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TITLE: RISK ASSESSMENT OF CST-7 PROPOSED WASTE TREATMENT AND STORAGE FACILITIES

Hazardous Waste Treatment Facility (HWTF)
Mixed Waste Receiving and Storage Facility (MWRSF)
HWTF Drum Storage Building (DSB)

Volume I: Limited-Scope Probabilistic Risk Assessment (PRA) of Proposed CST-7 Waste Treatment and Storage Facilities

Volume II: Preliminary Hazards Analysis of Proposed CST-7 Waste Treatment and Storage Facilities

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VOLUME I:

LIMITED-SCOPE PROBABILISTIC RISK ASSESSMENT (PRA) OF PROPOSED CST-7 WASTE TREATMENT AND STORAGE FACILITIES

Hazardous Waste Treatment Facility (HWTF)
Mixed Waste Receiving and Storage Facility (MWRSF)
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CONTENTS

Page

CONTENTS (Cont)

RISK ASSESSMENT OF CST-7 PROPOSED WASTE TREATMENT AND STORAGE FACILITIES

EXECUTIVE SUMMARY

In FY 1993, the Los Alamos National Laboratory Waste Management Group [CST-7 (formerly EM-7)] requested the Probabilistic Risk and Hazards Analysis Group [TSA-11 (formerly N-6)] to conduct a study of the hazards associated with several CST-7 facilities. Among these facilities are the Hazardous Waste Treatment Facility (HWTF), the HWTF Drum Storage Building (DSB), and the Mixed Waste Receiving and Storage Facility (MWRSF), which are proposed for construction beginning in 1996. These facilities are needed to upgrade the Laboratory's storage capability for hazardous and mixed wastes and to provide treatment capabilities for wastes in cases where offsite treatment is not available or desirable. These facilities will assist Los Alamos in complying with federal and state regulations.

A Preliminary Hazards Analysis (PHA) was chosen as the initial assessment, and a limited Probabilistic Risk Assessment (PRA) was derived from the PHA as the next logical step. The PHA method is based on techniques outlined in AIChE,* the California Risk Management Prevention Program (RMPP),** and the Process Safety Management (PSM)*** rule. A multidisciplinary team of senior technical personnel was assembled to conduct this study; the team included representatives from TSA-11, CST-7, and PLG, Inc. (PLG, Inc. is a private consulting firm specializing in chemical and nuclear facility risk analysis.) The team included specialists in nuclear and chemical engineering, process chemistry, risk analysis, environmental risk, human reliability, and facility conduct of operations.

The limited PRA is a more rigorous analysis of the most serious risks identified by the PHA. PRA consists of event- and fault-tree analyses and consequence analysis, the results of which quantify the most serious risks associated with the proposed storage facilities.

In summary, the results of the PHA indicated that there are a number of hazard scenarios that may affect the worker or have a localized effect on adjacent facilities. Several hazards were identified that were thought to potentially affect the public and/or environment significantly. The team made a number of recommendations in the PHA that we consider prudent and easy to implement at the conceptual design stage. Volume II of this report provides a full description of the PHA, including the results and recommendations.

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*"Guidelines for Hazard Evaluation Procedures," Second Edition with Worked Examples, AIChE, 1992.

**F. A. Lercari, "Guidance for the Preparation of a Risk Management and Prevention Program," State of California, Office of Emergency Services unnumbered report (November 1989).

***OSHA "Process Safety Management (PSM) of Highly Hazardous Chemicals," 29 CFR 1910.119.

The PRA provides a more quantitative assessment of possible offsite consequences. It was limited to an analysis of the release of large quantities of toxic gases because the PHA results indicated that this was the only accident that could potentially affect the public. Seismic events and fires were identified as the only means of potentially releasing toxic gases in sufficient quantities to have a potential offsite effect. The PRA results indicate that there are not severe offsite public consequences on a credible frequency (e.g., the frequency is <1.0E-6/yr); however, there could be some short-duration exposure to persons traveling the roadway adjacent to TA-63 at a frequency of approximately 1.0E-6/yr. For this reason, we recommend that CST-7 ensure that there is a well-developed emergency response capability that is clearly written, reviewed with Laboratory emergency planning specialists, and practiced during training exercises. Volume I of this report provides a full description and the results of the PRA.

LIST OF TABLES

LIST OF FIGURES

LIMITED-SCOPE PROBABILISTIC RISK ASSESSMENT (PRA) OF PROPOSED CST-7 WASTE TREATMENT AND STORAGE FACILITIES

SUMMARY

In FY 1993, the Los Alamos National Laboratory Waste Management Group [CST-7 (formerly EM-7)] requested the Probabilistic Risk and Hazards Analysis Group [TSA-11 (formerly N-6)] to conduct a study of the hazards associated with several proposed CST-7 facilities. Among these facilities are the Hazardous Waste Treatment Facility (HWTF), the HWTF Drum Storage Building (DSB), and the Mixed Waste Receiving and Storage Facility (MWRSF), which are proposed for construction beginning in 1996. These facilities are needed to upgrade the Laboratory's storage capability for hazardous and mixed wastes and to provide treatment capability for wastes in cases where offsite treatment is not available or desirable. These facilities will assist Los Alamos in complying with Federal and state regulations and agreements.

A Preliminary Hazards Analysis (PHA) was chosen as the initial assessment, and a limited Probabilistic Risk Assessment (PRA) was derived from the PHA as the next logical step. The PHA method is based on techniques outlined in AIChE,[1] the California Risk Management Prevention Program (RMPP),[2] and the Process Safety Management (PSM)[3] rule. A multidisciplinary team of senior technical personnel was assembled to conduct this study; the team included representatives from TSA-6, CST-7, and PLG, Inc. PLG, Inc. is a private consulting firm specializing in chemical and nuclear facility risk analysis. The team included specialists in nuclear and chemical engineering, process chemistry, risk analysis, environmental risk, human reliability, and facility conduct of operations.

The limited PRA is a more rigorous analysis of the most serious risks identified by the PHA. PRA consists of event and fault tree analysis and consequence analysis, the results of which quantify the most serious risks associated with the proposed storage facilities.

