2002 . 0002449

Department of Energy
Washington, DC 20585

RECEIVED
02 OCT 23 PM 1:25
DNF SAFETY BOARD

October 21, 2002

The Honorable John T. Conway, Chairman
Defense Nuclear Facilities Safety Board
625 Indiana Avenue, NW
Suite 700
Washington, DC 20004-2901

Dear Mr. Chairman:

The Department has completed a review of options for returning the Savannah River Site's (SRS) Tank 48-H to high level waste (HLW) service by treating the benzene generating waste that is currently stored in that tank. A report discussing the options evaluated and recommending a path forward is enclosed as the deliverable required under Commitment 3.5 of our implementation plan for Defense Nuclear Facilities Safety Board Recommendation 2001-1.

The Department's priorities with respect to the SRS HLW system are to safely and expeditiously disposition waste in accordance with our Accelerated Cleanup Plan. As we implement this plan, we will continue to process sludge through the Defense Waste Processing Facility and anticipate near term disposition of low curie salt solution via the Saltstone Disposal Facility. At the same time, we are developing the Salt Waste Processing Facility to disposition higher curie salt waste. This disposition of salt waste, coupled with continuing evaporation, will provide for sufficient HLW storage space and operational flexibility in the tank farms. As we proceed, we will continue to monitor tank space utilization and allocate the appropriate resources to the recovery of Tank 48, should it become necessary to avoid impacts to our waste disposition efforts.

Please feel free to contact me, should you have any questions concerning the enclosed report at (202) 586-7709.

Sincerely,

Paul Golan
Chief Operating Officer
Office of Environmental Management

Enclosure:
Report

cc w/o enclosure:
M. Whitaker (S-3.1), DOE-HQ
J. Allison, Acting Manager, SR

02-2449

Westinghouse
Savannah River Company
Aiken, SC 29808

BNFL

JUL 15 2002

HLW-2002-00096
Retention: Permanent, offer
To NARA when no longer
Needed by the Department
Disposal Auth: DOE-ADM
18-11.1(g) (1)
Track # 10048

Mr. C. E. Anderson, Assistant Manager
High Level Waste Division
U. S. Department of Energy
Savannah River Operations Office
P. O. Box A
Aiken, SC 29808

Dear Mr. Anderson:

DNFSB 2001-01, COMMITMENT 3.5 DELIVERABLE

Reference 1: Letter, S. Abraham to J. T. Conway, "Department of Energy Revised Implementation Plan Concerning the Defense Nuclear Facilities Safety WSAG's *Recommendation, High Level Waste Management at the Savannah River Site*", dated 9/14/01.
Reference 2: Letter, S. Piccolo to C. Anderson, DNFSB 2001-01, Commitment 3.5 Deliverable Expectations, HLW-2002-00073

As you are aware, deliverables for the Defense Facility Nuclear Safety WSAG (DNFSB) Recommendation 2001-0 (Reference 1), include "Assess the technical feasibility of dispositioning the current Tank 48 material and returning Tank 48 to HLW service." Originally the deliverable consisted of "This evaluation will focus on the technical options for dispositioning the material, discuss the confidence level of success based on technical and regulatory risks and identify any research and development work that must be accomplished. Lessons learned from returning Tank 49 to service will be incorporated into the future Tank 48 plans." Per our agreement, the expectation for the Tank 48 deliverable was clarified in reference 2. The attached report, HLW Tank 48H Disposition Alternatives Identification Phase 1 & 2, satisfies Reference 1 and 2 and completes the HLW deliverable. No additional Tank 48 scope is included in the contract baseline.

If you have any questions please contact Bob Adams (phone 7-5045, pager 12308).

Sincerely,

S. F. Piccolo
Vice President and General Manager
High Level Waste Division

RECEIVED
02 OCT 23 PM 1:25
DNF SAFETY BOARD

BA:cs

c:

N. R. Delaplane, DOE-SR, 704-S
C. A. Everatt, DOE-SR, 704-S
C. S. Martin, DOE-SR, 704-S
T. J. Spears, DOE-SR, 704-3N
V. G. Dickert, 703-H
T. J. Lex, 703-H
S. S. Cathey, 703-H
F. E. Wise, 703-H
D. L. Becker, 703-A
C. J. Boasso, 742-2G
Records Admin, 773-52A
ECATS, DOE, 703-A
M. A. Mikolanus, DOE-SR, 704-S
W. F. Spader, DOE-SR, 704-S
W. D. Clark, DOE-SR, 704-3N
M. D. Johnson, 703-H
W. R. Tucker, 703-H
P. S. Kennedy, 703-H
E. M. Foster, 703-H
R. A. Adams, 704-3N
HLW Files, 703-H, 116

02-2449

WSRC-RP-2002-00154
Revision 1

HLW TANK 48H DISPOSITION ALTERNATIVES IDENTIFICATION
PHASE 1 & 2
SUMMARY REPORT

UNCLASSIFIED
DOES NOT CONTAIN UNCLASSIFIED CONTROLLED NUCLEAR INFORMATION

RTJones
ADC/RO Robert T Jones Date: 7/15/02

Westinghouse Savannah River Company
Savannah River Site
Aiken, South Carolina 29808

DISCLAIMER

HLW TANK 48H DISPOSITION ALTERNATIVES IDENTIFICATION PHASE 1 & 2 SUMMARY REPORT

WSRC-RP-2002-00154

APPROVAL PAGE

7/15/02

Bob Adams, Project Owner — Date

Dan — 7-15-02

Dan Lambert, SRTC Engineering Member — Date

R E Edwards for Rick Fowler — 7/15/02

Rick Fowler, HLW Process Engineering — Date

Thomas B. Peters — 7-15-02

Tom Peters, SRTC Science Member — Date

GAVIN C WINSHIP — 7/15/02

Gavin Winship, Systems Engineering Member — Date

R. V[illegible] [illegible] FOR M. NORTON — 7/15/02

Michael Norton, Design Authority Member — Date

Narinder P. Malik — 7/15/2002

Narinder Malik, Regulatory Authority Member — Date

Robert J. Bentley — 7/15/02

Bob Bentley, Safety Authority Member — Date

REVISION SUMMARY

Rev. No.	Rev. Date	Affected Sections	Description of Revision
0	2/28/02	N/A	Initial Issue, Phase 1
1	7/15/02	N/A	Initial Issue, Phase 1 & 2

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ATTACHMENTS

Attachment 1 – Phase 1 Screening Tables

APPENDICES

1.0 Executive Summary

The High Level Waste (HLW) Tank 48H Disposition Team (henceforth referred to as Team) was formed on December 13, 2001 under the sponsorship of the WSRC High Level Waste Vice President and General Manager. The Team was chartered to identify options, evaluate alternatives and recommend a selected alternative(s) for processing HLW Tank 48H contents to a waste form capable of being processed or stored by existing or planned facilities.

The Team was comprised of appropriately qualified experts from WSRC and its partners. Team membership is identified in Appendix 2, Team Membership. The overall methodology for achieving the Team's mission is described in the Systems Engineering Management Plan (SEMP)[1].

During Phase 1 multiple approaches were used to identify alternative processes to meet the production and safety requirements for tank disposition. Formal brainstorming sessions with a range of stakeholders were supplemented by historical reviews and literature surveys. In addition, a Briefing Package for soliciting site wide experience was distributed to SRS Operations, Engineering and DOE. All ideas were captured on information sheets included in this report as Attachment 2.

In 1996-1998, chemistry studies aimed at developing an understanding of the reaction mechanisms and kinetics associated with the ITP process were performed. These studies were intended to lead to closure of DNFSB Recommendation 96-1 and the results were an input to the process for evaluating alternatives.

The resulting list of 40 alternatives was screened against a set of minimum screening criteria, which included engineering maturity, safety, and permitting. Alternatives were either accepted as written, modified by combination or addition, or dropped. Ranking was performed within four (4) decomposition categories to focus on the alternatives with the highest potential for success. The result of the exercise was an "Initial List" of fifteen (15) alternatives selected as written or in part for further evaluation.

The main focus of the Team's work in Phase 2 was on the technical investigation of the initial alternatives, the identification of technical risk and the application of selection criteria for complexity, science maturity, interfaces and process rate to establish a short list for further evaluation. New thoughts on three "dropped" alternatives required the alternatives to be reconsidered. To evaluate these remaining options, more information was needed concerning these processes. As a result, SRTC performed simple, screening experiments designed to determine the feasibility of these 18 processing options. A Task Plan and a Technical Report[3] summarize the work performed to evaluate the potential of these processing options. Most of the processing focused on four possible decomposition schemes: namely use of catalysts, use of oxidants, use of acids and thermal.

Tank 48H and its chemistry have been well characterized as a result of the in-tank demonstration of the ITP process in 1983 and the startup of the ITP facility in 1995. However, no well-mixed samples have been analyzed since 1998. As a result, the simulants used in this testing were based on the well-mixed samples pulled in 1998. No attempt was made to correct the 1998 sample results for radiolysis of the nitrite and nitrate or absorption of carbon dioxide by the waste in Tank 48H. However, a 6.5% decomposition of the KTPB was assumed because of the consistent data since 1997. It was also assumed the solids that have settled in Tank 48H can be easily resuspended. A well-mixed Tank 48H sample needs to be obtained to confirm the Phase 2 testing. In addition, samples are needed to allow demonstration of the preferred treatment options with actual waste.

Sixty-nine scoping tests and six carbon balance experiments were performed using options associated with (1) acid hydrolysis, (2) thermal decomposition, (3) oxidation (4) catalytic destruction and combinations of these four methods. The catalyst test included catalyst composed of platinum, palladium, copper and iron at concentrations of 25 mg/L. The four oxidants chosen for these tests were sodium perborate, sodium potassium ferrate, sodium permanganate and hydrogen peroxide at 2 and 5 times the TPB stoichiometry. Acid solutions comprised of either formic, nitric, or 8 wt % oxalic acid were used for the acid hydrolysis test. Temperature was a variable applied to acid, oxidation and catalytic destruction. The details of these tests are included in references to this report. The overview of the tests is contained in section 7 of this report. A private company under contract to WSRC/SRTC is continuing investigation of a possible bioremediation solution. Their results should be available in October 2002.

The selection process used an analytical hierarchy process employing the ECPro software tool and a "pair-wise" comparison of criteria. The technical and science risks were considered the critical elements of the selection criteria and were therefore weighted accordingly.

The results of the process indicated the Salt Cell technology and Steam Reforming were the first and second choices. This is not surprising since both processes are well understood when compared to the limited knowledge gained from the scoping studies for catalyst, acid and oxidation.

Note: The term "in-tank" as used in the text of this report does not imply the process is limited Tank 48H. The use of Tank 48H as a reaction vessel will incur some risks. The intent of the research for "in-tank" solutions was to identify options with minimum risks and minimum infrastructure requirements, e.g., a reaction tank coupled to the actinide removal process.

If the weighting factors for the alternatives are set equal, the first and second choices are the two alternatives that could possibly use Tank 48H as a processing tank, permanganate and catalytic destruction. The third ranked option was the salt cell process. This indicates that further research in the areas suitable for in-tank processing, along with increasing the technical maturity and science knowledge, has a high probability of indicating a change in treatment options.

Therefore the Team recommends the following work be accomplished in FY03:

1. Additional data on oxidation, catalyst and acidic processes and the use of sodium permanganate and Fenton's reagent to oxidize the TPB should be developed as possible in-tank alternatives.

2. The results of the bioremediation study should be reviewed by WSRC/SRTC.

3. WSRC/SRTC observe the progress and problems with Hanford's efforts to use steam reforming and fund Hanford to test simulates of Tank 48H and actual waste, the composition of Tank 48H with MST/TPB. In addition, simple lab testing with simulates started by SRTC should be completed (see 7.3.7.2 and Attachment 4).

4. Actual waste samples are needed to understand the current composition of Tank 48H contents and to support the real waste testing of the three most promising alternatives. This should be completed to demonstrate no unexpected issues exist for processing actual waste.

5. When these four items are complete the alternative selection process should be re-visited.

The Team believes that this work effort for technology development (excluding the Hanford Steam Reforming Process) could be accomplished in about 11 months (Attachment 4) after funding is available. The team was unable to determine the Hanford testing dates.

2.0 Purpose

The purpose of this report is to document the progress and process used by the Team to systematically develop alternative methods or technologies for final disposition of HLW Tank 48H contents. This report will document the process utilized to reduce the total list of identified alternatives through the down select phases.

Revision 0 of this report meets the milestone Deliverable for the Phase 1 report specified in the Team Milestones, Appendix 3. Revision 1 of this report meets the milestone Deliverable for the Phase 2 Report specified in Appendix 3.

3.0 Introduction

The HLW System is a set of six different interconnected processes (Figure 3.1) operated by WSRC. These processes function as one large treatment plant that received, stored, and treated high-level wastes at SRS and convert these wastes into forms suitable for final disposal. The three major permitted disposal forms are borosilicate glass, planned for disposal at a Federal repository; saltstone grout, disposed in vaults on the SRS site; and treated water effluent, released to the environment.

These processes currently include:

1) High-Level Waste Storage and Evaporation (F and H Area Tank Farms)
2) Salt Processing (not yet functional)
3) Sludge Processing (Extended Sludge Processing Facility)
4) HLW Processing and Vitrification (Defense Waste Processing Facility)
5) Wastewater Treatment (Effluent Treatment Facility)
6) Solidification (Saltstone Facility)

F and H Tank Farm, Extended Sludge Processing, Defense Waste Processing Facility, Effluent Treatment Facility, and Saltstone Facility are all operational. Salt processing operations are limited to safe storage and direct transfer of low-cesium waste to the Saltstone Facility. The Late Wash Facility (Building 512-S) has been tested and is in the process of being brought out of a dry lay-up status to support a planned actinide removal process. The In-Tank Precipitation Facility (ITP) initiated radioactive operation in Tank 48H in September of 1995. During pump operation in December of 1995, benzene evolved from Tank 48H at higher rates than expected; though the operational safety limit was never approached. The benzene formede as a byproduct of the process from the catalytic decomposition of sodium tetraphenylborate (NaTPB) and consequently made the contents of Tank 48H incompatible with the current facilities to treat waste.

In August 1996, the Defense Nuclear Facility Safety Board (DNFSB) issued Recommendation 96-1. The DNFSB recommended that operating and testing in the ITP Facility not proceed without an improved understanding of the mechanisms of benzene generation, retention, and release. In response to Recommendation 96-1 efforts to explain, through chemistry research, benzene generation, retention and release were conducted from August 1996 through the present. To date a definitive explanation of the mechanism for the decomposition has not been determined. In 1998, following evaluation of technical and safety issues, DOE abandoned the project and researched new technologies for cesium removal. However the selected new technology – solvent extraction – cannot readily treat the waste in Tank 48H, which contains significant quantities of TPB from the ITP operation.

As a result of work completed under Recommendation 96-1, controls are in place to maintain Tank 48H in a safe interim condition. Only the disposition of the waste in Tank 48H remains a safety issue. Recovery of Tank 48H was addressed in the Board's Recommendation 2001-1, High-Level Waste Management at the Savannah River Site. As discussed in the implementation plan for that Recommendation, the Board expects the DOE to evaluate the options for Tank 48H recovery. The evaluation should consider the technical and regulatory risks and identify any research and development work that must be accomplished.

The site desires to return High Level Waste (HLW) Tank 48H to routine service to provide more space in the HLW System. Tank 48H currently contains 250,000 gallons of a salt solution, which contains potassium and cesium tetraphenylborate (KTPB and CsTPB) slurry. To return this tank to service, the TPB must be destroyed or removed. This TPB solution was designed to be processed in the In Tank Precipitation (ITP) Facility, the Late Wash Facility, and the Defense Waste Processing Facility (DWPF) Salt Cell. These facilities were designed to concentrate the TPB, wash out the non-radioactive salts and reduce the nitrite concentration, decompose the TPB to benzene and separate the benzene from the aqueous waste. However, operation of these facilities stopped due to high benzene generation during startup of the ITP Facility.

A team has been established to evaluate processing options, which would return Tank 48H to routine HLW service. The team is using a Systems Engineering approach[1] to evaluate the alternatives and make a recommendation to HLW management. The group evaluated a total of 40 options. As noted in section 1, these options were in part historical efforts and therefore refer to CIF, the Salt Cell at DWPF, etc. The Team recognized these facilities were no longer available but parts of the processes could be viable. The team narrowed these to 18 options using the Team's screening criteria.

To evaluate these remaining options, more information was needed concerning these processes. As a result, SRTC was tasked to perform simple, screening experiments designed to determine the feasibility of these 18 processing options. This report summarizes the work completed and the work necessary to evaluate the success of potential processing options. Most of the processing focuses on four possible decomposition schemes: namely use of catalysts, use of oxidants, use of acids and thermal.

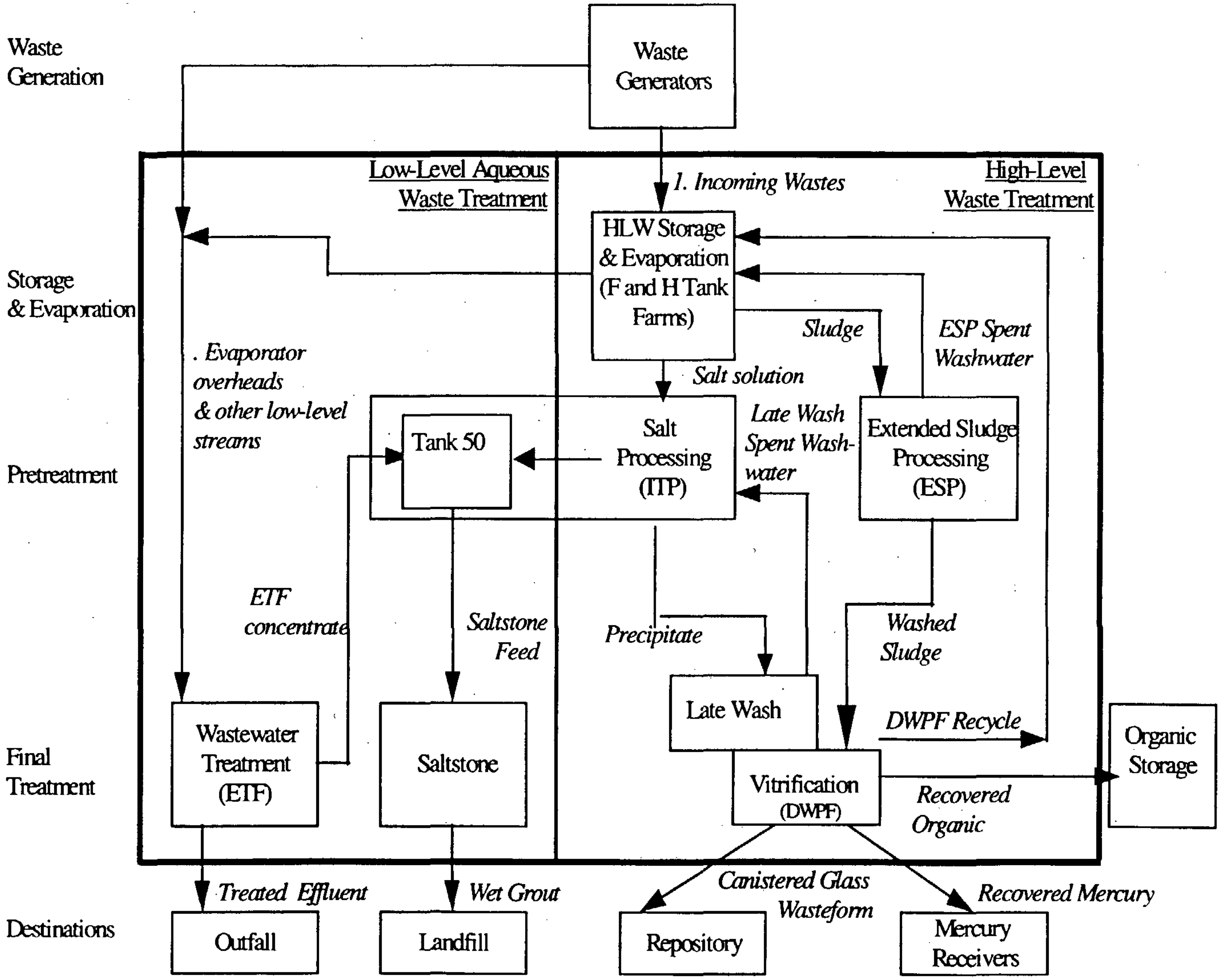


Figure 3.1 – HLW System Process

4.0 Tank 48 Disposition Team

A Tank 48H Team was proposed to systematically develop and recommend technologies for the disposition of Tank 48H contents. A Team Charter (Appendix 1) was developed to establish an overview of method and direction and the team membership (Appendix 2) was staffed to ensure required areas of expertise were available.

As a starting point the Team used the DNFSB Recommendation 2001-1, High Level Waste Management at the Savannah River Site, Commitment 3.5. This Commitment required an evaluation, focusing the technical options to disposition the material in Tank 48H, discussing the confidence level of success based on technical and regulatory risks and identify any research and development work that must be accomplished.

The Team recognized that two categories of options would emerge: (1) options where the technology is understood and (2) where a process would need development. The Team also recognized that any comparison with respect to confidence of success would by default lean toward the more understood technology.

The mission was established as "Evaluate processing technologies to return Tank 48H to Service by making the contents compatible with current or planned High Level Waste Facilities."

The goal was to determine, through a selection process, the technology(s) with the highest potential to meet the mission and recommend a path forward.

The problem was approached in two phases and sets of milestones (Appendix 3) and the solution(s) where constrained to the critical needs, boundary conditions and constraints listed in section 4.1.

4.1 Critical Needs, Boundary Conditions and Constraints

Critical Needs

- Shall meet all applicable safety criteria
- Shall meet all applicable environmental regulations
- All waste must go to final disposal forms
- Shall meet FFA and Site Treatment Plan Regulatory commitments
- Shall accommodate other SRS missions and associated schedules
- Shall meet all applicable final disposal product quality requirements
- Shall meet all applicable waste acceptance criteria

Boundary/Constraints

- Safety of the process
- Impact to HLW final waste form disposition
- Programmatic/technical risk
- Relative cost/schedule
- Regulatory/safety/permit acceptability
- Operational complexity

- Ability to support currently planned future SRS missions and schedules
- Maximum tank farm space kept available
- Use of existing or planned facilities
- Constructability
- Reliability, Availability, Maintainability, and Inspectability (RAMI)

5.0 Background

The objective of the ITP process was to chemically treat radioactive salt solution such that the bulk of the radionuclides could be separated into a low volume, high activity stream that could be vitrified with radioactive sludge; and a high volume, low activity stream that could be solidifed as grout, and disposed of as low level waste.

In the ITP process, monosodium titanate (MST), and sodium tetraphenylborate (NaTPB) are added to salt solution to adsorb Sr-90/Pu-238 and precipitate Cs-137, respectively. The chemical addition and subsequent reaction form precipitate slurry that is then filtered. The filtrate is decontaminated salt solution that is stripped of benzene, sampled and then pumped to a separate facility, Saltstone, where it is mixed with cement, slag and fly ash to form a grout and disposed of as low level waste. The precipitate remaining after filtration is washed with water to reduce the Na concentration, sampled and transferred to the DWPF to be combined with radioactive sludge and vitrified.

The ITP process was demonstrated at Savannah River in 1983. The demonstration facility consisted of a 1.3 million gallon HLW tank (the current ITP processing tank – Tank 48H) retrofitted with chemical addition facilities, slurry pumps, process feed pumps, filters, filtrate hold tanks, and process monitoring instrumentation. The actual demonstration was considered to be "full scale" in the 500K gallon batch of radioactive salt solution that was chemically treated and filtered producing 450K gallons of decontaminated filtrate and 53K gallons of 2.5 wt % precipitate. The precipitate was then washed to reduce the sodium concentration. The demonstration was considered a success and design of the permanent ITP facility started in 1985.

During the demonstration, the amount of benzene released during the precipitate washing step was greater than anticipated. This was the subject of further study at Savannah River and at the University of Florida from 1983 to 1986. The conclusion of the studies was that benzene generated by radiolytic decay of the TPB was retained within the TPB crystal until the addition of water during the precipitate washing step. It was believed that the TPB crystal was dissolved during water addition thus rapidly releasing "trapped" benzene present within the crystal lattice. The permanent ITP facility was designed on this basis.

The ITP facility initiated radioactive operation in September 1995 with the addition of 130K gallons of salt solution and 37.3K gallons of NaTPB to the heel of precipitate in Tank 48 that remained from the 1983 demonstration. Initial operations were conducted under the guidance of a test plan that specified controlled evolutions and additional sampling and monitoring requirements. During October, the first of three pump tests was conducted in which the effect of tank mixing was determined. This test was characterized by a nearly constant benzene release from the liquid phase to the vapor phase that maintained the vapor space concentration at nearly 60 ppm during pump operations.

Following the completion of the first pump run on October 12,1995, the tank remained quiescent until October 20, 1995.

Filtration began on October 20, 1995 and continued until October 25 producing 140K gallons of filtrate. Filtration was conducted at a nearly constant temperature of 39°C. Filtration was followed by the second pump run starting October 26. The benzene concentration in the vapor space was higher than expected, but well below the Operational Safety Requirements (OSR). A water addition was made without an expected increase in benzene concentration. A second filtration step was conducted producing 160K gallons of filtrate and bringing the liquid level in Tank 48H to 160K gallons. The third pump run, which was designed to be conducted at higher temperatures to support oxygen control testing, resulted in heating the tank to 52°C. Again, the benzene concentration was higher than expected but still below the OSR. The tank was quiescent during ventilation tests and had cooled to 30°C by December 1, 1995.

On December 1, 1995, all four slurry pumps were operated for about 3.5 hours to prepare the tank for sampling. Pump operation was then halted due to the observed high benzene readings (2,000 ppm) in the tank vapor space (well before the operational safety requirement was approached). Data from Tank 48H instrumentation and tank sample analyses indicated that NaTPB decomposition had occurred. Efforts began to remove the benzene that had accumulated. A Justification for Continued Operation (JCO) was written to incorporate additional fuel controls on the rate of benzene release that would be allowed during pump operation. A series of single pump runs were conducted under the JCO to deplete the benzene from the tank between December 8, 1995 and January 3, 1996. From January 3 to March 5, 1996, the tank was quiescent. During this period, an alternate nitrogen system was installed and the Justification for Continued Operation was revised to credit nitrogen inerting and to provide restrictive pump operating limits.

On March 5, 1996, one slurry pump was operated at low (600 rpm) speed. A large quantity of benzene was immediately seen in the tank vapor space and pump operation was terminated after 14 minutes. This data indicates periods of non-uniform distribution of benzene in the tank vapor space. Starting on March 8, periodic pump operations were resumed in a conservative, controlled manner in continued efforts to deplete benzene from the tank. Initial operations employed only one slurry pump. As benzene release rates decreased, additional pumps were started. By April 25, 1996, all four pumps were operating at the maximum speed of 1,180 rpm. From November 5, 1995 to April 22, 1996, an estimated 8,500 kg of benzene was removed from Tank 48H. Since April 1996, Tank 48 has essentially been depleted of benzene as indicated by the very small releases observed even with operation of all four pumps since that time.

Savannah River had planned to proceed with a series of Process Verification Tests (PVTs) in Tank 48H designed to increase the level of understanding of NaTPB chemistry and release mechanisms. The tests were to proceed after installation of a backup nitrogen supply as part of a program to transition from fuel control to oxygen control as the primary means of assuring safe operation of the ITP Facility. The first such test, PVT-1, required the addition of a small amount of NaTPB to reprecipitate soluble cesium before filter operation and filter-cleaning operations. Key objectives of this test included: determination of the effectiveness of cesium recovery, validation of benzene generation in Tank 48H, validation of the benzene generation rate in Tank 50H, and to determine the impact of oxalic acid addition to Tank 48H. The next test, PVT-2, included significant quantities of new waste and NaTPB to be added to Tank 48H. The Department of Energy deferred the conduct of PVT-2 until such time as an improved understanding of NaTPB chemistry is achieved and the appropriate modifications to facility hardware engineered controls and administrative controls have been completed.

6.0 Phase 1

The SRS High Level Waste Tank 48H Disposition Team ("Team") was chartered to systematically develop and recommend alternative methods, and/or technologies for disposition of High Level Waste Tank 48H by the end of FY2002. Major milestones (Appendix 3) were established to accomplish the task. One of these major milestones is a report summarizing the activities leading to an initial list of alternatives and screening criteria for the short list. This section provides the details pertaining to the evaluation methods and criteria used to create the "initial list," the alternatives considered in the process and the disposition of the considered alternatives in support of the required report.

6.1 Alternative Identification Process Overview

Two aspects of the Team Charter had to be accommodated in the final process - the need to comprehensively consider all available alternatives and the goal of recommending a preferred alternative(s) within a six-month time frame. The process also had to document the technical concerns of non-viable alternatives with the potential to be modified or combined to create a new alternative.

Figure 6.1 is a representation of the selection process for the initial list. The selection methodology has explicit steps to require full consideration of potentially favorable fragments of dropped alternatives (such as choices among possible reagents and/or engineering implementations).

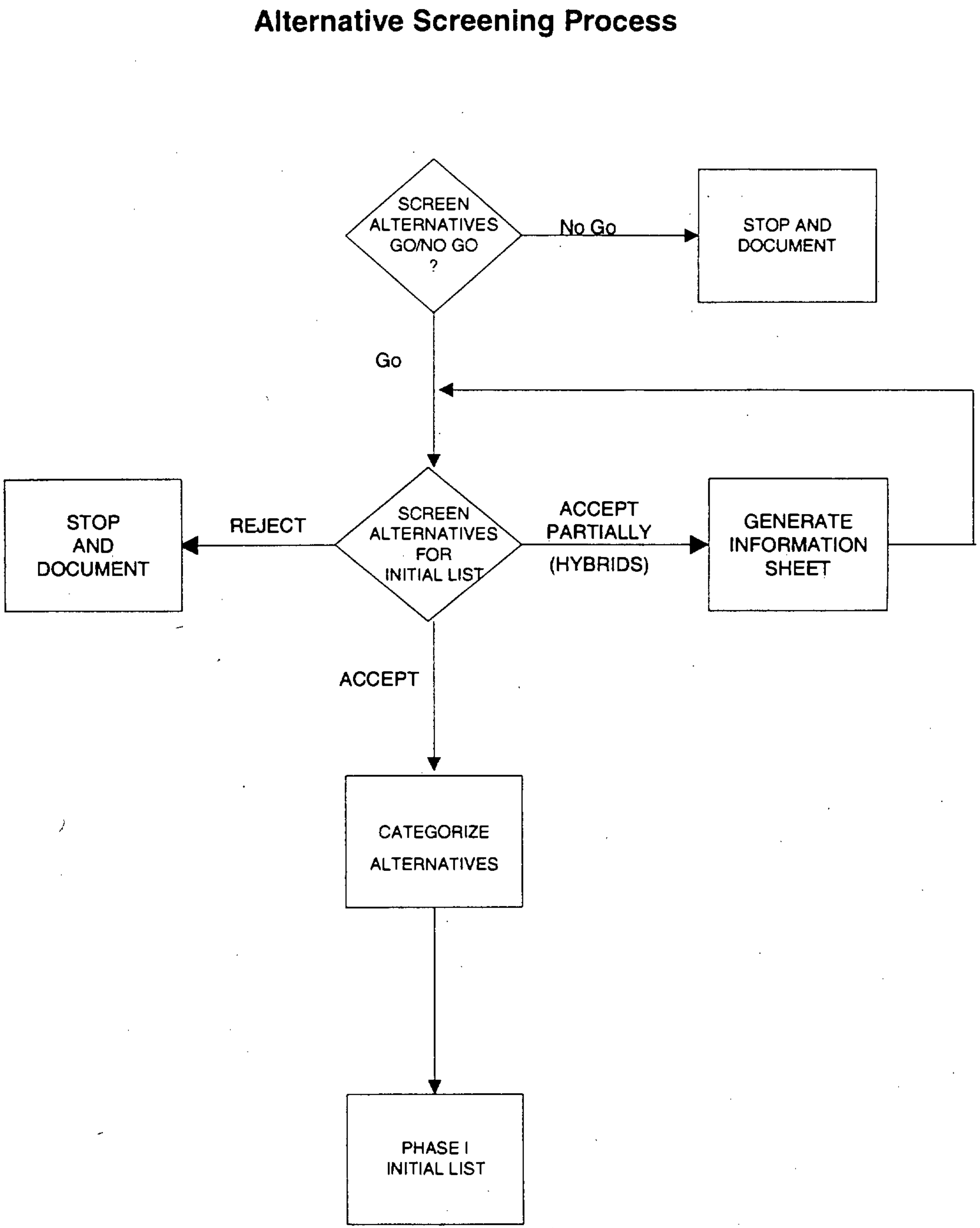


Figure 6.1 – Logic Diagram for Screening Process

6.2 Generation and Organization of Alternatives

As described in SEMP (Ref 1), the input for the selection of the initial list was generated from a number of sources, including SRS employee input, historical reviews, formal brainstorming and early, informal, results from independent subject matter experts. This input was documented on information sheets. These information sheets were used to assure an adequate description of the proposed method or technology, to support screening, and to capture the originators' views on safety aspects, permitting, facility interfaces, strengths and weaknesses of the proposal. The Team then grouped these alternatives into the following decomposition categories:

- Catalyst
- Oxidation
- Thermal
- Acidic

The information sheets were numbered. Additional information sheets were later created by the Team based on subsequent input and Team discussions and were also grouped into the categories. All of the information sheets generated during the creation of the initial list are in Attachment 2.

6.3 Go/No Go Screening of Alternatives

The first step of the screening process was to assure that the alternatives were viable for continued consideration (Per Figure 6.1). In the case of go/no-go screening, it was necessary to simplify the evaluation criteria due to the lack of specificity inherent in a technology category and a requirement that the screening be sufficiently conservative so alternatives were not discarded if there was any potential that they could ultimately emerge as the preferred alternative. These considerations resulted in the Team choosing to apply two evaluation criteria and two rules for this screening:

Evaluation Criteria:

1. Technical Maturity – Does this category reflect concepts, which have never been tested, or, at the other extreme, are they fully proven in nuclear/chemical applications?
2. Reasonable Chance of Deployment – Given the technical maturity, degree of complexity of the technology and infrastructure requirements, does it have a reasonable chance of deployment on the time line needed?

