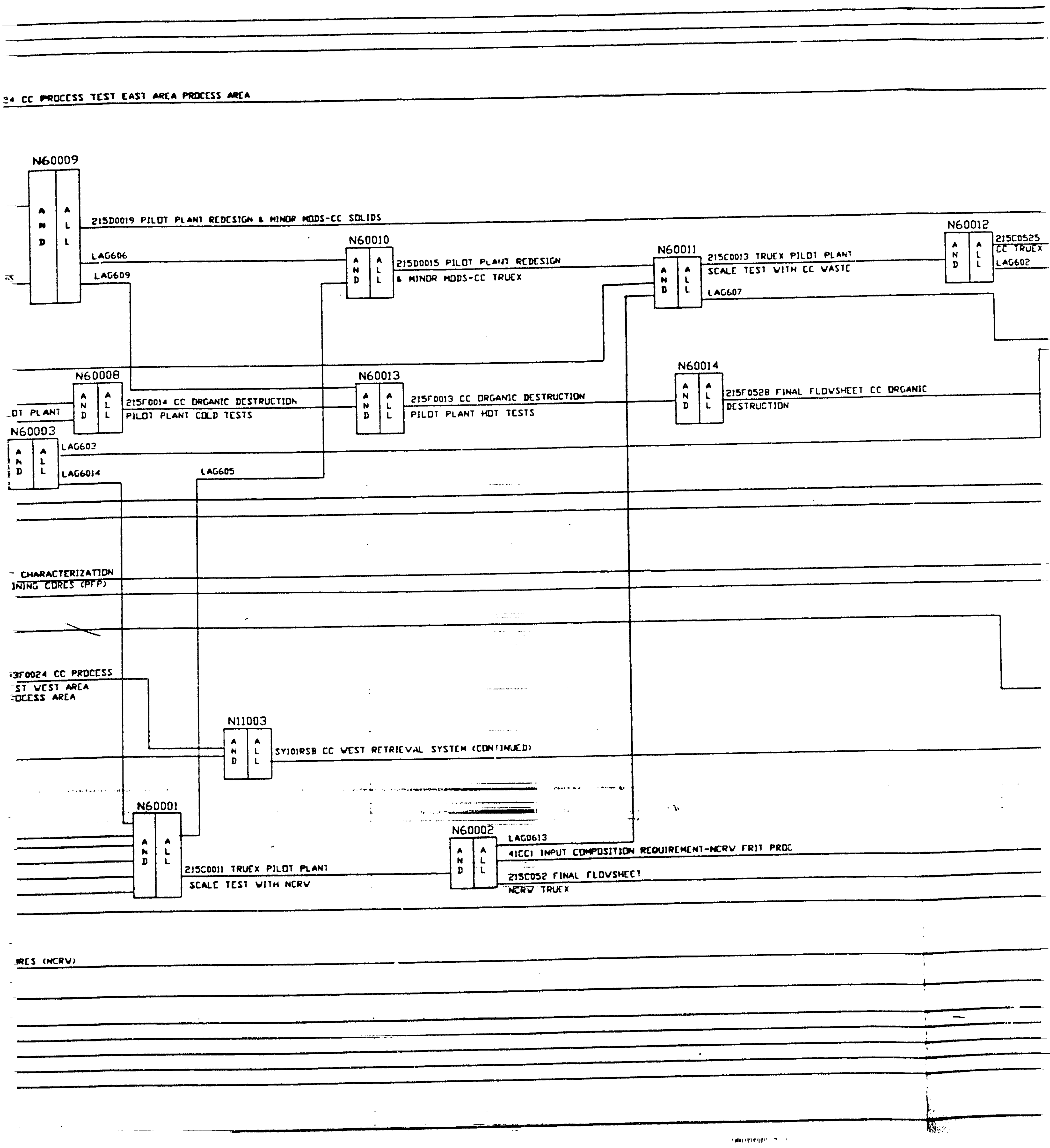
Figure 4-7. Neutralized Current Acid Waste Network Diagram.



INIT
ALL
98 AN102RSA CC EAST RETRIEVAL SYSTEM
94 137400 V-096 CC/OXIDATION MODIFICATIONS-B PLANT
215H0C SMALL SCALE CC SOLIDS TRANSFER SYSTEM
94 213E CC EAST RETRIEVAL PROCESS TEST PREPARATIONS
N10003
AND ALL
213E0024 CC PROCESS
N07004
LAG0709
LAG0707
N60009
N07003
212CE02C CHARACTERIZE REMAINING CORES
212CE01C CORE & CHARACTERIZATION CC-FY91
LAG0701
N60007
215A022 CC PROCESS DEVELOPMENT - PHASE II
215A021 CC PROCESS DEVELOPMENT PHASE I
NLAG601
LAG604
95 215H0B SMALL SCALE CC SUPERNATE TRANSFER SYSTEM
LAG6011
215E OXIDATION PILOT PLANT
N60003
LAG0703
4122310 WASTE FORM DEVELOPMENT
LAG0713
215H0E SMALL SCALE PFP SOLIDS RETRIEVAL SYSTEM
137300 PFP PROCESS MODIFICATIONS-B PLANT
N07002
93 212CE07P CORE SAMPLE & CHARACTERIZATION (PFP) FY92
212CE08P CHARACTERI... OF REMAINING CORES
94 SY102RS0 PFP RETRIEVAL SYSTEM
75058 W-058 CROSS SITE TRANSFER LINE
N10002
93 213F CC WEST RETRIEVAL PROCESS TEST PREPARATIONS
213F0024 CC PRO... TEST WEST AREA PROCESS AREA
LAG0710
N054
215A01 TRUEX PROCESS DEVELOPMENT
LAG054
LAG6014
N11002
LAG0704
75SY103S 103-SY SAFETY ISSUE RESOLUTION
75SY101S 101-SY SAFETY ISSUE RESOLUTION
SY101RSA CC WEST RETRIEVAL SYSTEM
215H0A SMALL SCALE NCRW RETRIEVAL SYSTEM
214A1 TRU MONITOR - HOT PILOT PLANT
215B W-153 TRUEX PILOT PLANT
93 137200 W-095 NCRW PROCESS MODIFICATIONS - B PLANT
N07001
LAG0712
92 212CE05N CORE AND CHARACTERIZATION (NCRW) FY91
212CE06N CHARACTERIZATION OF REMAINING CORES (NCRW)
93 213D NCRW RETRIEVAL PROCESS TEST PREPARATIONS
95 AW103RSA NCRW RETRIEVAL SYSTEM
137128 W-128 B PLANT CELL CLEANOUT
A6 LAG LINK (CONTINUED FROM NCAW DIAGRAM - B PLANT PRETREATMENT)
AP001 GROUT NCAW OPNS (CONTINUED FROM NCAW DIAGRAM)
MELTER 1 (CONTINUED FROM NCAW DIAGRAM)
LAG023 (CONTINUED FROM NCAW DIAGRAM - GROUT PREPARATIONS)