The most serious risks identified by the PHA were those associated with the release of toxic gases from compressed cylinders that may be stored at the new hazardous waste facility. A number of compressed gas cylinders are now stored in an open field at TA-54. Many of these are legacy wastes (generated from past operations), and they may contain unidentified gases or be contained in cylinders of questionable integrity or conformance to standards. Additional high-risk gas cylinders are expected to be identified during the course of future operations and environmental restoration activities. At the time of this study, CST-7 staff were uncertain whether gas cylinders would be stored in the new facilities. The PHA team decided to review storage as if gas cylinders would be stored in the facility. The PHA found that these cylinders represent a substantial hazard during transportation, storage, and treatment. Special precautions are recommended for cylinders containing the

most highly toxic gases (hydrogen fluoride, phosgene, arsine, hydrogen sulfide) or those that contain unidentified gases. The following were among the precautions recommended by the PHA team.

- Double containment of the most highly toxic gases before movement and storage.

- Special precautions at loading sites; e.g., installation/use of windsocks, training of operators on proper evacuation techniques, availability of self-contained breathing apparatus, etc.

- Special transportation restrictions for the most highly toxic or unidentified gases, e.g., escort vehicle, road closure, etc.

- Special storage restrictions; e.g., do not store legacy wastes in these buildings and provide special enclosed storage compartments for nonlegacy cylinders.

The PRA assumes that the above recommendations, as well as those not to allow storage of highly energetic, shock-sensitive materials in these facilities, are implemented. The hazards analyzed by the PHA that appear to present the most potential to the public (offsite) are releases of toxic gases from gas cylinders as a result of seismic or fire events. These two events (seismic and fire) have the capability of releasing a large percentage of the gas in storage. These also bound other scenarios for release of gas, such as the rupture of a single gas cylinder as a result of accident conditions or cylinder degradation.

The results of the event-tree/fault-tree analysis for the large fire and seismic scenarios gave an overall frequency of release on the order of 3.5E-4/yr. The frequency of the initiating events is based on site data, analysis, or industry data for facilities of this type. The dependent-failure probabilities (e.g., building breach given a seismic event, building or container breach given a facility fire) are screening-level estimates that are as accurate as possible given that the final facility design is not complete. Screening-level estimates typically are used in first-order PRAs to determine the degree of importance of accident scenarios.

The team performed consequence calculations for large releases of toxic gases. The six most toxic gases currently stored and planned to be stored in the new facilities were chosen for analysis: hydrogen fluoride, hydrogen sulfide, arsine, phosgene, phosphine, and cyanogen. For these calculations, we reviewed the CST-7 current storage inventory to estimate maximum release inventories. The maximum inventories were judged not to be overly conservative but are considered indicative of the upper bound for future storage needs for these gases.

The consequence dispersion analysis used two codes, MIDAS and QCRR. MIDAS, or Meteorological Information and Dispersion Analysis System, is a PLG code installed at Los Alamos in the Health and Safety Division. MIDAS is installed on a dedicated machine, collects on-line meteorological data from four stations, and can track onsite releases of radiological or chemical materials for emergency response activities. It also can be used to predict release paths from postulated accidents. MIDAS provides a color plot of the most likely plume of the material along with concentration isopleths of the gases at the ERPG-2 and ERPG-3 levels. ERPG-2 and ERPG-3 represent the maximum airborne concentrations below which individuals could be exposed for up to 1 h without experiencing irreversible/serious health effects (ERPG-2) or life threatening health effects (ERPG-3).

The team used the QCRR (Quantification of Chemical Release Risk) code to calculate risk contours. (Note that risk denotes an element of frequency.) The risk contours calculated by QCRR used the following inputs.

- Toxic gas release frequencies calculated by the event-tree/fault-tree analysis
- Local meteorological data statistics, or wind rose, which is a measure of the most likely wind directions and stability
- Dispersion analysis using MIDAS

QCRR calculated a risk contour for each gas release. The contour indicates the distances from the release site (TA-63) that the ERPG levels would be expected to be exceeded on a 1-million-year (1.0E-6/yr) basis. The QCRR plots use a more conservative 10-min averaging time, i.e., the risk contour is the area that would exceed ERPG levels for 10 min, not a full 60-min period.

The risk contours indicate a very short segment of Pajarito Road for which the ERPG levels could be exceeded on a frequency of 1.0E-6/yr. As discussed above, individuals would be required to be exposed to these levels for an hour or more to incur the expected health effects. Additional analysis indicates that individuals traveling this segment of road would traverse the distance in a matter of minutes; therefore, a significant health effect would not be expected.

The Department of Energy (DOE) and Los Alamos have concluded that Pajarito Road is not considered to be public domain for safety analysis purposes because this highway is DOE property under the jurisdiction of DOE and can be closed at any time necessary. The mobile home park on East Jemez Road is considered to be the closest public offsite property for dose calculation purposes. Persons at that location would be more likely to remain in one location for an hour or more as compared with the residence time of persons traveling down Pajarito Road. The dispersion analysis indicates the chance of an effect at the mobile home park from a release at TA-63 is well below the 1.0E-6/yr value normally considered as a credible cut-off for safety analysis purposes.

In summary, the PHA indicates that there are a number of hazard scenarios that may affect the worker or have a localized effect to adjacent facilities (see Volume II). A number of recommendations were made in the PHA that are considered prudent and easy to implement at the conceptual design stage.

The PRA provides a more quantitative assessment of possible offsite consequences. Although the analysis does not indicate severe offsite public consequences on a credible frequency (1.0E-6/yr), there could be some short-duration exposure to persons traveling the roadway adjacent to TA-63 at a frequency of approximately 1.0E-6/yr. For this reason, it is recommended that CST-7 ensure a well-developed emergency response capability that is clearly written, reviewed with Los Alamos emergency planning specialists, and exercised during training exercises.

1.0. INTRODUCTION, PURPOSE, AND SCOPE

1.1. Project Background

Routine operations and research activities at the Los Alamos National Laboratory generate a variety of radioactive, hazardous, and mixed wastes. By definition, mixed waste contains both a hazardous chemical component and radioactive materials. The types and quantities of wastes generated have varied greatly during the more than 50 yr of Laboratory operations. Los Alamos currently has an aggressive program to minimize new waste generation, thereby reducing the capacity needs for storage. However, there remain significant amounts of existing (or legacy) wastes that must be processed and stored appropriately.

The options for the treatment of wastes generated by the Laboratory are limited. Some hazardous wastes can be shipped offsite to approved commercial facilities for treatment. For other hazardous wastes and all mixed wastes, no offsite treatment methods are available, and Federal and state regulations are restrictive in terms of the storage and treatment of these remaining wastes. Thus, Los Alamos currently is evaluating a number of options for treatment and storage of hazardous and mixed wastes to develop a suitable plan that ensures compliance with all Federal and State regulations.