Rules:

1. In the event that insufficient expertise existed for the Team to determine in this screening that an alternative clearly failed to meet one or both of the criteria, the alternative passed this screening and went on to the next level of review. Thus, insufficient knowledge to reject the alternative resulted in initial acceptance.

2. If an alternative meets the two criteria, the alternative is accepted.

   Note that cost was not explicitly used as a criterion for alternative screening due to the lack of implementation detail for the individual alternatives to support an evaluation against such a criterion.

   Any alternative screened out at this level would have the causative failure documented and the alternative would be dropped from further consideration and documented in Table 1A.

6.4 Screening of Alternatives

The next step of screening used the following criteria extracted from Section 4.3 and Level 1 mission requirements of Reference 1.

1. Safety

   Does the process have inherent hazards that preclude it from being made safe?

2. Permits

   Can permits be approved for the process?

   (a) Is the process covered under existing permits?

   (b) Can existing permits be modified?

   (c) Can new permits be approved?

3. Interfaces

   Can interfaces be established/maintained?

   (a) Does expected waste produced meet the Waste Acceptance Criteria of receiving facilities?

4. Maturity

   Will the process be sufficiently matured for successful near term deployment?

   (a) Is there evidence the process has or will have sufficient R&D to support successful near term deployment?

   (b) Is there likelihood for successful field application?

   After review against the criteria above, each alternative received one of three dispositions:

   - Reject (The failure to meet a specific criterion was documented, the alternative was not carried forward for further review)
   - Included / Accept (Carried on to the next level of review)
   - Hybrid (The alternative appeared to have merit when used in combination with other alternatives and/or hybrids and would be further considered in that context)

Table 1B is a list of alternatives that failed one or more criteria and were not carried forward. A brief statement of criteria that was not met is given in the "Disposition" column and the "Comment" column briefly states the reasons. Table 1C is a list of alternatives that, while not accepted as stand–alone alternatives, contain attributes for hybrid consideration. The "Disposition" column briefly addresses criteria not met. Table 1D is a list of the alternatives that were accepted for ranking.

6.5 Selected Alternatives

It is important to note that the initial list generated by the process described in Phase 1 of this report was not "frozen" at the 15 alternatives. As information from literature searches, professional and commercial inquiries, and other submitted information becomes available, new alternatives were screened by the process already described for addition to the list. Both the initial list and short list could be added to at any time up to completion of the final Team deliverable of the recommendation of the preferred alternative(s).

The following alternatives were accepted onto the Phase 1 "Initial List:"

Alternative	Alternative Description
3 *	Feed KTPB Slurry To DWPF Salt Cell For Catalytic Decomposition
5	Catalytic Decomposition Of TPB Directly In Tank 48
6	Catalytic Decomposition Of TPB In A New Or Existing Facility.
7	Catalytic Decomposition Of TPB Directly In Tank By Lowering pH (Acid Addition)
33	Catalytically Decompose TPB Using Tank 49 as a Reaction Vessel
38	Volume-Reduce By Filtration, Sending Filtrate To Tk 49/50, Catalytic Decomposition of Residual In-Tank
8	Oxidation Of TPB Using UV Catalyzed TiO_2
9	Oxidation Of TPB Using Water Soluble Mild Oxidant
10	Oxidation Of TPB Using Permanganate
35	Hybrid - Actinide Removal Process (ARP) Oxidation of TPB Using Permanganate
11	Thermal Decomposition Of TPB
37	Hybrid - Microwave Destruction Of Organics
39	Steam Reforming / Fluidized Bed Destruction Of Organics
26	Hybrid - Metathesize With Cold Cesium
36	Hybrid - Tank In Tank

* Considered for the process/technology

7.0 Phase 2

Phase 2 of the effort to select an alternative(s) to process the contents of Tank 48H, was divided into four steps.

Step 1 divided the 15 alternatives from Phase 1 into three groupings for technical investigation. The first line of inquiry combined acidic, oxidation, catalyst and thermal. The second was microwave decomposition and the third was ultraviolet (UV) decomposition. The options to metathesize with cold cesium and tank-in-tank processing were not in the grouping since they only provide partial solutions to the problem.

Step 2 of the down select process was the development of selection criteria. The criteria had to contribute to the effort to differentiate between the alternatives and be independent enough to allow the criteria to be weighted with regard to relative importance.

Step 3 was to compare the selection criteria to the studies in the lines of inquiries to ensure the lab studies provided the information to address the questions required for the evaluation.

Step 4 combines the previous steps and essentially results in a de-selection process by comparing the data for each alternative, by criterion, to each other. This process results in alternatives with strong to weak attributes that when weighted and compared results in the alternatives best suited for the processing of Tank 48H contents. This list is recommended for further evaluation.

7.1 Organization of Alternatives

The Tank 48H Team identified 18 alternatives that should be investigated to determine if any of these are feasible for returning Tank 48H to HLW service. The 18 alternatives differed in chemical reaction requirements as indicated by the "How" column in Table 7.1.

All but two these ideas contain at least one of four destruction mechanisms, namely (1) catalyzed destruction, (2) oxidation, (3) thermal and (4) acidic hydrolysis. The two exceptions are metathesize with cold cesium and Tank-in-Tank options, which are really partial solutions that might be used in combination with other destruction options to return Tank 48H to service. Alternatives 17, 18 and 23, from the initial "Rejected" list were added for further consideration. Alternative 17 is the idea of transferring the waste to many waste tanks in the Tank Farm and alternative 18, Direct Grout disposal as part of tank closure, were grouped together as dilution and were considered a paper study. Alternative 23, Bioremediation, was reconsidered due to the industrial success of PMC Technology, Inc. in this field, bringing the total number of alternatives to 18 and the groupings for technical inquiry to five.

To determine whether any of these options is feasible, scoping tests were completed during Phase 2 using a Tank 48H simulant. The testing investigated (1) catalysts, (2) oxidants, (3) acids, and (4) thermal destruction methods. The reaction components and products helped determine the environment required for the process, i.e. "Where". The bioremediation process is being pursued by PMC under contract to WSRC/SRTC[2].

Alternative #	**Alternative Description**	**How?**
3*	Feed KTPB Slurry to DWPF Salt Cell for Catalytic Decomposition	Thermal + Catalytic + Acidic
6	Catalytic Decomposition of TPB in a New or Existing Facility	Thermal + Catalytic + Acidic
5	Catalytic Decomposition of TPB Directly in Tank 48	Catalytic
7	Catalytic Decomposition of TPB Directly in Tank by Lowering pH (Acid Addition)	Acidic
11	Thermal Decomposition of TPB	Thermal
37	Hybrid – Microwave Destruction of Organics	Thermal
39	Steam Reforming/Fluidized bed Destruction of Organics	Thermal
38	Volume-Reduce by Filtration, Sending Filtrate to Tk 50, Catalytic Decomposition of Residual In-Tank	Catalytic
33	Catalytically Decompose TPB Using Tank 49 as a Reaction Vessel	Catalytic
35	Hybrid – Actinide Removal Process (ARP) Oxidation of TPB Using Permanganate	Oxidation
36	Hybrid – Tank In Tank	
8	Oxidation of TPB Using UV Catalyzed TiO_2	Catalyzed Oxidation
17	Distribute Among Other Tank	Data Study
18	Direct Grout	Data Study
9	Oxidation of TPB Using Water Soluble Mild Oxidant	Oxidation
10	Oxidation of TPB Using Permanganate	Oxidation
23	In-Tank (or a coupled tank) Bioremediation	Bioremediation/ Contract
26	Hybrid – Metathesize with Cold Cesium	

* Considered for the process/technology

Table 7.1 – Phase 2 Alternatives List

7.2 Selection Criteria

NOTE: No programmatic risks have been identified that discriminate between the options at this time. The Team recognized that some of the process options may require the use of selected facilities (e.g., the ITP filter/stripper building) and may conflict with other program activities from the accelerated mission.

Similarly, the selection criteria does not include cost or schedule. The Team understood the System Plan requires return of Tank 48H to routine service in FY06 (i.e., Cases 2 & 3 of Revision 13. However, development of the best processes does not depend upon cost or schedule. The application of the selected process will effect cost and schedule and should be considered in the final selection phase.

7.2.1 Criteria Development

During Phase 2, the Team developed criteria to evaluate the Initial List options. The goal of the Team was to develop criteria that would:

Differentiate between options
Relate to goals, objectives and values of stakeholders
Be reasonably measurable or estimable
Be independent of each other
Be well understood by all team members

It would not serve the alternative selection process to select criteria, which when applied to each option results in an approximately equal score. Therefore, the team developed criteria that could clearly be used to differentiate between the Initial List options.

The mission, goal, (as identified in Section 4.0) and values of the stakeholders were used to guide the team in developing criteria. The criteria were developed to facilitate the evaluation of those risks threatening the successful achievement of stakeholder interest.

As performance must be capable of being measured or estimated for each of the criterion applied, the team developed criteria applicable to all of the Initial List options.

Another major factor that was considered by the team was to develop criteria that are independent of each other. If the criterion were not to be independent it could skew the results of the evaluation by amplifying the positive or negative aspects of an option by counting the same criterion multiple times.

It was very important for all the team members to fully understand the criteria. This was accomplished by obtaining the consensus of the entire team for each selection criterion and by, when necessary, adding clarifying notes to help "focus" the reader.

During the investigation of alternatives (subsequent to initial screening), the potential could exist to identify a previously unknown safety risk. Therefore, as part of the evaluation process each alternative was screened one final time to ensure no alternatives were carried forward that had a newly identified safety risk.

The team approved selection criteria is shown in Table 7.2.1

Table 7.2.1 – Phase 2 – Selection Criteria

1. Safety
   How difficult is it to control the hazards in the process?

2. Technical Risk
   How mature is the process with respect to a radioactive environment. This question is to differentiate between a process that can treat radioactive material from those that would require extensive design changes or re-design. For example, the portable equipment used to decompose organics in the soil does a great job of destroying PCBs but would be almost impossible to use if the soil was radioactive.

3. Science
   Is the process supported by experimental and other data where the outcome is understood and the results are acceptable?

   This question looks at the chemical process, intermediate and final products in terms of how well the basic science is understood.

4. Design Complexity

   Are the parameters that must be controlled (temperature, pH, pressure, etc.) so sensitive that the process design could be complicated?

   The purpose of this question is to highlight an alternative that, based on what we know now, will require a tightly controlled chemical process.

5. Operation Complexity
   Is operation made more difficult by the complexity or instability of the process (upsets, control, sampling, etc.)?
   The purpose of this question is to highlight an alternative that, based on what we know now, will require many controls and/or many operators.

6. Infrastructure

   Does the process have the potential to use existing Systems, Structures and Components (SSC) as opposed to new SSC?

   It is more desirable to use existing infrastructure.

7. Process Rate

   Does the process support maximum net space gain versus time? This question deals only with the process rate exclusive of design, construction, etc.

8. Regulatory Risk

   Does the process and products fall within the current regulatory envelope and if not, how difficult is it to modify the regulatory envelope?

   The purpose of this question is to ensure that any required changes to permits are considered.

7.2.2 Weighting of Criteria

The selection criteria identified in Table 7.2-1 was weighted by the team. The weighting of criteria was necessary to ensure the correct measure of relative importance was placed on each of the selection criterion. The Team employed an analytical hierarchy process by using the ECPro software tool and a "pair-wise" comparison of criteria. The results of the process weighted technical risk and science heavier than the other criterion as the Team consistently judged them to pose the greatest risk to the successful deployment of any option. Safety, although the most important of all aspects, was weighted above the remaining criteria but below technical risk and science as no unsafe options will be allowed to be deployed and all options which are deployed will have the necessary controls in place to maintain safe operation. The discriminating factor of safety is not how safe the option is but how difficult it will be to make the option safe. The remaining criteria of design complexity, operational complexity, infrastructure, process rate and regulatory risk were not considered by the team to involve risks that would severely jeopardize the deployment of a selected option and therefore were not weighted as heavy as technical maturity, science or safety.

The criteria weights developed by the Team are shown in Table 7.2.2

No.	Criterion	Weight
1	Science	0.329
2	Technical Risk	0.245
3	Safety	0.152
4	Regulatory Risk	0.092
5	Operational Complexity	0.076
6	Design Complexity	0.045
7	Infrastructure	0.037
8	Process Rate	0.024

Table 7.2.2 – Criteria Weights

The ECPro software performs a data check of the pair-wise comparisons to ensure that the comparisons are logical and consistent. This calculation produces an "inconsistency ratio." For this type of analytical hierarchy process (AHP) an inconsistency ration of less than 0.1 would be preferred. The data produced an inconsistency ratio of 0.07 that was within the desired range.

7.3 Screening Experiments

SRTC researchers completed a series of tests to evaluate the Team's alternatives and to develop additional alternatives for consideration. The experimental design allowed direct comparison of the various chemical treatment options under comparable conditions. The bulk of the tests examined the destruction efficiency at 7 days for different chemical recipes with a subset of the tests aimed at determining the influence of temperature and the stoichiometry of the reactions (i.e., amount destroyed as a function of the amount of reagent added). A final set of experiments collected and analyzed samples of the slurry and the offgas as a function of time in an attempt to complete a carbon balance for several of the most promising decomposition options.

Analyzing the filtrate for soluble potassium and boron provided indirect measure of the degree of TPB decomposition. As the TPB decomposes, the byproducts become soluble and the soluble potassium and boron increase. In comparing the alternatives, we present graphs showing the percent TPB destruction based on the increase in soluble potassium and boron concentration. The soluble potassium is more accurate than soluble boron for the prediction of TPB decomposition since insoluble boron compounds form during decomposition, especially under acidic conditions.

Testing used either unwashed or washed precipitate. It would be preferable for the process to treat unwashed precipitate as this would simplify processing and minimize additional waste generation through processing. The current Tank 48H contents are unwashed and contain a high concentration of sodium hydroxide, sodium nitrate and sodium nitrite. Historical processing required washing of the precipitate slurry to remove the nonradioactive salts which would have been processed by the Saltstone Facility. This washing reduced the concentration of sodium to 0.13 M and the nitrite from 0.47 M to 0.01 M. This degree of washing assumes pretreatment of the contents of Tank 48H by addition of 2 million gallons of inhibited water (i.e., 0.01 M NaOH) and filtration to remove the excess volume (1.75 million gallons). Washing would most likely need to occur in Tank 48H using the Building 241-96H filters. The wash water will require evaporation or disposal through the Saltstone facility.

It should be noted that percent destruction means that the cesium and potassium are being released into solution although the decomposition of the TPB to benzene or CO_2 may not be complete. As a result, additional analysis of the organic present for the options with high destruction rates determined the degree of decomposition for the organic.

In addition, personnel measured the solution pH after each 7-day test and twice per day in the final set of tests. The solution pH is especially important in the tests that may be processed in-tank. Attempts were made to complete some of the tests at pH 9.5. However, due to the over addition of acid in the experiments, the final solution pH was lower than planned.

7.3.1 Catalytic Options

A number of catalytic options were proposed to destroy the TPB in Tank 48H. This is because of the success of the copper catalyzed acid hydrolysis process used in DWPF cold chemical runs and the successful use of the copper catalyst to destroy TPB in Tank 49H[3]. However, the destruction of the TPB in Tank 48H is expected to be much more difficult than Tank 49H due to the higher concentration of TPB and the insolubility of the KTPB and CsTPB. (Tank 49H contained primarily soluble NaTPB.)

Catalyst testing considered four catalysts based on previous catalyst testing: copper, palladium, platinum and iron. Copper and palladium have been used at SRS to decompose TPB. Platinum was chosen due to its good catalytic activity in similar chemistry. Iron was chosen due to its ability to catalyze peroxide through Fenton's chemistry. The catalysts were tested at 25 °C and 40 °C.

Feed KTPB Slurry to DWPF Salt Cell for Catalytic Decomposition
Catalytic Decomposition of TPB in a New or Existing Facility

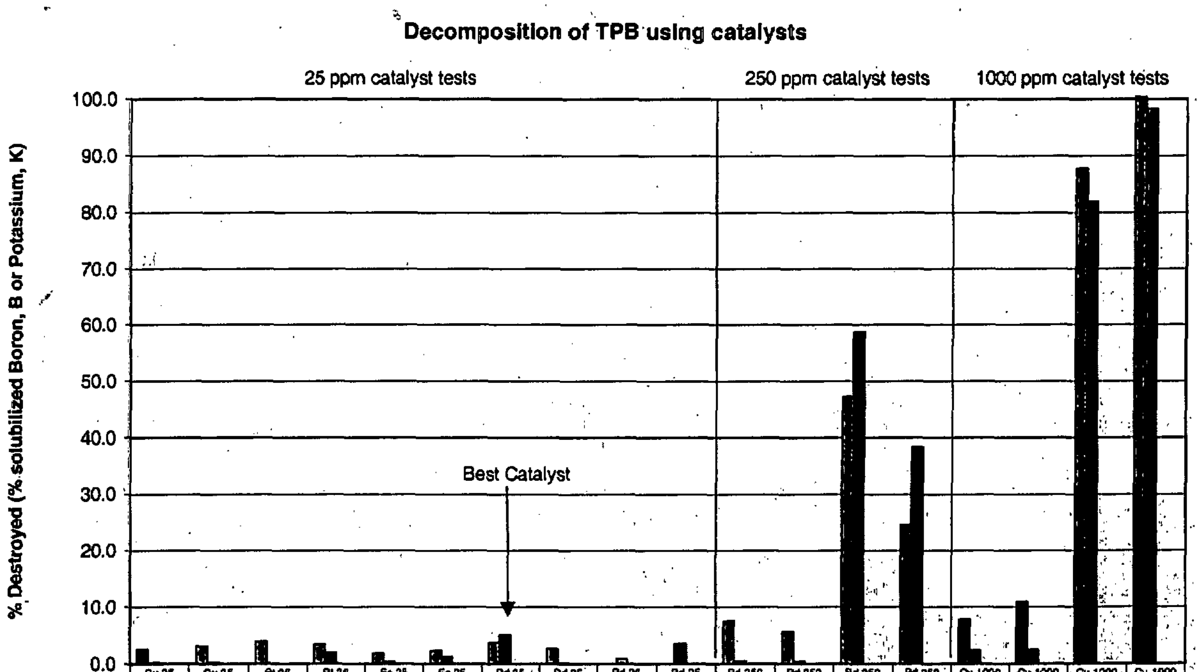
Both of the above processes use a copper catalyzed, formic acid hydrolysis reaction to destroy the TPB. This process was used in DWPF during cold, chemical startup. No testing was completed to duplicate this processing, as this is a very mature technology[4]. However, several tests were completed at similar processing conditions. These tests used 1000 ppm Cu with added formic acid using a washed precipitate. These tests resulted in 80% and 100% destruction of the TPB at 25 °C and 40 °C, respectively.

Catalytic Decomposition of TPB Directly in Tank 48H

Several of the experiments examined whether it would be feasible to add a catalyst to Tank 48H to complete the destruction of TPB in the tank. Catalytic decomposition is likely to lead to a large production of benzene. Figure 7.3.1.1 shows that the catalysts tested had low TPB destruction rates at 25 mg/kg.

Because of the low TPB destruction during the seven days of testing at 25 mg/kg, personnel conducted additional tests at higher catalyst concentrations. The testing conditions chosen were 250 mg/kg palladium and 1000 mg/kg copper. These concentrations were chosen, as these were the maximum concentrations tested by other researchers. In testing at higher catalyst concentrations, the catalysts were most effective in the washed simulate. The destruction rate increased approximately six-fold with the Palladium catalyst and roughly ten-fold with the copper catalyst.

The TPB destruction rate of the catalysts in the unwashed precipitate was much less effective than in the washed precipitate. In testing with the washed precipitate, increasing the palladium concentration ten-fold led to a ten-fold increase in TPB destruction. However, in testing the unwashed precipitate, increasing the palladium concentration ten-fold led to just a two-fold increase in TPB destruction. The use of a catalyst in-tank (unwashed precipitate) might be effective, but would have a slower destruction rate than many of the other alternatives. If the development of an in-tank alternative is desirable, consideration should be given to testing the Pd catalyst at 250 – 1000 ppm in experiments with unwashed precipitate for longer time periods (continue testing for several months) to determine the time necessary to completely destroy the TPB.



	Cu 25 None Unwashed	Cu 25 None Unwashed	Pt 25 None Unwashed	Pt 25 None Unwashed	Fe 25 None Unwashed	Fe 25 None Unwashed	Pd 25 None Unwashed	Pd 25 None Unwashed	Pd 25 None Washed	Pd 25 None Washed	Pd 250 None Unwashed	Pd 250 None Unwashed	Pd 250 None Washed	Pd 250 None Washed	Cu 1000 Formic Unwashed	Cu 1000 Formic Unwashed	Cu 1000 Formic Washed	Cu 1000 Formic Washed
▨% K Destroyed	2.5	3.0	3.9	3.4	1.8	2.3	3.7	2.7	-6.0	-1.2	7.5	5.7	47.1	24.5	7.8	10.9	87.6	103.1
■% B Destroyed	0.2	0.2	0.1	1.9	0.3	1.3	5.1	0.1	0.8	3.5	0.4	0.4	58.8	38.3	2.3	2.4	82.0	98.3
Temp, C	25	40	25	40	25	40	25	40	25	40	25	40	25	40	25	40	25	40
pH	12.95	13.06	13.11	13.10	12.80	13.03	13.05	12.94	12.40	12.20	13.1	13.1	9.43	9.39	12.2	11.5	2.08	2.45

Figure 7.3.1.1 - Comparison of Catalysts for TPB Destruction

Catalytic Decomposition of TPB Directly in Tank by Lowering pH (Acid Addition)

We examined whether the combination of catalyst and acid would lead to rapid TPB decomposition. In these experiments, formic acid and 1000 ppm of copper catalyst were added. The results are summarized in the last four columns of Figure 7.3.1.1. Copper was much less effective in destroying TPB in unwashed precipitate. However, the TPB rapidly decomposed in experiments with washed precipitate. This is not a viable in-tank process due to the pH being too low.

Catalytically Decompose TPB Using Tank 49H as a Reaction Vessel

This option would feed the contents of Tank 48H to Tank 49H where the decomposition would take place. A catalyst would be present in Tank 49H to decompose the TPB. Tank 49H would be suitable for this service since it was modified to allow the use of nitrogen to inert the tank and prevent a flammable mixture from forming during processing. This has some advantages over catalytic destruction in Tank 48H as the precipitate volume can be controlled.

There are some disadvantages to this option including it would tie up an additional HLW tank throughout the duration of the processing. Tank 49H has been returned to service as a high level waste tank and is not currently available for this service. This is a more controlled reaction than completing the decomposition in Tank 48H because it would be possible to control the slurry volume fed to the reaction vessel. However, it requires an additional waste tank and is impractical at this time.

This was considered as one of several options for catalytic destruction of the TPB. This could be accomplished for catalytic destruction of the TPB in a new tank, in an existing tank or in a processing vessel inside the tank.

Volume-Reduce by Filtration, Sending Filtrate to Tank 50H, Catalytic Decomposition of Residual In-Tank

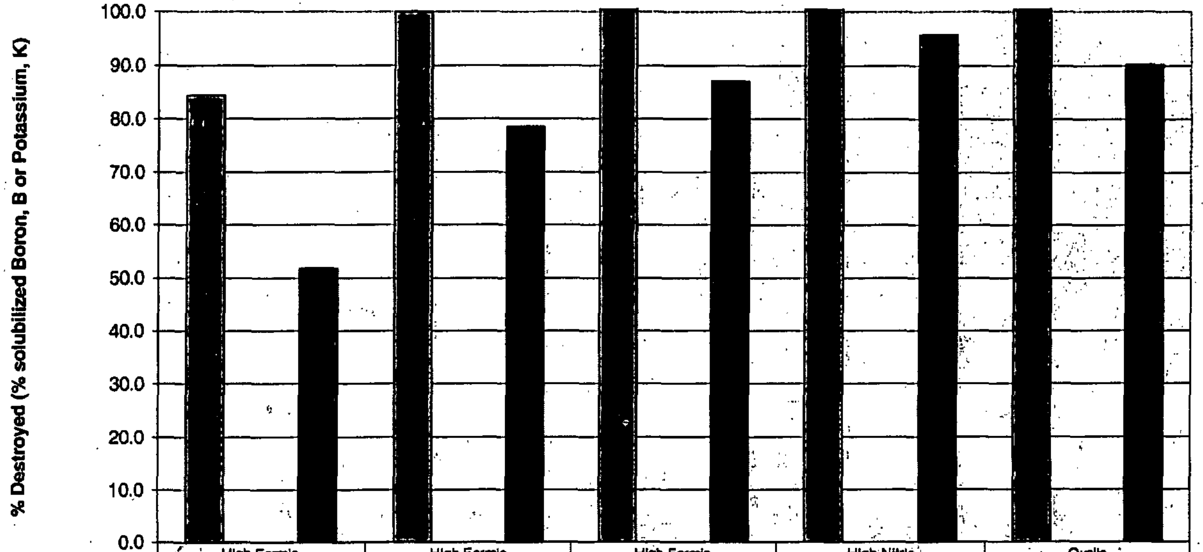
This option is similar to the above option but also requires the startup and operation of the ITP filters to concentrate the waste. Current HLW plans call for this equipment to be used as part of the Actinide Removal Process. As was noted previously, the use of a catalyst by itself is unlikely to be effective. This option was not evaluated independent of catalytic destruction inside Tank 48H by the Team.

7.3.2 Thermal Options

A number of thermal conditions were explored to determine the impact of temperature on TPB decomposition. Based on previous experience with TPB, higher temperature was expected to have a strong impact on TPB decomposition. The Salt Cell Process destroys the TPB by hydrolyzing the TPB to benzene at 90 °C. Testing was planned at 25 °C and 40 °C, as these are the typical ranges for in-tank processes, and at 90 °C as this temperature exceeds benzene's boiling point. Other thermal options such as steam reforming would be processed at much higher temperatures.

Testing was performed at room temperature (~25 °C), 40 °C, and 90 °C. For most of the testing with catalyst, acids and oxidants, higher temperatures led to more complete destruction of TPB. The exception was that the palladium catalyst led to lower destruction at higher temperatures, which defies expectations from prior studies. Most likely, the difference either reflects a variance in the inducting period for the Pd between the two experiments or some other uncontrolled variable that altered the activity of the added Pd.

Below is an evaluation of the thermal treatment options. Figure 7.3.2.1 is a comparison of TPB destruction at various temperatures.



	High Formic Unwashed B8	High Formic Unwashed C8	High Formic Unwashed D2	High Nitric Unwashed D4	Oxalic Unwashed D6
■ % K Destroyed	84.4	99.9	119.9	113.9	105.8
Temp, C	25	40	90	90	90
pH	4.77	4.18	5.80	3.74	4.61
■ % B Destroyed	51.7	78.5	87.1	95.6	90.2

Figure 7.3.2.1 - Comparison of Catalysts for TPB Destruction

Thermal Decomposition of TPB

The TPB will decompose under extreme conditions of temperature and pressure. Previous thermogravimetric testing measured the TPB auto-ignition temperature of ~325 °C[5]. For that reason, thermal (i.e., high temperature) and steam reforming (600-800 °C) processes are very likely to result in TPB decomposition. However, these processes would not be deployable as in-tank processes. Steam reforming has the added advantage that control of the oxidizing conditions in the column would lead to conversion of nitrite and nitrate to nitrogen and conversion of TPB to carbon dioxide.

Personnel began a series of 8 Thermogravimetric Analyses (TGA) to understand the decomposition of TPB using both thermal and steam reforming. Half of the experiments used sugar, a reductant that might be used in steam reforming to reduce nitrite and nitrate to nitrogen. Experiments were completed using both an inert off-gas and air as the dilution gas. The thermal testing was not completed by July 15, 2002.

Steam Reforming/Fluidized bed Destruction of Organics

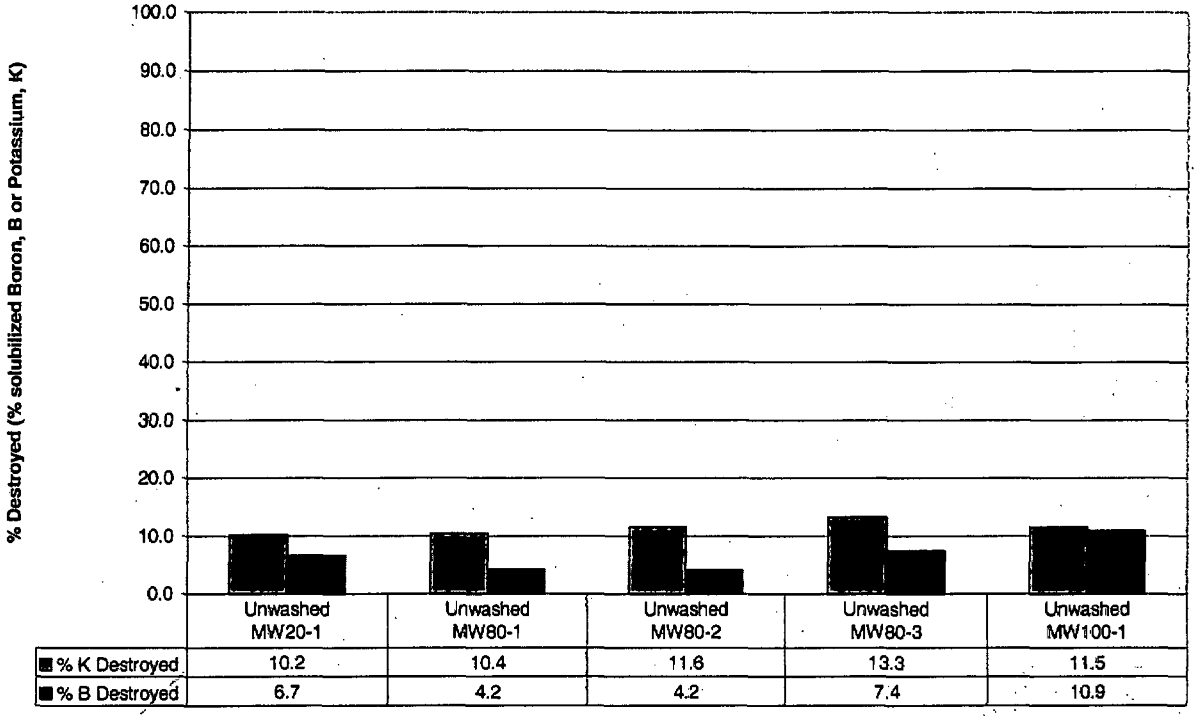
In the steam reforming process, the Tank 48H slurry, superheated steam, and co-reactants (reductant such as coal or sugar) are introduced into the steam reformer vessel where liquids are evaporated, organics are destroyed, nitrite and nitrate are reduced to nitrogen and reactive chemicals are converted to a stable waste product or liquid that incorporates almost all of the radionuclides. For the waste to fully and quickly react, the steam reformer vessel should provide a large surface area as in a fluidized bed. Off-gases from the steam reformer vessel are treated to neutralize corrosive acids or bases so that the only emissions released to the atmosphere from the process ideally are carbon dioxide and water vapor.

In the steam reformer, the Tank 48H slurry is combined with superheated steam and co-reactants. In tests with other alkaline wastes, greater than 99% of S, Cl, and F stayed in the solid product with less than 1% of the incoming S, Cl, and F in the waste going to the off-gas. Additionally, waste feed nitrates and nitrites are converted into nitrogen gas. Organics are initially converted into carbon monoxide, hydrogen, carbon dioxide, and water in the lower part of the fluidized bed. In the upper part of the bed, oxygen is injected to oxidize the gases. Off-gas from the reformer consists of water vapor, carbon dioxide, and nitrogen with less than 1% of the acid gases and less than 300 ppm NO_x.

The steam reformer is operated at 650°C to 800°C and can be electrically heated or operated in an auto thermal mode, whereby the energy needs are supplied by the incoming superheated steam and by the oxidation of organics in the waste and co-reactants.

Microwave Destruction of Organics

A series of five experiments were performed to evaluate the use of microwave radiation to destroy TPB. The results are summarized in the Figure 7.3.2.2. The five experiments all led to approximately 10% destruction of the TPB. The last experiment, MW100-1, microwaved the sample to dryness (approximately 180 °C). Use of microwave energy may be a quick way to heat and decompose the organic slurry but does not seem to have an advantage over other, simpler chemical methods.