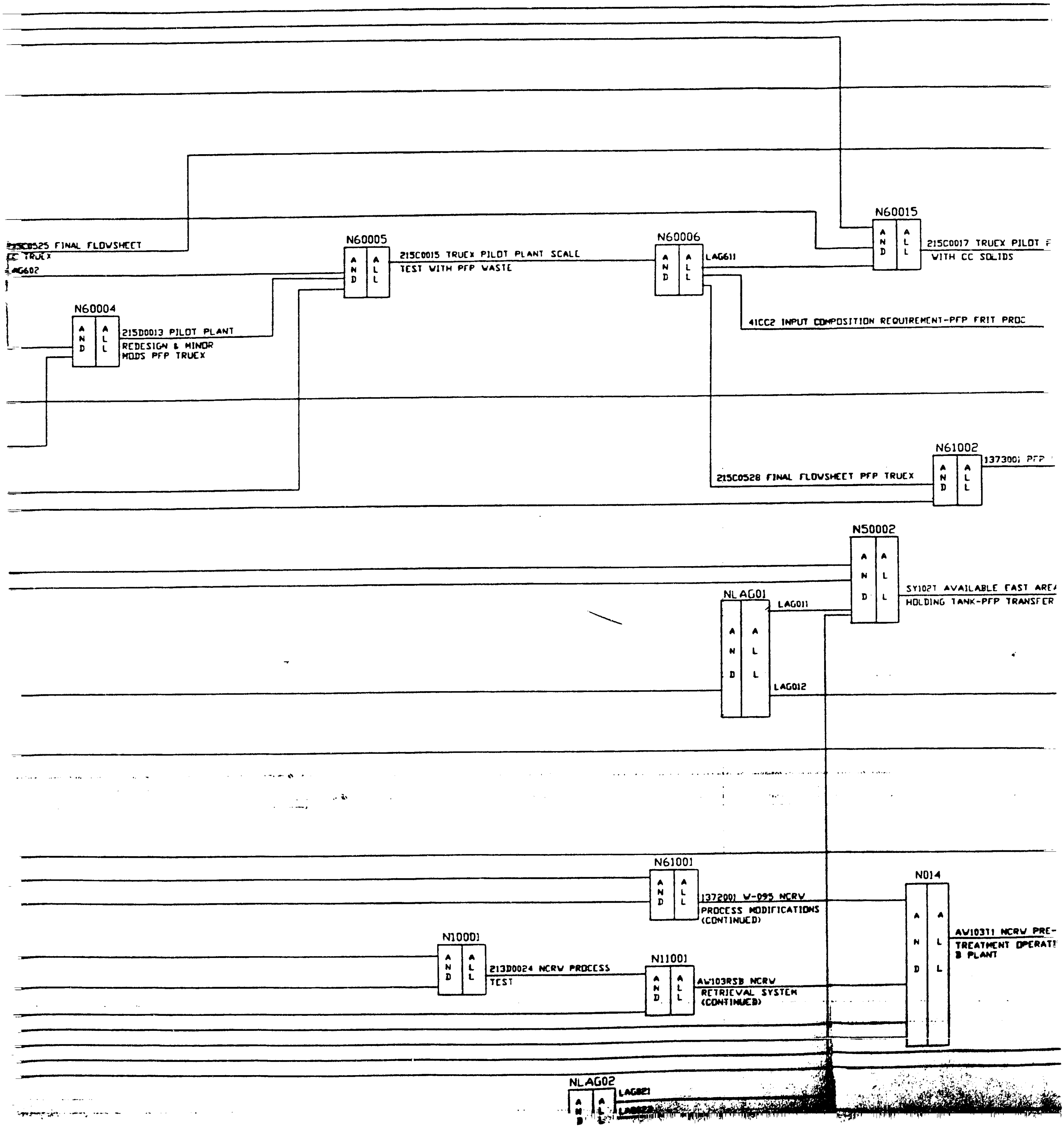


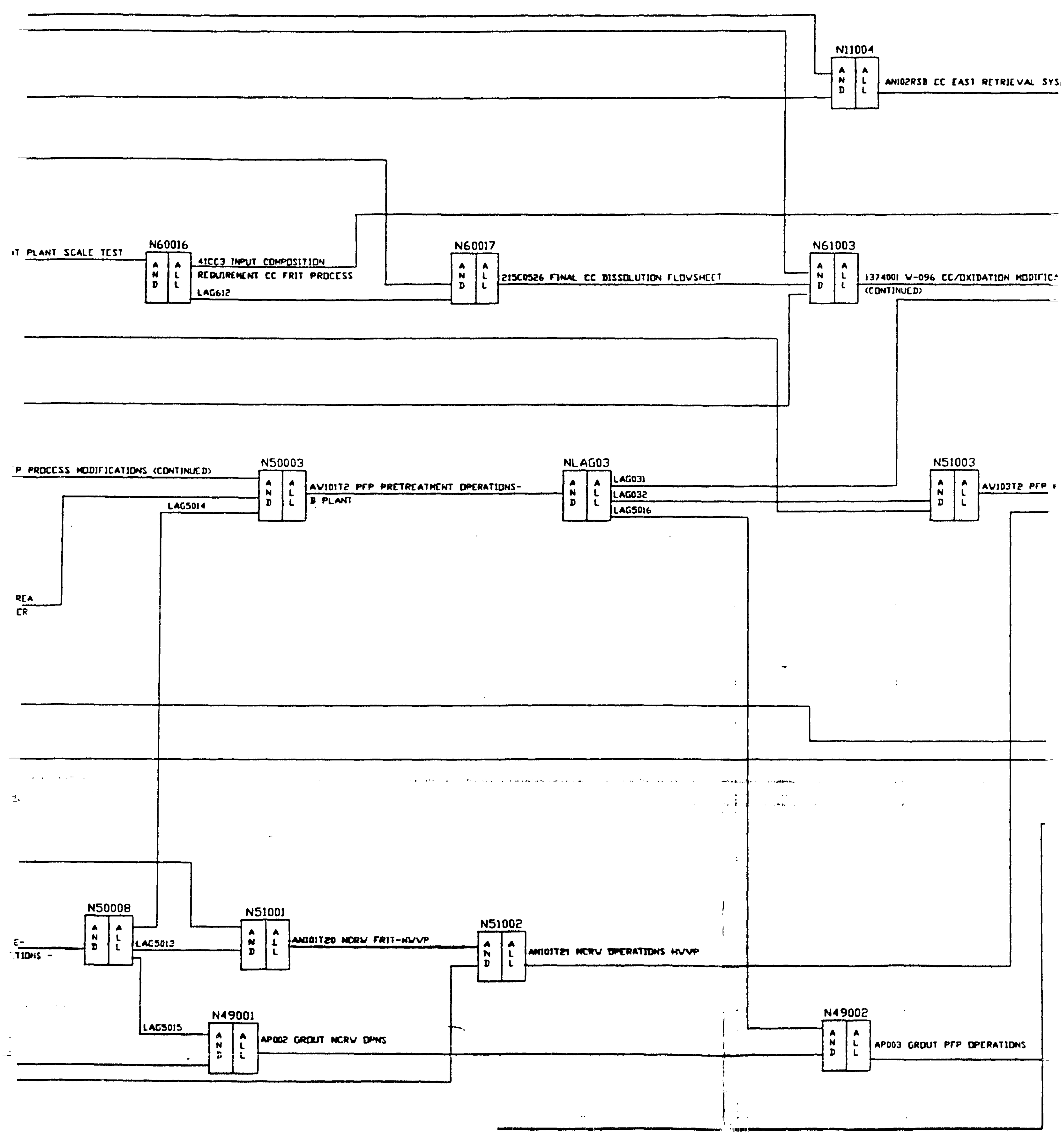
CC PROCESS TEST EAST AREA PROCESS AREA
N60009
AND
ALL
215D0019 PILOT PLANT REDESIGN & MINOR MODS-CC SOLIDS
LAG606
LAG609
N60010
215D0015 PILOT PLANT REDESIGN & MINOR MODS-CC TRUEX
N60011
215C0013 TRUEX PILOT PLANT SCALE TEST WITH CC WASTE
LAG607
N60012
215C0525
CC TRUEX
LAG602
N60008
215F0014 CC ORGANIC DESTRUCTION PILOT PLANT COLD TESTS
N60013
215F0013 CC ORGANIC DESTRUCTION PILOT PLANT HOT TESTS
N60014
215F0528 FINAL FLOWSHEET CC ORGANIC DESTRUCTION
N60003
LAG603
LAG6014
LAG605
CHARACTERIZATION
CORES (PFP)
CC PROCESS
WEST AREA
PROCESS AREA
N11003
SY101RSB CC WEST RETRIEVAL SYSTEM (CONTINUED)
N60001
215C0011 TRUEX PILOT PLANT SCALE TEST WITH NCRW
N60002
LAG0613
41CC1 INPUT COMPOSITION REQUIREMENT-NCRW FRIT PROC
215C052 FINAL FLOWSHEET NCRW TRUEX
RES (NCRW)