Los Alamos Group CST-7, Waste Management, is responsible for all aspects of waste management at the Laboratory (characterization, storage, offsite shipment, and any onsite treatment). The new facilities to be constructed, beginning in FY 1996 or later, will be located at TA-63 on Pajarito Road. These facilities are important to future operations to ensure compliance with regulations regarding the treatment and storage of hazardous and mixed wastes. The primary facilities proposed for TA-63 are the Hazardous Waste Treatment Facility (HWTF), the HWTF Drum Storage Building (DSB), and the Mixed Waste Receiving and Storage Facility (MWRSF). The HWTF will consist of two buildings: (1) a treatment building that is capable of treating both mixed and hazardous wastes and (2) the DSB for storing hazardous wastes only. The MWRSF will receive and store mixed wastes; some rebulking or repackaging operations will be performed. The facilities are currently in the conceptual design stage; a final design has not been accepted, and approval for construction has yet to be granted.

The Probabilistic Risk and Hazards Analysis Group (TSA-11) was requested to analyze the potential hazards associated with these facilities. Performing a hazards analysis during the conceptual design stage allows facility improvements and design changes to be implemented without costly expenditures. Therefore, a Preliminary Hazards Analysis (PHA) of these facilities was conducted.

PHA is a systematic approach for identifying hazards associated with a process and assessing the risk of those hazards qualitatively. A process is composed of activities, which are logical groupings of process steps. In a PHA, each activity is examined using a predefined set of possible hazards. If the PHA team agrees that a particular hazard poses a problem, then the team assesses the problem in terms of its causes, consequences, severity, existing protective features, and expected frequency of occurrence. Therefore, a set of possible scenarios is developed for each hazard.

The results of the PHA indicated areas of potentially significant risks to the public, workers, or environment that warrant further study. A more detailed Probabilistic Risk Analysis (PRA) investigates the accident scenarios determined by the PHA to be of high risk. The risk is quantified by assessing the frequency of occurrence followed by an offsite consequence analysis. This report documents the findings and recommendations of the PRA.

1.2. Project Scope

This limited-scope PRA builds on the PHA conducted for the MWRSF, the HWTF, and the DSB. The PRA is limited to those hazards that have the potential for releasing amounts of material that would be expected to have significant consequences to the public, co-located workers, or the environment.

The PHA analyzed activities associated with both hazardous and mixed wastes. These activities are generally classified as (1) transportation within the TA-63 complex, (2) storage of the waste containers after arrival at TA-63, (3) rebulking or repackaging of some wastes, and (4) processing or treatment.

1.2.1. Storage of Acutely Hazardous Materials. The PHA team reviewed the broad range of waste materials that could be stored to gain an understanding of their degree of flammability, toxicity, and incompatibility with other wastes. The technical staff from CST-7 completed an exhaustive search for information related to the storage conditions and properties of the materials considered to possibly be placed in the storage facilities. The PHA report provides a more detailed account of this work (Vol. II).

Although a number of treatment processes are expected to be conducted in the HWTF, the PHA determined that the primary risk for major releases to the public came from the storage of large quantities of mixed or hazardous wastes in the storage facilities. Therefore, this limited PRA does not include further evaluation of the treatment processes.

1.2.2. General Description of the Facilities

1.2.2.1. Hazardous Waste Treatment Facility. The HWTF will be located at TA-63, north of Pajarito Road. It comprises the DSB, a treatment building, and an office building. The treatment building will house a treatment room for each of four kinds of waste: nonradioactive characteristic wastes, nonradioactive listed wastes, radioactive characteristic wastes, and radioactive listed wastes. These separate treatment rooms will (1) allow workers to avoid mixing waste types, (2) prevent cross contamination, and (3) treat only one waste type at a time to avoid mixing incompatible wastes.

As currently designed, the DSB is an open structure consisting of a concrete base with a roof. Eight or more individual storage compartments are planned, each with a 4-ft-high segregating wall. Each storage compartment will have its own sump that is designed to hold at least 10% of the volume of the materials in storage. A forklift will be used to move materials in and out of storage.

1.2.2.2. Mixed Waste Receiving and Storage Facility. The MWRSF will be located at TA-63 near the HWTF. This facility consists of only one building. An enclosed loading dock will allow removal of waste containers from incoming trucks. These containers then will be transported by low-impact walk-behind air pallets or bridge cranes, if necessary. Wastes will be stored in one of eight segregated storage rooms/compartments. Each storage area will be designed with a fire protection system appropriate for the type of waste stored. Individual drainage sumps will be provided for each location. The facility will be provided with a heating, ventilating, and air conditioning (HVAC) system that includes high-efficiency particulate air (HEPA) filtration, charcoal filters, and a caustic scrubber.

A separate room will be designed for rebulking or repackaging some types of waste. As this activity is expected to be one of the more dangerous operations, the room will be provided with increased fire protection, exhaust systems (e.g., portable hoods), monitoring, supplied air for respirators, and other safety features.

The facility will include all other service areas necessary for it to be independent—change rooms, decontamination rooms, a mechanical/electrical room, and office areas.

1.2.3. Storage Classification System. Based on the PHA, a storage classification system based on EPA regulations (40 CFR 264, Storage of Incompatible Wastes) is recommended. This classification approach was reviewed by CST-7 process experts and determined to be the most appropriate way to segregate the various types of waste materials, thereby reducing the hazards associated with the mixing of incompatible wastes. The classification system currently in use at the TA-54 storage complex is based on DOT shipping regulations. The DOT system was compared with the EPA system and found to be deficient in terms of segregating various waste types. The waste classification areas for storage to be provided in the HWTF, DSB, and MWRSF according to EPA regulation 40 CFR 264 are as follows.

Group 1A: Caustics

Group 1B: Acids

Group 2A: Reactives (metals, metal hydrides)

Group 4A: Flammables

Group 5A: Cyanides, Sulfides

Group 6A: Oxidizers

Group 7A: Compressed Gases

Group 8: Polychlorinated Biphenyls (PCB)

Group 9: Unregulated

2.0. SUMMARY OF PRA METHODOLOGY

2.1. Overview

A PRA was performed for the waste storage and treatment facilities to answer three questions.

1. What can go wrong in the HWTF, DSB, and MWRSF during operation or maintenance or as a consequence of internal or external events that could result in accident sequences?