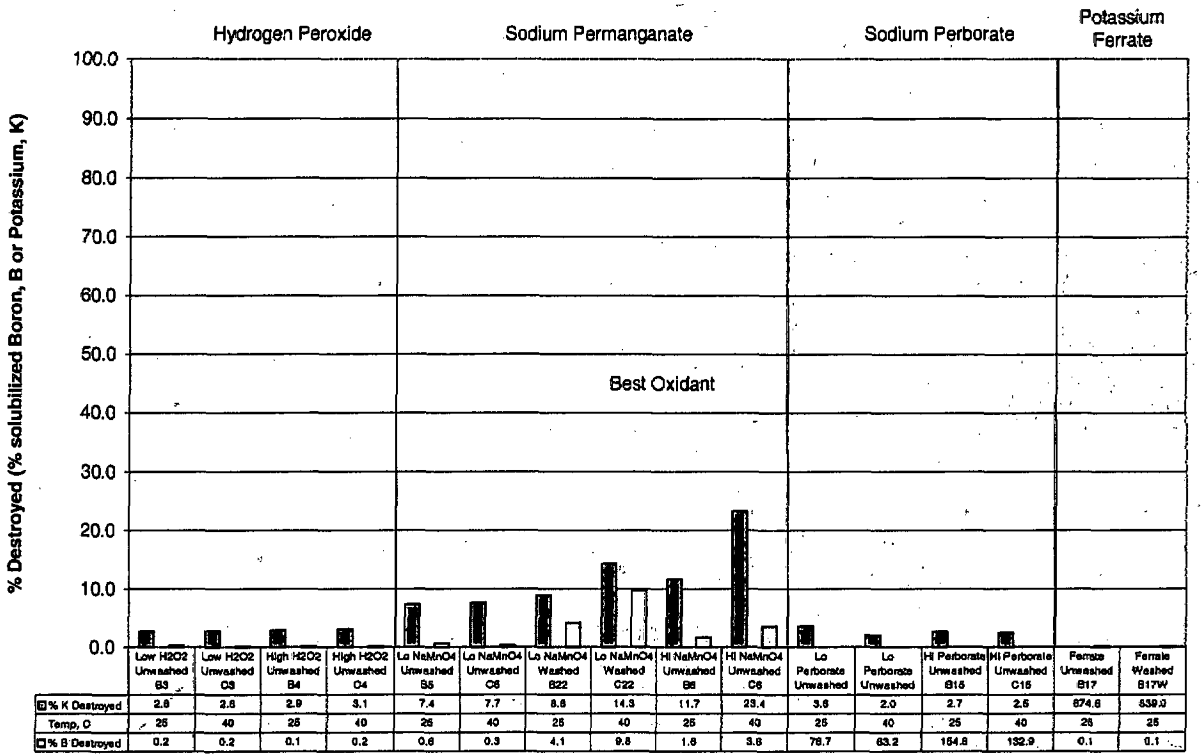
	Unwashed MW20-1	Unwashed MW80-1	Unwashed MW80-2	Unwashed MW80-3	Unwashed MW100-1
■ % K Destroyed	10.2	10.4	11.6	13.3	11.5
■ % B Destroyed	6.7	4.2	4.2	7.4	10.9

Figure 7.3.2.2 - Comparison of Microwave for TPB Destruction at 20%, 80% and 100% Power

7.3.3 Oxidation Options

Four oxidants – sodium permanganate ($NaMnO_4$), hydrogen peroxide (H_2O_2), sodium perborate ($NaBO_3$) and potassium ferrate (K_2FeO_4) – were tested to determine the best oxidant for destruction of TPB. Because of difficulty finding a commercial source of potassium ferrate, only two ferrate experiments were performed using an old and suspect sample of the reagent.

The use of an oxidant may lead to lower benzene production and high generation of carbon dioxide and other decomposition products that are less flammable than benzene. Sodium permanganate was the best oxidant in our testing. Testing was completed at oxidant levels of two (i.e., low) and five (i.e., high) moles of oxidant per mole of TPB. The most complete destruction of TPB (25%) occurred at 40 °C, so there is a definite advantage at this higher temperature. The TPB decomposition was more complete with washed precipitate, but that may be due to the lower pH of the washed precipitate as testing of permanganate plus formic acid also led to a higher TPB destruction. The results of these experiments are summarized in Figure 7.3.3.1



	Low H2O2 Unwashed B3	Low H2O2 Unwashed C3	High H2O2 Unwashed B4	High H2O2 Unwashed C4	Lo NaMnO4 Unwashed B5	Lo NaMnO4 Unwashed C5	Lo NaMnO4 Washed B22	Lo NaMnO4 Washed C22	Hi NaMnO4 Unwashed B6	Hi NaMnO4 Unwashed C6	Lo Perborate Unwashed	Lo Perborate Unwashed	Hi Perborate Unwashed B15	Hi Perborate Unwashed C15	Ferrate Unwashed B17	Ferrate Washed B17W
▨ % K Destroyed	2.8	2.6	2.9	3.1	7.4	7.7	8.8	14.3	11.7	23.4	3.6	2.0	2.7	2.5	874.6	839.0
Temp, C	25	40	25	40	25	40	25	40	25	40	25	40	25	40	25	25
☐ % B Destroyed	0.2	0.2	0.1	0.2	0.6	0.3	4.1	9.8	1.6	3.6	76.7	63.2	164.8	132.9	0.1	0.1

Figure 7.3.3.1 -- Comparison of Oxidants for Destruction of TPB

Actinide Removal Process (ARP) Oxidation of TPB Using Permanganate Oxidation of TPB Using Permanganate

These two options used permanganate as an oxidant to destroy TPB. The first option above, the oxidation of TPB in the Actinide Removal Facility, is an out of tank alternative to the second option, the Oxidation of TPB In-tank.

The experiments using sodium permanganate led to the destruction of 7% to 23% of the TPB as measured by the increase in soluble potassium. Figure 7.3.3.1 summarizes the results of the various oxidants tested. As can be seen from Figure 7.3.3.1, sodium permanganate was the best oxidant tested. It should also be noted that the TPB destruction was more complete at 40 °C than at 25 °C. The last fact to be noted from this testing is that the higher addition of sodium permanganate (5 moles of oxidant per mole of TPB) led to a significantly higher TPB destruction than the lower addition of sodium permanganate (2 moles of oxidant per mole of TPB).

A carbon mass balance was performed to understand the degree of TPB decomposition and the byproducts that formed during decomposition. The simple TPB decomposition products for hydrolysis are (oxidation and other competing reactions are more complex):

$Na(C_6H_5)_4$ (TPB or 4PM) → 3PB + Benzene [1]

3PB → 2PB + Benzene [2]

2PB → 1PB + Benzene [3]

1PB → Boric Acid + Benzene [4]

Analysis of the decomposition products from the experiment using 5 moles permanganate per mole of TPB based on HPLC analysis showed that 11.7% of the TPB decomposed, primarily to 3PB and 2PB. Based on the carbon balance, 4.8% of the original organic carbon was present as 3PB and 4.2% of the original organic carbon was present as 2PB. Phenol, 1PB and other decomposition products accounted for <1% of the decomposition products. If the TPB decomposed to form benzene along with the 2PB and 3PB, it was calculated that 3.7% of the original organic carbon would be present as benzene. Summing these 3 decomposition products (3PB + 2PB + benzene) should equal the amount of TPB decomposed. This sum is 12.7%, which agrees well with the 11.7% decomposition predicted by the HPLC analyses. Note that this is a much lower decomposition than was predicted by the soluble potassium analysis (23% decomposition predicted by soluble K. The agreement between soluble K and TPB destruction by HPLC was excellent in the other experiments where both analyses were performed.

The disadvantage of using $NaMnO_4$ is that it will result in the addition of MnO_2, an insoluble oxide in HLW. The quantity of MnO_2 that would result from the addition of five moles of $NaMnO_4$ per mole of TPB (127,000 lb) would lead to the addition of 70,500 lb of MnO_2 to the HLW. This is equivalent to the Mn present in 600,000 gallons of Batch 2 sludge. Linear extrapolation of the data suggests that Iit doesn't seem feasible to destroy the TPB with permanganate by itself without the addition of a huge quantity of $NaMnO_4$ such as 21.7 moles of $NaMnO_4$ per mole of TPB (560,000 lb. of $NaMnO_4$).

Oxidation of TPB Using UV Catalyzed TiO2

This is an option that we planned to test using a vendor. In our discussions with vendors, it was decided that this is not a workable process for an opaque liquid, such as a TPB slurry. Because of this discovery, a decision was made not to establish a contract with Calgon Carbon.

Oxidation of TPB Using Water Soluble Mild Oxidant

Testing with water-soluble mild oxidants (sodium perborate and hydrogen peroxide) was much less effective than testing with sodium permanganate. These tests led to high foam generation, which would make the mild oxidant hard to process in Tank 48H. The picture below (Figure 7.3.3.2) shows the foaming during testing with hydrogen peroxide. In addition, these tests resulted in much lower TPB decomposition than sodium permanganate (see Figure 7.3.3.1). The decomposition rate of these oxidants was approximately equal to that of the blanks, experiments conducted without the addition of extra chemicals (i.e., no oxidants, no acid, and no catalyst). There was virtually no difference between the low peroxide addition and the high peroxide addition. This suggests that the peroxide must have reacted with the sodium hydroxide instead of the TPB leading to little decomposition. However testing with Fenton's Reagent (hydrogen peroxide with iron catalyst) was very successful in destroying TPB with the addition of sufficient acid to reduce the solution pH to 9.5 (see Figure 7.3.10.1).

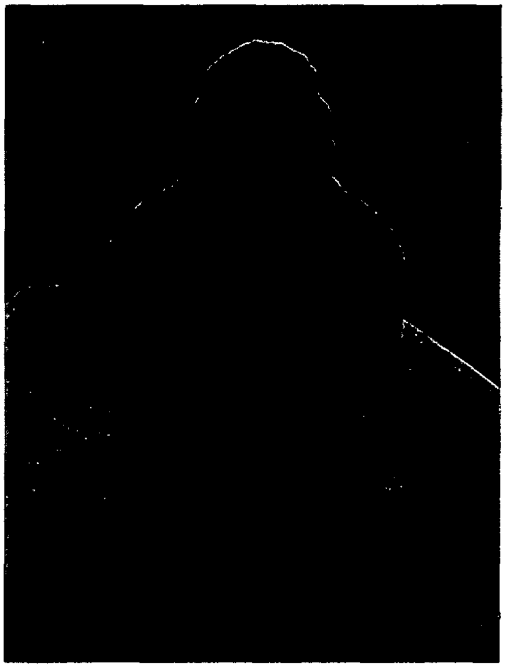


Figure 7.3.3.2 - Foaming produced during peroxide addition to Unwashed Precipitate

7.3.4 Acid Hydrolysis Options

The reference flowsheet for the destruction of TPB uses formic acid as the acid source for acidic hydrolysis of TPB. Several acids were investigated to determine whether formic acid is the best acid for this process. Oxalic and nitric acid were tested in addition to formic acid. The advantage to these acids is that they all will decompose in the melter/offgas system and will not produce more glass in DWPF. In addition, they are not particularly corrosive to the DWPF process (although any acid will be corrosive in the carbon steel waste tanks if the solution pH is low enough). Oxalic acid has a low solubility in water (~8 wt %) so it would not be practical to bring the pH down below 9.5 through the addition of >750,000 gallons of water. Many strong acids – including HCl, HF, and H_2SO_4 – were rejected as they would be too corrosive or cause other problems such as glass solubility in the downstream processing. However, the decomposition of TPB through acid hydrolysis is likely to produce benzene, which may lead to flammability issues.

Nitric Acid

Nitric Acid was the most effective of the three acids tested, leading to complete destruction of the TPB via the addition of 4.1 moles of acid per mole of TPB. Formic acid was nearly as effective and produced fewer tar-like organics as judged by visual inspection. Based on the semi-volative organic analysis, twice as many aromatic compounds, 16 in total, were detected in the experiment with nitric acid than were detected in the nitricformic acid run. Many of these additional compounds were nitrated organics. Oxalic acid was not as effective as nitric or formic acid in our testing at 25 °C or 40 °C but was equally effective at 90 °C. Acids were very effective in destroying TPB but are not deployable as in-tank solutions as they would likely lead to excessive tank corrosion. Figures 7.3.4.1 and 7.3.3.1 summarize the results of this testing.

An organic carbon mass balance was performed to understand the degree of TPB decomposition and the byproducts that are formed during decomposition. The HPLC analysis of the decomposition products showed that all of the TPB decomposed, primarily to 1PB. Based on the carbon balance, 8.2% of the original organic carbon was present as 1PB from the experiment using 4.1 moles of nitric acid per mole of TPB. If all of the TPB had decomposed to 1PB and stopped, there would be 25% of original carbon still present. This means that roughly two-thirds of the 1PB decomposed to benzene or another decomposition product. The data is summarized later in the report in Table 7.3.4.

Table 7.3.4 - Carbon Balance - %C based on HPLC analysis of selected samples

Description of Experiment	4PB	3PB	2PB	1PB	Others
5 moles NaMnO4 per mole TPB	88.28%	4.77%	4.23%	0.28%	52.00%
5 moles NaMn04 per mole TPB	5.28%	0.05%	0.19%	12.67%	8.08%
4.1 moles Formic Acid per mole TPB	0.04%	0.05%	0.04%	8.12%	1.59%
4.1 moles Nitric Acid per mole TPB	0.04%	0.05%	0.04%	14.06%	8.68%
1000 ppm Cu + 4.1 moles Formic Acid per mole TPB	0.04%	0.05%	0.04%	14.06%	8.68%

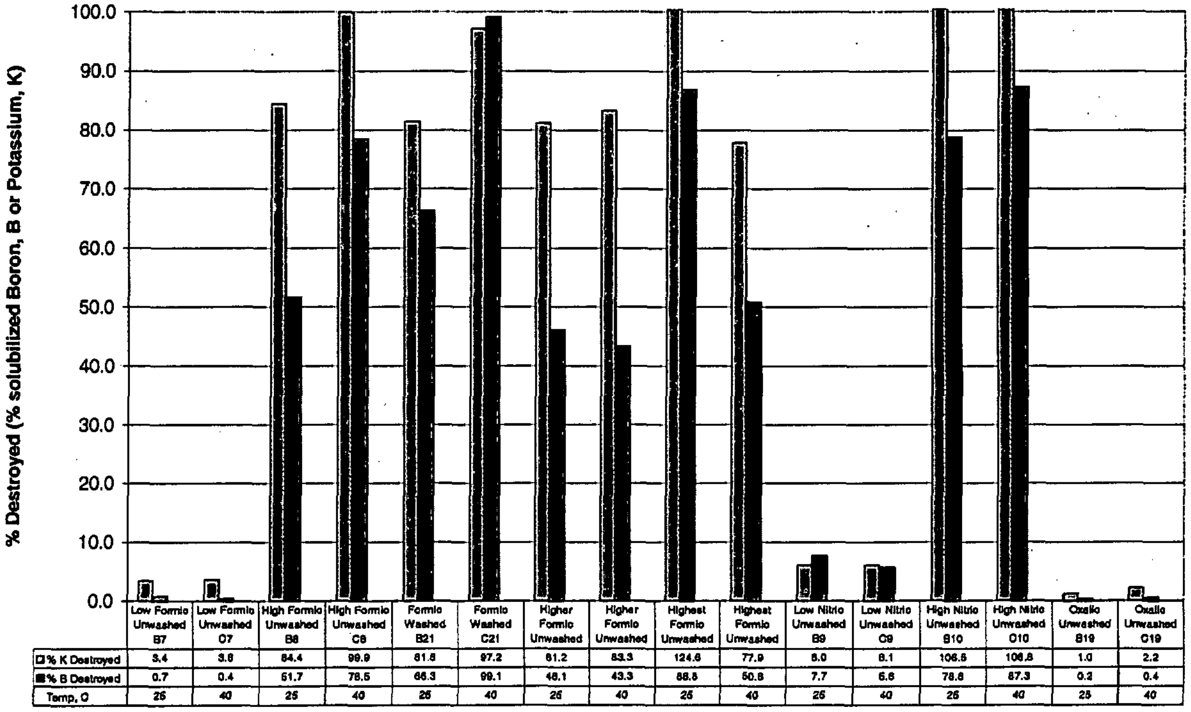
Nitric acid proved very effective in decomposing the TPB within the seven day testing period. Nitric acid led to 100% decomposition, as measured by soluble K, at both 25 °C and 40 °C. The disadvantage of this testing is that it led to a final pH of approximately 1, which would lead to increased tank corrosion. This alternative is viable, but is most likely to be successful in a separate processing tank rather than in Tank 48H.

Formic Acid

Formic acid was the second most effective of the three acids tested, leading to complete destruction of the TPB, as measured by soluble K, via the addition of 4.1 moles of acid per mole of TPB at 40 °C. As was mentioned above, formic acid produced fewer tar-like organics than nitric acid.

An organic carbon mass balance was performed to understand the degree of TPB decomposition and the byproducts that formed during decomposition. The HPLC analysis of the decomposition products showed that all of the TPB decomposed, primarily to 1PB. Based on the carbon balance, 14.1% of the original organic carbon was present as 1PB. If all of the TPB had decomposed to 1PB and stopped, there would be 25% of original carbon still present. This means that roughly 56% of the PBA decomposed to benzene or another decomposition product not measured by HPLC. The data is summarized in Table 7.3.4.

Formic acid was very effective in decomposing the TPB within the seven day testing period. Formic acid led to 84% decomposition at 25 °C and 100% decomposition at 40 °C. The disadvantage of this testing is that it led to a final pH of approximately 5, which may lead to increased tank corrosion. This alternative is viable, but is most likely to be successful in a separate processing tank rather than in Tank 48H.



	Low Formic Unwashed B7	Low Formic Unwashed C7	High Formic Unwashed B8	High Formic Unwashed C8	Formic Washed B21	Formic Washed C21	Higher Formic Unwashed	Higher Formic Unwashed	Highest Formic Unwashed	Highest Formic Unwashed	Low Nitric Unwashed B9	Low Nitric Unwashed C9	High Nitric Unwashed B10	High Nitric Unwashed C10	Oxalic Unwashed B19	Oxalic Unwashed C19
☐ % K Destroyed	3.4	3.8	84.4	99.9	81.8	97.2	81.2	83.3	124.6	77.9	6.0	6.1	106.5	106.8	1.0	2.2
■ % B Destroyed	0.7	0.4	51.7	78.5	66.3	99.1	46.1	43.3	86.5	50.8	7.7	6.6	78.8	87.3	0.2	0.4
Temp, C	25	40	25	40	25	40	25	40	25	40	25	40	25	40	25	40

Figure 7.3.4.1 -- Comparison of Acids for TPB Destruction

7.3.5 Distribute Waste Among Other HLW Tanks

Calculations were completed which determined that it is not a feasible to distribute the Tank 48H waste to other HLW tanks. Transfer of the Tank 48H contents to four other waste tanks would provide sufficient dilution to meet the organic limit in the tanks. However, there would be a flammability issue in each of these tanks if the TPB decomposed to benzene. To prevent a flammable mixture from forming due to a transfer to another waste tank, small additions (as small as 625 gallons) would have to be made. If each mole of the TPB decomposed to four moles of benzene in a Tank with 250,000 gallons of liquid, the vapor space benzene concentration would exceed 25% of the Lower Explosion Limit with the addition of 625 gallons of Tank 48H slurry. In addition, any tank receiving greater than 625 gallons addition of the TPB containing waste would likely require benzene monitoring and nitrogen blanketing. However, even if controls and monitoring could lead to the safe deployment of this option, it may lead to future processing problems as this material is evaporated or fed to DWPF.

7.3.6 Direct Grout

The Team considered three possible methods for disposing the Tank 48H solution as grout. The first idea was to grout the waste in place in Tank 48H and later return the tank to service with a lower volume due to the loss of the grouted volume. This would lower the volume of the tank by at least 250,000 gallons unless the waste could be concentrated. This option was considered too risky as leaving grout in a HLW tank has not been demonstrated before and because it will take longer to receive regulatory approvals.

The second idea was to transfer the waste to another waste tank that will be closed and use it as the liquid necessary for grout. This is feasible, although this would be a radical departure from current plans, which call for a nonradioactive addition of grout to a tank that has been cleaned of radiation. This was judged an unrealistic option as it would increase the complexity of closing a waste tank and will take longer to receive regulatory approvals.

The third idea is to use the Tank 48H slurry as feed to the Saltstone Facility. If the proposed higher ^{137}Cs activity limit of 0.05 Ci/gal is adopted, it would take approximately 8-million gallons of waste free of ^{137}Cs to blend with Tank 48H to meet the ^{137}Cs limit. This is not a feasible option to quickly empty Tank 48H, as the feed to Saltstone will likely be approaching the ^{137}Cs limit. Calculations and information to support these conclusions are contained in a lab notebook[6].

7.3.7 In-Tank Bioremediation

This option has not been tested. A subcontract has been awarded to PMC, Inc. to complete testing to determine whether this option is practical. It will be approximately mid October before results will be available. It is recommended that this option be maintained as an acceptable option until the results of this testing is available.

7.3.8 Metathesize with Cold Cesium

Virtually all of the tetraphenylborate in Tank 48H is trapped as the cesium and potassium salt. This material is highly insoluble in the salt solution. It may be possible to remove the radiocesium from the K/CsTPB slurry, through a process known as isotopic dilution. Isotopic dilution is the process of adding one isotope (Cs-134) to lower the relative concentration of an existing isotope (Cs-137). If successful, isotopic dilution would exchange out most of the radiocesium with cold (Cs-134) cesium. The radiocesium would end up in the supernate, which could be pumped to other tanks. The resulting TPB slurry would possess a much lower activity and be much simpler to work with from a shielding perspective.

The researchers generated a small quantity of ^{137}CsTPB. This slurry was added to the Tank 48H salt simulant (unwashed), and the resulting slurry was well mixed. The slurry was aged for two days before a 1000 fold excess of $^{134}CsNO_3$ (i.e., non-radioactive or "cold" cesium) was added. The filtered supernate from this mixture was sampled over a period of one week and analyzed by gamma spectroscopycan.

If the isotopic dilution occurred as we predicted, the amount of radiocesium in the supernate should increase over time (up to a theoretical maximum of 5.9E+07 dpm/mL), to a point where 99.9% of the radiocesium should be in solution. What we observed was a decrease in radiocesium over time (see figure 7.3.8.1). By the end of the experiment, only 0.058% of the radiocesium remained in solution. The solution was not at equilibrium prior to the addition of the cold cesium despite waiting two days prior to adding the cold cesium. Due to the lower solubility constant (k_{sp}) of CsTPB vs KTPB, small quantities of free cesium in solution likely exchanged with the excess KTPB to form ^{137}CsTPB. That caused the cesium activity in solution to decrease. The addition of the cold cesium seemed to have little effect on the hot cesium in solution, possibly due to the slow exchange kinetics between the hot and cold cesium.

This scoping test does not show favorable enough results to pursue.

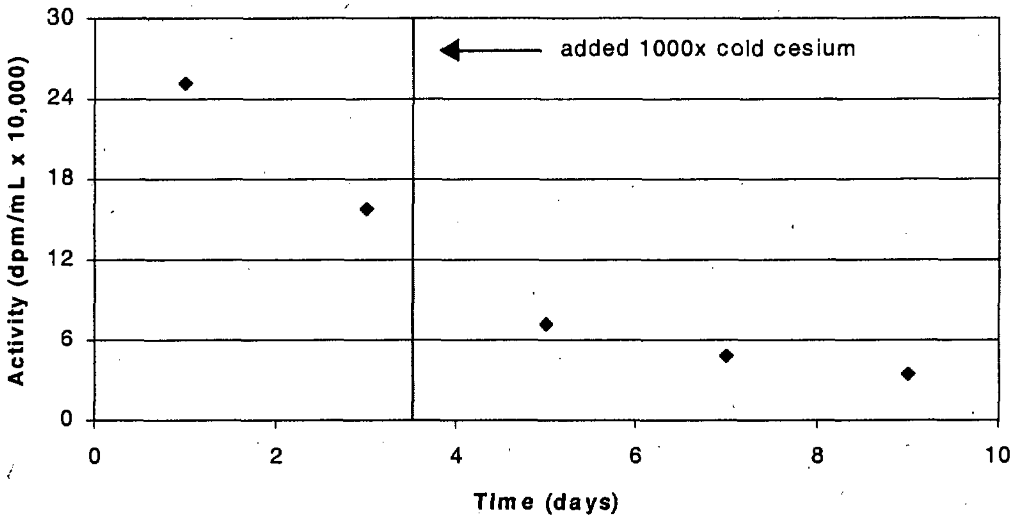


Figure 7.3.8.1 - Results of Metathesis Testing using Cold Cesium

7.3.9 Tank In Tank

The Tank-in-tank option involves to placing small and simple processing equipment into Tank 48H to eliminate the need for new equipment above the tank. Since Tank 48H is already shielded, this would lead to lower radiation exposure during processing. In-Tank filters were as used during the 1983 demonstration of the TPB precipitation and concentration. The type of equipment for the Tank-in-Tank processing has not been defined as it depends on the process chosen. As a result, this option was not studied. It is one of the hybrids that must be combined with other options to produce an acceptable solution.

7.3.10 New Options

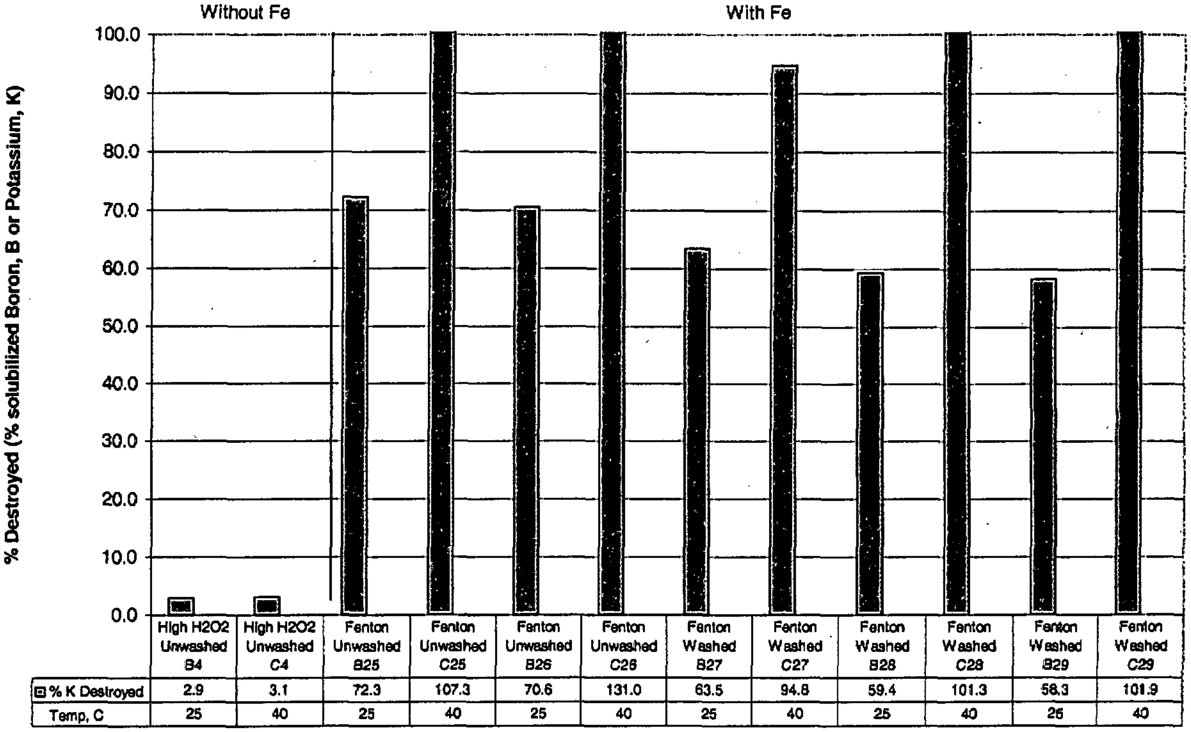
Two new options, Fenton's Reagent and Acidified Permanganate destruction, were devised after the first set of testing proved successful in destroying TPB. It is recommended that further testing be completed to determine whether these can be used to destroy the TPB in Tank 48H.

Fenton's Reagent

The addition of hydrogen peroxide with an iron catalyst (i.e., Fenton's reagent) was effective in destroying the TPB in all the experiments (see Figure 7.3.10.1). The experiments were tested at two levels of iron catalyst and the destruction was complete at both levels at 40 °C. Testing should be completed at lower concentrations so that the minimum amount of iron will be added. The testing was more effective at 40 °C but still destroyed 70% of the TPB at 25 °C in the seven days of testing. The final pH of all the solutions were much lower than planned. The final pH of the unwashed runs was approximately 5 (pH 9.5 was the target) due to over adding acid.

The recipe used in this experiment would result in the addition of 30,000 gallons of 90 wt % formic acid, 92,000 lb or 11,000 gallons of 30 wt % hydrogen peroxide, and 10,000 lb of ferric nitrate. The advantage of using Fenton's reagent is that it will result in the addition of iron hydroxide and water (i.e., the hydrogen peroxide will decompose to water) to the HLW. The quantity of Fe_2O_3 that would result from the addition of five moles of hydrogen peroxide per mole of TPB (127,000 lb) would lead to the addition of 2,000 lb of Fe_2O_3 to the HLW. This is equivalent to the Fe present in 2,500 gallons of Batch 2 sludge.

Future testing should be completed with a decreasing acid addition to determine if the reaction is effective at a higher pH.



	High H2O2 Unwashed B4	High H2O2 Unwashed C4	Fenton Unwashed B25	Fenton Unwashed C25	Fenton Unwashed B26	Fenton Unwashed C26	Fenton Washed B27	Fenton Washed C27	Fenton Washed B28	Fenton Washed C28	Fenton Washed B29	Fenton Washed C29
▣ % K Destroyed	2.9	3.1	72.3	107.3	70.6	131.0	63.5	94.8	59.4	101.3	58.3	101.9
Temp, C	25	40	25	40	25	40	25	40	25	40	25	40

Figure 7.3.10.1 - Comparison of Fenton's Reagent for TPB Destruction

Acid Plus Permanganate

The addition of sodium permanganate was effective in partially destroying the TPB. The combination of acid and permanganate is often used to destroy organics. (The combination of phosphoric acid and potassium permanganate is used in the Containment Facility in SRTC's Shielded Cell Facility to destroy TPB.) We examined whether TPB could be completely destroyed using a combination of sodium permanganate plus and acid (to lower the tank to 9.5). Two experiments used this combination. Figure 7.3.10.2 summarizes the results. The combination led to approximately a five-fold increase in TPB decomposition (100%) compared to experiments using only permanganate.

The recipe used in this experiment would result in the addition of 30,000 gallons of 90wt % formic acid and 127,000 lb of $NaMnO_4$. It is recommended that this combination be considered for treatment of the Tank 48H contents.

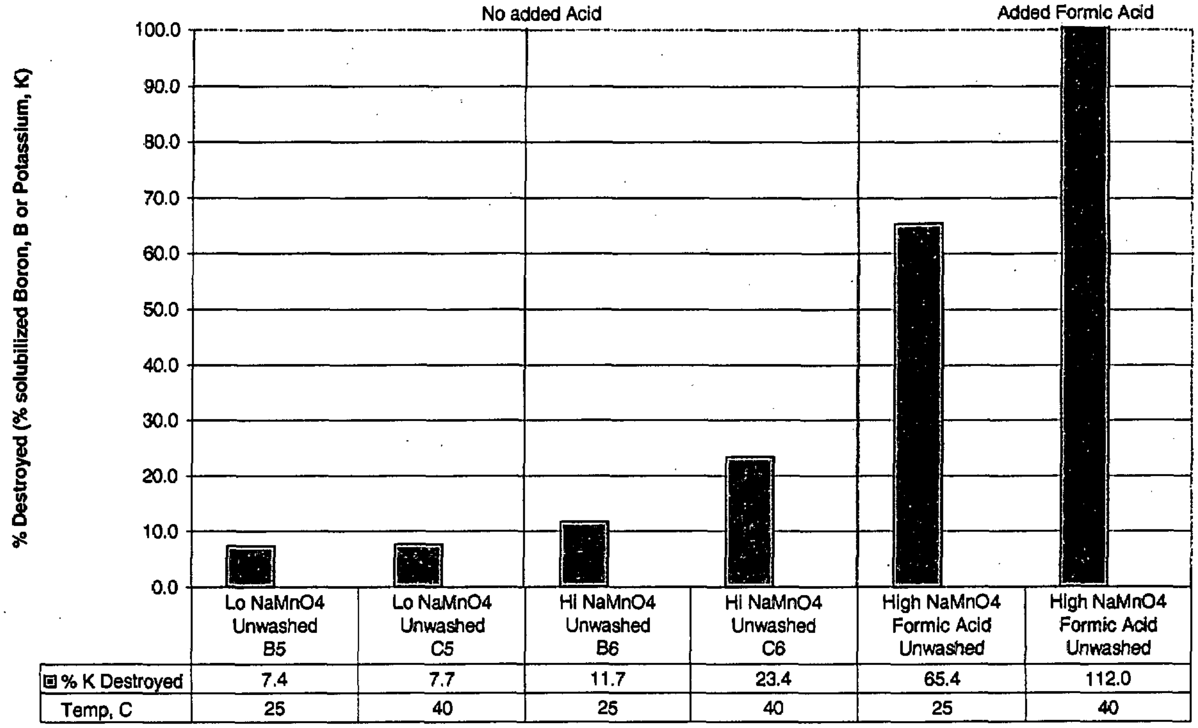


Figure 7.3.10.2 Comparison of Permanganate with and without Added Formic Acid for TPB Destruction

7.4 Risk Identification

As stated earlier, no programmatic risks could be identified that could be used to discriminate between the options at this stage of development. This does not mean to say that there are no programmatic risks associated with the options but merely that the programmatic risks are more or less equally applicable to all of the options. Technical risk however was judged significantly different between the options. There was enough difference in the regulatory risks to warrant using this area for comparison also. This approach required that technical and regulatory risk be employed as discriminating criteria during the evaluation. The technical and regulatory risks associated with each option were discussed in depth during the evaluation. The team employed subject matter experts during the evaluation to assist with risk identification and comparing the magnitude of risks between options during the pair-wise comparison.

7.4.1 Environmental Risks

Regulatory risks consist of both safety and environmental concerns. Safety risks are discussed in the appropriate Safety Analysis Report; therefore, this section will only discuss environmental concerns. These concerns include the generation of waste (including hazardous waste), waste minimization, and the impacts of air emissions and liquid effluents. For the reasons discussed below, the environmental risks for the removal of benzene from Tank 48H are believed to be known, and would have minimal impact to the alternatives as currently contemplated.

The South Carolina Department of Health and Environmental Control (DHEC) has issued an Industrial Wastewater Permit, # 17,424-IW, for the F/H Tank Farms (including Tank 48H). Tank 48H is also covered under a DHEC Bureau of Air Quality permit number 0080-0041-H. There are also radiological NESHAP limits for the tank farm. However for Tank 48H a special condition has been specified in the permit. That condition is for the emission of benzene and diphenyl mercury. The maximum permissible Benzene emission rate is 0.61pounds per hour (annual average) and 46.30 lbs./hr. instantaneous max. For diphenyl mercury, the maximum emission rate is 0.00055 pounds per hour (on an annual average). Currently, a new Part 70 Air Quality Permit application affecting Tank 48H and other HLW facilities is on file with DHEC. This application has been out for public comment, and is now awaiting a public hearing at a time and place to be determined by DHEC. Any changes to the Part 70 application on file arising from the public hearing and subsequent regulatory reviews will require a review of this section 7.4.1 for any impacts.

During this investigation to return Tank 48H to tank farm service, nine processes have been determined to be viable alternatives to eliminating the organics within the waste.