PNCAW NETWORK

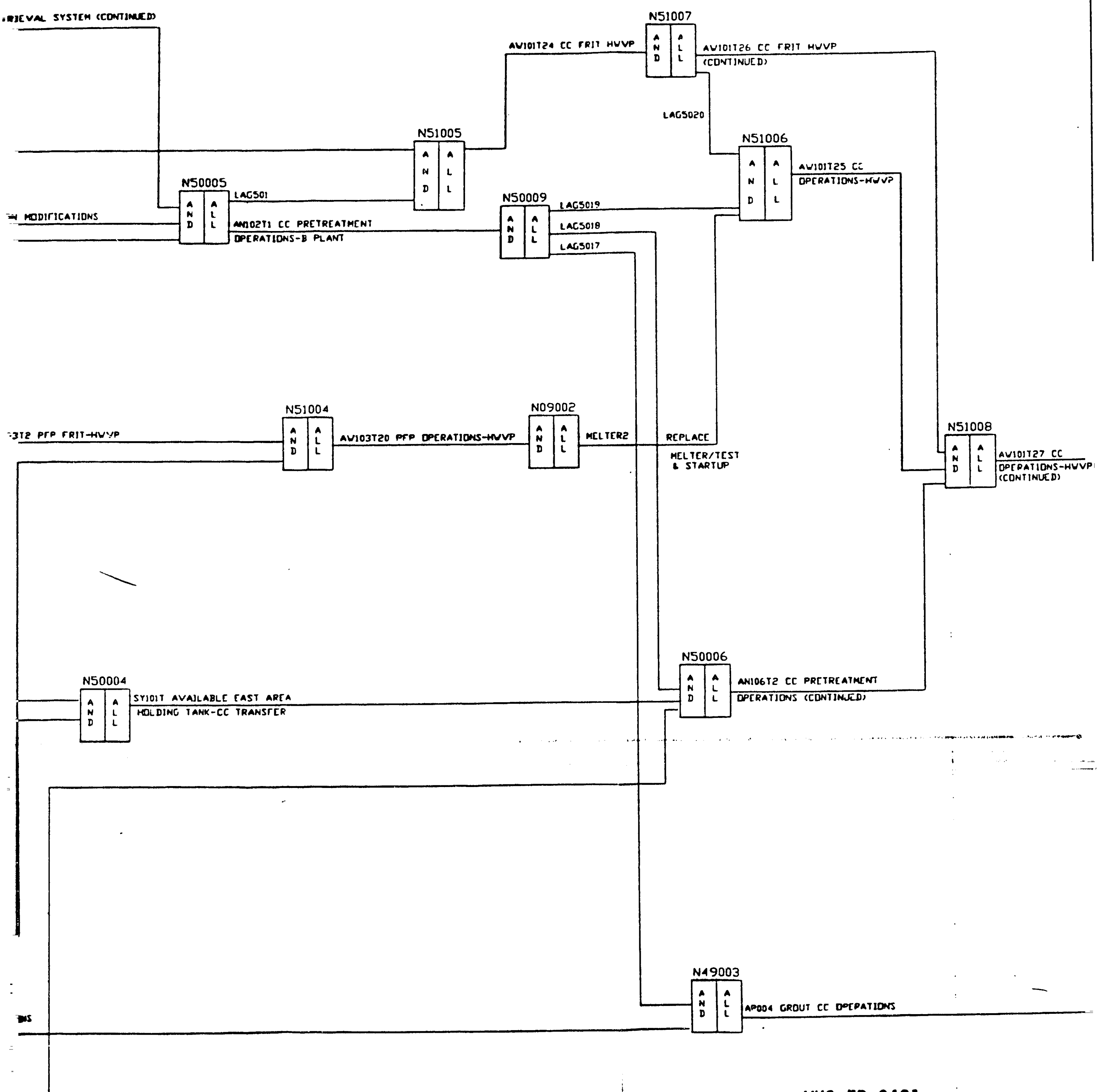
PREPARED BY SAIC

09 AUGUST 1991

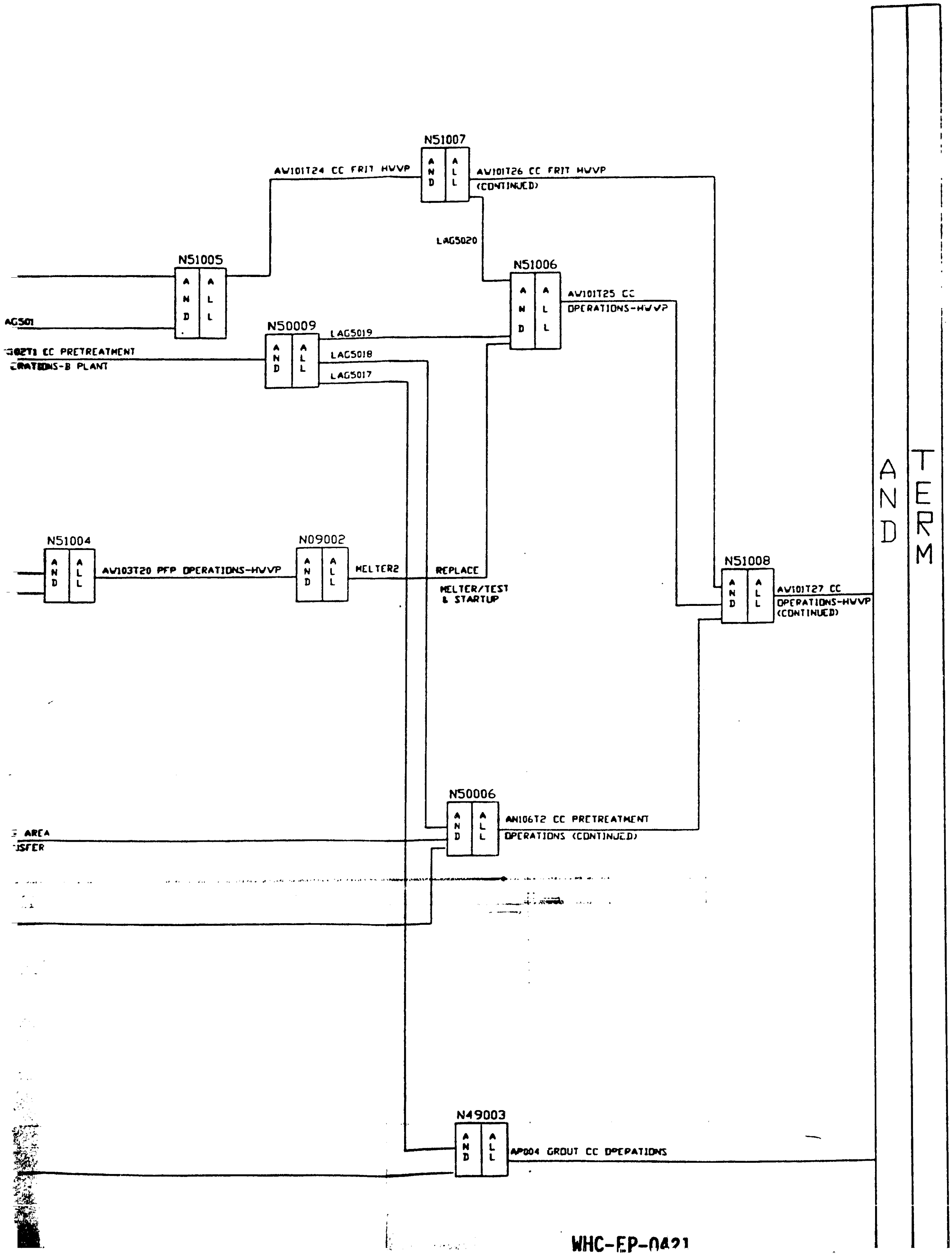


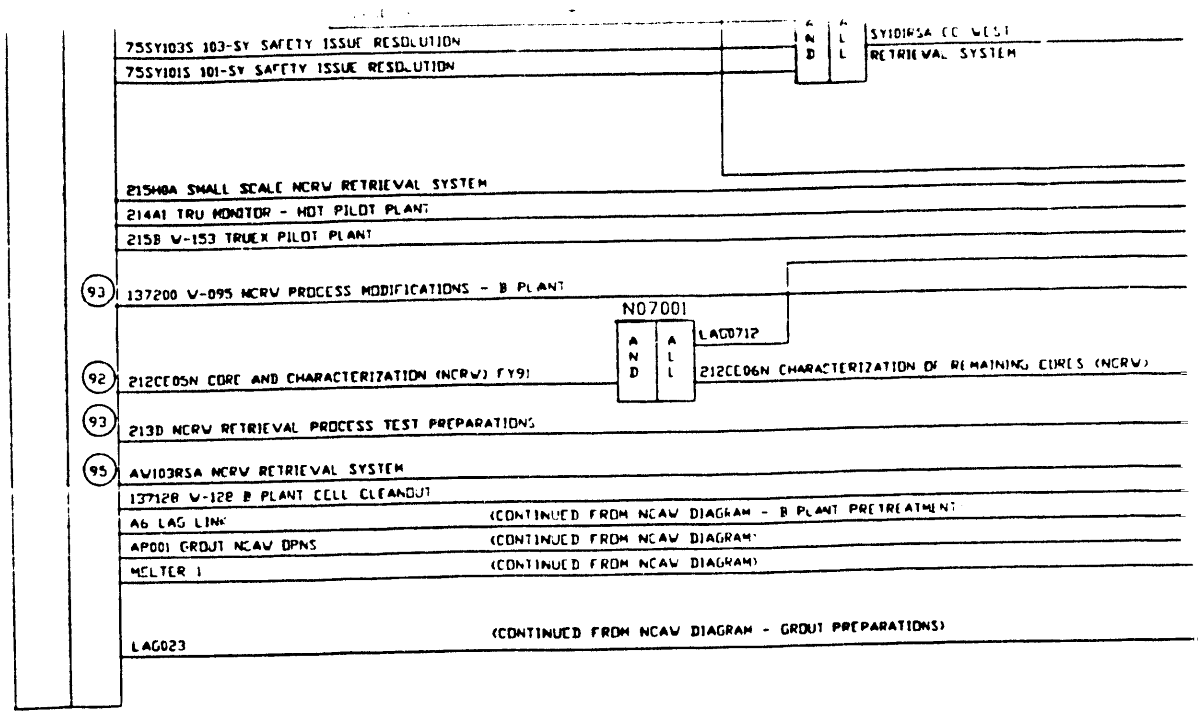


N11004
AN102RSB CC EAST RETRIEVAL SYS
T PLANT SCALE TEST
N60016
41CC3 INPUT COMPOSITION
REQUIREMENT CC FRIT PROCESS
LAG612
N60017
215C0526 FINAL CC DISSOLUTION FLOWSHEET
N61003
1374001 V-096 CC/OXIDATION MODIFIC
(CONTINUED)
P PROCESS MODIFICATIONS (CONTINUED)
N50003
AV101T2 PFP PRETREATMENT OPERATIONS-
B PLANT
LAG5014
NLAG03
LAG031
LAG032
LAG5016
N51003
AV103T2 PFP
REA
ER
N50008
LAG5013
N51001
AN101T20 NCRW FRIT-HWVP
N51002
AN101T21 NCRW OPERATIONS HWVP
LAG5015
N49001
AP002 GROUT NCRW OPNS
N49002
AP003 GROUT PFP OPERATIONS