2. How likely are these sequences to occur?

3. What is the potential level of exposure?

To answer these questions, a scenario-based approach was applied that is consistent with the guidelines set forth in draft guidance DOE-DP-3005-93. This systematic framework for defining accident sequences is shown in Fig. 2-1. Section 2.0 discusses how these questions can be answered for the HWTF, DSB, and MWRSF using simplified methods that have proved both effective and efficient for addressing a limited-scope analysis.

The first question was addressed by the recently completed Preliminary Hazard Analysis (PHA) (Vol. II). The PHA systematically identified hazards associated with the HWTF, DSB, and MWRSF and assessed the risks of those hazards qualitatively.

To answer the second question, the frequencies of occurrence must be computed for the accident scenarios determined in the PHA to be of high risk. This requires that the frequencies for the events that could initiate the accident sequences and the failure frequencies for the equipment or human action that could mitigate the release be quantified. From this information, a model can be developed using fault and event trees. The model provides the link between the computed risk and the underlying causes. Because of the limited scope of this accident analysis, the quantification effort was focused on the accident scenarios having the most severe consequences. This concentrated the study on the worst-case scenarios that can be used to bound the risk from all HWTF, DSB, and MWRSF accident scenarios.

The third question is addressed by conducting an offsite consequence analysis. The input used for the dispersion calculation is based on release of hazardous materials given that the initiating event has occurred. A worst-case scenario was developed for each release type.

This methodology, as it applies to the CST-7 waste storage and treatment facilities, requires that four tasks be completed.

1. Identification of accident scenarios that have a potential effect on co-located workers and the public.

2. Quantification of the hazard scenario frequencies by developing simple fault trees and event trees.

3. Estimation of the maximum inventories of the toxic gases that are to be stored in the facilities.

4. Analysis of the offsite consequences for an individual release of the entire toxic gas inventory.

Toxic gas release was chosen because the other materials in storage or processing either are nonvolatile or cannot be released in large enough quantities to have potential consequences to co-located workers and the public. The focus on toxic gas release and its effect on people who are not in the immediate vicinity of the accident, i.e., co-located workers and the public, is discussed in Secs. 3 and 4.

2.2. Event-Tree Methodology

An event tree represents the transformation of the pertinent qualitative details of the PHA into a functional logic framework. The event tree is composed of top events. In developing the event trees, it is important to arrange the top events so that the sources of dependency are on the left of the tree and the effects of these sources are on the right. When organized in this way, the conditions under which the dependent event is challenged are fully resolved along the sequence path by prior top events.

The following terms are used to describe the structure and components of event trees.

Initiating Event	The entry state to the event tree, located at the upper left.
Top Events	The questions listed across the top of the event tree.
Success Branch	The branch running straight across from left to right.
Failure Branch	Downward branch beneath a failed top event. If there is no downward branch, the top event is considered unimportant at that point.
Sequence	A unique path of successes and failures leading from the initiating event through the event tree to an end state.
End State	The condition of the facility resulting from a specific sequence.

Split Fraction The numerical value used for the failure probability of a top event under specific boundary conditions.

Accident-sequence quantification involves combining the frequency of equipment operation and operator actions in response to initiating events with the frequency of those initiating events. The sequences of failures that are of most interest here are those that result in toxic gas release, although the quantification process can treat all sequences, including those resulting in successful event mitigation. For the limited scope of this accident analysis, only those sequences representing the most severe consequences for the co-located worker and the public are quantified. The event trees are presented and discussed in Sec. 4.

2.3. Fault-Tree Methodology

Sequence quantification requires that a split fraction value be assigned to each branch in each event tree. A split fraction value is the conditional frequency of failure of a given event-tree top event. Top events may be questions related to the physical progression of the accident or the likelihood that human intervention can mitigate the consequences as well as those related to the performance of systems. It can be dependent on the status of top events in previous trees, the specific initiating event, and on the success or failure of the previous top events of the same tree. In other words, each specific split fraction value represents the frequency of failure of the event-tree top event based on preceding scenario conditions.

Simple fault-tree models were developed for each top event to provide the logic structure for quantifying the split fractions. A fault tree is a graphical block diagram depicting failure logic. Only those split fractions necessary for the limited-scope accident analysis were quantified. The fault trees are presented in Sec. 4.

2.4. Sequence Quantification

The annual frequency of each accident sequence is simply the initiating-event annual frequency multiplied by the conditional split fraction value of each top event that is applicable to that sequence. The result of sequence assembly and quantification is a set of scenarios, each leading to one of various release categories (or to successful mitigation). For a complete quantification, the sequences include all of the possible combinations of success and failure of the event-tree top events. The individual sequence frequencies are summed by release category to determine the annual frequency per release category (and of successful mitigation). The total of all of the sequence frequencies is equal to the sum of all of the release categories' frequencies (including success), which is also equal to the sum total of all of the initiating-event frequencies. This is true because the event-tree sequences represent a set of exhaustive and mutually exclusive outcomes of the initiating events.

As previously discussed, only those sequences representing the most severe consequences for the co-located worker and the public are quantified because of the limited nature of this PRA.

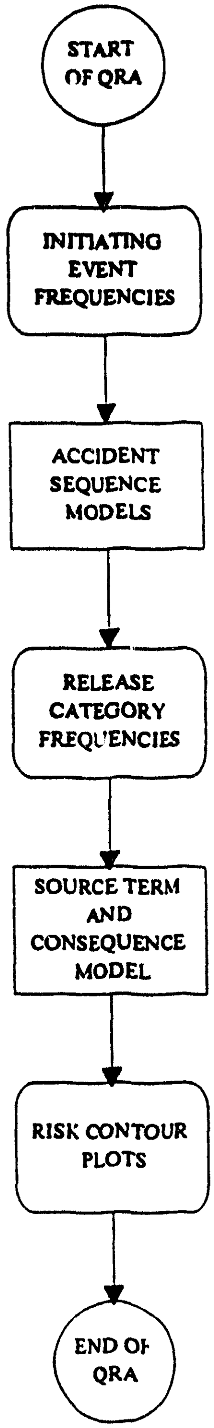


Fig. 2-1. The scenario approach for accident analysis quantification.

3.0. SCENARIO SELECTION FOR ACCIDENT ANALYSIS

3.1. Selection of Severe Consequence Scenarios

The scope of the PRA was limited to those hazard scenarios identified by the PHA has having the potential to significantly affect co-located workers, i.e., those workers not in the immediate vicinity of the hazard, and the general public. A discussion of methodology is provided in the PHA (Vol. II of this report).