At the present time, no permit modifications or new permits are believed to be required for any of the processes which could be performed within the tank, so long as the tank temperatures and any required chemicals to be added to Tank 48H would not alter the composition of the tank farm effluent from that which was evaluated for the existing NPDES permits.

For the nine identified processes, any process which would require the contents of Tank 48H to be transferred to other existing facilities, such transfer(s) may require permit modifications to both the Industrial Wastewater and Air emissions permits. Regardless, a NEPA evaluation shall be performed for assessing the environmental impacts due to the selected process.

For the unlikely event of the construction of new facilities, a NEPA evaluation shall also be performed. New permits (or exemptions) for Industrial Wastewater effluents and Air emissions would be required from the regulators. Additionally, no new construction or modifications or the purchase of new equipment could begin until approval (or an exemption) has been received from DHEC's Bureau of Air Quality.

7.4.2 Safety

The current tank level in Tank 48H is approximately 70 inches and the evaluation results reported below are valid up to a tank level of 248 inches. It should be noted that no credit is taken for the fact that the increase in tank level would actually dilute the concentration of radionuclides in the tank. Therefore, the results are conservative. In addition, the inventory of radionuclides is limited to that which is currently in the tank because the Authorization Agreement (AA) only permits the storage of precipitate in Tank 48H and does not permit the transfer of waste into or out of Tank 48. In addition, the Authorization Basis (AB) does not permit the transfer of waste material into or out of Tank 48H. The current deflagration analysis for Tank 48 shows that the consequences of a deflagration event are well below Evaluation Guidelines for both onsite (TEDE is 58 mrem at 100 meters using ICRP-30 guidelines and 50th% quantile dose level) and offsite (TEDE is 28 mrem using ICRP-30 guidelines and 95th quantile dose level) receptors. These results support a likely determination that there will be no SAR controls required for any option from a radionuclide consequence standpoint. For this evaluation, it is assumed that this conclusion is unlikely to change during an in-tank detonation scenario.

For the in-tank catalytic disposition process, an evaluation (S-CLC-H-00757, Rev. 1) was performed for Tank 49H using a benzene release rate of 1000 g/min to determine the affects to the onsite worker. A 1000 g/minute release rate is expected to be a reasonable assumption, especially considering the experience on Tank 49H. Since it is a ground release, the difference in stack height between these tanks is inconsequential. The results showed that the concentrations at 100 meters was 1.3%, 0.03%, and 3.4% of ERPG-2 limits assuming a release form of benzene, CO2, and CO, respectively.

If higher benzene release rates were to occur, the consequence increase would be linear and thus, even if extreme rates are assumed, the consequences would still be a small percentage of ERPG-2 guidelines. This evaluation is reasonably expected to bound all other processes involving the production of benzene. For instance, batch processing will result in only a fraction of the consequence of the in-tank process. Based on the above, it is expected that no Safety Class or Safety Significant AB controls are warranted for any option involving benzene production.

Regardless of the option ultimately chosen, an evaluation would be included in the SAR that provides the basis for no AB controls. At this time, available documentation is indicating that no SAR controls are likely to be warranted. Other factors such as capital risk may affect the determination as to where the standard industrial type of controls would be captured and approved. In the most challenging circumstances of benzene release, the in-tank process, the ability to maintain the vapor space inerted for the duration of the activity has already been demonstrated in Tank 49H. In that case, the Tank 49H vapor space remained inerted for a few years with no process difficulties with respect to inerting. Knowing the above, the team chose to look at each process and provide a safety determination based on relative risk from a standard industrial hazard standpoint. For instance, even if benzene is produced in less quantity in one option (which involves an acid addition to lower the pH) than in another option, the lower benzene generation rate is likely to be offset by the need to have acid in a nearby storage tank. Another example involved the steam reforming/fluidized bed destruction of organics. In this option, the benzene generation was essentially eliminated and, relatively speaking, it was considered the safest option. However, the capability to maintain steam temperature at 600 degrees C presents its own safety challenges. As a result, the options did not vary significantly from a safety standpoint from one option to another and there was no substantive safety discriminator between each option.

7.4.3 Process Safety

Identifying the process risks is necessary in comparing the alternative processes. If any of the processing can be completed in Tank 48H, the processing must protect the integrity of the carbon steel tank. For processing in another facility, it is assumed that the materials of construction chosen are appropriate for the process chemistry.

There are risks that are common to each of the alternatives. The slurry in Tank 48H contains TPB, radioactive cesium, and radioactive sludge. As a result, these processes will all have similar radiological risks. In addition, the decomposition of TPB will produce some benzene, a potentially flammable and toxic gas and other TPB decomposition products. As a result, a flammability strategy involving dilution with air or nitrogen is expected. Unless the benzene production rate is small and constant, it is expected that a flammability strategy using nitrogen to minimize the oxygen concentration will be necessary in all options except the steam reforming.

All the options will produce a variety of TPB degradation products. For example, the Tank 49H decomposition produced considerable biphenyl. The biphenyl collected and solidified in the condenser and hindered heat transfer. Any of the processes could be designed to handle the production of biphenyl and other solid decomposition products.

Any of the processes below would need to be well mixed to control the reaction rate and maximize the TPB decomposition. Good mixing together with cooling is necessary to ensure the slurry temperature can be controlled. Any of the decomposition reactions will produce gaseous byproducts. The offgas system will need to handle this generation rate and prevent pressure excursions. This gas generation is also likely to produce foam which can be stable in this TPB matrix.

Below is a summary of the major process hazards expected for each of the process alternatives. This listing is based on studies to date and is not complete but will be developed as new risks are identified through the proposed follow-on studies, lessons learned findings, literature surveys and other testing designed to identify potential problems.

7.4.3.1 Salt Cell Process

The risks of the Salt Cell Process are well understood. The TPB is decomposed using acid hydrolysis, which requires concentrated formic acid (a reducing agent and organic acid), and copper catalyst at elevated temperature (90 °C) to decompose the TPB. The benzene produced is condensed and collected in a decanter. High boiling point organics are removed from remaining aqueous slurry via steam stripping. The resultant solution, approximately the same volume as the original solution, would be fed to the DWPF SRAT for processing. The other liquid product would be benzene and other organic decomposition products that are soluble in benzene. The organic decomposition products will have to be disposed of via an offsite vendor or a new processing facility.

7.4.3.2 Catalytic Process

A catalytic process, without the addition of additional reagents, could occur in Tank 48H or another facility. Although decomposition of TPB during processing generates mainly benzene, a number of other TPB decomposition byproducts, including biphenyl would be produced. The TPB is decomposed at ambient tank temperatures (25-40°C). The benzene from this process would be removed via natural evaporation to the atmosphere. The product from catalytic decomposition is a salt solution containing nonvolatile TPB decomposition products. This solution would likely be fed to the Salt Processing Facility. The solids from the Salt Processing Facility would be fed to DWPF for processing. The decontaminated supernate would be fed to

Saltstone. Testing would be needed to ensure that this slurry is compatible with the Salt Processing Facility, DWPF, and Saltstone.

7.4.3.3 Acid Only

The risks of the Acid Only Process are similar to the risks in the DWPF Salt Cell. The benzene produced could be condensed and collected in a decanter. This would produce more high boiling point organics and less benzene than the DWPF Salt Cell process. The resultant solution, approximately the same volume as the original solution, would be fed to the DWPF SRAT for ultimate processing. The other liquid product would be benzene and other organic decomposition products that are soluble in benzene. Testing would need to be completed to ensure that this slurry is compatible with DWPF.

7.4.3.4 Acid Plus Catalyst in a New Facility

The risks of the Acid Plus Catalyst Process are similar to the risks in the DWPF Salt Cell. This process would be similar in complexity to the DWPF Salt Cell process. This would produce more high boiling point organics and less benzene than the DWPF Salt Cell process. The resultant solution, approximately the same volume as the original solution, would be fed to the DWPF SRAT for ultimate processing. The other liquid product would be benzene and other organic decomposition products that are soluble in benzene. Testing would need to be completed to ensure that this slurry is compatible with DWPF.

7.4.3.5 Thermal Decomposition (Steam Reforming)

The risks of steam reforming are fairly well understood as steam reforming is used commercially. Decomposition of TPB during processing generates mainly CO_2 and Nitrogen, although incomplete reduction would lead to NO_x production and incomplete oxidation of benzene could lead to CO production. The TPB is decomposed using elevated temperatures (600-800°C), which requires superheated steam, a reductant such as coal or sugar, and a catalyst. The product from steam reforming would be a dehyrated solid. This solid would be combined with water and fed to the DWPF for ultimate processing. Testing would be required to ensure this slurry is compatible with DWPF.

7.4.3.6 Oxidant Process

An oxidation process may be possible in Tank 48H using sodium permanganate. Although decomposition of TPB during processing would produce relatively less benzene and more carbon dioxide, a number of other TPB decomposition byproducts, including benzene, phenol, and biphenyl would still be produced. The TPB is decomposed at ambient tank temperatures (25-40°C). However, oxidation of TPB leads to heat generation so higher temperatures can be reached if the oxidation reaction rate is not properly controlled. The benzene from this process would be removed via natural evaporation to the atmosphere. The product from the oxidation of TPB is a salt solution containing nonvolatile TPB decomposition products. This solution would likely be fed to the Salt Processing Facility. The solids from the Salt Processing Facility containing a large concentration of MnO_2, would be fed to DWPF for ultimate processing. The decontaminated supernate would be fed to Saltstone. Testing would be needed to ensure that this slurry is compatible with the Salt Processing Facility, DWPF, and Saltstone.

7.4.3.7 Oxidant Plus Acid Process

The addition of sodium permanganate, an oxidant together with formic acid can be combined to increase the TPB decomposition. This process may be possible in Tank 48H or another facility. An acid addition leading to a final solution pH of 9.5 is possible in-tank while a lower solution pH of 4 or less would probably be performed in a new facility. The TPB is decomposed at ambient tank temperatures (25-40°C). However, oxidation of TPB leads to heat generation so higher temperatures can be reached if the oxidation reaction is not properly controlled. The benzene from this process would be removed via natural evaporation to the atmosphere. The product from the oxidation of TPB is a salt solution containing any nonvolatile TPB decomposition products. This solution would likely be fed to the Salt Processing Facility. The solids from the Salt processing facility containing a large concentration of $Mn0_2$, would be fed to DWPF for ultimate processing. The decontaminated supernate would be fed to Saltstone. Testing would be needed to ensure that this slurry is compatible with the Salt Processing Facility, DWPF, and Saltstone.

7.4.3.8 Fenton Process

The addition of sodium peroxide, an oxidant, iron, a catalyst together with formic acid can be combined to increase the TPB decomposition. The risks are very similar to the permanganate plus acid process. One additional risk is that hydrogen peroxide can react with itself andd decomposed to oxygen plus water. As a result, the process would have to be inerted and have oxygen monitoring to prevent a flammable mixture from forming. Although decomposition of TPB during processing would produce relatively less benzene and more carbon dioxide, a number of other TPB decomposition byproducts, including benzene, phenol, and biphenyl would be produced. The TPB is decomposed at ambient tank temperatures (25-40°C) but the tank contents could be cooled or diluted if the reaction rate is higher than expected. The benzene from this process would be removed via natural evaporation to the atmosphere. The product from the oxidation of TPB is a salt solution containing nonvolatile TPB decomposition products. This solution would probably be fed to the Salt Processing Facility.

The solids from the Salt Processing Facility containing iron, would be fed to DWPF for processing. The decontaminated supernate would be fed to Saltstone. Testing would be needed to ensure that this slurry is compatible with the Salt Processing Facility, DWPF and Saltstone.

7.4.3.9 Catalyst Plus Acid Process

A catalyst process may be possible in Tank 48H or another facility. An acid addition leading to a final solution pH of 9.5 is possible in-tank while a solution with a pH of 4 or less would probably be performed in a new facility. Formic acid plus a catalyst would be combined with the TPB slurry to decompose the TPB. The main risk of an acid hydrolysis process is the benzene generation during TPB decomposition. As a result, the process would have to be inerted to prevent flammability. Although decomposition of TPB during processing would produce less benzene and more carbon dioxide, a number o other TPB decomposition byproducts, including benzene, phenol, and biphenyl would be produced. The TPB is decomposed at ambient tank temperatures (25-40°C), but the tank contents could be cooled or diluted if the reaction rate is higher than expected. The benzene from this process would be removed via natural evaporation to the atmosphere. The product from the oxidation of TPB is a salt solution containing nonvolatile TPB decomposition products. This solution would likely be fed to the Salt Processing Facility. The solids from the Salt Processing Facility containing the catalyst, would be fed to DWPF for ultimate processing. The decontaminated supernate would be fed to Saltstone. Testing would be needed to ensure that this slurry is compatible with the Salt Processing Facility, DWPF, and Saltstone.

7.5 Selection Process

7.5.1 Re-Screening

In the initial screening (Phase 1), no option was rejected based upon lack of knowledge, however; several potentially fatal flaws were uncovered within some of the initial list options after reviewing the technical data obtained during Phase 2. If this knowledge had been available at the time of initial screening, it would have resulted in the exclusion of these options. As a result, the team decided to re-screen the all current options using the original Phase 1 screening criteria to reduce the number of alternatives for Phase 2 evaluation by eliminating those that are no longer viable.

The initial list was modified to add three new options:

- Permanganate + Acid
- Fenton's Reagent
- Acid Only

After screening the number of options was reduced down to nine see (Table 7.5-1).

Table 7.5.1 Options Carried Forward To Selection Process

Evaluation Code	**Initial list Option upon which Selection option is based**	**Alternative Description**	**How?**	**Re-Screening Result**
CDAT-D	3	DWPF Salt Cell Catalytic Decomposition Process (considered for technology/process)	Thermal + Catalytic + Acidic	Pass
CDAT-N	6	Catalytic Decomposition of TPB in a New Facility	Thermal + Catalytic + Acidic	Pass
CD	5	Catalytic Decomposition of TPB	Catalytic	Pass
CDA	7	Catalytic Decomposition of TPB by Lowering pH (Acid Addition)	Acidic + Catalytic	Pass
THERMAL	11	Thermal Decomposition of TPB	Thermal	Pass
	37	Hybrid – Microwave Destruction of Organics	Thermal	Testing showed tThis isto be another form of thermal and has been grouped with Alternative 11
	39	Steam Reforming/Fluidized bed Destruction of Organics	Thermal	Grouped with Alternative 11
	38	Volume-Reduce by Filtration, Sending Filtrate to Tk 50, Catalytic Decomposition of Residual In-Tank	Catalytic	Grouped with Alternative 5
	33	Catalytically Decompose TPB Using Tank 49 as a Reaction Vessel	Catalytic	Grouped with Alternative 5
	35	Actinide Removal Process (ARP) Oxidation of TPB Using Permanganate	Oxidation	Grouped with Alternative 10
	36	Hybrid – Tank In Tank		Considered for use with alternatives where applicable but not carried on as an option itself
	8	Oxidation of TPB Using UV Catalyzed TiO_2	Catalyzed Oxidation	Reject- vendor indicated technology will not work on opaque solutionsHas not been successfully proven

Evaluation Code	**Initial list Option upon which Selection option is based**	**Alternative Description**	**How?**	**Re-Screening Result**
	17	Distribute Among Other Tank	Data Study	Reject-Too great an impact on existing tanks and not allowed per current AB, 96-1 and regulatory restrictions
	18	Direct Grout	Data Study	Reject-Does not meet WAC without significant (approx ~32X) dilution which is not feasible for implementation
	9	Oxidation of TPB Using Water Soluble Mild Oxidant	Oxidation	Reject-Testing showed no favorable results
PERM	10	Oxidation of TPB Using Permanganate	Oxidation	Pass
	23	In-Tank (or coupled tank) Bioremediation	Contract	Investigation to be carried along in a parallel effort and re-introduced into the evaluation if favorable test results are achieved
	26	Hybrid – Metathesize with Cold Cesium		Considered for use with alternatives where applicable but not carried on as an option itself
PERM+ACID	New Option	Permanganate + Acid	Acid + Oxidation	Pass
FENTON	New Option	Fenton's Reagent (iron, acid and peroxide)	Acid + Catalyst + Oxidation	Pass
ACID	New Option	Acid Only	Acid	Pass

7.5.2 Methodology/Tool

The weighted selection criteria (Table 7.2-2) was used to evaluate the options listed in Table 7.5-1. The team employed an analytical hierarchy process by using the ECPro software tool and a "pair-wise" comparison of options. Each option was successively compared against each other for each of the selection the criteria. The ECPro software tool applied the selection criteria weights to the numerical values obtained from the comparisons to establish a score for each of the options.

To assist in the comparison of the options for process rate it was necessary to estimate additional data and assume the location (i.e. "in-tank" or "out-of-tank") for the option based on compatibility of the process chemistry with the tank. The process rates estimated and used in pair –wise comparison are shown in Table 7.5.2-1.

Table 7.5.2-1 Process Rates

Option	In Tank	gal/batch	Weeks to Process
Salt Cell Process	No	5,000	50
Catalytic Process	Yes	250,000	30
Acid Only	No	5,000	50
Acid + Cattiest New Facility	No	5,000	50
Thermal	No	5,000	50
Oxidant Only	Yes	250,000	20
Permanganate + Acid[1]	No	5,000	50
Catalyst + Acid[1]	No	5,000	50
Fenton[1]	No	5,000	50

[1] The team evaluated these processes as out of tank due to the lack of a complete data set at pH 9.5; however, the team expects that these processes will function at pH>9.5 and may be acceptable as in tank processes.

Although different hazards were associated with the options, the level of control necessary to make the hazards safe was relatively similar throughout. To assist in discriminating between the options Table 7.5.2-2 was developed.

Table 7.5.2-2 Process Hazards

Option	In Tank[1]	Benzene[2]	Chemical Interaction (CI) and Other
Salt Cell Process	No	100%	CI-Moderate
Catalytic Process	Yes	100%	CI-Low
Acid Only	No	100%	CI-Moderate
Acid + Catalyst New Facility	No	100%	CI-Moderate
Thermal	No	0%	CI-Low; Superheated Steam
Oxidant Only	Yes	50%	CI-High
Permanganate + Acid	No	50%	CI-High
Catalyst + Acid	No	100%	CI-Moderate
Fenton	No	50%	CI-High

[1] Easier to design controls for a well engineered out of tank process than to retrofit Tank 48 to accomplish the same process.

[2] Relative benzene production (a thermal method would destroy all of the benzene, while an oxidation reaction would destroy most of the benzene and the other reactions would produce virtually all benzene as the primary decomposition product).

After the pair-wise comparisons were completed the AHP determined the score of each option. The results are shown in Attachment 3-1.

7.6 Sensitivity Analysis

A sensitivity analysis was performed on the selected alternatives to see if change in the weighting of any Selection criterion would alter the final selection. The dynamic sensitivity analysis feature of the selection support software, ECPro, was used to perform this analysis. By increasing the weight of a selection criteria by 50%, the program proportionally adjusted the remaining criteria and recalculated the score for each option. This was done for each selection criteria and demonstrated that the rankings based on the obtained scores did not change for the firsttop and second ranked options. The leading two options were shown to be robust selections as the sensitivity analysis did not change their rankings. The third through fifth options remained relatively close during the analysis but did change in ranking order. (Refer to Attachments 3-2 through 3-9)

The team then adjusted the selection criteria weighting to equalize all weights. The resulting ranking (Attachment 3-1) shows Permanganate and Catalytic Decomposition ranked first and second with Salt Cell process and Thermal Decomposition ranked second and third. This demonstrates that if the technical risk and science issues could have been resolved with these in-tank options they would have been ranked first and second instead of the Salt Cell process and Thermal Decomposition.

7.7 Selection Conclusions

The first and second ranked options were Salt Cell Technology/Process and Thermal Decomposition.

The Team concluded that the first and second option should be carried forward to the final selection and recommendation phase where cost and schedule considerations will be investigated and considered in a final recommendation.

The research on the Bioremediation option should be allowed to continue to completion as this option, sufficiently matured and tested could provide the most favorable solution if the R&D results are acceptable.

The amount of research needed to complete development of the technical bases for the in-tank process options appears relatively modest versus the costs required to pursue the two leading candidates (see Attachment 4). Hence, continued research on the most promising of those options – i.e., use catalyst and permanganate – appears prudent. The Team recommends aggressive pursuit of these options.

If any of the remaining options are matured further before the final recommendation, the Team should perform a review as part of the final recommendation process to ensure that a desirable option has not been excluded.

8.0 References

1 WSRC-RP-2002-00131, HLW Tank 48 Disposition Systems Engineering Management Plan, Revision 0, February 5, 2002.
2 WSRC Purchase Order AC2607N to PMC Technologies, June 18, 2002.
3 WSRC-TR-2000-00253, Rev. 0, Tank 49 Disposition Plan, K.B. Martin, T.B. Peters, R.C. Fowler, R.J. Bentley, C.D. Banaszewski, M. R. Poirier, July 2, 2000.
4 WSRC-RP-93-527, Rev. 0, DWPF Coupled Feed Flowsheet Material Balance with Batch One Sludge and Copper Nitrate Catalyst, A.S. Choi, September 28, 1993.
5 WSRC-RP-94-149, Technical Investigation of the Aquafine Incident (U), M.J. Barnes, February 4, 1994.
6 WSRC-NB-2002-00031, Laboratory Notebook, "Tank 48 Decomposition Studies", pages 22-26.
7 HLW-SDT-99-0266, Salt Cell Equipment Relocation Study, Revision 0, August 31, 1999.

9.0 List of Abbreviations

The following abbreviations are used through the report and are listed for clarification.

1PB – phenylboronic acid – $C_6H_5B(OH)_2$
2PB – diphenylborinic – $(C_6H_5)_2BOH$
3PB – triphenylbor - $(C_6H_5)_3B$
4PB – tetraphenylborate or tetraphenyl boron, also TPB
CD - Critical Decision
CIF - Consolidated Incineration Facility
Cs - Cesium
D&D - Decontamination and Decommission
DNFSB - Defense Nuclear Facility Safety Board
DOE - Department of Energy
DOE-SR - Department of Energy - Savannah River
DWPF - Defense Waste Processing Facility
e.g. - for example
EPA - Environmental Protection Agency
ESP - Extended Sludge Processing
ETF - Effluent Treatment Facility
FFA - Federal Facility Agreement
HLW - High Level Waste
ITP - In-Tank Precipitation
JCO – Justification for Continued Operations
MST – Monosodium Titanate
N/A - Not Applicable
NaTPB - Sodium Tetraphenylborate
RAMI – Reliability, Availability, Maintainability and Inspectability
R&D – Research and Development
SCDHEC - South Carolina Department of Health and Environmental Control
SE - Systems Engineering
SEMP - Systems Engineering Management Plan
SRS - Savannah River Site
SRTC – Savannah River Technology Center
SSC – Systems, Structures and Components
TBD - To Be Determined
TPB – Tetraphenylborate $(NaB(C_6H_5)_4$
WSMS - Westinghouse Safety Management Solutions, Inc.
WSRC - Westinghouse Savannah River Company

Attachment 1 - Phase 1 Screening Tables

Table 1A – Alternatives Rejected (Go-No Go)

Alternative #/Title	Disposition - Comments
15 - Remove Cs/K with Organic Solvent and burn residue at CIF	Reject – Facilities do not exist Reject – Technical Maturity is too low Reject – Residue disposal path/criticality unknown
16 – Burn Tank 48H contents at CIF after Appropriate Dilution	Reject -- Facilities nor interface do not exist
19. – Do Nothing	Reject – Doesn't meet mission
20 – Partner with GrayStar for Cs sources	Reject – Facilities do not exist to strip Cs Reject – Does not address the organic problem
25. – Use an Outside Vendor for Disposal	Reject – Interface Complexity
29 – Remove Supernate and react phenylborate heel in solvent	Reject – This is an intermediate step requiring an unknown solvent and leading to an undetermined outcome

Attachment 1 - Phase 1 Screening Tables

Table 1B – Alternatives That Failed To Meet Screening Criteria

Alternative #/Title	Disposition	Comments
1. Sodium Tetraphenylborate Strike and Filter	Reject –	Produces No Gain Toward Goal
2. Feed KTPB Slurry to DWPF Melter Directly	Reject – Safety Interface	Off Gas Problem Limited Process Rate
4. Feed KTPB Slurry to DWPF Chemical Processing Cell for Decomposition	Reject – Safety Interface	Flammability in the Chem Cell Limited Process Rate
12. Electrochemical Decomposition of TPB	Reject – Maturity	
13. Supercritical Solvent Oxidation	Reject – Safety	
14. DuPont NaTPB Destruction Scheme	Reject – Safety Interface	High Temperature/Pressure A Recycle Process
17. Distribute Tank 48 Contents Among the Other Waste Tanks	Reject – Interface	Compounds the Problem
18. Direct Grout	Reject – Permit ./Interface	Permit Changes Required Interference with Current Feed Plans
21. Add Waste to Tank 48 and Decompose Radiolytically	Reject – Safety Interface	Change in Source Term will effect Authorization Bases. Slow Process
22. Transfer Tank 48 Material to Another Waste Tank and Decompose Radiolytically	Reject – Interface	Takes a Second Tank from Service and The Process is Slow

Alternative #/Title	Disposition	Comments
23. In Tank Bioremediation	Reject – Maturity	
24. Add Tank 48 Material to Another Tank Scheduled to be Decommissioned (Grouted)	Reject – Permit Interface	Curie Content and Organics Would Require New Permit
27. Add Tank 48 Contents to Tank 49	Reject – Interface	Moves the Problem from 48 to 49 with Nothing Gained
28. Send to Containment Facility	Reject – Duplicate of 10	
30. Evaporate to Dryness and Bury or Add to Grout	Reject – Safety Maturity	Handling and Transportation of Dry Material
31. Develop Method to Stabilize Material and Use Tank 48 "As-is"	Reject – Maturity	
32. Pyrolytic Decomposition of Precipitate	Reject – Duplicate of 11	
34. Use of Solvent to Extract KTPB, Park Solvent in Unused Waste Tank	Reject – Safety Interface	Flammability Organics Sill Exist
35. MST/TPB Strike in the Flow Sheet for the HLW System	Reject – Interface	Requires MST/TPB and Salt Cell – Neither Existing or Planned

Attachment 1 - Phase 1 Screening Tables

Table 1C – Alternatives That Are Accepted In Part

Alternative #/Title	Disposition	Comments
26. Metathesize with Cold Cesium	Consider in Part – Does not Satisfy Mission Statement	Precursor to Another Solution
35. Actinide Removal Process (ARP) Using Permanganate	Consider in Part – Hybrid – Does not Utilize Existing or Planned Facilities	
36. Tank in Tank	Consider in Part – Hybrid – Does not Utilize Existing or Planned Facilities	
37. Microwave Destruction of Organics	Consider in Part – Hybrid – Maturity may not Exist for Tank 48 Material	

Attachment 1 - Phase 1 Screening Tables

Table 1D – Alternatives That Are Accepted

Alternative #/Title	Disposition	Comments
3. Feed KTPB Slurry to DWPF Salt/Cell for Decomposition	Accept	
5. Chemically Decompose TPB Directly in Tank Using a Catalyst	Accept	
6. Chemically Decompose Directly in a New or Existing Facility Outside Tank 48 Using a Catalyst	Accept	
7. Chemically decompose Directly in Tank by Lowering pH (Acid Addition)	Accept	
8. Photolytically Decompose Tetraphenylborate Compounds Using TiO_2	Accept	
9. Decompose by Addition of Water Soluble Mild Oxidant	Accept	
10. TPB Decomposition Using Permanganate1	Accept – New Tank/Facility	
11. Thermal Decomposition in DWPF, Send Residue to Melter	Accept	
33. Tank 49 as a Reaction Vessel	Accept	
38. Volume – Reduce by Filtration, Sending Filtrate to Tank 50, Decompose Residual In-Tank	Accept	
39. Steam Reforming/Fluidized Bed	Accept	

ATTACHMENT 2 – ALTERNATIVE INFORMATION SHEETS

The following pages are the summaries from each of the alternatives that were considered by the team. For each alternative, a summary was prepared that included the following information:

- Alternative Number
- Sponsor
- Date
- Title
- Description:
- Advantages
- Disadvantages
- Safety Issues
- Permitting Issues
- Interface Issues
- Technical Issues
- Technical Maturity

HLW TANK 48 ALTERNATIVE DATA SHEET

Alternative # 1	**Sponsor:** R. C. Fowler	**Date:** 1/14/02
Title	Sodium Tetraphenylborate Strike and Filter	
Description	Make a NaTPB strike in Tank 48 to reduce soluble cesium-137 content. Filter supernate until the tank contains approximately 10 % solids. Dispose of the filtrate in Tank 50 (and subsequently Saltstone). Use remaining space in Tank 48 for addition of new waste.	
Advantages	Relatively simple and involves no new technology development	
Disadvantages	Limited gain in space. Tank would still contain organic material making it unsuitable for transfer to rest of Tank Farm.	
Safety Issues	Addition of NaTPB and fresh waste to Tank 48 would require modification and approval of the current Authorization Basis	
Permitting Issues	None	
Interface Issues	None	
Technical Issues	None	
Technical Maturity	High. Proposal uses existing ITP Technology	

HLW TANK 48 ALTERNATIVE DATA SHEET

Alternative #	2	**Sponsor**	Dan Lambert	**Date**	1-14-2002

Title	Feed KTPB slurry to DWPF melter directly
Description	A small transfer of the Tank 48 Contents would be metered into the DWPF SME at the completion of the SME cycle. The SME slurry is transferred to the DWPF MFT and fed to the DWPF melter.
Advantages	1. This is a simple disposal method with no processing required in DWPF. No washing of the KTPB slurry is necessary 2. If the TPB slurry is dilute (<10 wt % insoluble solids), the slurry can be concentrated further and the filtrate fed to Saltstone. This will minimize the volume to be processed by DWPF.
Disadvantages	1. The tetraphenylborate may decompose to benzene in the SME or MFT. These tanks and their purges were not designed to handle that a large quantity of benzene. DWPF PHA was limited to 53 ppm PBA (equivalent to 30 ppm benzene) to prevent a flammable mixture from forming in the feed tanks or during processing. 2. The tetraphenylborate may decompose to tar-like organics that may lead to processing problems (organic buildup hindering heat transfer and plugging piping) in DWPF. 3. The tetraphenylborate and its decomposition products will be oxidized in the melter cold cap. If it is not completely oxidized to CO_2, it may lead to a flammable mixture (CO) in the melter offgas system. 4. The tetraphenylborate may reduce the metals present in the melter feed particularly the noble metals. This could shorten melter life. 5. As with any process done outside of Tank 48, there will likely be a significant heel left in Tank 48. 6. A new DWPF flowsheet would be necessary to add unwashed KTPB slurry to DWPF. The unwashed slurry would have significant sodium that may impact the choice of frit that is used in DWPF.
Safety Issues	Flammability of benzene in the CPC offgas system and flammability of CO in the melter offgas.
Permitting Issues	None
Interface Issues	1. Any direct feeding of KTPB slurry to the DWPF melter would likely exceed the DWPF Total Organic Carbon limit for the melter feed. 2. DWPF piping would need to be modified to allow transport the KTPB slurry into the SME or MFT.
Technical Issues	1. Transportation of KTPB slurries can be a challenge. Foaming and the high yield stress of KTPB slurries make transportation difficult. 2. Decomposition of the KTPB in the DWPF SME will lead to steam stripping of organics into the offgas system. Presence of these tar-like organics has lead to operational problems in pilot operations.
Technical Maturity	Medium – This was considered as an alternative in the development of the DWPF process.