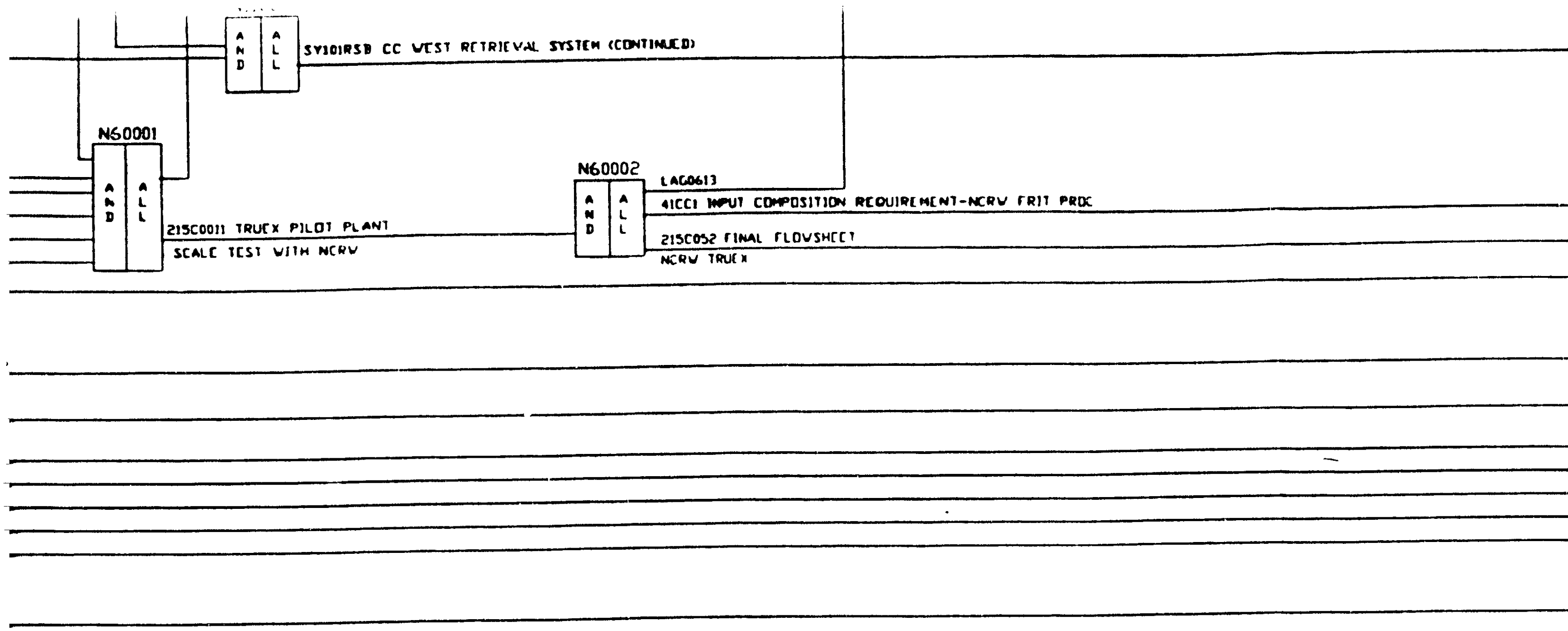


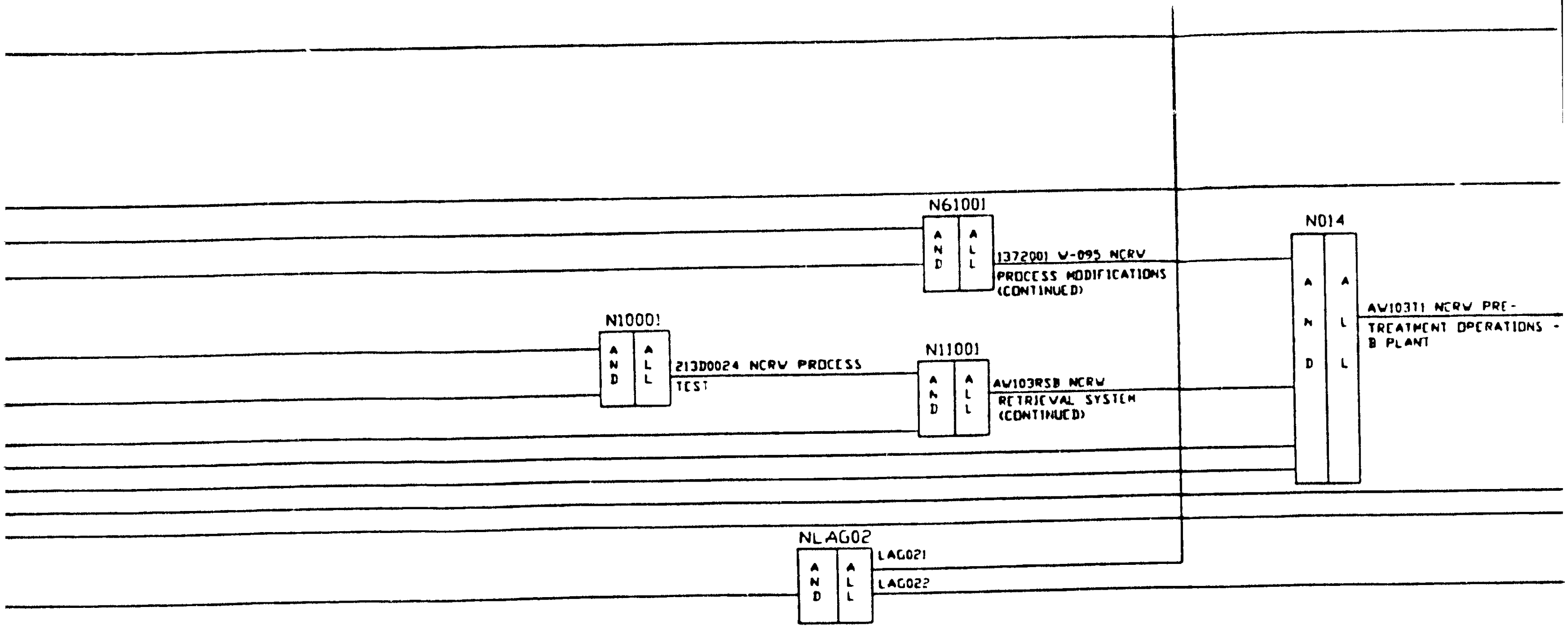
RIEVAL SYSTEM (CONTINUED)
N51007
AV101T24 CC FRIT HWVP
AV101T26 CC FRIT HWVP
(CONTINUED)
LAG5020
N51005
N51006
AV101T25 CC
OPERATIONS-HWVP
N50005
LAG501
N50009
LAG5019
MODIFICATIONS
AN102T1 CC PRETREATMENT
OPERATIONS-B PLANT
LAG5018
LAG5017
N51004
N09002
N51008
3T2 PFP FRIT-HWVP
AV103T20 PFP OPERATIONS-HWVP
MELTER2
REPLACE
MELTER/TEST
& STARTUP
AV101T27 CC
OPERATIONS-HWVP
(CONTINUED)
N50006
N50004
AN106T2 CC PRETREATMENT
OPERATIONS (CONTINUED)
SY101T AVAILABLE EAST AREA
HOLDING TANK-CC TRANSFER
N49003
AP004 GROUT CC OPERATIONS