The type of hazardous material influences the severity of the consequences associated with a scenario. Of those scenarios that could affect co-located workers and the public, the release of toxic gases was identified as the only feasible path. The study excludes toxic, but nonvolatile, materials as well as nonvolatile low-level radiation materials because of their localized effects. Because the study is limited to bounding calculations, the release of all toxic gases simultaneously constitutes the premise for the worst-case scenarios. The most highly toxic gases that are to be stored or processed at the CST-7 facilities were identified by the PHA as

- phosgene,
- hydrogen fluoride,
- arsine,
- HCN,
- hydrogen sulfide,
- cyanogen, and
- phosphine.

Three general classes of scenarios were identified in the PHA with respect to a release of toxic gas.

1. Seismic events that lead to collapse or partial collapse of the storage building and release of toxic gases or volatile toxic materials from the storage containers.

2. Fire or explosion events that cause a release of toxic gases or volatile materials from storage containers in conjunction with a breach of the storage building and/or disruption of the ventilation/scrubber system.

3. Spill events that lead to a release of toxic gases in conjunction with the failure of the ventilation/scrubber system. An alternate scenario is a spill event outside of the storage building during a transport activity, or a spill event in the open-sided DSB.

Insofar as severity is concerned, the seismic and fire/explosion scenarios can potentially release the entire toxic gas inventory. These could affect co-located workers, the public, and potentially the environment and thus are worst-case scenarios. The spill scenarios are limited to the inventory of one or two containers, which is considered to have a localized and controllable affect on the environment and the public.

3.2. Results from the PHA

The accident scenarios that were determined by the PHA to expose co-located workers and the general public to consequences of severity category A are associated with one of four initiating events: seismic, internal fire/explosion, external fire/explosion, and spill. All initiator types, except for a spill event, could lead to a release of the entire inventory of toxic gases. The following discussion summarizes the relevant findings of the PHA.

Table 3-1 lists the seismic events. There is one scenario each for the HWTF/DSB and the MWRSF. The cause is the same in each facility: a high-intensity seismic event. Regardless of facility, it is anticipated that a seismic event that exceeds the design criteria will cause the roof to collapse, thereby instigating a release of the toxic gas inventory. This scenario has been quantified; the results of the quantification are discussed in Sec. 4.3.

Table 3-2 lists the internal and external fire/explosion events. One of each initiator type is associated with both the HWTF/DSB and the MWRSF. The risk is greater for an internal fire/explosion event than for an external fire/explosion event. This is attributed to the higher frequency of occurrence for the internal event. Because fire/explosion events that are extremely severe can lead to worst-case scenarios, these scenarios have been quantified. Fires of the magnitude addressed are expected to cause building and container breaches regardless of whether the storage building is enclosed. The internal and external events are quantified separately because of different sets of circumstances in each case that would result in release of the toxic gas inventory.

Table 3-3 lists the spill events. Although a worst-case scenario resulting from a spill event is not anticipated, the scenarios with severe consequences are included to demonstrate that an initiating event is not required to be catastrophic to still result in adverse effects on co-located workers and the general public. For example, a truck accident on a public road could result in a breach of the gas cylinders being transported. However, it is understood that transportation may be outside the scope of the TA-63 safety analysis. As previously discussed, the spill scenarios are limited to the inventory of one or two containers, which has a localized and controllable effect. Therefore, the frequency of such spill events has not been quantified.

TABLE 3-1
SEISMIC SCENARIOS: CONSEQUENCE "A" FOR PUBLIC AND/OR CO-LOCATED WORKER EXPOSURE

Node	Description of Scenario	Risk Rank	Frequency	Consequence	Consequences of Scenario	Recommendations
HWG	High-intensity seismic event with horizontal acceleration of 0.3 g or greater.	3	IV	A	Structural collapse of building, breach of multiple drums, major fire, release of toxic gas to environment. (A; A; A; A)	(1) Review seismic design criteria. (2) Minimize storage time of most flam-mable/toxic materials.
MWG	High-intensity seismic event with horizontal acceleration of 0.3 g or greater.	3	IV	A	Structural collapse of building, breach of multiple drums, major fire, release of toxic gas to environment, and radioactive contamination. (A;A;A;A)	(1) Review seismic design criteria. (2) Minimize storage time of most flam-mable/toxic materials.

TABLE 3-2
FIRE/EXPLOSION SCENARIOS: CONSEQUENCE "A" FOR PUBLIC AND/OR CO-LOCATED WORKER EXPOSURE

Node	Description of Scenario	Risk Rank	Frequency	Consequence	Consequences of Scenario	Recommendations
HW7A	Internal fire (initiated within the building)	2	III	A	Pressurization and rupture of gas cylinders Highly toxic gas release and potential cylinder missile generation. (A;A;A;A)	(1) Initiate fire suppression sprinklers given fire in adjacent areas. (2) Enclose the HW storage area and store gas cylinders in an enclosed area.
MW7A	Internal fire (initiated within the building)	2	III	A	Pressurization and rupture of gas cylinders. Highly toxic gas release and potential cylinder missile generation. (A;A;A;A)	Store gas cylinders in an enclosed area with fire door and fire wall.
HWG	External fire (e.g., forest or brush fire)	3	IV	A	Fire penetrates the HWTF, major fire releases toxic gas to the environment. (A;A;A;A)	None
MWG	External fire (e.g., forest or brush fire)	3	IV	A	Fire penetrates the MWRSF, major fire releases toxic gas to the environment and radioactive contamination (A;A;A;A)	None

TABLE 3-3
SPILL SCENARIOS: CONSEQUENCE "A" FOR PUBLIC AND/OR CO-LOCATED WORKER EXPOSURE

Node	Description of Scenario	Risk Rank	Frequency	Consequence	Consequences of Scenario	Recommendations
HW7A	Breach of legacy cylinder of doubtful integrity during storage	1	II	A	Release of highly toxic gases (phosphine, phosgene, arsine, and others). Worker fatality, potential co-located worker and public exposure. (A;A;A;D)	(1) Do not store legacy cylinders in HWTF Areas. (2) Process legacy cylinders without intermediate storage. (3) Provide secondary containment for the cylinders. (4) Consider enclosing the HWTF storage and providing HVAC and scrubber.
GC2	Truck accident on public road between TA-54 and TA-63 with breach of gas cylinder(s)	2	III	A	Potential release of toxic gases with public and worker exposure. (A;C;A;D)	Administrative controls (1) Provide escort for the transport vehicle and consider road closure during transport. (2) Driver training. (3) Restrict night or poor weather deliveries. (4) Consider secondary containment for cylinders of questionable integrity, unknown contents, or those containing most highly toxic materials.
HW4A	Picric acid dropped or jarred	2	III	A	Detonation, major fire in HWTF storage area, multiple toxic gases (e.g., phosgene, HCN, etc.) released directly to environment, worker fatality, public exposure. (A;A;A;A)	Develop and enforce policy not to store explosives or shock-sensitive materials in this building.