HLW TANK 48 ALTERNATIVE DATA SHEET

Alternative #	3	**Sponsor**	Dan Lambert	**Date**	1-14-2002
Title	Feed KTPB slurry to DWPF salt cell for decomposition				
Description	The Tank 48 Contents would be washed in the late wash facility, processed in the DWPF Salt Cell to destroy the TPB and combined with the sludge in the DWPF SRAT. This is the current DWPF process.				
Advantages	The DWPF Salt Cell was designed to process the KTPB slurry. If the TPB slurry is dilute (<10 wt % insoluble solids), the slurry can be concentrated further and the filtrate fed to Saltstone. This will minimize the volume to be processed by DWPF.				
Disadvantages	As with any process done outside of Tank 48, there will likely be a significant heel left in Tank 48. It is likely that significantly more than 250,000 gallons of waste will be generated. The startup of the Late Wash Facility and the restart of the SPC will be complicated by the presence of radioactivity in DWPF. The SPC canyon space could not be used for other processing that is being considered such as alpha removal. Additional processing in DWPF is likely to extend processing time, as the analytical laboratory may become the DWPF bottleneck. The DWPF analytical lab will have to reestablish analytical support for the salt cell processing.				
Safety Issues	None.				
Permitting Issues	None.				
Interface Issues	The KTPB slurry would have to be washed prior to processing. This would involve restarting the DWPF Late Wash Facility and the DWPF Salt Cell. A method would need to be developed to dispose of benzene with the shutdown of the Consolidated Incinerator Facility.				
Technical Issues	Transportation of KTPB slurries can be a challenge. Foaming and the high yield stress of KTPB slurries make transportation difficult.				
Technical Maturity	High				

HLW TANK 48 ALTERNATIVE DATA SHEET

Alternative #	4	**Sponsor**	Dan Lambert	**Date**	1-14-2002
Title	Feed KTPB slurry to DWPF salt cell for decomposition				
Description	The Tank 48 Contents would be washed in the late wash facility processed in the DWPF Salt Cell to destroy the TPB and combined with the sludge in the DWPF SRAT. This is the current DWPF process.				
Advantages	1. The DWPF Salt Cell was designed to process the KTPB slurry. 2. If the TPB slurry is dilute (<10-wt % insoluble solids), the slurry can be concentrated further and the filtrate fed to Saltstone. This will minimize the volume to be processed by DWPF.				
Disadvantages	1. As with any process done outside of Tank 48, there will likely be a significant heel left in Tank 48. It is likely that significantly more than 250,000 gallons of waste will be generated. 2. The startup of the Late Wash Facility and the restart of the SPC will be complicated by the presence of radioactivity in DWPF. 3. The SPC canyon space could not be used for other processing that is being considered such as alpha removal. 4. Additional processing in DWPF is likely to extend processing time, as the analytical laboratory may become the DWPF bottleneck. The DWPF analytical lab will have to reestablish analytical support for the salt cell processing.				
Safety Issues	None.				
Permitting Issues	None.				
Interface Issues	1. The KTPB slurry would have to be washed prior to processing. This would involve restarting the DWPF Late Wash Facility and the DWPF Salt Cell. 2. A method would need to be developed to dispose of benzene with the shutdown of the Consolidated Incinerator Facility.				
Technical Issues	1. Transportation of KTPB slurries can be a challenge. Foaming and the high yield stress of KTPB slurries make transportation difficult.				
Technical Maturity	High				

HLW TANK 48 ALTERNATIVE DATA SHEET

Alternative #	5	**Sponsor**	Dan Lambert	**Date**	1-15-2002
Title	Chemically decompose TPB directly in tank using a catalyst				
Description	Adding a catalyst would increase the decomposition rate of the TPB present in Tank 48. The benzene produced in the tank would be removed through evaporation.				
Advantages	1. This is disposal method would utilize existing processing facilities. 2. This is similar to the method used for Tank 49. 3. If the TPB slurry is dilute (<10 wt % insoluble solids), the slurry can be concentrated further and the filtrate fed to Saltstone. This will minimize the quantity to be processed. 4. No washing of the KTPB slurry is necessary. 5. Since the processing will be completed in the waste tank, there will be no unprocessed material in the tank.				
Disadvantages	1. Would need to resolve DNFSB 96-1 issues prior to commencing processing. 2. It will be difficult to control the rate of TPB decomposition and the byproducts of the decomposition in a waste tank. The decomposition products of the decomposition are likely to form tar-like organics that may cause future processing problems. 3. The decomposition reaction rate will be controlled by the concentration of catalyst, waste temperature and liquid pH. To prevent high benzene generation, it is likely that reaction rate will initially be high and will decrease over time. It is likely that higher temperature and lower pH will be required to maximize the decomposition rate. 4. The Tank 48 waste after decomposition will likely require additional treatment to meet WAC requirements due to the organic byproducts of the TPB decomposition. 5. The benzene disposal path is through evaporation. If all the potential benzene in the TPB decomposes to benzene and evaporates, approximately 100,000 kg of benzene will be released. Permit modifications may be required to handle benzene emissions				
Safety Issues	Flammability of benzene in Tank 48. Tank 48 was not designed to be a reaction vessel. Benzene is heavier than air and will accumulate near the liquid surface. A loss of ventilation would lead to flammability concerns, especially if temperature cycling leads to the addition of oxygen to the waste tank.				
Permitting Issues	The benzene limit might need to be readdressed, as the annual benzene limit will be exceeded if all the TPB decomposes to benzene and evaporates.				
Interface Issues	Additional processing may be necessary to handle the Tank 48 waste after decomposition is complete. Additional processing (organic removal) may be necessary.				
Technical Issues	1. How to control the decomposition rate. 2. How to minimize the production of unwanted byproducts. 3. Decomposition of KTPB is much more difficult than NaTPB. 4. How to accomplish decomposition without damaging waste tank (corrosion).				
Technical Maturity	Medium				

HLW TANK 48 ALTERNATIVE DATA SHEET

Alternative #	6	**Sponsor**	Dan Lambert	**Date**	1-15-2002
Title	Chemically decompose directly in a new or existing facility outside Tank 48 using a catalyst				
Description	A new process facility would be built to chemically decompose the TPB slurry using a catalyst. This new facility could take that place of the late wash facility and the DWPF salt cell or be used to decompose the TPB solution without washing.				
Advantages	1. A well-designed facility can be constructed to process the KTPB slurry. This is known technology that would require minimal development. 2. Benzene can be purified (radioactivity removed) to the point that it can be incinerated offsite. 3. The TPB will be decomposed to benzene so the final slurry should be acceptable for feeding to DWPF or returning to a waste tank.				
Disadvantages	1. There would be a significant investment in the construction of a new facility. 2. As with any process done outside of Tank 48, there will likely be a significant heel left in Tank 48.				
Safety Issues	None.				
Permitting Issues	A new facility would require new permits.				
Interface Issues	1. A method would need to be developed to dispose of benzene with the shutdown of the Consolidated Incinerator Facility.				
Technical Issues	1. Transportation of KTPB slurries can be a challenge. Foaming and the high yield stress of KTPB slurries make transportation difficult.				
Technical Maturity	High				

HLW TANK 48 ALTERNATIVE DATA SHEET

<table>
<tr><td>Alternative #</td><td>7</td><td>Sponsor</td><td>Dan Lambert</td><td>Date</td><td>1-15-2002</td></tr>
<tr><td>Title</td><td colspan="5">Chemically decompose directly in tank by lowering pH (acid addition)</td></tr>
<tr><td>Description</td><td colspan="5">Lowering the pH would increase the decomposition rate of the TPB present in Tank 48. It is likely that higher temperature and a catalyst would be required to maximize the decomposition rate. The benzene produced in the tank would be removed through evaporation.</td></tr>
<tr><td>Advantages</td><td colspan="5">1. This is disposal method would utilize existing processing facilities.
2. This is similar to the method used for Tank 49.
3. If the TPB slurry is dilute (<10 wt % insoluble solids), the slurry can be concentrated further and the filtrate fed to Saltstone. This will minimize the quantity to be processed.
4. No washing of the KTPB slurry is necessary.
5. Since the processing will be completed in the waste tank, there will be no unprocessed material in the tank.</td></tr>
<tr><td>Disadvantages</td><td colspan="5">1. Would need to resolve DNFSB 96-1 issues prior to commencing processing.
2. It will be difficult to control the rate of TPB decomposition and the byproducts of the decomposition in a waste tank. The decomposition products of the decomposition are likely to form tar-like organics that may cause future processing problems.
3. The decomposition reaction rate will be controlled by the concentration of catalyst already present in Tank 48, waste temperature and liquid pH. To prevent high benzene generation, it is likely that reaction rate will initially be high and will decrease over time.
4. The Tank 48 waste, after decomposition will likely require additional treatment to meet Waste acceptance requirements due to the organic byproducts of the TPB decomposition.
5. The benzene disposal path is through evaporation. If all the potential benzene in the TPB decomposes to benzene and evaporates, approximately 100,000 kg of benzene will be released. The likely benzene emissions are significantly lower. Permit modifications may be required to handle benzene emissions.</td></tr>
<tr><td>Safety Issues</td><td colspan="5">1. Flammability of benzene in Tank 48. Tank 48 was not designed to be a reaction vessel. Benzene is heavier than air and will accumulate near the liquid surface. A loss of ventilation would lead to flammability concerns, especially if temperature cycling leads to the addition of oxygen to the waste tank.
2. Corrosion will be increased by the addition of acid to lower the pH. A low pH (bulk solution or locally) is expected to increase the Tank corrosion rate.</td></tr>
<tr><td>Permitting Issues</td><td colspan="5">The benzene limit might need to be readdressed, as the annual benzene limit will be exceeded if all the TPB decomposes to benzene and evaporates.</td></tr>
<tr><td>Interface Issues</td><td colspan="5">1. Additional processing may be necessary to handle the Tank 48 waste after decomposition is complete. Organic removal may be necessary.</td></tr>
<tr><td>Technical Issues</td><td colspan="5">1. How to accomplish decomposition without damaging waste tank (corrosion).
2. How to control the decomposition rate.
3. How to minimize the production of unwanted byproducts.
- Decomposition of KTPB is much more difficult than NaTPB.</td></tr>
<tr><td>Technical Maturity</td><td colspan="5">Medium</td></tr>
</table>

HLW TANK 48 ALTERNATIVE DATA SHEET

Alternative #	8	**Sponsor**	R. C. Fowler	**Date**	1-14-2002
Title	Photolytically Decompose Tetraphenylborate Compounds Using TiO_2				
Description	An ultraviolet (UV) source and a titanium dioxide bed would be used to decompose the organic material in Tank 48. The slurry would be drawn from the tank using the existing transfer pump and passed through the bed allowing the UV light to breakdown the organic material while the TiO_2 would serve as a catalyst. The operation would require a shielded facility such as the filter cells in building 241-96H (the old ITP filter building). Once the organics were destroyed, the tank would be capable of accepting waste from the Tank Farm and vice versa.				
Advantages	Uses existing facilities and does not introduce new chemical compound to the system				
Disadvantages	Research required for determining reaction rates and effectiveness of operation. Refurbishing of the ITP Filter Building for new use. A technology not used before on HLW				
Safety Issues	The new system will have to be addressed by the Authorization Basis. Shielding workers from UV source				
Permitting Issues	None				
Interface Issues	None				
Technical Issues	New technology for HLW. Effectiveness and speed of decomposition not known.				
Technical Maturity	Low. Development still needed				

Alternative #	9	**Sponsor**	Peters	**Date**	1-21-2002
Title	Decompose by addition of water soluble mild oxidant				
Description	We propose to locate a water soluble, stable, mild oxidant, such as a metal peroxide/superoxide. Such a compound could react in a stoichiometric fashion to destroy the TPB (and possibly the other phenylborates). Ideally, the byproducts of such a reaction would be inconsequential (phenol or CO2, for example).				
Advantages	The reaction would be controlled by the gradual addition of the oxidant (a non-catalytic reaction). Byproducts should be of no issue.				
Disadvantages	The target compound has to be located and tested. It may not exist, but a literature search can determine that.				
Safety Issues	A new compound would be added to the tank, and the reaction capability of this material must be well understood.				
Permitting Issues	No new waste streams should be generated.				
Interface Issues	This should require no new facilities or structures.				
Technical Issues	The candidate compound/s/ must be located. The reaction rates and byproducts must be determined.				
Technical Maturity	None at the scale of the waste tank.				

HLW TANK 48 ALTERNATIVE DATA SHEET

Alternative #	10	**Sponsor**	Peters	**Date**	1-21-2002
Title	TPB decomposition using permanganate				
Description	Using a procedure similar in nature to what is used in the SRTC Containment building, it may be possible to completely break the phenylborates down into benzene and boric acid. This process involves adding sodium permanganate, oxalic acid and phosphoric acid. The ratio currently used at SRTC involved about 2 L of added chemicals to 1 L of TPB waste, although this varies somewhat.				
Advantages	The process, in smaller scale, is already being used. The chemistry is fairly understood. The process is also not catalytic and reaction runaway can be avoided.				
Disadvantages	Process may not scale up well and requires close monitoring during the addition of the chemicals.				
Safety Issues	Does this reaction need a corrosion study to insure to corrosion problems do not exist, if we do this in a steel reactor?				
Permitting Issues	: Potential issues in adding new materials to the tank (oxalic, phosphoric acids and permanganate).				
Interface Issues	A small reactor would be constructed.				
Technical Issues	May not scale up well.				
Technical Maturity	Fairly well understood and utilized.				

HLW TANK 48 ALTERNATIVE DATA SHEET

Alternative #	11	**Sponsor**	Dan Lambert	**Date**	1-17-2002
Title	Thermal decomposition in DWPF, send residue to melter				
Description	High temperature (~350°C) process for destroying TPB. TPB would further decompose to form a salt/carbon/boron residue that will be fed to the DWPF melter. The decomposition product would be benzene in an inert environment and CO_2 in an air environment.				
Advantages	1. High temperature (but not high pressure) leads to high reaction rate for decomposition of TPB. 2. It is likely that no addition chemicals (such as formic acid and cupric nitrate) are needed to complete the reaction. .				
Disadvantages	1. As with any process done outside of Tank 48, there will likely be a significant heel left in Tank 48. 2. A new facility would be required. 3. Significant research would be necessary to develop workable process. 4. It may be difficult to transfer the residue to the DWPF melter. 5. The addition of the residue to the melter may lead to a glass that is more reducing. 6. As with any process done outside of Tank 48, there will likely be a significant heel left in Tank 48.				
Safety Issues	1. How to safely thermally decompose the TPB. 2. High temperature process.				
Permitting Issues	1. New facility will need benzene permit for processing. 2. Need way to get rid of produced benzene.				
Interface Issues	1. . Will need to transfer TPB slurry to new facility. 2. Will need to transfer the residue to the DWPF melter.				
Technical Issues	1. What are the conditions for rapid but safe TPB decomposition? - How to safely operate high temp radioactive process safely?				
Technical Maturity	Medium				

HLW TANK 48 ALTERNATIVE DATA SHEET

Alternative #	12	**Sponsor**	Peters	**Date**	1-21-2002
Title	Electrochemical decomposition of TPB				
Description	TPB is a mild reducing agent and so should be susceptible to attack by oxidizing agents. In this case, an oxidizing current in the tank may decompose the TPB. **(talk to David)**				
Advantages	No new chemicals added to the tank. The process would be controlled by delivery of current and thus could be stopped quickly.				
Disadvantages	Does it work? New equipment needs to be designed to add to the tank (electrodes).				
Safety Issues					
Permitting Issues					
Interface Issues					
Technical Issues	Totally untried, but sound in theory.				
Technical Maturity	None from our perspective, but the theory is sound.				

HLW TANK 48 ALTERNATIVE DATA SHEET

Alternative #	13	**Sponsor**	Peters	**Date**	1-21-2002
Title	Supercritical solvent oxidation				
Description	Supercritical solvents (water, CO_2, etc) can dissolve otherwise intractable solids. Furthermore, supercritical water is known to be able to completely destroy organic compounds. Experiments performed at Sandia demonstrated effective destruction of the organic components of a simulated DOE mixed waste (radioactive plus organic waste).				
Advantages	Offers complete destruction of phenylborates with the use of no new solvents or chemicals. A very "green" technology.				
Disadvantages	Would require building of new equipment, including a high-pressure (220 psig+ in the case of supercritical water) reactor.				
Safety Issues	Would require a high-pressure reactor and building. This is most likely a large safety issue.				
Permitting Issues	None, other than high-pressure equipment.				
Interface Issues	Would require some sort of vessel/building to be constructed.				
Technical Issues	Would this scale up well?				
Technical Maturity	Supercritical solvent work is being extensively pursued in the industry as well as some government labs (LANL).				

HLW TANK 48 ALTERNATIVE DATA SHEET

Alternative #	14	**Sponsor**	Dan Lambert	**Date**	1-16-2002
Title	DuPont NaTPB destruction scheme (same as supercritical water oxidation?) to decomposed TPB outside Tank 48.				
Description	DuPont developed a high temperature hydrolysis process for destroying triphenylborane (3PB) using a high temperature (200°C), high-pressure process (250 psig) to hydrolyze 3PB to benzene. This process should work as well for TPB as 3PB. The process is carried out at a near neutral pH (~7)				
Advantages	1. High temperature leads to high reaction rate for decomposition of TPB. 2. It is likely that no addition chemicals (such as formic acid and cupric nitrate) are needed to complete the reaction.				
Disadvantages	1. A new facility would be required. 2. Significant research would be necessary to develop workable process. 3. As with any process done outside of Tank 48, there will likely be a significant heel left in Tank 48.				
Safety Issues	1. Flammability of benzene in new facility. 2. High temperature and high pressure process. This is the original TPB destruction process before the copper catalyst allowed the reaction to occur at 100°C.				
Permitting Issues	1. New facility will need benzene permit for processing. 2. Need way to get rid of produced benzene.				
Interface Issues	1. Will need to transfer resulting product (B, Cs, K) to waste tank. 2. Will need to transfer TPB slurry to new facility.				
Technical Issues	1. What are the conditions for rapid but safe TPB decomposition? 2. How to safely operate high temp, high-pressure radioactive process?				
Technical Maturity	Medium				

HLW TANK 48 ALTERNATIVE DATA SHEET

Alternative #	15	**Sponsor**	R. C. Fowler	**Date**	1-14-2002
Title	Remove Cs/K with Organic Solvent and burn residue at CIF				
Description	Develop an organic solvent to strip the cesium from the Tank 48 material. Some potassium would probably be absorbed in the process. This would deplete the tetraphenylborate precipitate of most of its radioactive content allowing it to be burned at CIF. The solvent containing the cesium would have to be stored or processed further at a later time				
Advantages	Concentrates radioactive cesium segment into a smaller volume, phenylborates are destroyed.				
Disadvantages	The need for an organic radioactive storage still remains, however at a smaller volume. Need to find another storage vessel in order to reclaim Tank 48 for Tank Farm use.				
Safety Issues	New process. Need to have an Authorization Basis update before implementation. Worker training needs to handle new solvent and new process.				
Permitting Issues	Organic solvent may require modification to environmental permits				
Interface Issues	Impact of solvent will have to be evaluated for impact to CIF, DWPF and Tank Farm				
Technical Issues	Development of suitable solvent and determination if process can be implemented in-tank and if it must be performed out of tank.				
Technical Maturity	Low, no work done in this area to date.				

HLW TANK 48 ALTERNATIVE DATA SHEET

Alternative #	16	**Sponsor**	R. C. Fowler	**Date**	1-14-2002
Title	Burn Tank 48 Contents at CIF After Appropriate Dilution				
Description	Dilute the contents of Tank 48 to meet the waste acceptance criteria of CIF. Transport the material to CIF and incinerate it.				
Advantages	Existing technology.				
Disadvantages	No direct path to CIF. Need to find pipeline or some way to "truck it"to the CIF. Radiological content of the tank is high, which might require a very large dilution. CIF is currently shutdown and in standby.				
Safety Issues	Effect of the radiological release need to be evaluated for co-located workers and off-site personnel.				
Permitting Issues	Evaluation of the proposed activity against existing permits must be done.				
Interface Issues	Neither facility is designed for this type of waste movement.				
Technical Issues	Shipment of the material. Meeting the CIF waste acceptance criteria				
Technical Maturity					

HLW TANK 48 ALTERNATIVE DATA SHEET

Alternative #	17	**Sponsor**	R. C. Fowler	**Date**	1-14-2002
Title	Distribute Tank 48 Contents Among the Other Waste Tanks				
Description	Using the current waste transfer system, distribute small amounts of Tank 48 material to all available tanks throughout the Tank Farm. By placing small amounts of the precipitate in many tanks, the hope is to maintain any individual tank below the threshold of declaring it an organic tank, thus freeing Tank 48 for new waste transfers.				
Advantages	No technology development. Relatively inexpensive.				
Disadvantages	An evaluation must be performed for each tank receiving the material to ensure it meets the organic limit. There may be to great a quantity of organics to be distributed in the Tank Farm. Administrative and Operational problems trying to make many very small transfers				
Safety Issues	Need to ensure the LFL limits of individual tanks are not challenged by the addition of organics.				
Permitting Issues	None				
Interface Issues	Need evaluation of impact of adding this material to remaining tanks on the eventual waste processing facilities (DWPF, Saltstone).				
Technical Issues	None				
Technical Maturity	High, waste transfers are common in the Tank Farm				

HLW TANK 48 ALTERNATIVE DATA SHEET

Alternative #	18	**Sponsor**	R. C. Fowler	**Date**	1-14-2002
Title	Direct Grout				
Description	Send the material in Tank 48 to Saltstone to be disposed of as grout. Movement of the precipitate to Tank 50 may be required before transferring it to Saltstone. Material can be diluted with existing Tank 50 material and				
Advantages	Existing technology. Relatively quick and inexpensive.				
Disadvantages	Phenylborate content may be too high for Saltstone. Radioactive content may be too high for Saltstone. Permitting issues				
Safety Issues	Addition of Tank 48 to Tank 50 could cause a reaction of waste with the precipitate resulting in unwanted benzene emissions. Tank 50 has no inerting capability.				
Permitting Issues	Material may not meet Saltstone Waste Acceptance Criteria				
Interface Issues	Material may not meet Saltstone Waste Acceptance Criteria.				
Technical Issues	None				
Technical Maturity	High. The transfer and processing of ITP Batch1 and ETF bottoms has been done in Saltstone for years.				

HLW TANK 48 ALTERNATIVE DATA SHEET

Alternative #	19	**Sponsor**	R. C. Fowler	**Date**	1-14-2002
Title	Do Nothing				
Description	Keep conditions at the status quo. No transfers into or out of Tank 48				
Advantages	Cheapest alternative				
Disadvantages	No gain in available space to the Tank Farm				
Safety Issues	None				
Permitting Issues	None				
Interface Issues	None				
Technical Issues	None				
Technical Maturity	High, currently being done.				

HLW TANK 48 ALTERNATIVE DATA SHEET

Alternative #	20	**Sponsor**	Peters	**Date**	1-21-2002
Title	Partner with GrayStar for Cs-137 sources				
Description	The GrayStar company (www.graystarinc.com) has formulated a plan to privatize all the Cs-137 in the government inventory and use it for food irradiation. It is possible to collect the Cs-137 in Tank 48H (among) others and sell it to GrayStar. This is not a solution in and of itself, but part of a disposal pathway.				
Advantages	The cesium-137 goes to someone else.				
Disadvantages	This would require chemical stripping and separation of the cesium. A new reactor and/or facility would be required.				
Safety Issues					
Permitting Issues	GrayStar would likely have to do all the paperwork to accept the Cs-137.				
Interface Issues	Would require some sort of vessel/building to be constructed.				
Technical Issues	There is 250,000 gal we would have to process.				
Technical Maturity	: The cesium stripping is not a new technology. It is well understood, but the difficulty is in processing such a large amount of material.				

HLW TANK 48 ALTERNATIVE DATA SHEET

Alternative #	21	**Sponsor**	R. C. Fowler	**Date**	1-14-2002
Title	Add Waste to Tank 48 and Decompose Radiolytically				
Description	Add radioactive waste to Tank 48 to promote the radiolytic decomposition of the precipitate. Use the existing nitrogen purge ventilation system to exhaust the benzene vapor produced				
Advantages	No new technology. Uses existing systems. Relatively inexpensive				
Disadvantages	Possibly very slow, which would consume a substantial quantity of nitrogen. Would need development of reaction rate constants to predict benzene generation. If benzene generation too high, could pose LFL problem				
Safety Issues	LFL issues related to unknown benzene generation rate				
Permitting Issues	May need air permit revision for this quantity of benzene release.				
Interface Issues	Pathway to transfer waste into Tank 48 would need to be evaluated. Might require some diversion box work.				
Technical Issues	Phenylborate decomposition rates with the waste to be transferred need development				
Technical Maturity	Low, radiolytic decomposition rates are unknown				

HLW TANK 48 ALTERNATIVE DATA SHEET

Alternative #	22	**Sponsor**	R. C. Fowler	**Date**	1-14-2002
Title	Transfer Tank 48 Material to Another Waste Tank and Decompose Radiolytically				
Description	Transfer the precipitate material from Tank 48 to another radioactive waste tank to promote the radiolytic decomposition of the phenylborate compounds. The transfer would use the existing pumps and piping. The existing ventilation system to exhaust the benzene vapor produced.				
Advantages	No new technology. Uses existing systems. Relatively inexpensive				
Disadvantages	Possibly very slow. Would need development of reaction rate constants to predict benzene generation. If benzene generation too high, could pose LFL problem. Would not have nitrogen purge system as a "defense in depth".				
Safety Issues	LFL issues related to unknown benzene generation rate				
Permitting Issues	Would require air permit revision for this quantity of benzene release.				
Interface Issues	Pathway to transfer waste into Tank 48 would need to be evaluated. Might require some diversion box work.				
Technical Issues	Phenylborate decomposition rates with the waste to be transferred need development				
Technical Maturity	Low, radiolytic decomposition rates are unknown				

HLW TANK 48 ALTERNATIVE DATA SHEET

Alternative #	23	**Sponsor**	Peters	**Date**	1-21-2002
Title	In tank bioremediation				
Description	A wide variety of organic compounds can be degraded through the use of different bacterial strains. Although there is no record of any bacteria strain specifically attacking phenylborates, it may be possible for suitable bacteria to act in this way.				
Advantages	Benzene, as an end product, is usually avoided in bioremediation.				
Disadvantages	Organics are not totally degraded (to CO2). Left over organics may be problematic. Bacteria unlikely to survive in high caustic, so a reactor may be required.				
Safety Issues	Various organics would be introduced in the tank as byproducts of the bioremediation.				
Permitting Issues	None known				
Interface Issues	A reactor is likely to be needed.				
Technical Issues	A suitable species must be located and tested. The byproducts of the degradation must be known.				
Technical Maturity	Bioremediation, as a general process is well known and understood. With respect to phenylborates, this is an unknown technology.				

HLW TANK 48 ALTERNATIVE DATA SHEET

Alternative #	24	**Sponsor**	R. C. Fowler	**Date**	1-14-2002
Title	Add Tank 48 Material to Another Tank Scheduled to be Decommissioned (Grouted)				
Description	Transfer the material in Tank 48 to one of the waste tanks scheduled to be decommissioned. The decommissioned tank is slated to be filled with grout after its contents have been removed. The Tank 48 precipitate material would be mixed into the grout matrix as a final disposal method.				
Advantages	Relatively inexpensive. No new technology involved				
Disadvantages	Possible evolution of benzene from the grout matrix could cause an LFL problem. Leaching of material from the matrix may be a TCLP problem.				
Safety Issues	Possible buildup of benzene vapors from the grout reaching LFL levels				
Permitting Issues	Disposal of high level radioactive waste by this method likely not permitted. Would require extensive re-negotiation with environmental authorities. May not be allowed under current law				
Interface Issues	Pathway to transfer waste into Tank 48 would need to be evaluated. Might require some diversion box work				
Technical Issues	Stability of phenylborates in grout would need to be evaluated				
Technical Maturity	High				

HLW TANK 48 ALTERNATIVE DATA SHEET

Alternative #	25	**Sponsor**	Dan Lambert	**Date**	1-17-2002
Title	Use an Outside vendor for disposal				
Description	Find an outside vendor (such as an incinerator vendor) and use the vendor's equipment to decompose or incinerate TPB.				
Advantages	1. Would be cheaper than building a new facility.				
Disadvantages	1. This is likely to be expensive. 2. This may lead to liability issues. 3. It may lead to pretreatment (removal of radioactivity) prior to acceptance by vendor. 4. The vendor may want to return the residue. 5. Transportation of slurry (40-60 tanker trucks?) will be difficult. It almost would have to be done at site. 6. If the vendor brings equipment on site, how will it be decontaminated or disposed of? 7. As with any process done outside of Tank 48, there will likely be a significant heel left in Tank 48.				
Safety Issues	1. How would a vendor safely handle the radioactive slurry? 2. How would the vendor prevent an explosion or radioactive release during processing?				
Permitting Issues	1. Permit will depend on vendor's processing. 2. A new permit will likely be required.				
Interface Issues	1. What will be done with vendor's residue? How will it be transferred to DWPF? 2. How will the slurry be transferred to the vendor's facility?				
Technical Issues	This would depend on the vendor's process and equipment.				
Technical Maturity	Medium				

HLW TANK 48 ALTERNATIVE DATA SHEET

Alternative #	26	**Sponsor**	Peters	**Date**	1-21-2002
Title	Metathesize with cold cesium				
Description	A certain amount of Cs-137 is locked up in the solid CsTPB. If we can find a way to release the Cs-137 into the supernatant liquid, the liquid could be decanted and removed to other tanks. It may be possible to metathesize (exchange) the Cs-137 with Cs-133 that we add. The exchange should be thermodynamically neutral, and only kinetic factors should influence the rate of exchange. Removal of most of the Cs-137 might allow the remaining solids to be treated in the same way Tank 49H was treated.				
Advantages	This is a very simple process; a cold cesium salt is added and the tank mixed.				
Disadvantages	The exchange might be slow. This is not a complete solution by itself.				
Safety Issues	If successful, the supernatant liquid will show a great increase in beta-gamma activity				
Permitting Issues	None known				
Interface Issues	If the increased activity supernatant is pumped to another tank, is the shielding adequate.				
Technical Issues	A very simple process				
Technical Maturity	None. A test to determine if this can work should be quite simple.				

HLW TANK 48 ALTERNATIVE DATA SHEET

Alternative #	27	**Sponsor**	R. C. Fowler	**Date**	1-14-2002
Title	Add Tank 48 Contents to Tank 49				
Description	Transfer the contents of Tank 48 to Tank 49 thus freeing up the space in Tank 48 for use				
Advantages	None.				
Disadvantages	No net benefit. The phenylborate material in Tank 49 has been destroyed and the material was transferred to Tank 50 for eventual disposal in Saltstone. Tank 49 has since been returned to Tank Farm service. Moving the Tank 48 material to Tank 49 would remove Tank 49 from Tank Farm service again. Would still have to deal with TPB left in heel of Tank 48 and the phenylborates transferred to Tank 49.				
Safety Issues	1. Tank 49 is covered under the Tank Farm SAR. A large quantity of organic material is not allowed by the Tank Farm SAR. The AB would need modification to permit this action. 2. Tank 49 does contain the necessary equipment to inert the tank with nitrogen. This equipment would need to be maintained to the appropriate safety classification if the material was transferred.				
Permitting Issues	None. Tank 49 previously contained phenylborate compounds similar to those currently in Tank 48 and this alternative would be covered under existing permits.				
Interface Issues	Because Tank 49 has been re-established as part of the H Area Tank Farm, this alternative would impact the Tank Farm and DWPF Waste Acceptance Criteria. A solution would be to isolate Tank 49 from the rest of the tank farm, as Tank 48 is isolated currently.				
Technical Issues	None				
Technical Maturity	This alternative only requires transferring material through existing pumps and lines and therefore is very mature technology.				

HLW TANK 48 ALTERNATIVE DATA SHEET

Alternative #	28	**Sponsor**	R. C. Fowler	**Date**	1-14-2002
Title	Send to Containment Facility				
Description	Reduce the volume of the slurry in Tank 48 through filtration, evaporation, or other process and package the remaining material to be disposed of in an containment facility onsite (i.e. Solid Waste vaults).				
Advantages	Returns Tank 48 to Tank Farm service				
Disadvantages	1. Doesn't permanently dispose of the organic material, only changes the storage location 2. Requires personnel to handle significant quantity of high level waste 3. Presents a flammable vapor hazard to the storage facility				
Safety Issues	Potential flammable hazard for the storage facility Personnel exposure from high level waste				
Permitting Issues	No facility exists onsite that is permitted for this type of waste. Extensive permit revisions would be required				
Interface Issues	None				
Technical Issues	Handling and transport of the highly radioactive material would present a challenge from a personnel safety standpoint.				
Technical Maturity	Low, this operation would be a new initiative onsite.				

HLW TANK 48 ALTERNATIVE DATA SHEET

Alternative #	29	**Sponsor**	Peters	**Date**	1-21-2002
Title	Remove supernate and react phenylborate heel in solvent				
Description	The supernate liquid can be removed, leaving a TPB heel. The insoluble heel will not react quickly unless solubilized. It may be possible to locate an appropriate solvent to dissolve the heel, such a perflourocarbon. Once dissolved, the material can be reacted more easily.				
Advantages	Keeps the process in the tank.				
Disadvantages	Addition of a new chemical. This is not a complete solution in and of itself.				
Safety Issues	Adding a new chemical to the tank				
Permitting Issues	Adding a new chemical to the tank				
Interface Issues					
Technical Issues	Need to locate a suitable candidate solvent.				
Technical Maturity	Not tried on site.				

HLW TANK 48 ALTERNATIVE DATA SHEET

Alternative # 30	**Sponsor:** R. C. Fowler	**Date:** 1-14-2002
Title	Evaporate to Dryness and Bury or Add to Grout	
Description	Evaporate the material in Tank 48 to dryness and dispose of the resulting material as solid waste. The dried material could be added to grout and disposed of at Saltstone or in a decommissioned tank or transferred to the E Area vaults. The evaporation process would likely take place outside Tank 48. And require a shielded facility.	
Advantages	Smaller volume to dispose of. Complete recovery of Tank 48 space.	
Disadvantages	Storage of the dried material in the E Area vaults would not be a permanent solution	
Safety Issues	Radiological content may be to high for Saltstone, a grouted tank or the E Area vaults.	
Permitting Issues	Neither Saltstone, decommissioned tanks nor the E Area vaults are permitted to take precipitate waste in these quantities	
Interface Issues	Transportation. The material would be highly radioactive.	
Technical Issues	Precipitate may be difficult to dry without decomposing.	
Technical Maturity	Low, the difficulty of drying this material is unknown	

HLW TANK 48 ALTERNATIVE DATA SHEET

Alternative # 31	**Sponsor:** R. C. Fowler	**Date:** 1-14-2002
Title	Develop Method to Stabilize Material and Use Tank 48 "As-is"	
Description	Develop an additive or a processing method to render the phenylborate material stable from decomposing such as removing the mercury from the tank or the addition of sulfide. Then use Tank 48 for receiving fresh radioactive waste.	
Advantages	Mostly performed in-tank. Relatively simple.	
Disadvantages	Phenylborates are not destroyed and may prove to be a problem for the eventual salt processing process.	
Safety Issues	Need assurance of the long-term stability of the phenylborate compounds. Their decomposition would impact LFL.	
Permitting Issues	A new chemical addition to the waste tanks would require a review of impacts to the current permits.	
Interface Issues	None	
Technical Issues	Development of a stability reagent	
Technical Maturity	Low.	