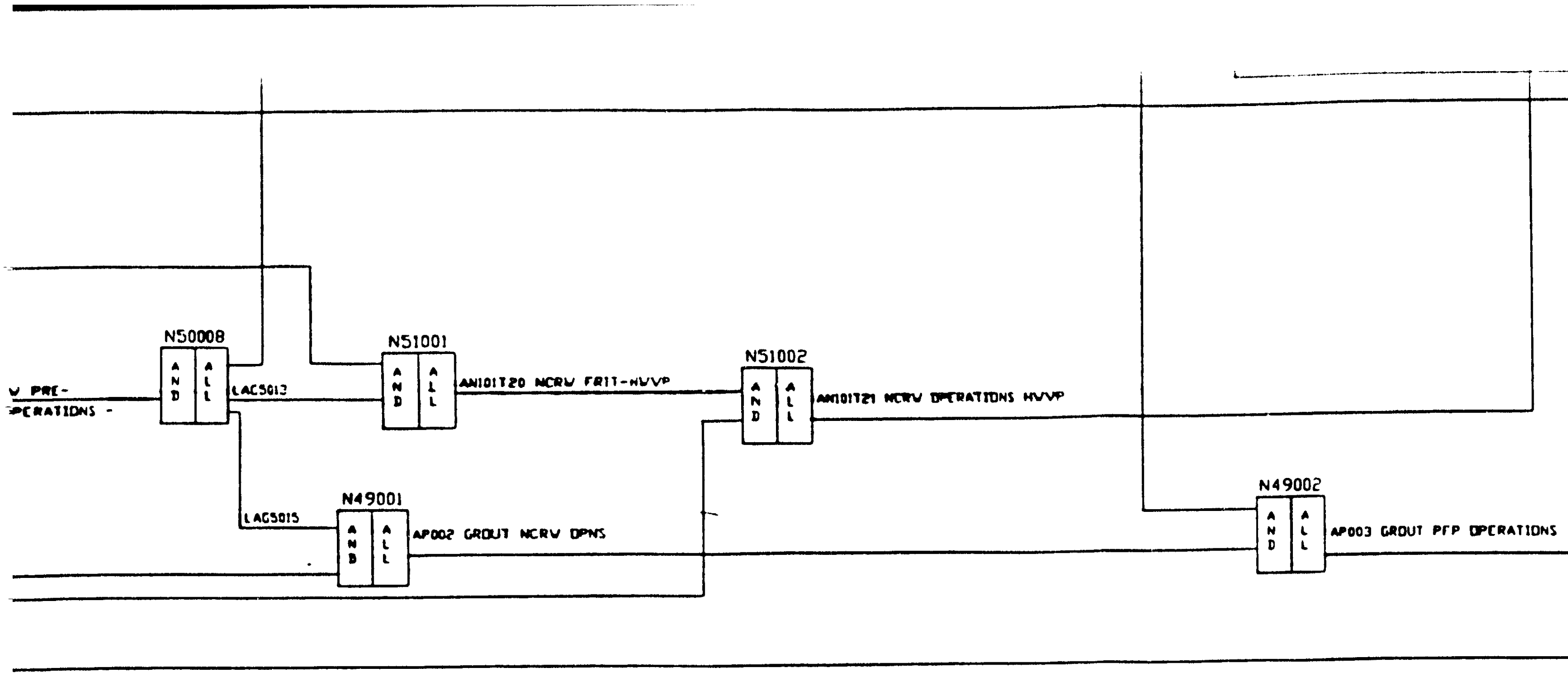

N51007
AND ALL
AW101T24 CC FRIT HWVP
AW101T26 CC FRIT HWVP (CONTINUED)
LAG5020
N51005
AND ALL
AG501
N51006
AND ALL
AW101T25 CC OPERATIONS-HWVP
N50009
AND ALL
LAG5019
LAG5018
LAG5017
CC PRETREATMENT
PERATIONS-B PLANT
N51004
AND ALL
AW103T20 PFP OPERATIONS-HWVP
N09002
AND ALL
MELTER2
REPLACE
MELTER/TEST & STARTUP
N51008
AND ALL
AW101T27 CC OPERATIONS-HWVP (CONTINUED)
AND
TERM
N50006
AND ALL
AN106T2 CC PRETREATMENT OPERATIONS (CONTINUED)
AREA
SFER
N49003
AND ALL
AP004 GROUT CC OPERATIONS



75SY103S 103-SY SAFETY ISSUE RESOLUTION
75SY101S 101-SY SAFETY ISSUE RESOLUTION
AND
ALL
SY101RSA CC WEST RETRIEVAL SYSTEM
215H0A SMALL SCALE NCRW RETRIEVAL SYSTEM
214A1 TRU MONITOR - HOT PILOT PLANT
215B W-153 TRUEX PILOT PLANT
93
137200 W-095 NCRW PROCESS MODIFICATIONS - B PLANT
N07001
LAG0712
92
212CE05N CORE AND CHARACTERIZATION (NCRW) FY91
212CE06N CHARACTERIZATION OF REMAINING CORES (NCRW)
93
213D NCRW RETRIEVAL PROCESS TEST PREPARATIONS
95
AW103RSA NCRW RETRIEVAL SYSTEM
137128 W-128 B PLANT CELL CLEANOUT
A6 LAG LINK
(CONTINUED FROM NCAW DIAGRAM - B PLANT PRETREATMENT)
AP001 GROUT NCAW OPNS
(CONTINUED FROM NCAW DIAGRAM)
MELTER 1
(CONTINUED FROM NCAW DIAGRAM)
LAG023
(CONTINUED FROM NCAW DIAGRAM - GROUT PREPARATIONS)


AND
ALL
SY101RSB CC WEST RETRIEVAL SYSTEM (CONTINUED)
N60001
AND
ALL
215C0011 TRUEX PILOT PLANT
SCALE TEST WITH NCRW
N60002
AND
ALL
LAG0613
41CC1 INPUT COMPOSITION REQUIREMENT-NCRW FRIT PROC
215C052 FINAL FLOWSHEET
NCRW TRUEX


N61001
AND
ALL
1372001 W-095 NCRW
PROCESS MODIFICATIONS
(CONTINUED)
N014
AND
ALL
AW10311 NCRW PRE-
TREATMENT OPERATIONS -
B PLANT
N10001
AND
ALL
213D0024 NCRW PROCESS
TEST
N11001
AND
ALL
AW103RSB NCRW
RETRIEVAL SYSTEM
(CONTINUED)
NLAG02
AND
ALL
LAG021
LAG022



W PRE-
OPERATIONS -
N50008
AND
ALL
LAG5013
LAG5015
N51001
AN101T20 NCRW FRIT-HWVP
N51002
AN101T21 NCRW OPERATIONS HWVP
N49001
AP002 GROUT NCRW OPNS
N49002
AP003 GROUT PFP OPERATIONS