TABLE 3-3 (CONT)

Node	Description of Scenario	Risk Rank	Frequency	Consequence	Consequences of Scenario	Recommendations
HW6A	Forklift accident or freezing causing dual spill of incompatible materials because of mislabeling of waste drum, e.g., oxidizer waste mixed with (1) NAOH(1A), (2) acetic acid(1B), (3) sodium(2A), (4) organics such as chlorobenzene(4A), (5) gold cyanide(5A)	2	III	A	Release of toxic gases, potential explosion and potential fire. Fire involving chlorobenzene could generate phosgene gas; potential worker fatality. (B;A;A;B)	(1) Verify drum contents and labeling at waste generator's site. (2) Implement the ES&H Manual procedures for waste identification and labeling of waste containers. (3) Enclose the HWTF storage building and install scrubber system. (4) Review/consider air monitoring in the air.
HW7A	Breach of cylinder (nonlegacy) as a result of accidental causes (e.g., cylinder dropped and regulator line breaks)	2	III	A	Release of highly toxic gases (phosphine, phosgene, arsine, and others). Worker fatality, potential co-located worker and public exposure. (A;A;A;D)	(1) Transport and store cylinders securely. (2) Consider secondary containment for most hazardous cylinders. (3) Gas cylinders to be processed with high priority. (4) Work in this area to be performed with protection (i.e., wear SCBA, operate under the buddy system). (5) Protective cap for cylinder regulators should be in place at all times. (6) Consider storing gas cylinders in enclosed room in an enclosed building.

TABLE 3-3 (CONT)

Node	Description of Scenario	Risk Rank	Frequency	Consequence	Consequences of Scenario	Recommendations
HWG	Accident during transportation of waste (toxic gas cylinders or incompatible waste drums) from HW storage to CAI or other facility.	2	III	A	Spill leading to the unmitigated release of toxic gases. Public exposure. (A;A;AA)	(1) Consider road closure while trans-porting the most hazardous materials between lab areas. (2) Review procedures for securing waste drums during trans-portation. (3) Do not transport incompatible waste drums together.
MWG	Accident during transportation of the most toxic waste drums (e.g., toxic gas cylinders or incompatible wastes) from MWRSF to CAI or other facilities.	2	III	A	Spill leading to the unmitigated release of toxic gases. Public exposure. (A;A;A;A)	(1) Consider road closure while trans-porting the most hazardous materials between Laboratory areas. (2) Review procedures for securing waste drums during trans-portation. (3) Do not transport incompatible waste drums together.
GC4	Breach of cylinder from accidental causes (e.g., cylinder dropped and regulator line breaks).	3	IV	A	Release of highly toxic gases (phosphine, phosgene, arsine, and others), worker fatality. (A;A;A;D).	(1) Transport and store cylinders securely. (2) Consider secondary contain-ment for most haz-ardous cylinders. (3) Protective cap for cylinder regulators should be in place at all time.

4.0. ACCIDENT SEQUENCE MODELING AND QUANTIFICATION

4.1. Technical Approach

To build an event tree, it is necessary to define an initiating event. For the CST-7 PRA, the initiating events must have the potential to lead to a worst-case scenario. Thus, the attributes of the initiating events are

- potential for severe consequences with respect to co-located workers and the public and
- full inventory release of toxic gases.

For the general classes of seismic events and fire/explosion events, as discussed in Sec. 3.1, initiating events that would result in worst-case scenarios were postulated.

1. A seismic event that exceeds the design specification of the facilities. (The HWTF/DSB and MWRSF will be built to withstand a 0.17-g temblor, which corresponds to a moderate design per UCRL-15910. An earthquake with an acceleration of 0.3 g was chosen as the seismic event exceeding the design criterion.)
2. A fire/explosion that starts inside one of the facilities and results in a building breach.
3. A fire/explosion that starts outside a facility and propagates into a facility because of a building breach.

4.1.1. Event-Tree Development. An event tree was constructed for each identified initiating event. An initiating event associated with the general class of spill events could not be posed that would lead to the severe consequences or toxic gas release as stipulated for a worst-case scenario. Top events are listed in Table 4-1 in order of appearance in each event tree. The two-letter designator is the variable name of the top event. The top events that are quantified for the worst-case sequences are indicated with references.

The event trees are presented in Figs. 4-1 through 4-3 for the seismic, internal fire/explosion, and external fire/explosion initiating events, respectively. The bold branch indicates the sequence leading to the most severe consequences for co-located workers and the general public. In each figure, this sequence represents the worst-case scenario for the given initiating event. Because of the attributes of the initiating events, some top events are guaranteed to fail. Many top events were deemed unimportant with respect to the release frequency calculations of the worst-case sequences. Thus, explicit downward branching is not necessary for the quantification.

4.1.2. Fault-Tree Development. To compute a frequency of occurrence, the split fraction values for the failure branches along the path of each worst-case sequence must be determined. The extent to which fault trees are required to compute split fraction values is minimal given the scope of the CST-7 PRA. Nonetheless, fault trees were developed for each top event in the event trees for completeness. Furthermore, this ensured that all failure modes that are applicable given the initiating event and dependent top events are examined. The fault trees for the seismic event are shown in Fig. 4-4. Figures 4-5 and 4-6 depict the fault trees for the internal and external fire/explosion events, respectively.

The split fraction values that are required for the computation of worst-case scenario frequencies were determined using the fault trees and point- estimate data from previous studies. Split fraction values that are applicable to the bounding calculations are shown in Figs. 4-1 through 4-3 at relevant downward branches.

In support of any future quantification, the fault tree for a spill event is shown in Fig. 4-7. It is not quantified in this study because spill events do not lead to severe consequences for the co-located workers or the public, as discussed in Sec. 3.2.

4.1.3 Accident Sequence Quantification. The annual frequency of each accident sequence is simply the initiating-event annual frequency multiplied by the conditional split fraction value of each top event that is applicable to that sequence. The result of sequence assembly and quantification is a set of accident scenarios. For the PRA, only the worst-case sequences were quantified.