HLW TANK 48 ALTERNATIVE DATA SHEET

Alternative # 32	**Sponsor:** R. C. Fowler **Date:** 1-14-2002
Title	Pyrolytic Decomposition of Precipitate
Description	Develop a process to decompose the phenylborate compounds using heat. Material from Tank 48 would be pumped from the tank and processed at high temperature to break down the organic chemical. The remaining radioactive inorganic material would be incorporated into Tank Farm storage. Tank 48 would then be returned to Tank Farm service. The thermal degradation facility could be small enough to locate in the ITP filter cell area.
Advantages	Would rid Tank 48 of unwanted organic material. Could use existing ITP filter building ventilation system to vent resulting benzene.
Disadvantages	
Safety Issues	High temperature processing would need to be evaluated in the Authorization Basis.
Permitting Issues	Benzene release rates from the new process would need to be reviewed against the current ITP air permits.
Interface Issues	Transfer paths between Tank 48 and the filter building would need to be re-established.
Technical Issues	New process. Operating parameters need to be developed.
Technical Maturity	Low

HLW TANK 48 ALTERNATIVE DATA SHEET

Alternative # 33	**Sponsor: R. A. Adams** **Date:1-16-2002**
Title	Tank 49 as a reaction vessel
Description	Feed a predetermined amount of sludge to tank 49 to act as a catalyst. Feed a predetermined amount of tank 48 slurry to tank 49. Plot the gas generation rate and determine the half-life. At the end of the 2nd or 3rd half-life pump 49 back to 48 and observe the gas generation half-life. If the same as tank 49 prior to pumping, the reaction rate is determined. Continue to feed sludge to tank 49 and add slurry from tank 48; allow reaction and return to tank 48. If volumes of slurry and sludge remain approximately equal per cycle the observed gas generation rate should decrease at each cycle. Once determined, the volumes could be increased.
Advantages	No new equipment or facilities. All reactions take place in tanks that have a nitrogen purge capability. Reaction rate can be controlled and bracketed by sludge/ slurry volume. Uses the same reasoning as used in the recovery of tank 49.
Disadvantages	Loss of emergency space for tank 48 by the addition of sludge.
Safety Issues	Inability to predict the gas generation rates due to inconsistent concentration of elements/compounds.
Permitting Issues	None
Interface Issues	Sludge in tank 49.
Technical Issues	Low volume transfers between tank 48 & 49.
Technical Maturity	Proven on tank 49 with Cu catalyst.

HLW TANK 48 ALTERNATIVE DATA SHEET

Alternative # 34	**Sponsor:** Dan Lambert	**Date:** 1-17-2002

Title	Use solvent to extract KTPB, park solvent/TPB in unused waste tank.
Description	Extract the KTPB with a lower density solvent. Decant the lower density solution (estimated volume ~10,000 gallons) and pump to another waste tank (such as a leaking waste tank). The solution will be processed at a later date. The resulting supernate can be fed to Saltstone.
Advantages	1. Would need to resolve DNFSB 96-1 issues prior to commencing processing. 2. Would be cheaper than many of the options. 3. The KTPB would be completely removed from the Tank (as clean as practical). Virtually all other options will leave a significant residue of organics in Tk 48. 4. No new facility would be required to return Tank 48 to service. 5. The supernate left in the tank would be fed to Saltstone.
Disadvantages	1. A process will have to be developed later to dispose of the TPB and solvent. 2. If the new TPB storage tank leaked, it would be irresponsible to have moved it. 3. Would need to inert the new tank where the solvent and TPB will be stored. 4. Would need to set up a sampling protocol for the new tank.
Safety Issues	Would need to develop a solvent that will not lead to flammability issues.
Permitting Issues	A benzene permit will be required for the new TPB storage tank.
Interface Issues	How will the slurry be safely transferred to the new tank?
Technical Issues	What is the decomposition rate of the TPB in the new solvent? Can a safe solvent be found that would not impact further processing?
Technical Maturity	Low

HLW TANK 48 ALTERNATIVE DATA SHEET

Alternative # 35	**Sponsor:** R. A. Adams	**Date:** 1-28-2002

Title	Actinide Removal Process (ARP) Using Permanganate
Description	
Advantages	There would not be a special process for tank 48.
Disadvantages	The process of breaking down the organics may not be fast enough to support the flow sheet requirements for ARP.
Safety Issues	The feeding of tank 48 contents to the ARP or blend tank may cause the generation of benzene.
Permitting Issues	Should be covered under current permits.
Interface Issues	This would enhance the interface by allowing tank 48 to become the feed tank to the ARP.
Technical Issues	Lab tests will be required to demonstrate the decomposition of organics and to identify reaction rates.
Technical Maturity	

HLW TANK 48 ALTERNATIVE DATA SHEET

Alternative # 36	**Sponsor:** R. A. Adams	**Date:** 2-5-2002

Title	Tank in Tank
Description	Through a riser opening insert a tank the height of tank 48 and the diameter of the riser opening. The tank would be valved near the bottom to allow flow into the tank. In the tank there would be a submergible pump to pump treated waste to tank 49 via flex hose. In process could be used in the tank because the reaction process would be limited to the capacity of the inner tank.
Advantages	The technology is simple, the cost is small and the reaction rates controllable.
Disadvantages	The process of breaking down the organics may not be fast enough to support flow sheet requirements.
Safety Issues	The feeding of solvent, catalyst, etc. to tank 48 contents, even a 2k-gallon tank will cause the generation of benzene.
Permitting Issues	Should be covered under current permits.
Interface Issues	The process would be limited to the East Hill.
Technical Issues	Lab tests will be required to demonstrate the decomposition of organics and to identify reaction rates.
Technical Maturity	

HLW TANK 48 ALTERNATIVE DATA SHEET

Alternative # 37	**Sponsor:** Jerry Morin	**Date:** 2-5-2002

Title	Microwave Destruction Of Organics
Description	Employ a tuned microwave system to irradiate the slurry in Tank 48 to reduce the organic phenylborate species to water and carbon dioxide or to organic levels, which can be safely dispositioned in other waste tanks. Such a system could be installed within a Tank-In-Tank vessel in one of the 24-inch risers. The electronics, controls etc would be outside the tank and the microwaves would pass through waveguides into the tank vessel.
Advantages	The technology has been shown for other organics, including benzene and the process is controllable. SRTC owns several patents and George Wicks is the expert on microwave destruction of the organics
Disadvantages	The process of breaking down the organics may not be complete enough to satisfy allowable organic levels in other tanks.
Safety Issues	The process may form some intermediates including benzene.
Permitting Issues	Should be covered under current permits.
Interface Issues	The process would be limited to the East Hill. Dispositioned waste would go to other waste tanks.
Technical Issues	Lab tests will be required to demonstrate the decomposition of organics and to identify reaction rates.
Technical Maturity	Medium

HLW TANK 48 ALTERNATIVE DATA SHEET

Alternative # 38	**Sponsor:** Pat Suggs	**Date:** 1/9/02

Title	Volume-Reduce by filtration, sending filtrate to Tank 49/50, Decompose residual in-tank
Description	Send filtrate to Tank 50, if necessary breaking into 2 batches (current Tk 50 inventory -- plus next generation Tank 50 inventory) Reduce free hydroxide of the residual contents (minimum level required to allow pump mixing) to the lowest hydroxide level possible, (~pH 10), which still within the tank corrosion guidelines (Tank 49 reached fairly low hydroxide levels). Historical research reports (WSRC –TR's 97-0285; 97-0073; 98-0070; 2000-459; and MS-97-0363) indicate tetraphenylborate decomposition is related to the quantity of sludge present. The decomposition of the contents of Tk 48 (under nitrogen) may be accomplished by agitating in the presence of 2.5 g/L_of sludge added from elsewhere in the tank farms, or by commercially procured nickel catalyst. (Nickel is immediately above palladium on the periodic table, and is present in much greater quantities in our sludge than palladium, also used in the petroleum/food industry as a hydrogenation catalyst). The rate of decomposition should be temperature-controllable by adjusting the frequency/duration of pump runs. After decomposition is essentially complete, one option is to strike the decomposed material with formate and permanganate to convert any unreleased benzene to phenol, which is not a flammability concern to us. Allowing us to transfer the contents to the tank farm if desired (Re-filter, sending sludge to Tank 51, clarified supernate to Tank 49).
Advantages	Fast, cheap, requiring no new infrastructure, uses existing pumps, nitrogen system
Disadvantages	Like other options, would require lab studies to support safety basis documentation of rates of reaction, similar to Tank 49 requirements. Releases carcinogenic benzene via the HEPA filters, though the possibility of decomposing in the presence of NaMnO4/formate could be investigated
Safety Issues	The in-place nitrogen system helps address the safety issues, the avoidance of any new tie-ins helps avoid flammable, vapor leaking concerns
Permitting Issues	Saltstone WAC. The current criteria are very restrictive, low curie salt (saltcake draining/dissolution) seeks to raise the existing allowable cesium level. The initial filtration could be performed in 2 batches, the first batch to the current contents of Tank 50.
Interface Issues	Interfaces required with SRTC, WSMS, DNFSB, etc
Technical Issues	Lab studies required with simulants to measure reaction rates with temperature, and effectiveness of permanganate/formate for benzene conversion
Technical Maturity	See technical reports. As mature as possible considering the 96-1 Research Program did not establish a repeatable relationship with a single catalyst such as palladium

HLW TANK 48 ALTERNATIVE DATA SHEET

Alternative # 39	**Sponsor:** Jerry Morin	**Date:** 2/6/02

Title	Steam reforming / fluidized bed
Description	This is a thermal treatment process presently commercialized. A versatile technology that can not only provide heat for a chemical oxidation reaction, similar to that of an incinerator, but it can also control process chemistry. It is used for organic destruction, conversion of materials, and the destruction of nitrates.
Advantages	Several vendors supply the system in several large projects. The system has been reviewed for use at SRS. Can be tied to the front end of an existing or planned facility.
Disadvantages	Process is privately owned therefore will require an out side contractor.
Safety Issues	May require AB effort.
Permitting Issues	May require a change to current permits.
Interface Issues	If added to the flow sheet for a planned project it may be easy. As an addition to an existing facility, it would probably be a major outage effecting production.
Technical Issues	
Technical Maturity	Medium

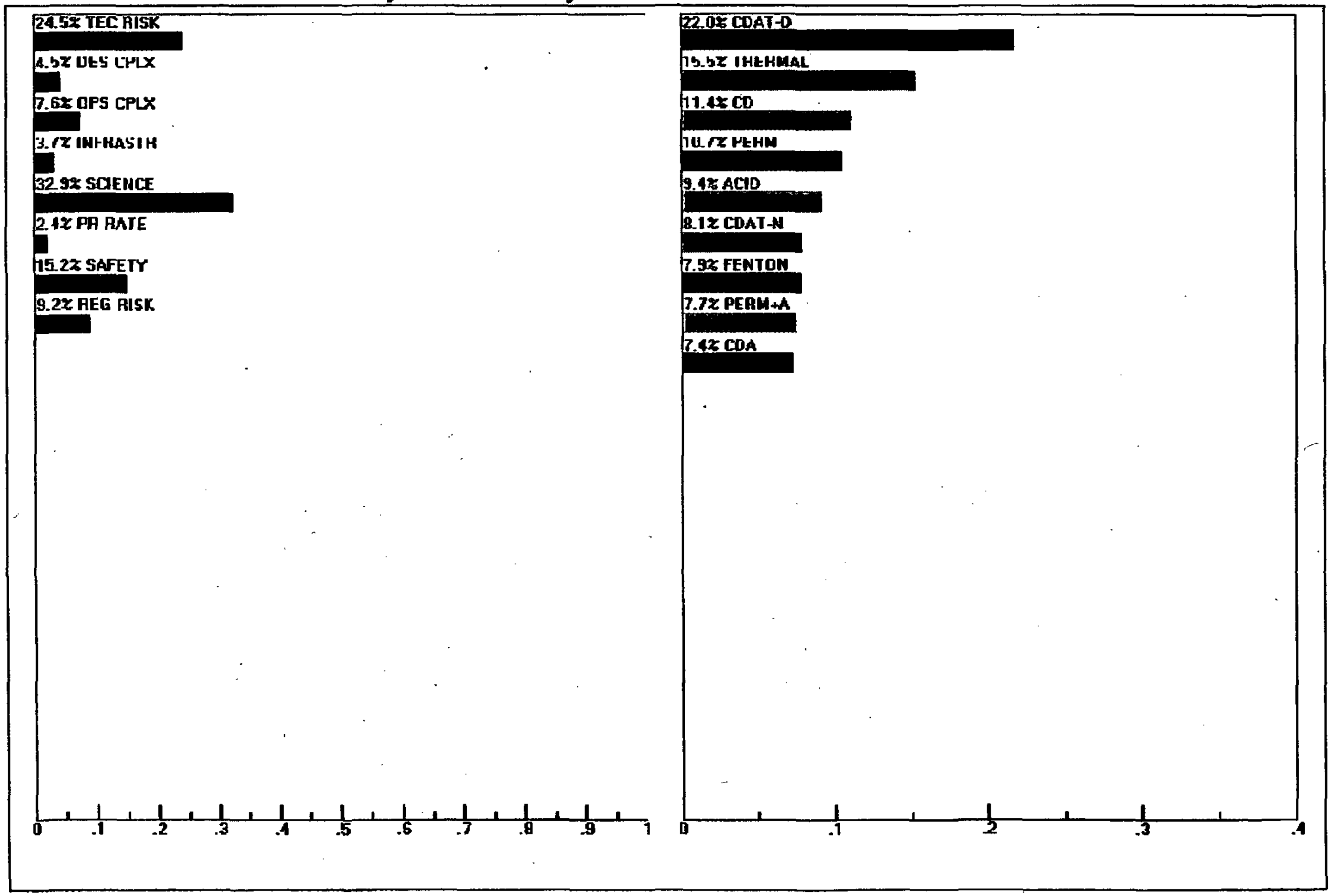
HLW TANK 48 ALTERNATIVE DATA SHEET

Alternative # 40	**Sponsor:** R. A. Adams	**Date:** 1/28/02
Title	MST / TPB strike in the flow sheet for the HLW system	
Description	Utilize a front-end process that adds monosodium titanate (MST) to incoming waste to absorb strontium and actinides and tetraphenylborate (TPB) to capture the Cs. The addition of a process similar to the Salt Cell concept added to the Small Tank flow sheet could be added to the low curie, actinide removal or the caustic side solvent extraction (CSSX) flow sheets as part of an overall waste treatment flow sheet. Tank 48 could be processed through the system as it currently exists.	
Advantages	There would not be a special process for tank 48. The process is well understood and significant work has been completed as part of the Alt Salt Program.	
Disadvantages	The process of breaking down the organics may not be fast enough to support the flow sheet requirements using tank 48 as a sole feed tank (may have blend which will require additional waste to be added to tank 48.	
Safety Issues	The feeding of tank 48 contents to the system or blend tank may cause the generation of benzene.	
Permitting Issues	Should be covered under current permits.	
Interface Issues	This would enhance the interface by allowing tank 48 to become the feed tank to the system.	
Technical Issues	96 - 1 requirements	
Technical Maturity	High	

Attachment 3 – Ecpro Output

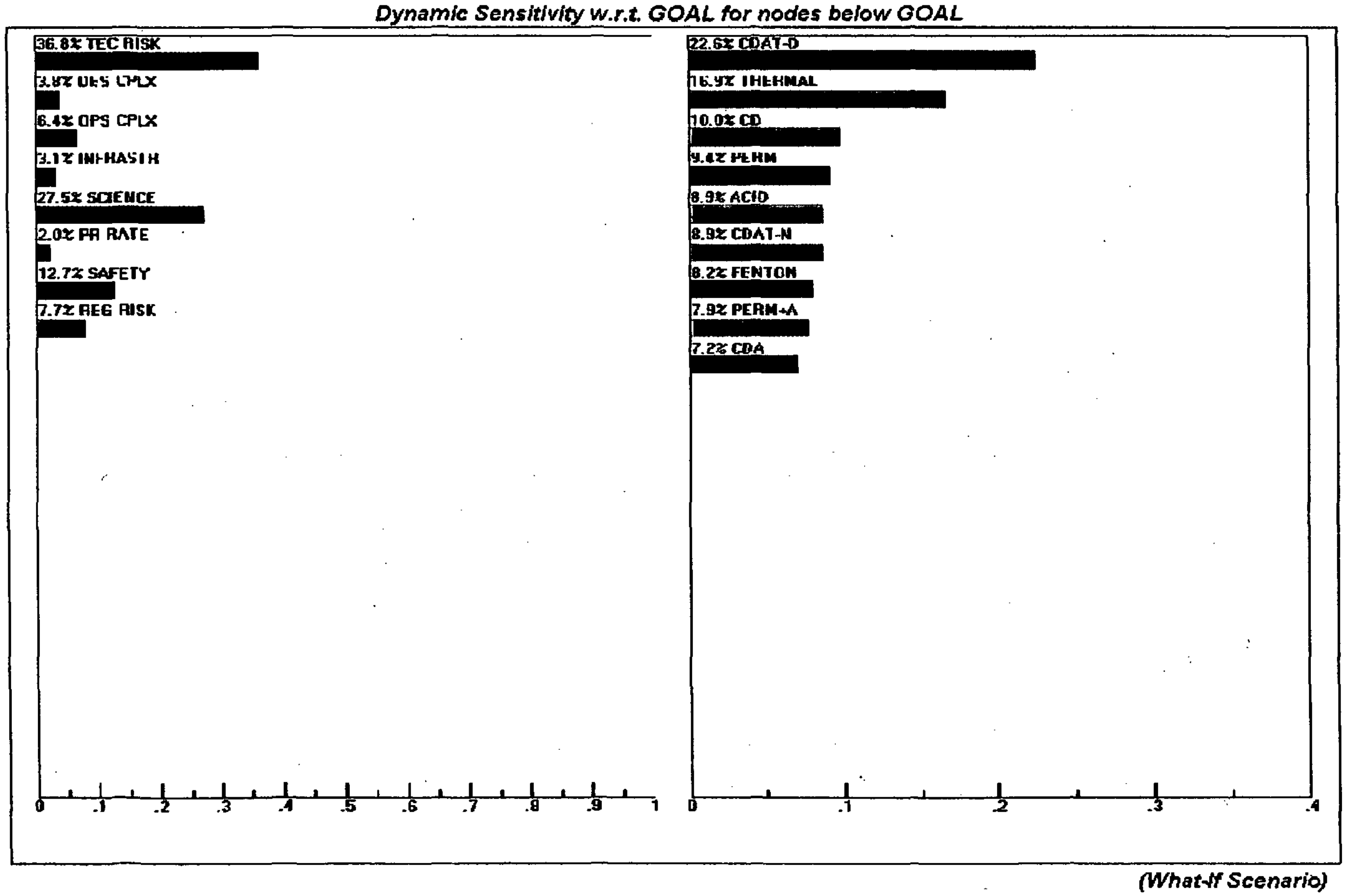
3-1 – Results

Dynamic Sensitivity w.r.t. GOAL for nodes below GOAL



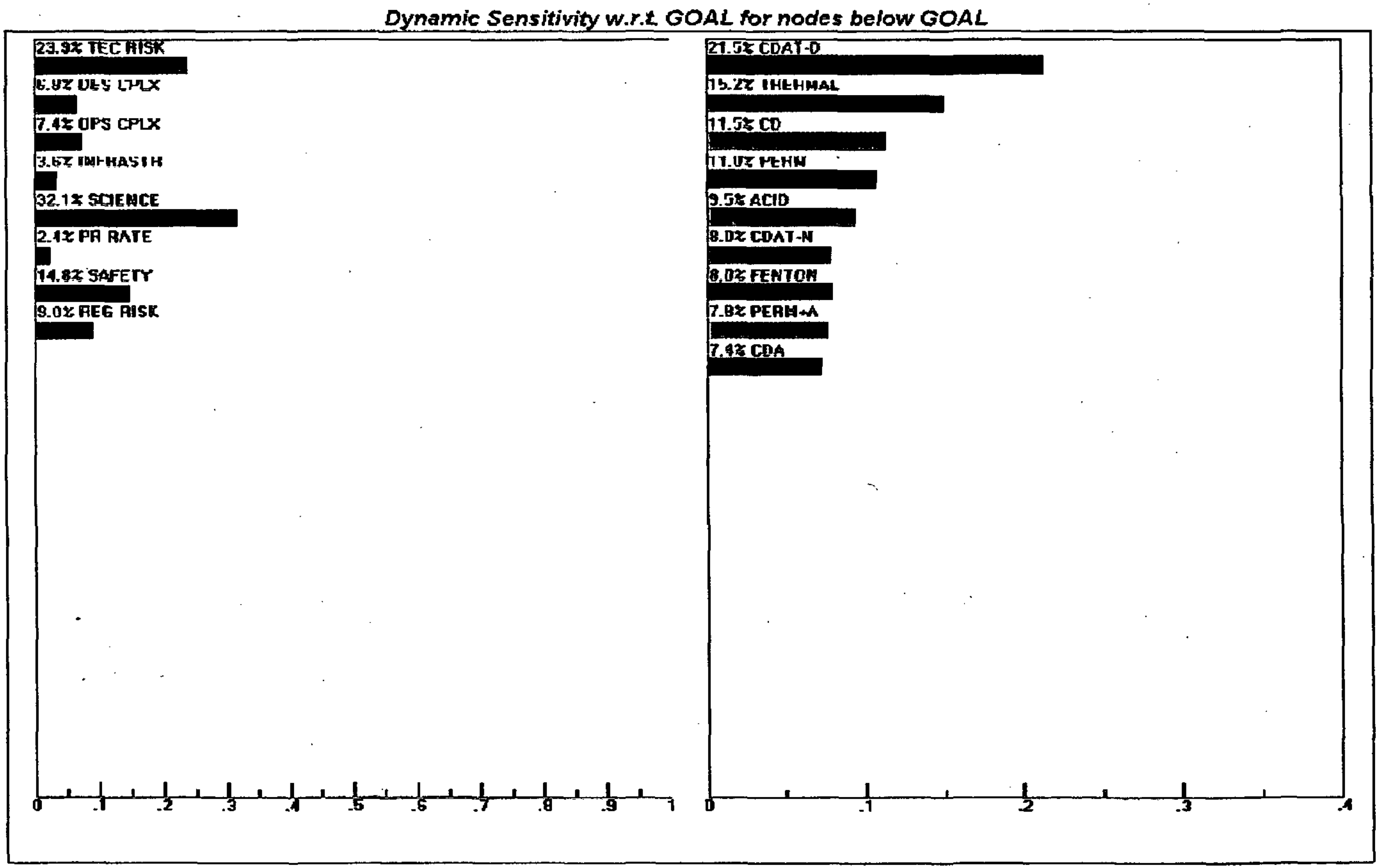
LEGEND: CDAT-D – Salt Cell Process; THERMAL – Thermal decomposition; CD – Catalytic Decomposition; PERM – Permanganate; ACID – Acid only; CDAT-N – Catalytic Decomposition in New Facility; FENTON – Fenton's Reagent; PERM+ACID – Permanganate + Acid; CDA – Catalytic Decomposition with Acid

Attachment 3 – Ecpro Output
3-2 – Results (Technical Risk wt +50%)



LEGEND: CDAT-D – Salt Cell Process; THERMAL – Thermal decomposition; CD – Catalytic Decomposition; PERM – Permanaganate; ACID – Acid only; CDAT-N – Catalytic Decomposition in New Facility; FENTON – Fenton's Reagent; PERM+ACID – Permanganate + Acid; CDA – Catalytic Decomposition with Acid

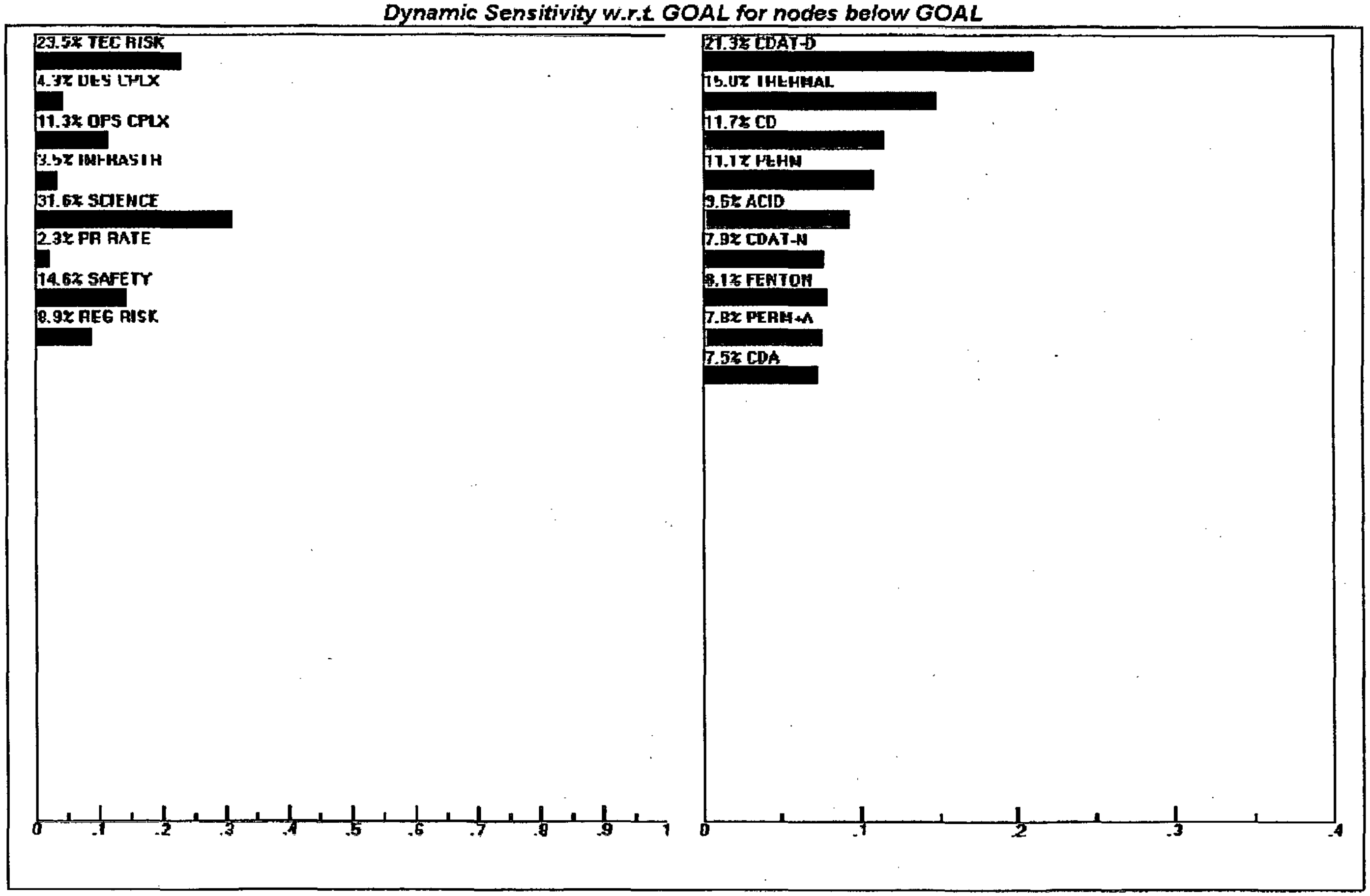
Attachment 3 – Ecpro Output
3-3 – Results (Design Complexity wt +50%)



(What-If Scenario)

LEGEND: CDAT-D – Salt Cell Process; THERMAL – Thermal decomposition; CD – Catalytic Decomposition; PERM – Permanganate; ACID – Acid only; CDAT-N – Catalytic Decomposition in New Facility; FENTON – Fenton's Reagent; PERM+ACID – Permanganate + Acid; CDA – Catalytic Decomposition with Acid

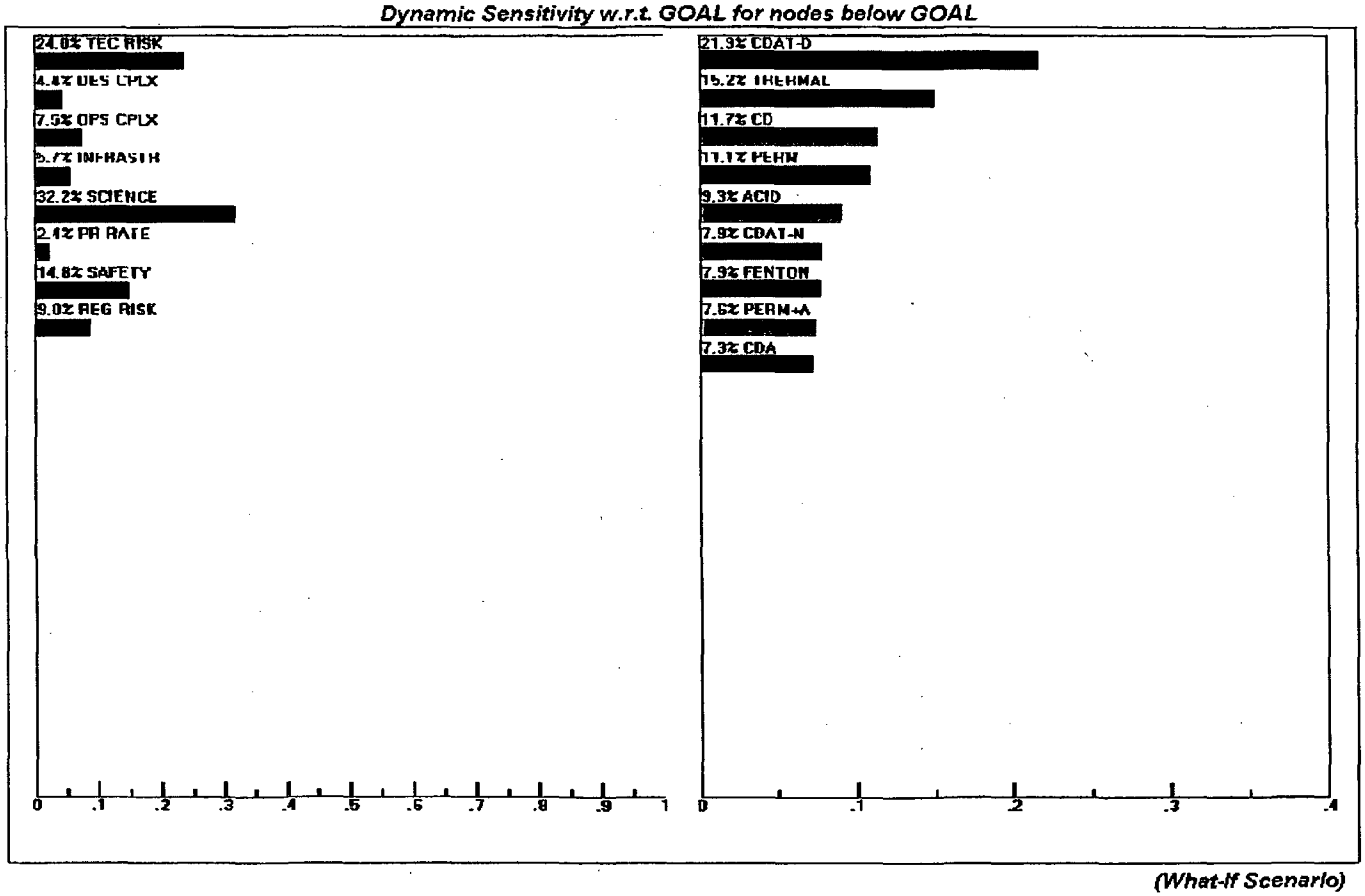
Attachment 3 – Ecpro Output
3-4 – Results (Operational Complexity wt +50%)



(What-If Scenario)

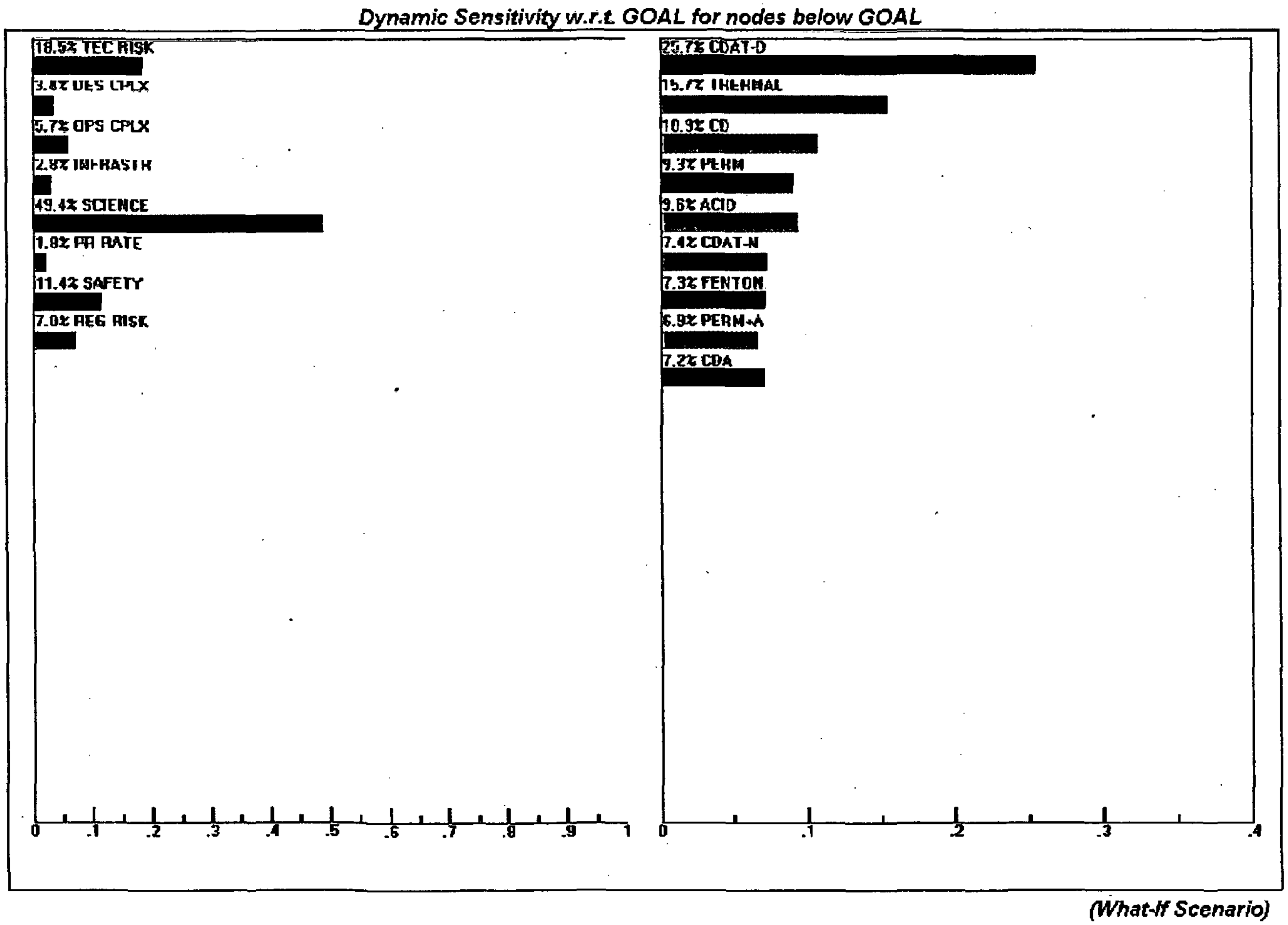
LEGEND: CDAT-D – Salt Cell Process; THERMAL – Thermal decomposition; CD – Catalytic Decomposition; PERM – Permanganate; ACID – Acid only; CDAT-N – Catalytic Decomposition in New Facility; FENTON – Fenton's Reagent; PERM+ACID – Permanganate + Acid; CDA – Cataleptic Decomposition with Acid