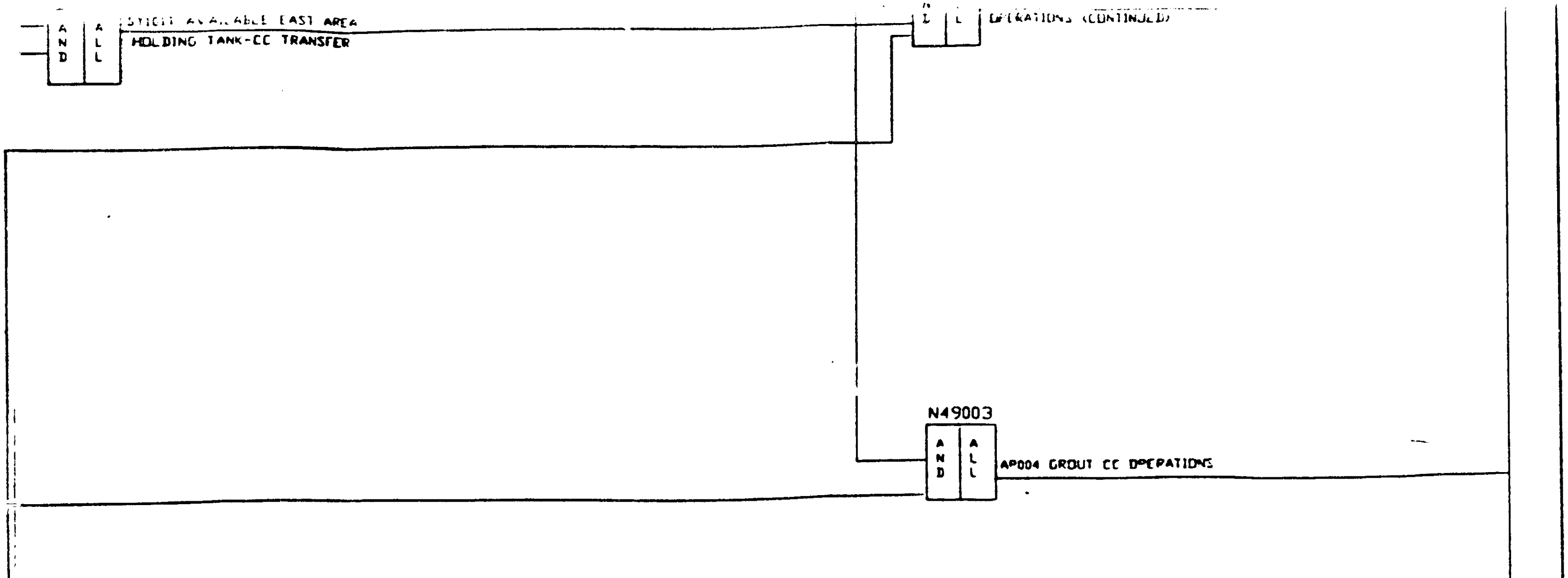
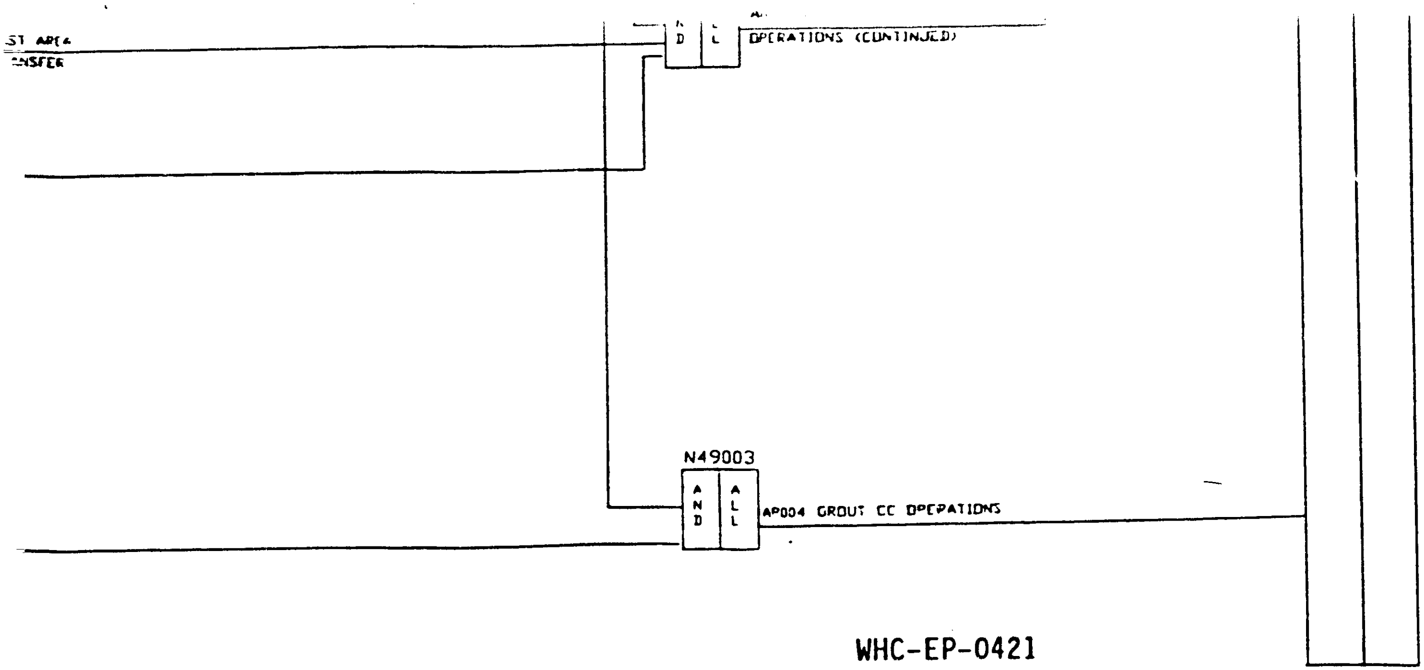


Figure 4-8. Post-Neutralized Current Acid Waste Network Diagra



WHC-EP-0421

Figure 4-8. Post-Neutralized Current Acid Waste Network Diagram.

END

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12/30/91