4.2. CST-7 Accident Sequence Modeling

4.2.1. Seismic Events. Figure 4-1 depicts the event tree for a seismic event. The top events that were defined for this event tree are described below. In addition, applicable split fractions and the quantification approach are included. The fault trees for each top event are in Fig. 4-4.

Top Event CB, Collapse of Building. If the building collapses as a result of a seismic event, then this top event can fail. The failure of top event CB falls along the path of the worst-case scenario; therefore, the split fraction was quantified. Using point-estimate data from previous studies (Ref. 1), the value of the split fraction is shown in Fig. 4-1 at the base of the downward branch.

Top Event BL, Breach of Service Lines (No Gas or Water Lines). This top event is not important if the building has collapsed. Therefore, split fraction values were not quantified.

Top Event BC, Breach of Container. This top event indicates the release of the toxic gas inventory. If the building has collapsed, this top event is considered to be a guaranteed failure. No additional quantification was required.

Top Event MX, Mixing of Incompatibles. This top event is not important if the building has collapsed. Therefore, split fraction values were not quantified.

Top Event FB, Fire in Building. This top event is not important if the building has collapsed. Therefore, split fraction values were not quantified.

Top Event VT, Ventilation System Malfunctions. This top event is not important if the building has collapsed. Therefore, split fraction values were not quantified.

Top Event EV, Evacuation Procedures Disregarded. This top event is not important in determining the release frequency. Therefore, split fraction values were not quantified.

4.2.2. Internal Fire/Explosion Events. Figure 4-2 depicts the event tree for an internal fire/explosion event. The top events that were defined for this event tree are described below. Applicable split fractions and the quantification approach are included as well. The fault trees for each top event are in Fig. 4-5.

Top Event BB, Breach of Building. If the building is breached as a result of an internal fire/explosion event, then this top event can fail. The failure of top event BB falls along the path of the worst-case scenario; therefore, the split fraction was quantified. Using point-estimate data from previous studies (Ref. 1), the value of the split fraction is shown in Fig. 4-2 at the base of the downward branch.

Top Event BC, Breach of Container. This top event indicates the release of the toxic gas inventory. If the building is breached, this top event can fail; thus, the split fraction value was determined using point-estimate data (Ref. 1) and expert judgment (fault tree for BC in Fig. 4-5) as noted in Fig. 4-2.

Top Event MX, Mixing of Incompatibles. This top event is not important if the building is breached. Therefore, split fraction values were not quantified.

Top Event VT, Ventilation System Malfunctions. This top event is not important if the building is breached. Therefore, split fraction values were not quantified.

Top Event EV, Evacuation Procedures Disregarded. This top event is not important in determining the release frequency. Therefore, split fraction values were not quantified.

4.2.3. External Fire/Explosion Events. Figure 4-3 depicts the event tree for an external fire/explosion event. The top events that were defined for this event tree are described below. The applicable split fractions and quantification approach are included as well. The fault trees for each top event are in Fig. 4-6.

Top Event BB, Breach of Building. If the building is breached as a result of an external fire/explosion event, then this top event can fail. The failure of top event BB falls along the path of the worst-case scenario; therefore, the split fraction was quantified. Using point-estimate data from previous studies (Ref. 1), the value of the split fraction is shown in Fig. 4-3 at the base of the downward branch.

Top Event BC, Breach of Container. This top event indicates the release of the toxic gas inventory. If the building is breached, this top event can fail; thus, the split fraction value was determined using point-estimate data (Ref. 1) and expert judgment (fault tree for BC in Fig. 4-6) as noted in Fig. 4-3.

Top Event MX, Mixing of Incompatibles. This top event is not important if the building is breached. Therefore, split fraction values were not quantified.

Top Event VT, Ventilation System Malfunctions. This top event is not important if the building is breached. Therefore, split fraction values were not quantified.

Top Event EV, Evacuation Procedures Disregarded. This top event is not important in determining the release frequency. Therefore, split fraction values were not quantified.

4.3. CST-7 Accident Sequence Quantification

4.3.1. Summary Of Quantification Inputs. The values of the initiating-event frequencies used during the quantification are included in Table 4-2. The references for these annual frequencies also are shown. The split fractions that were computed for use in the quantification are listed in Table 4-3 for each initiating event. As with the initiating-event frequencies, the reference for each split fraction value is noted.

4.3.2. Accident Sequence Results. Table 4-4 compares the qualitative measures of frequency from the PHA with the release frequencies computed in the PRA. The overall release frequency is 3.5E-4 per year.

TABLE 4-1
TOP EVENTS FOR INITIATING EVENTS OF WORST-CASE SCENARIOS

INITIATING EVENT	TOP EVENTS	IS TOP EVENT QUANTIFIED?	REFERENCE, IF QUANTIFIED
Seismic event of 0.3g intensity	CB - Collapse of Building	Yes	Applied Technology Council Publication 13, Earthquake Damage Evaluation Data for California
	BL - Breach of Service Lines	No	
	BC - Breach of Container	Yes	Expert Judgment
	MX - Mixing of Incompatibles	No	
	FB - Fire in Building	No	
	VT - Malfunction of Ventilation System	No	
	EV - Evacuation Procedures Disregarded	No	
Fire/explosion starting inside facility	BB - Breach of Building	Yes	Expert Judgment
	BC - Breach of Container	Yes	Expert Judgment
	MX - Mixing of Incompatibles	No	
	VT - Malfunction of Ventilation System	No	
	EV - Evacuation Procedures Disregarded	No	
Fire/explosion starting outside facility	BB - Breach of Building	Yes	Derived from "Probabilistic Safety Analysis for TA-63, HWTF," M. K. Sasser, 1992.
	BC - Breach of Container	Yes	Expert Judgment
	MX - Mixing of Incompatibles	No	
	VT - Malfunction of Ventilation System	No	
	EV - Evacuation Procedures Disregarded	No	