Attachment 3 – Ecpro Output
3-5 – Results (Infrastructure wt +50%)



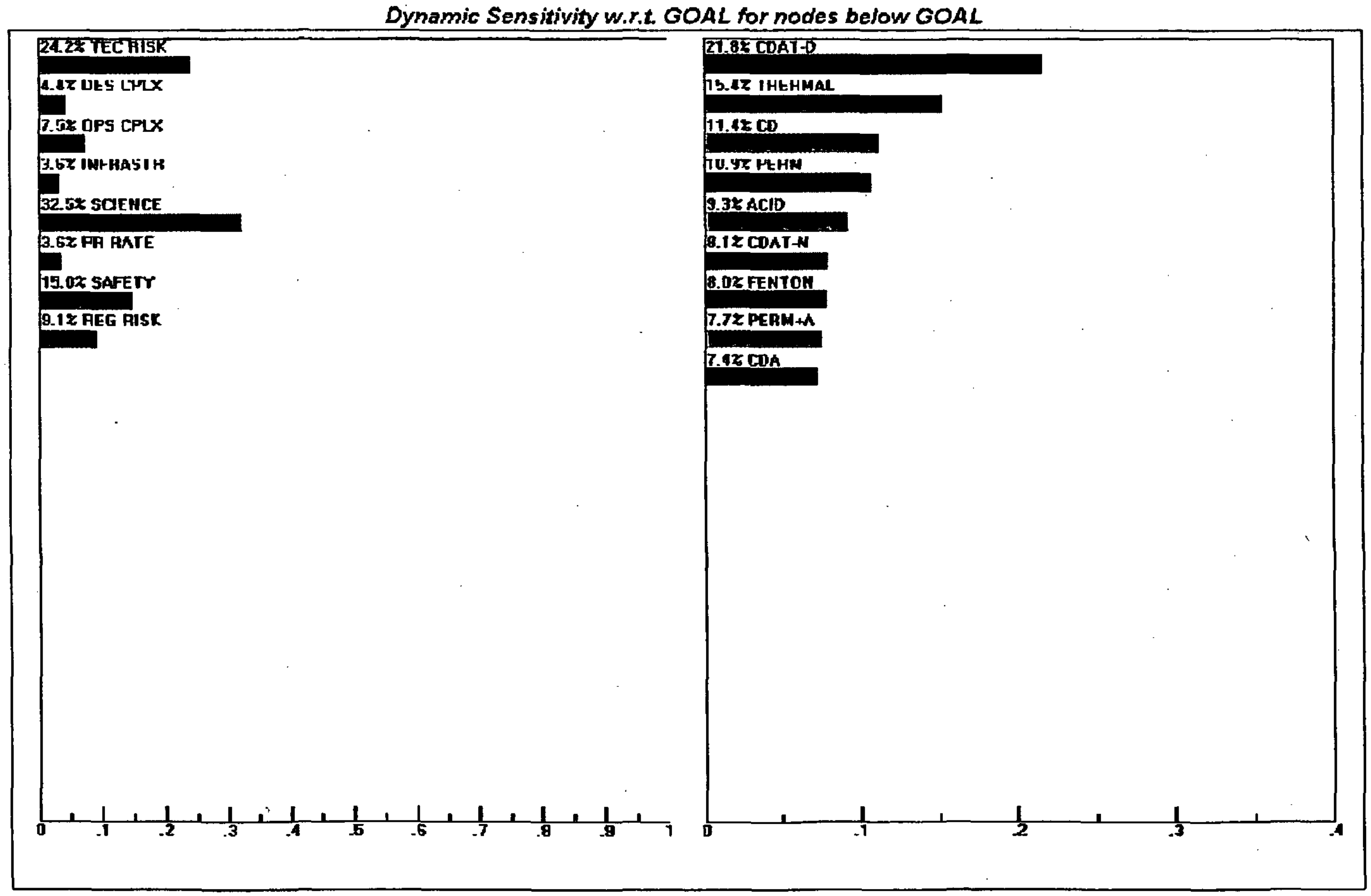
LEGEND: CDAT-D – Salt Cell Process; THERMAL – Thermal decomposition; CD – Catalytic Decomposition; PERM – Permanganate; ACID – Acid only; CDAT-N – Catalytic Decomposition in New Facility; FENTON – Fenton's Reagent; PERM+ACID – Permanganate + Acid; CDA – Catalytic Decomposition with Acid

Attachment 3 – Ecpro Output
3-6 – Results (Science wt +50%)



LEGEND: CDAT-D – Salt Cell Process; THERMAL – Thermal decomposition; CD – Catalytic Decomposition; PERM – Permanganate; ACID – Acid only; CDAT-N – Catalytic Decomposition in New Facility; FENTON – Fenton's Reagent; PERM+ACID – Permanganate + Acid; CDA – Catalytic Decomposition with Acid

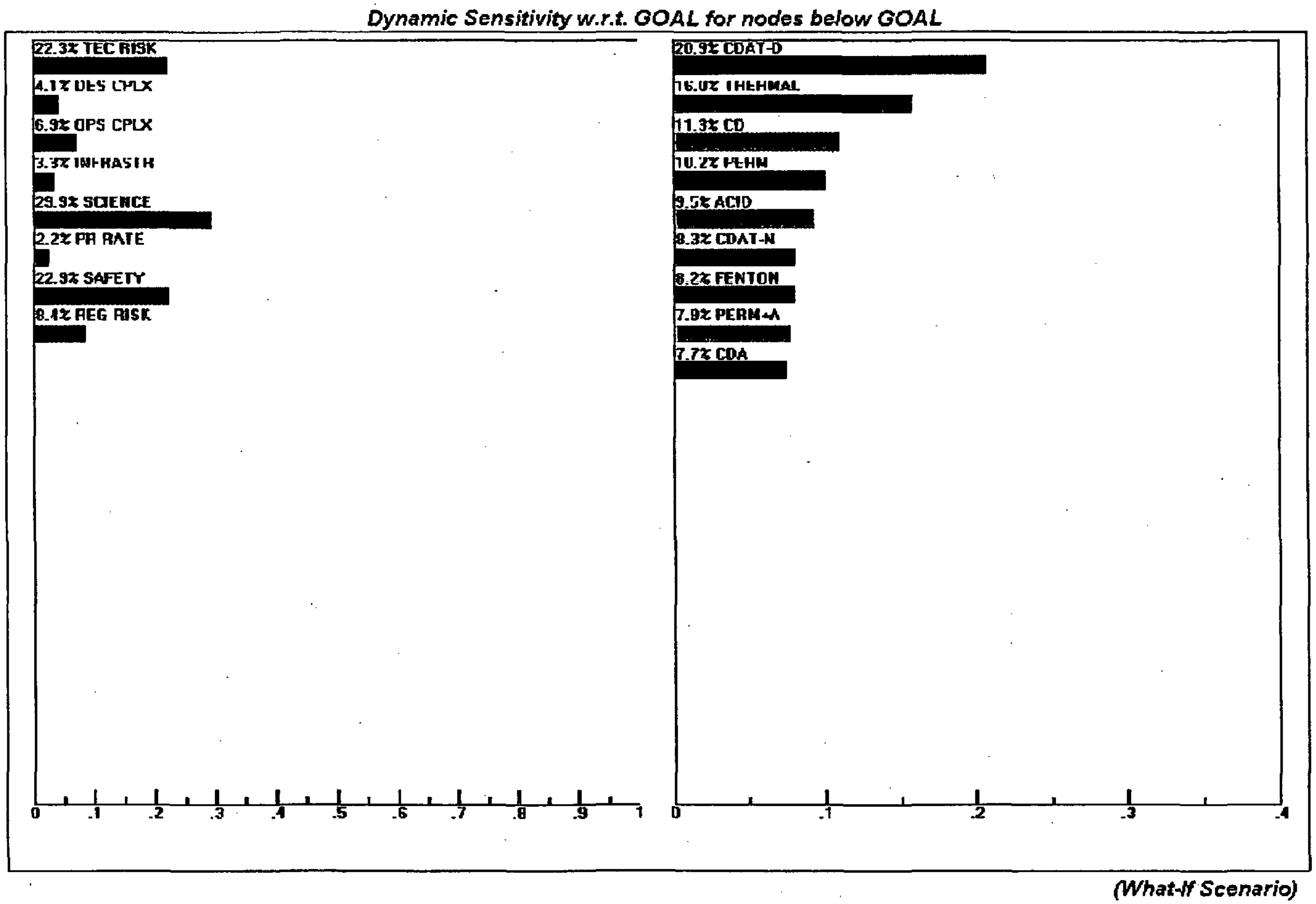
Attachment 3 – Ecpro Output
3-7 – Results (Process Rate wt +50%)



(What-If Scenario)

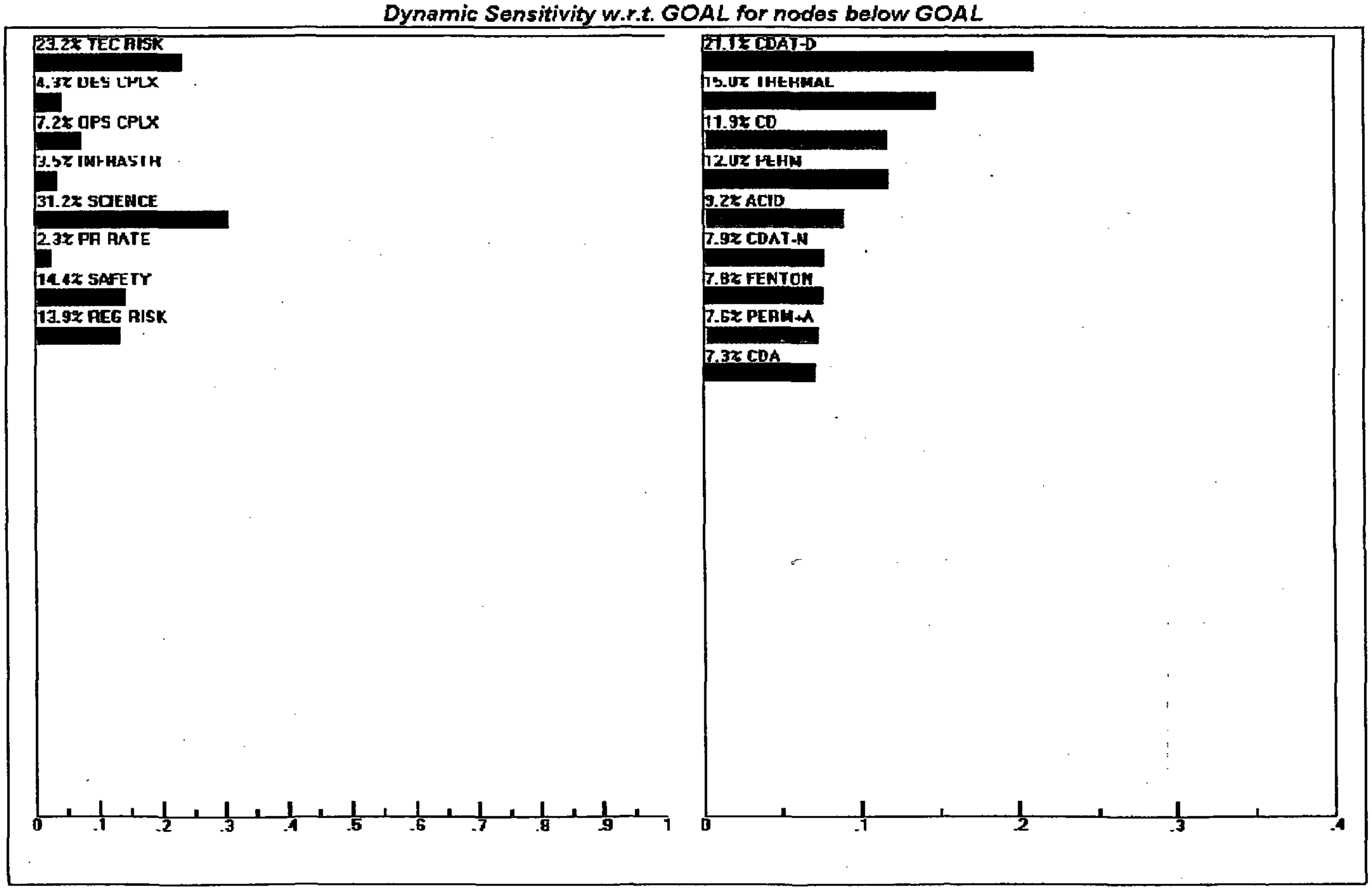
LEGEND: CDAT-D – Salt Cell Process; THERMAL – Thermal decomposition; CD – Catalytic Decomposition; PERM – Permanganate; ACID – Acid only; CDAT-N – Catalytic Decomposition in New Facility; FENTON – Fenton's Reagent; PERM+ACID – Permanganate + Acid; CDA – Catalytic Decomposition with Acid

Attachment 3 – Ecpro Output
3-8 – Results (Safety wt +50%)



LEGEND: CDAT-D – Salt Cell Process; THERMAL – Thermal decomposition; CD – Catalytic Decomposition; PERM – Permanganate; ACID – Acid only; CDAT-N – Catalytic Decomposition in New Facility; FENTON – Fenton's Reagent; PERM+ACID – Permanganate + Acid; CDA – Catalytic Decomposition with Acid

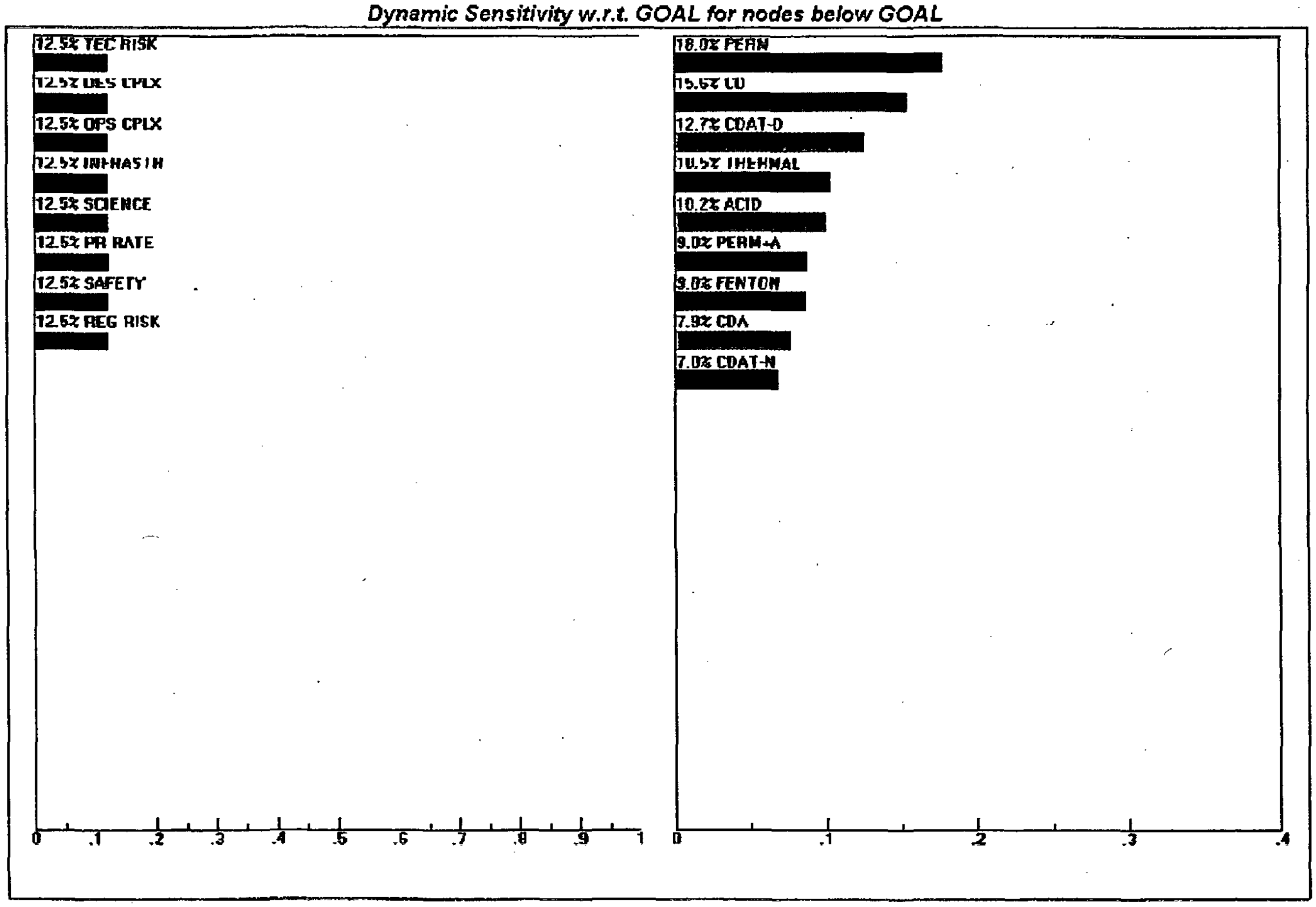
Attachment 3 – Ecpro Output
3-9 – Results (Regulatory wt +50%)



(What-If Scenario)

LEGEND: CDAT-D – Salt Cell Process; THERMAL – Thermal decomposition; CD – Catalytic Decomposition; PERM – Permanganate; ACID – Acid only; CDAT-N – Catalytic Decomposition in New Facility; FENTON – Fenton's Reagent; PERM+ACID – Permanganate + Acid; CDA – Catalytic Decomposition with Acid

Attachment 3 – Ecpro Output
3-10 – Results (All weights equal)



LEGEND: CDAT-D – Salt Cell Process; THERMAL – Thermal decomposition; CD – Catalytic Decomposition; PERM – Permanganate; ACID – Acid only; CDAT-N – Catalytic Decomposition in New Facility; FENTON – Fenton's Reagent; PERM+ACID – Permanganate + Acid; CDA – Catalytic Decomposition with Acid

Appendix 1 -Charter

It has been determined that the contents of Tank 48H are not compatible with the existing HLW process and require disposition to allow Tank 48H to be returned to service. The SRS HLW Tank 48 Disposition Team is charged with the task of systematically developing and recommending a technology for disposition of Tank 48H contents. The alternative(s) selected for final recommendation will be capable of safely and cost effectively processing organics from SRS High Level Waste (HLW) Tank 48H.

Team participants will be selected based on their proven subject matter expertise, objectivity, open-mindedness and not being predisposed to a single technology. A listing of Team members is shown in Appendix 2. The Team members should have other resources available to them from their parent organization in order to facilitate the completion of assigned action items, research, report writing, etc. relevant to the Team Charter.

Further, the Team is to follow the Systems Engineering (SE) approach in developing alternatives. The SE approach has proven effective both at SRS and elsewhere when solving a large and/or technically complex problem such as we have before us. The SE approach starts with defining the "top down" functions and requirements any solution must meet including an assessment of need. The other salient features of this process include the definition of external interfaces, brainstorming alternatives, risk management and developing screening criteria, e.g. boundary conditions against which alternatives can be objectively evaluated for viability. The critical needs and minimum boundary conditions/constraints that all alternatives should be evaluated against are shown in Section 4.1. The Team will develop and work to a detailed System Engineering Management Plan (SEMP).

The deliverables provided by the Team are divided into two phases in order to allow transmittal of information to both internal and external review teams for feedback and concurrence purposes. The major milestones required of the Team are listed in Appendix 3

Completion of the HLW Tank 48 Disposition Team report and recommendation of a preferred alternative(s) meets the requirement of the HLW Tank 48 Disposition Team Charter.

Appendix 2 – Team members

PROJECT OWNER -- BOB ADAMS

Bob has an extensive background in Operations, Plant Maintenance and Project Management. His primary contribution to the Team will be maintaining a path forward that is compatible with accepted operating and maintenance requirements and guidelines.

PROCESS ENGINEERING MEMBER -- RICK FOWLER

Rick is a chemical engineer in Process Engineering section of the High Level Waste Division. Rick was a member of the engineering group for the testing and initial operation of the In-Tank Processing facility. He also has been involved in the development and testing of the Small Tank Tetraphenylborate candidate for the Alternative Salt process. Rick was also the lead chemical engineer for the Tank 49 remediation project.

SRTC ENGINEERING MEMBER -- DAN LAMBERT

Dan is a Chemical Engineer working in the Waste Processing Technology Section in the Savannah River Technology Center. Dan has extensive experience in the hydrolysis of TPB through his work with small scale research, pilot plant process development and was involved in the cold chemical startup of the TPB hydrolysis process in the Defense Waste Processing Facility. Dan has led the research/development to develop and improve the sludge-only chemical processing used to operate DWPF since radioactive startup. Dan is also involved in the development of improved antifoam formulations for DWPF and the Small Tank TPB process.

SRTC SCIENCE MEMBER -- TOM PETERS

Tom is a chemist working in Sam Fink's group in Waste Processing Technology at SRTC. Tom was the principle investigator in the Tank 49H remediation study and following tank cleanup (see Attachment 3). Another related project Tom worked on was the CSTR real waste demo (small tank) in 2001.

SAFETY & REGULATORY ENGINEERING MEMBER -- ROBERT BENTLEY

Bob has over 21 years of Licensing and Regulatory experience at several commercial nuclear power plants and DOE facilities, including Hanford, Yucca Mountain, Pantex and SRS. Bob served as the Nuclear Safety representative on a five-member team chosen by DOE-RL overseeing the development of the TWRS-EIS. Bob was also the principal author of the Authorization Basis that was approved for the disposition of Tank 49 waste material and was extensively involved in the development of the accident analysis supporting the safety basis. Bob is currently serving as a Deputy Manager at the Tank Farm for WSMS Regulatory Programs.

REGULATORY ENGINEERING MEMBER NARINDER MALIK

Narinder is an environmental scientist/engineer with the High Level Environmental Compliance Authority. Narinder has over 25 years experience in environmental compliance and regulatory analyses. Narinder has extensive experience in environmental compliance at SRS facilities, including DWPF, High Level Waste Tank Farm – H Area, Salt Waste Processing Facility, and Actinide Removal Process. Narinder has participated in the development of Functional Design Description (FDD) for a variety of projects at SRS. His primary responsibilities were to ensure that the facility design meets all applicable environmental regulatory requirements. He served as a lead, for a number of years, for environmental protection and waste management functional areas of the WSRC S/RID.

SYSTEMS ENGINEERING MEMBER -- GAVIN WINSHIP

Gavin is a Systems Engineer working in the PE&CD Systems Engineering Department. Gavin has over 20 years experience working in commercial and government nuclear facilities in the US and overseas. Gavin has extensive experience in the application of Systems engineering at SRS facilities including DWPF, ITP, Salt Waste Processing Facility, Actinide Removal Process and has facilitated, participated and supported alternative evaluations, design reviews, functional analysis and requirement development within the HLW Division.

DESIGN AUTHORITY MEMBER -- MICHAEL NORTON

Mike is a B.S. Chemical Engineer working in the High level Waste Engineering Organization. He has over 11 years experience in the High Level Waste Division as a Design authority Engineer and a Design Authority Engineering Manager. His current assignment is the Design Authority Engineering Manager for the Actinide Removal Project.

HLWE SENIOR TECHNICAL ADVISOR -- JERRY MORIN (Phase 1)

Jerry is a Ph.D. Chemical Engineer working in the High Level Waste Engineering Division. Jerry has over 30 years experience at SRS working in nuclear reactors and high level waste programs including ITP, Salt Waste Processing and as Program Manager for the Alt Salt Program during the DOE baseline process selection.

CHEMISTRY ADVISOR -- JAMES BONCELLA

Jim is a Ph. D. Chemist and Professor at the University of Florida.

Appendix 3- Team Milestones

PHASE	DELIVERABLE	DATE
1	• Team Selection	12/13/01
	• Systems Engineering Management Plan	1/30/02
	• Approval of Screening Criteria	2/20/02
	• Report Documenting the Activities Leading to an "initial List" of Alternatives	2/28/02
2	• Develop Task Technical and Quality Assurance Plan for Scoping Studies	3/26/02
	• Develop/Schedule Activities Leading to a "Short List" of Alternatives	3/27/02
	• Approve Selection Criteria	4/21/02
	• Provide Report on Scoping Activities	6/15/02
	• Report Documenting the Activities Leading to the "Short List" of Alternatives	6/17/02
	• Provide Final Report on all Activities including: ♦ Preferred Alternative(s) ♦ Recommended R&D ♦ Relative Cost Estimate	7/15/02

NOTE: Throughout this process the HLW Tank 48H Disposition Team provided periodic briefings and status updates to the HLW Management and DOE via routine meetings and reports.

Appendix 4 - R&D, Schedule and Cost

The two highest-ranking alternatives are the two processes that the team considers the most mature technologies – Salt Cell Technology/Processing and Steam Reforming. These are probably the two most expensive process alternatives as they are complicated and will require the construction of a new facility. Based on a 1999 estimate to move the salt cell to Building 512-S[7] – the expected cost to move salt cell operations would cost ~$40M and take ~24 months. The steam reforming is expected to cost a little more and take longer due to develop and demonstration of the process. There are other potentially viable processes but these have not been optimized nor has testing been completed at a variety of scales or with radioactive waste. As a result, additional research is required to help to improve the scientific understanding and identify and address some of the risks inherent in each of these processing alternatives.

A preliminary schedule and budget estimate has been developed to complete the basic research that is required to allow the Tank 48H Team to recommended a process and a back up process for the destruction of the TPB in Tank 48H. The following are the main elements of research and development that are recommended:

1. Corrosion Study – If any of the alternatives is implemented in Tank 48H, an understanding of the chemistry changes is necessary prior to implementation. A corrosion study is necessary to determine the relative corrosion rates of the high-ranking in-tank alternatives. In addition, development of acceptable times, temperatures, and chemical concentrations for protecting the tank are necessary.
2. Stoichiometry study – In order to minimize the amount of reagents necessary for completing the reaction and to understand kinetics of the TPB decomposition, a study is required to optimize the process using simulants.
3. Carbon Balance study – One of the most important considerations in each of the processes is the identification of the TPB decomposition products for each of the processes. For example, a process that produces carbon dioxide would be preferable to a process that produces benzene. A process that produces fewer tar-like organic would be preferred. Analysis of the off-gas, the liquid and the solid deposits is necessary to identify the TPB decomposition products as this would be important in comparing the alternatives.
4. Tank 48H Characterization – Tank 48H will be sampled and the samples will be analyzed to understand the composition of this tank and develop a more complete simulant recipe. A thorough analysis of a well-mixed sample has not been completed since 1998. Since a radioactive tank's chemistry is constantly changing, a current analysis is needed.
5. Actual Waste Testing – Testing with actual waste is essential in demonstrating that the processing, developed using nonradioactive simulants, works with actual waste. HLW is an extremely complicated mixture of components. Not all of these components are in our simulants. As a result, real waste testing is necessary to ensure that one of these components does not impact the planned processing.

6. Demonstration at Scale – Scale-up is important in any process development. To minimize cost, early research is done at a very small scale. The testing completed to date has been at a volume of 100 ml. This is approximately 1:9,500,000 scale. If in-tank testing is desirable, it should be tested at the maximum scale practical. For example, a 250 gallon experiment would be 1:1,000 scale.
7. Steam Reforming Testing – Several steam reforming tests are recommended, including DTA/TGA studies to understand the TPB decomposition temperature and decomposition products under high temperature conditions. In addition, testing of calcined waste in Parr Bombs (vessels designed to handle high temperatures and pressures) is recommended to understand the composition of the solid product that will be produced via steam reforming. Larger scale and real waste testing of steam reforming may be performed by ORNL and PNNL because of existing equipment and processing experience.
8. Testing of downstream processing – The products of the processing will need further processing in existing SRS facilities. For example, the resulting salt solution will be processed in the Salt Disposition Facility creating a stream that will be processed via Saltstone and second stream that will be processed in DWPF. Testing will be necessary to ensure that the product of the Tank 48H process will be compatible with downstream processing facilities.

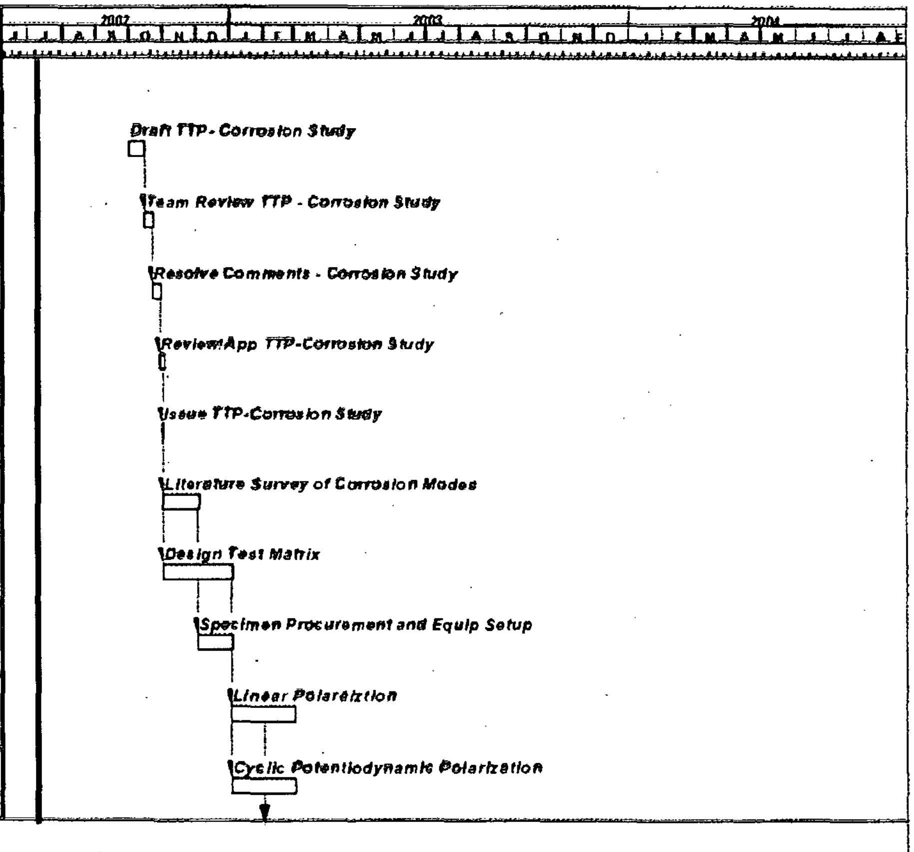
Cost Estimate for Research and Development

	Subcontract Cost	***TOTAL Cost***
Tank 48H Disposition Project	$887,700	$2,374,000
Corrosion Study		$220,000
Oxidation Options	$350,000	$760,000
Actual Waste Testing		$340,000
Bioremediation	$37,700	$90,000
Baseline Hydrolysis		$130,000
Tank 48H Characterization		$24,000
Steam Reforming	$500,000	$660,000
Downstream Facility Studies		$150,000

Corrosion Studies

Tank 48 Corrosion Study

Activity ID	Activity Description	Early Start	Early Finish
WP48F001	Draft TTP - Corrosion Study	01OCT02 07:00*	14OCT02 16:59
WP48F002	Team Review TTP - Corrosion Study	15OCT02 07:00	21OCT02 16:59
WP48F004	Resolve Comments - Corrosion Study	22OCT02 07:00	28OCT02 16:59
WP48F005	Review/App TTP-Corrosion Study	29OCT02 07:00	31OCT02 16:59
WP48F006	Issue TTP-Corrosion Study		31OCT02 16:59
WP48F100	Literature Survey of Corrosion Modes	01NOV02 07:00	02DEC02 16:59
WP48F110	Design Test Matrix	01NOV02 07:00	02JAN03 16:59
WP48F120	Specimen Procurement and Equip Setup	03DEC02 07:00	02JAN03 16:59
WP48F130	Linear Polaraiztion	03JAN03 07:00	28FEB03 16:59
WP48F140	Cyclic Potentiodynamic Polarization	03JAN03 07:00	28FEB03 16:59



Start Date	01JAN00 01:00
Finish Date	03DEC03 16:59
Data Date	08JUL02 07:00
Run Date	11JUL02 16:14

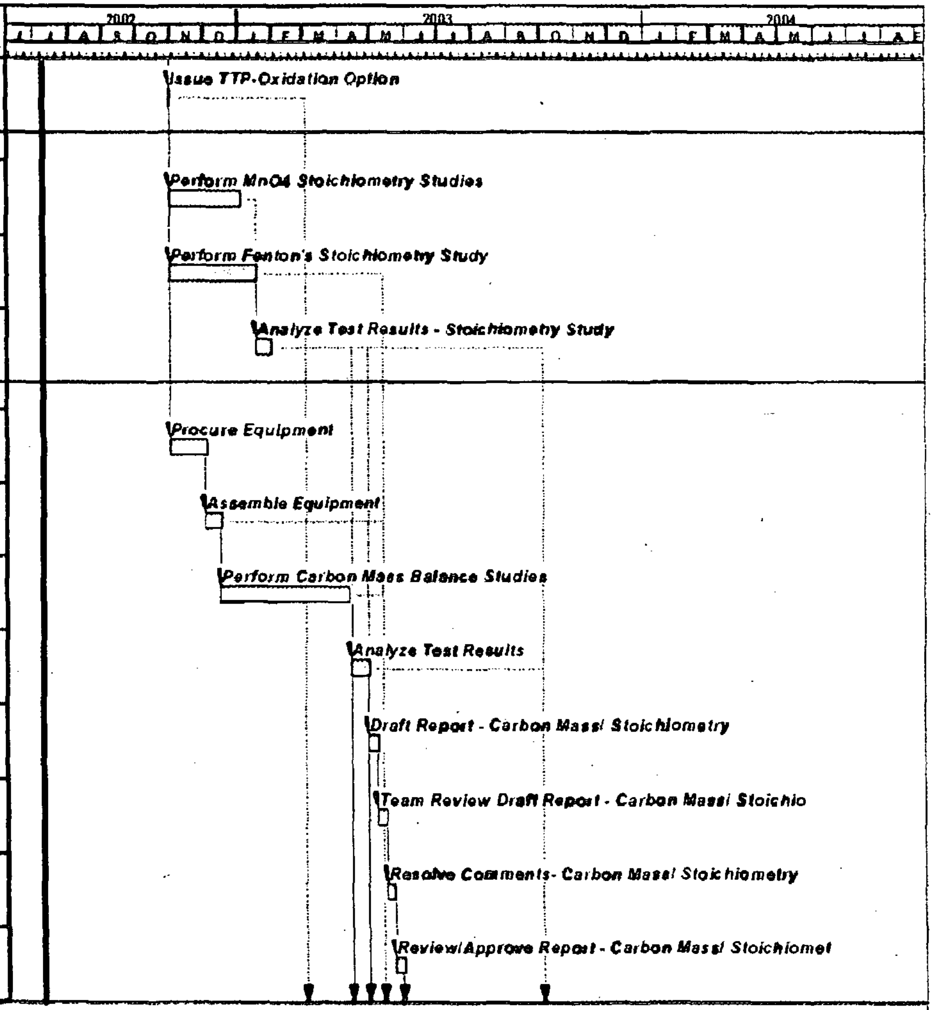
▭	Early Bar
▰	Progress Bar
■	Critical Activity

T48 Sheet 1

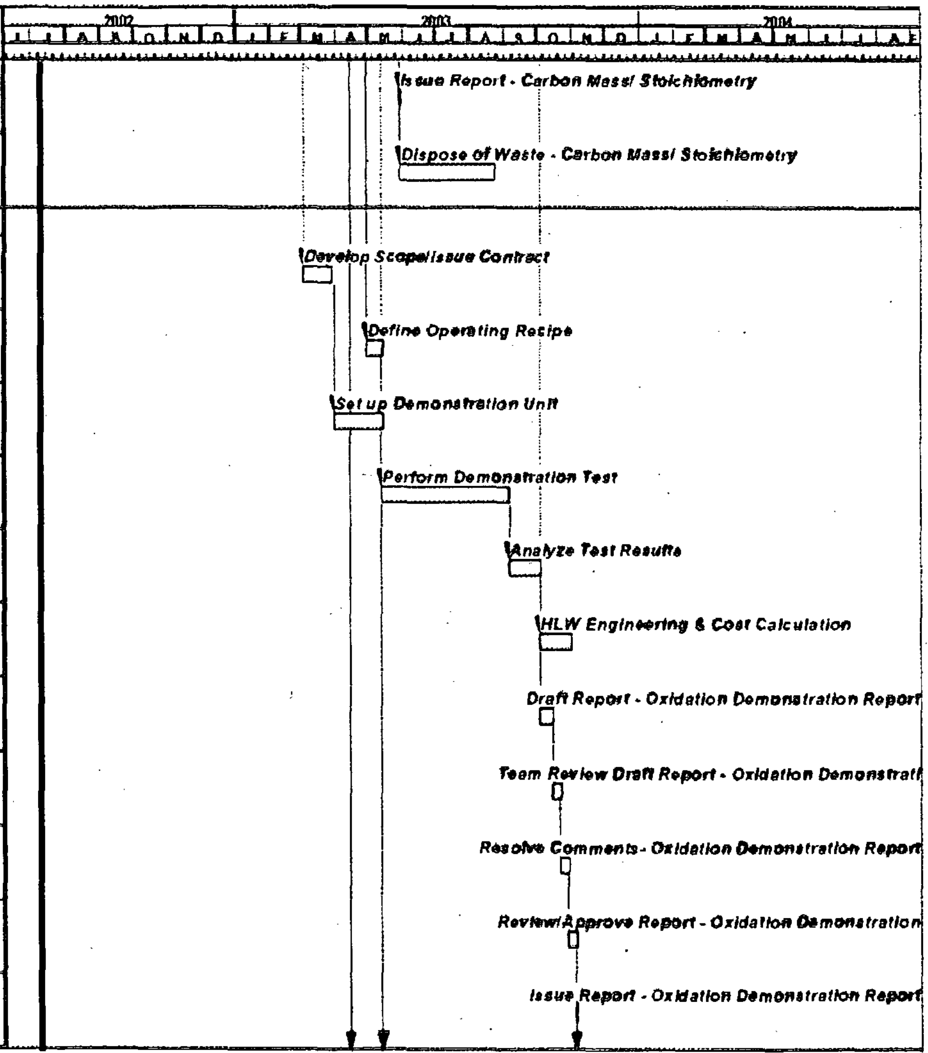
Tank 48 Disposition
Research & Development

Schedule of Activities

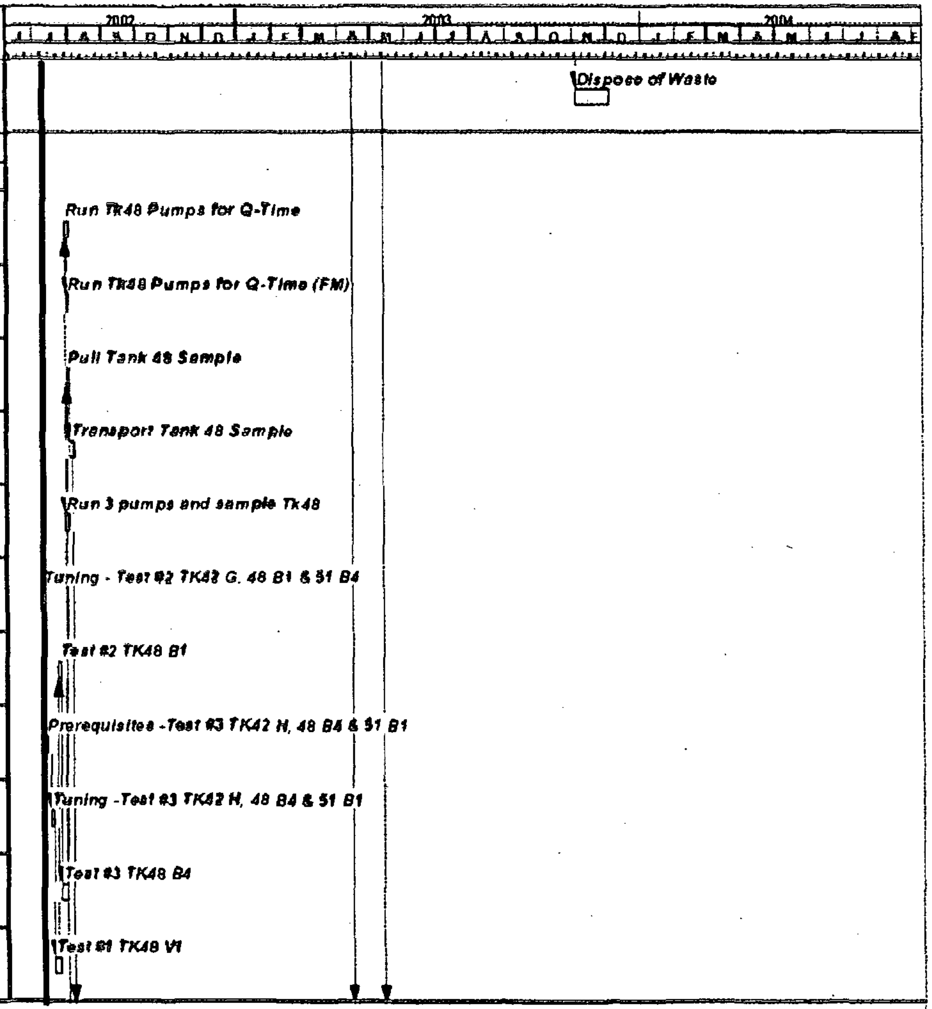
Activity ID	Activity Description	Early Start	Early Finish
WP48G150	Issue TTP-Oxidation Option		31OCT02 16:59
Stoichiometry Studies			
WP48H162	Perform MnO4 Stoichiometry Studies	01NOV02 07:00	02JAN03 16:59
WP48H164	Perform Fenton's Stoichiometry Study	01NOV02 07:00	16JAN03 16:59
WP48H170	Analyze Test Results - Stoichiometry Study	17JAN03 07:00	30JAN03 16:59
Carbon Mass Balance			
WP48J160	Procure Equipment	01NOV02 07:00	02DEC02 16:59
WP48J162	Assemble Equipment	03DEC02 07:00	16DEC02 16:59
WP48J164	Perform Carbon Mass Balance Studies	17DEC02 07:00	11APR03 16:59
WP48J170	Analyze Test Results	14APR03 07:00	29APR03 16:59
WP48J190	Draft Report - Carbon Mass/ Stoichiometry	29APR03 07:00	07MAY03 16:59
WP48J200	Team Review Draft Report - Carbon Mass/ Stoichio	08MAY03 07:00	14MAY03 16:59
WP48J210	Resolve Comments- Carbon Mass/ Stoichiometry	15MAY03 07:00	21MAY03 16:59
WP48J220	Review/Approve Report - Carbon Mass/ Stoichiomet	22MAY03 07:00	29MAY03 16:59



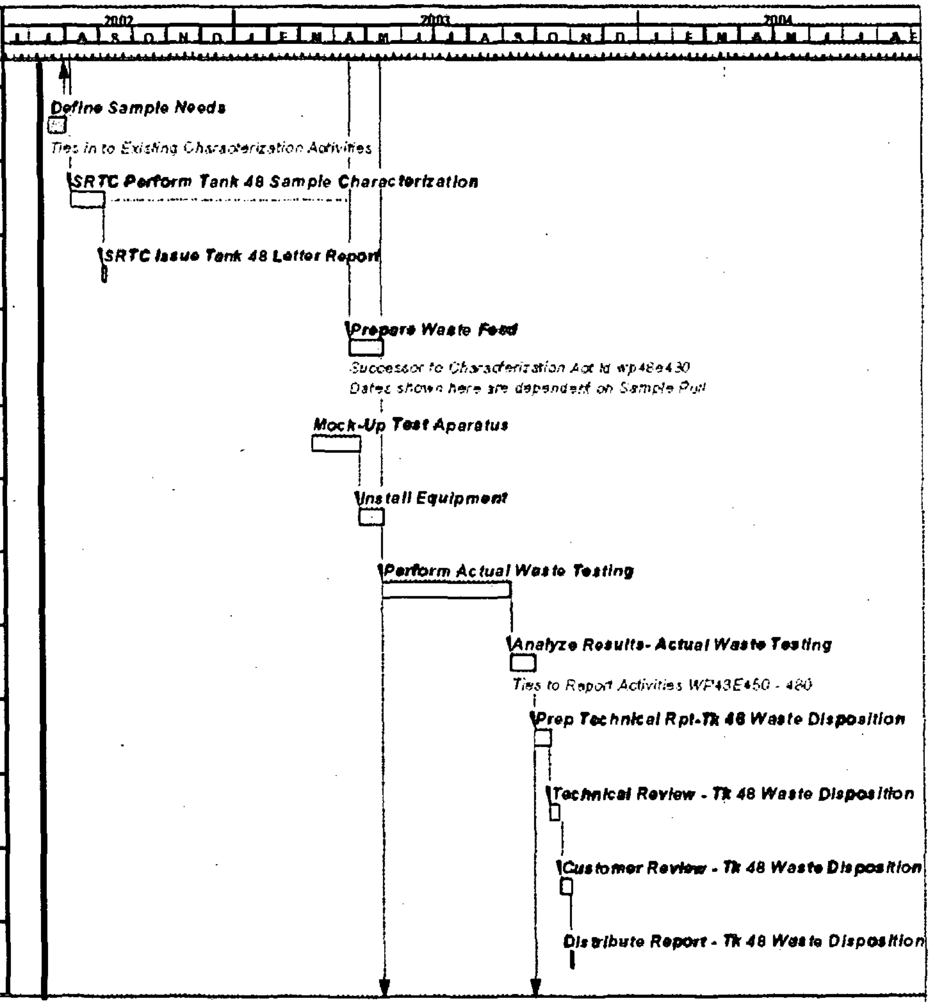
Activity ID	Activity Description	Early Start	Early Finish
WP48J230	Issue Report - Carbon Mass/ Stoichiometry		29MAY03 16:59
WP48J240	Dispose of Waste - Carbon Mass/ Stoichiometry	30MAY03 07:00	22AUG03 16:59
Demonstration Scale			
WP48K160	Develop Scope/Issue Contract	03MAR03 07:00	28MAR03 16:59
WP48K161	Define Operating Recipe	29APR03 07:00	12MAY03 16:59
WP48K162	Set up Demonstration Unit	31MAR03 07:00	12MAY03 16:59
WP48K164	Perform Demonstration Test	13MAY03 07:00	04SEP03 15:59
WP48K170	Analyze Test Results	05SEP03 07:00	02OCT03 16:59
WP48K180	HLW Engineering & Cost Calculation	03OCT03 07:00	30OCT03 16:59
WP48K190	Draft Report - Oxidation Demonstration Report	03OCT03 07:00	13OCT03 16:59
WP48K200	Team Review Draft Report - Oxidation Demonstrati	14OCT03 07:00	20OCT03 16:59
WP48K210	Resolve Comments- Oxidation Demonstration Report	21OCT03 07:00	27OCT03 16:59
WP48K220	Review/Approve Report - Oxidation Demonstration	29OCT03 07:00	03NOV03 16:59
WP48K230	Issue Report - Oxidation Demonstration Report		03NOV03 16:59



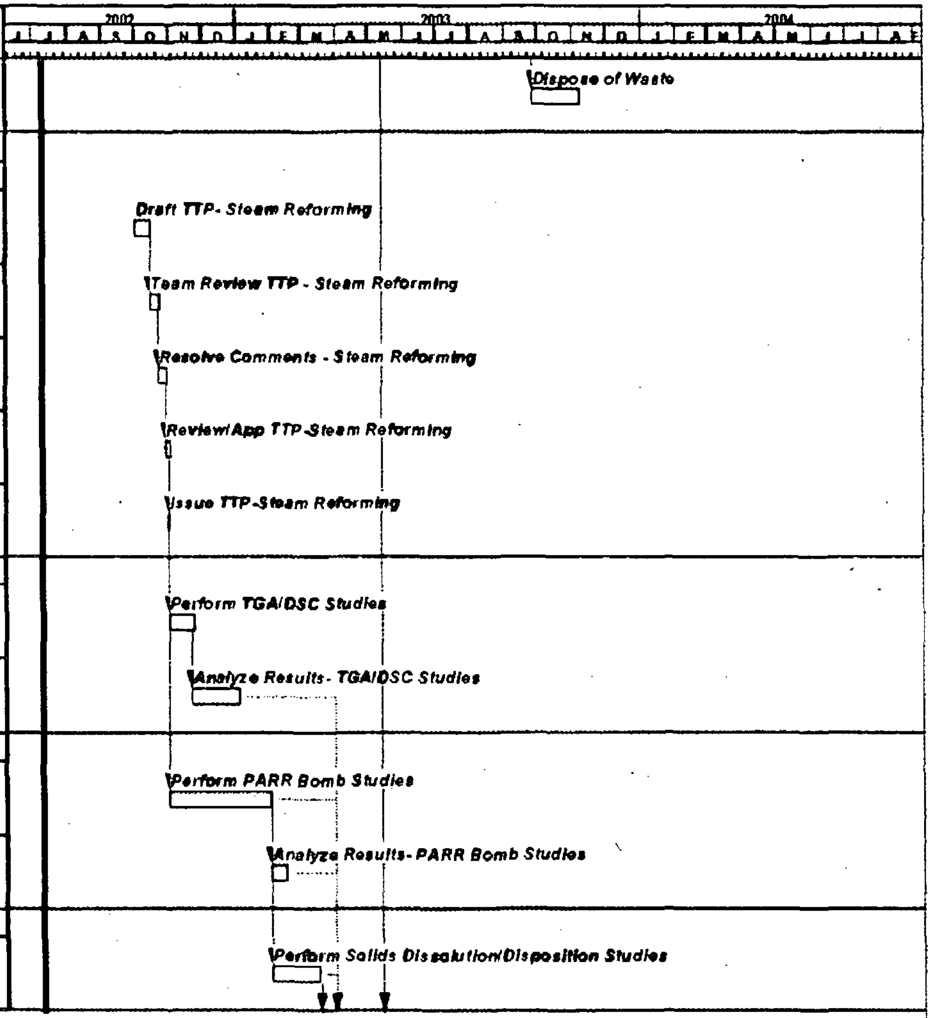
Activity ID	Activity Description	Early Start	Early Finish
WP48K240	Dispose of Waste	04NOV03 07:00	03DEC03 16:59
Confirmatory Actual Waste Testing			
Tank 48 Real Waste Testing - OPS			
WP48BZ-01D	Run Tk48 Pumps for Q-Time	29JUL02 17:00*	31JUL02 16:59
WP48BZ-XXX	Run Tk48 Pumps for Q-Time (FM)		31JUL02 16:59
WP48E410	Pull Tank 48 Sample	31JUL02 07:00	01AUG02 16:59
WP48E420	Transport Tank 48 Sample	02AUG02 07:00	05AUG02 16:59
WPALTNA-10	Run 3 pumps and sample Tk48	29JUL02 17:00	31JUL02 04:59
WPPH2TA3A2	Tuning - Test #2 TK42 G, 48 B1 & 51 B4	08JUL02 07:00*	10JUL02 16:59
WPPH2TA3Q3	Test #2 TK48 B1	23JUL02 07:00*	24JUL02 16:59
WPPH2TB3A1	Prerequisites -Test #3 TK42 H, 48 B4 & 51 B1	11JUL02 07:00*	11JUL02 16:59
WPPH2TB3A2	Tuning -Test #3 TK42 H, 48 B4 & 51 B1	15JUL02 07:00*	17JUL02 16:59
WPPH2TB3Q3	Test #3 TK48 B4	25JUL02 07:00*	29JUL02 16:59
WPPH2TC3Q3	Test #1 TK48 V1	18JUL02 07:00*	22JUL02 16:59



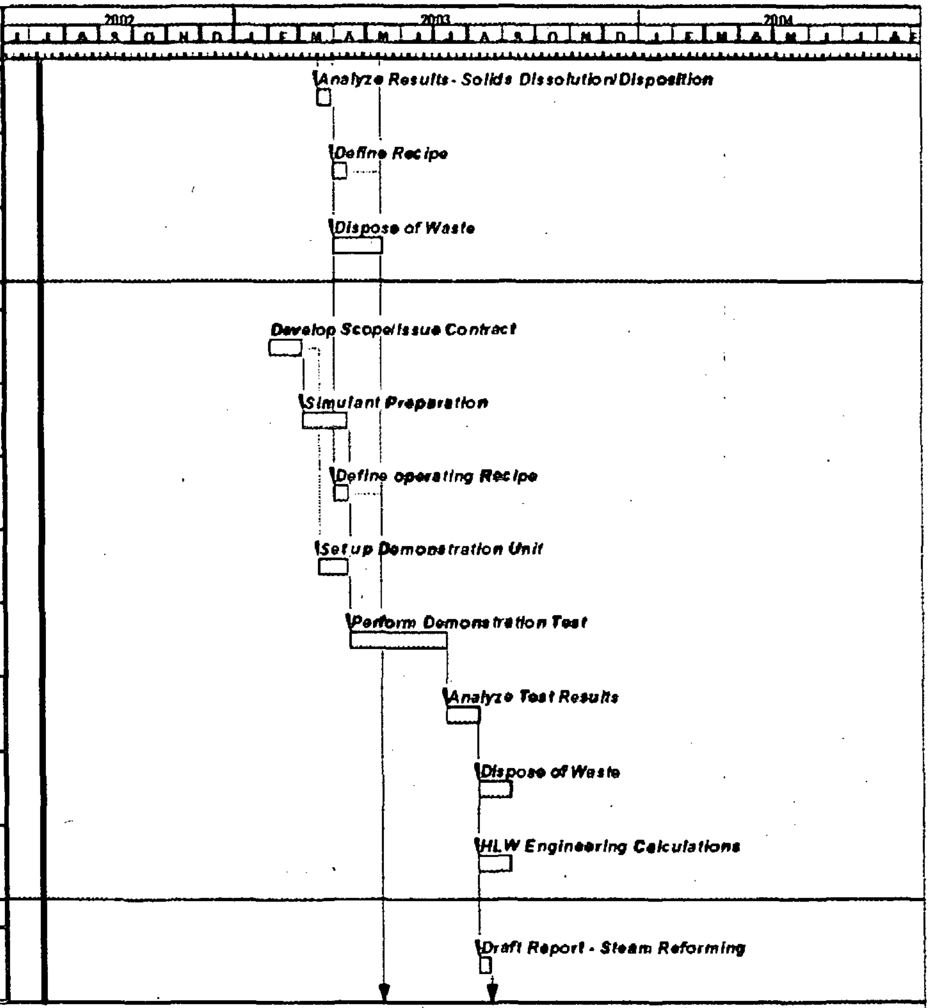
Activity ID	Activity Description	Early Start	Early Finish
Tank 48 Actual Waste Tests - R&D			
WP48N320	Define Sample Needs	17JUL02 07 00	30JUL02 16 59
WP48N330	SRTC Perform Tank 48 Sample Characterization	05AUG02 07 00	03SEP02 16 59
WP48N340	SRTC Issue Tank 48 Letter Report	04SEP02 07 00	05SEP02 16 59
WP48N360	Prepare Waste Feed	14APR03 07 00	12MAY03 16 59
WP48N370	Mock-Up Test Aparatus	10MAR03 07 00	21APR03 16:59
WP48N380	Install Equipment	22APR03 07 00	12MAY03 16 59
WP48N390	Perform Actual Waste Testing	13MAY03 07 00	04SEP03 16 59
WP48N400	Analyze Results- Actual Waste Testing	05SEP03 07 00	25SEP03 16 59
WP48N450	Prep Technical Rpt-Tk 48 Waste Disposition	26SEP03 07 00	09OCT03 16 59
WP48N460	Technical Review - Tk 48 Waste Disposition	10OCT03 07 00	17OCT03 16 59
WP48N470	Customer Review - Tk 48 Waste Disposition	26OCT03 07 00	27OCT03 16 59
WP48N490	Distribute Report - Tk 48 Waste Disposition	28OCT03 07 00	29OCT03 16 59



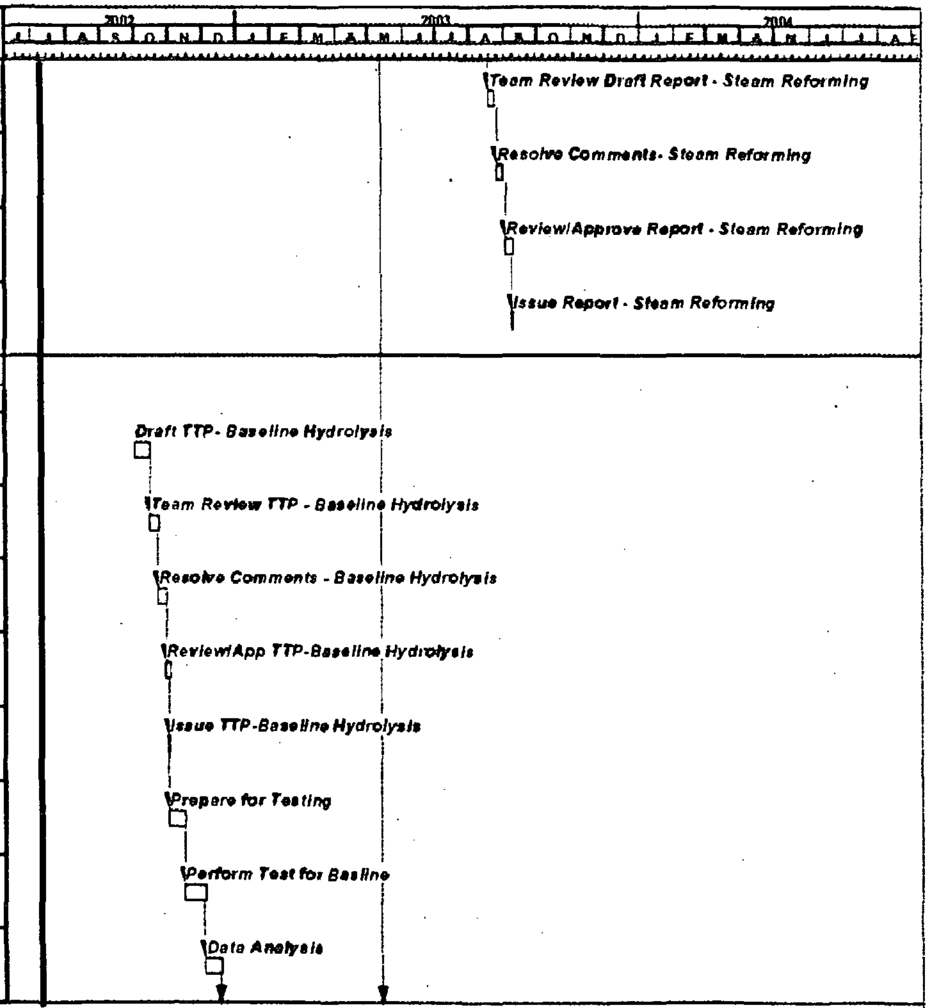
Activity ID	Activity Description	Early Start	Early Finish
WP49N500	Dispose of Waste	26SEP03 07:00	06NOV03 16:59
Steam Reforming			
Technical Task Plan			
WP49P100	Draft TTP- Steam Reforming	01OCT02 07:00*	14OCT02 16:59
WP49P110	Team Review TTP - Steam Reforming	15OCT02 07:00	21OCT02 16:59
WP49P130	Resolve Comments - Steam Reforming	22OCT02 07:00	28OCT02 16:59
WP49P140	Review/App TTP-Steam Reforming	29OCT02 07:00	31OCT02 16:59
WP49P150	Issue TTP-Steam Reforming		31OCT02 16:59
TGA/DSC Studies			
WP49Q100	Perform TGA/DSC Studies	01NOV02 07:00	21NOV02 16:59
WP49Q110	Analyze Results- TGA/DSC Studies	22NOV02 07:00	02JAN03 16:59
PARR Bomb Studies			
WP49R100	Perform PARR Bomb Studies	01NOV02 07:00	30JAN03 16:59
WP49R110	Analyze Results- PARR Bomb Studies	31JAN03 07:00	13FEB03 16:59
Solids Dissolution/Disposition Studies			
WP49S100	Perform Solids Dissolution/Disposition Studies	31JAN03 07:00	14MAR03 16:59



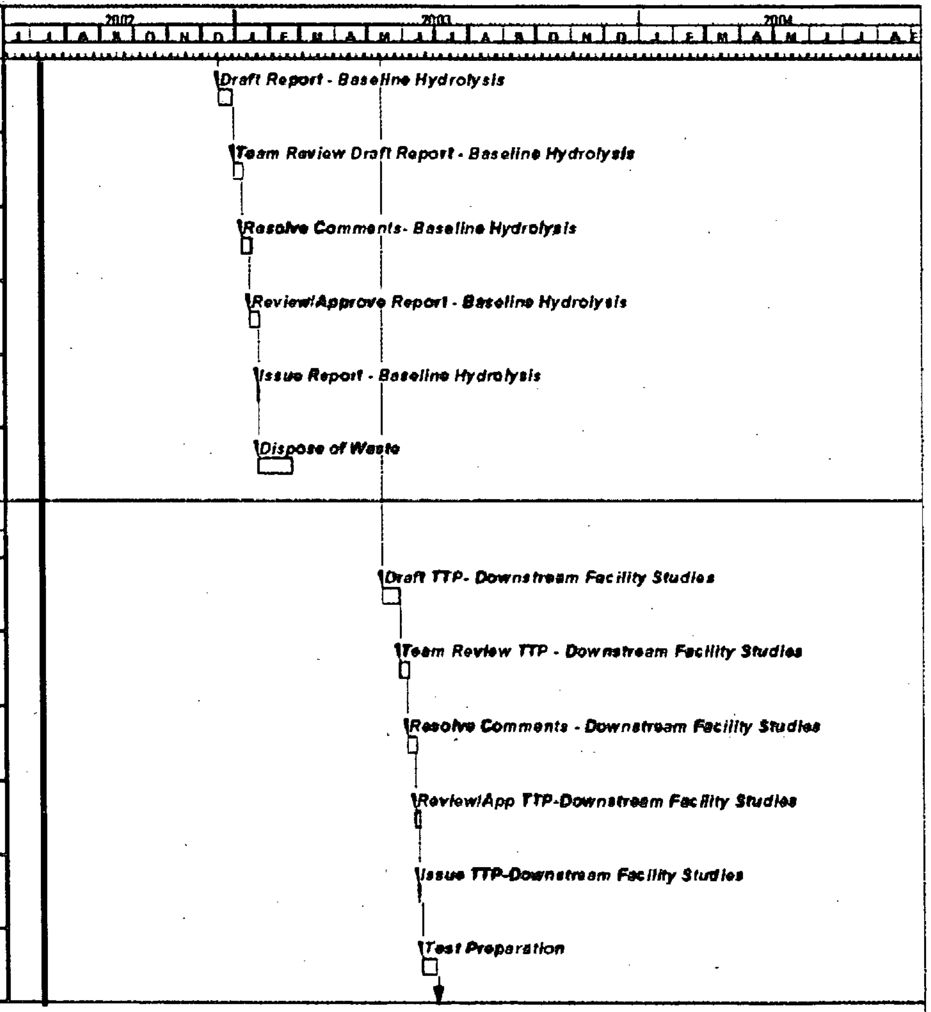
Activity ID	Activity Description	Early Start	Early Finish
WP48S110	Analyze Results- Solids Dissolution/Disposition	17MAR03 07:00	28MAR03 16:59
WP48S120	Define Recipe	31MAR03 07:00	11APR03 16:59
WP48S130	Dispose of Waste	31MAR03 07:00	12MAY03 16:59
Demonstration Scale			
WP48T100	Develop Scope/Issue Contract	31JAN03 07:00	28FEB03 16:59
WP48T105	Simulant Preparation	03MAR03 07:00	11APR03 16:59
WP48T106	Define operating Recipe	31MAR03 07:00	11APR03 16:59
WP48T110	Set up Demonstration Unit	17MAR03 07:00	11APR03 16:59
WP48T120	Perform Demonstration Test	14APR03 07:00	09JUL03 16:59
WP48T130	Analyze Test Results	10JUL03 07:00	06AUG03 16:59
WP48T135	Dispose of Waste	07AUG03 07:00	04SEP03 16:59
WP48T140	HLW Engineering Calculations	07AUG03 07:00	04SEP03 16:59
Summary Report			
WP48U100	Draft Report - Steam Reforming	07AUG03 07:00	15AUG03 16:59



Activity ID	Activity Description	Early Start	Early Finish
WP49U110	Team Review Draft Report - Steam Reforming	18AUG03 07 00	22AUG03 16 59
WP49U120	Resolve Comments- Steam Reforming	25AUG03 07 00	29AUG03 16 59
WP49U130	Review/Approve Report - Steam Reforming	02SEP03 07 00	09SEP03 16 59
WP49U140	Issue Report - Steam Reforming		09SEP03 16 59
Baseline Hydrolysis			
Baseline Hydrolysis			
WP49V001	Draft TTP- Baseline Hydrolysis	01OCT02 07 00*	14OCT02 16 59
WP49V002	Team Review TTP - Baseline Hydrolysis	15OCT02 07 00	21OCT02 16 59
WP49V004	Resolve Comments - Baseline Hydrolysis	22OCT02 07 00	29OCT02 16 59
WP49V005	Review/App TTP-Baseline Hydrolysis	29OCT02 07 00	31OCT02 16 59
WP49V006	Issue TTP-Baseline Hydrolysis		31OCT02 16 59
WP49V100	Prepare for Testing	01NOV02 07 00	14NOV02 16 59
WP49V110	Perform Test for Basline	15NOV02 07 00	02DEC02 16 59
WP49V160	Data Analysis	03DEC02 07 00	16DEC02 16 59



Activity ID	Activity Description	Early Start	Early Finish
WP48V170	Draft Report - Baseline Hydrolysis	17DEC02 07 00	27DEC02 16 59
WP48V180	Team Review Draft Report - Baseline Hydrolysis	30DEC02 07 00	06JAN03 16 59
WP48V200	Resolve Comments- Baseline Hydrolysis	07JAN03 07 00	13JAN03 16 59
WP48V210	Review/Approve Report - Baseline Hydrolysis	14JAN03 07 00	20JAN03 16 59
WP48V220	Issue Report - Baseline Hydrolysis		20JAN03 16 59
WP48V230	Dispose of Waste	21JAN03 07 00	18FEB03 16 59
Facility Studies			
Downstream Facility Studies			
WP48W001	Draft TTP- Downstream Facility Studies	13MAY03 07 00*	27MAY03 16 59
WP48W002	Team Review TTP - Downstream Facility Studies	29MAY03 07 00	03JUN03 16 59
WP48W003	Resolve Comments - Downstream Facility Studies	04JUN03 07 00	10JUN03 16 59
WP48W004	Review/App TTP-Downstream Facility Studies	11JUN03 07 00	13JUN03 16 59
WP48W005	Issue TTP-Downstream Facility Studies		13JUN03 16 59
WP48W100	Test Preparation	16JUN03 07 00	27JUN03 16 59



Activity ID	Activity Description	Early Start	Early Finish
WP48W110	Perform Glass/Saltstone Experiments	30JUN03 07:00	14JUL03 16:59
WP48W120	Conduct Test Data Analyses	15JUL03 07:00	28JUL03 16:59
WP48W130	Draft Report - Downstream Facility Studies	29JUL03 07:00	05AUG03 16:59
WP48W140	Team Review Draft Report - Downstream Facility S	07AUG03 07:00	13AUG03 16:59
WP48W150	Resolve Comments-Downstream Facility Studies	14AUG03 07:00	20AUG03 16:59
WP48W160	Review/Approve Report - Downstream Facility Stud	21AUG03 07:00	27AUG03 16:59
WP48W170	Issue Report - Downstream Facility Studies		27AUG03 16:59
WP48W180	Dispose of Waste	28AUG03 07:00	25SEP03 16:59