TABLE 4-2
INITIATING-EVENT FREQUENCIES FOR WORST-CASE SEQUENCES

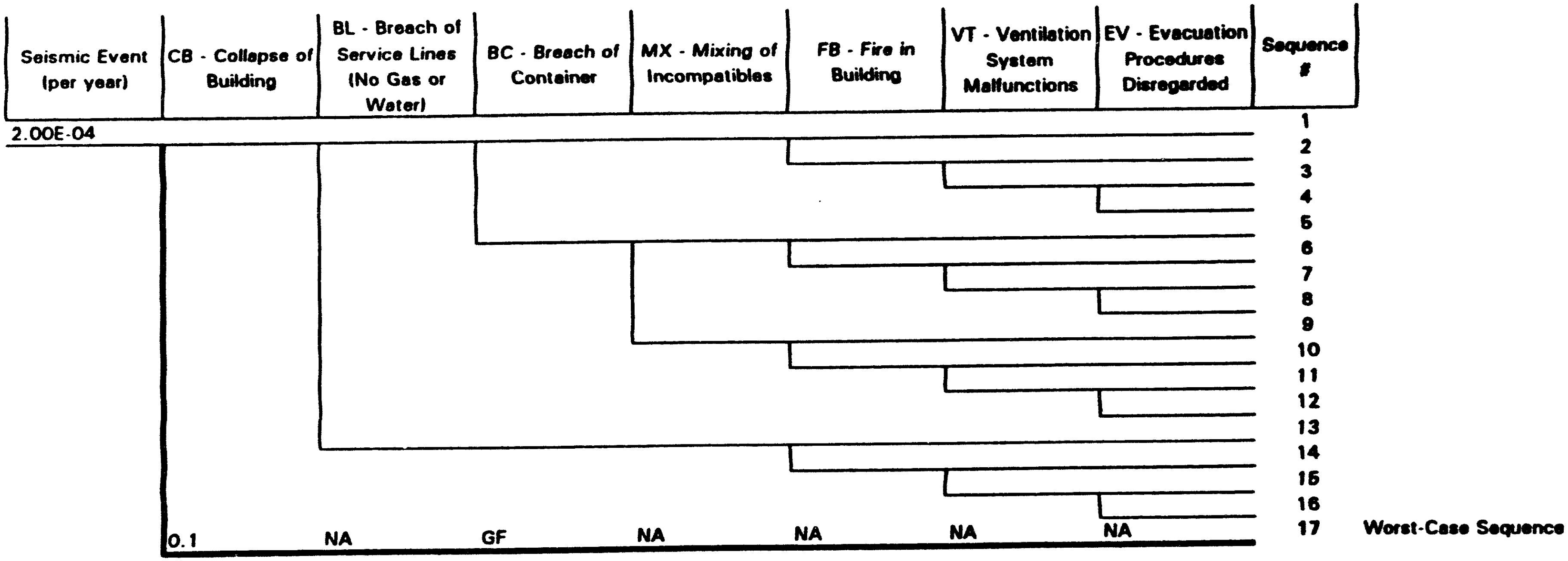
INITIATING EVENT	INITIATING-EVENT FREQUENCY (YR^{-1})	REFERENCE
Seismic event of 0.3-g intensity	2.0×10^{-4}	Woodward and Clyde, "Seismic Evaluation of Los Alamos Site," 1993.
Fire/explosion starting inside facility	3.3×10^{-2}	"Probabilistic Safety Analysis for TA-63, HWTF," M. K. Sasser, 1992.
Fire/explosion starting outside facility	2.0×10^{-2}	"Probabilistic Safety Analysis for TA-63, HWTF," M. K. Sasser, 1992.

TABLE 4-3
SPLIT FRACTION VALUES FOR WORST-CASE SEQUENCES

INITIATING EVENT	TOP EVENTS USED DURING QUANTIFICATION	SPLIT FRACTION VALUE	REFERENCE
Seismic event of 0.3 g intensity	CB	0.01	Applied Technology Council Publication 13, "Earthquake Damage Evaluation Data for California"
	BC	1.0 (Guaranteed Failure)	Expert Judgment
Fire/explosion starting inside facility	BB	0.1	Expert Judgment
	BC	0.1	Expert Judgment
Fire/explosion starting outside facility	BB	0.01	Derived from "Probabilistic Safety Analysis for TA-63, HWTF," M.K. Sasser, 1992.
	BC	0.1	Expert Judgment

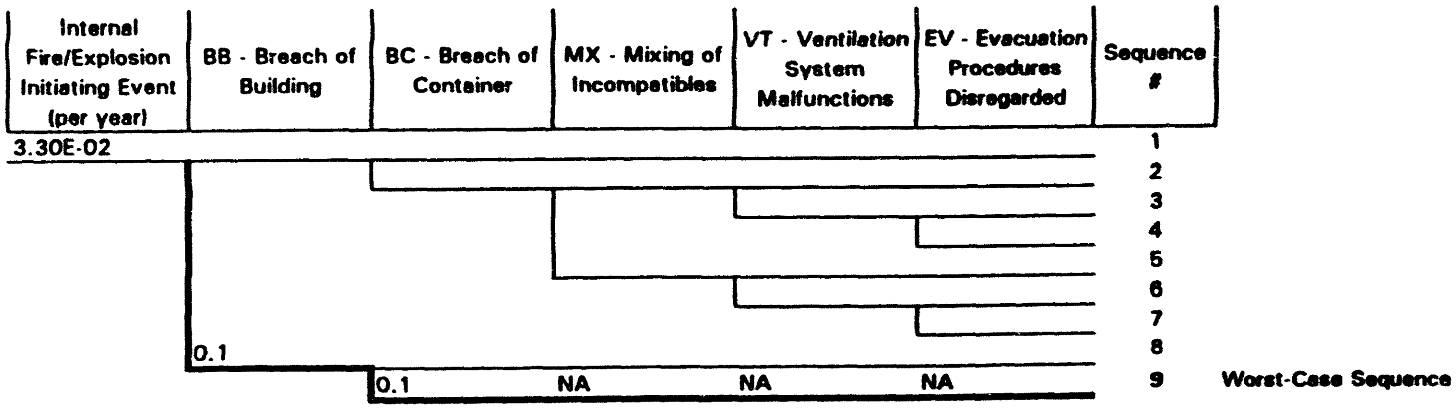
TABLE 4-4
RELEASE FREQUENCIES FOR WORST-CASE SEQUENCES

INITIATING EVENT	RELEASE FREQUENCY (YR^{-1}) FROM PRA	QUALITATIVE RELEASE FREQUENCY CATEGORY FROM PHA	RANGE OF QUALITATIVE MEASURE FROM PHA (YR^{-1})
Seismic event of 0.3-g intensity	2.0×10^{-6}	IV	10^{-6} to 10^{-4}
Fire/explosion starting inside facility	3.3×10^{-4}	III	10^{-4} to 10^{-2}
Fire/explosion starting outside facility	2.0×10^{-5}	IV	10^{-6} to 10^{-4}



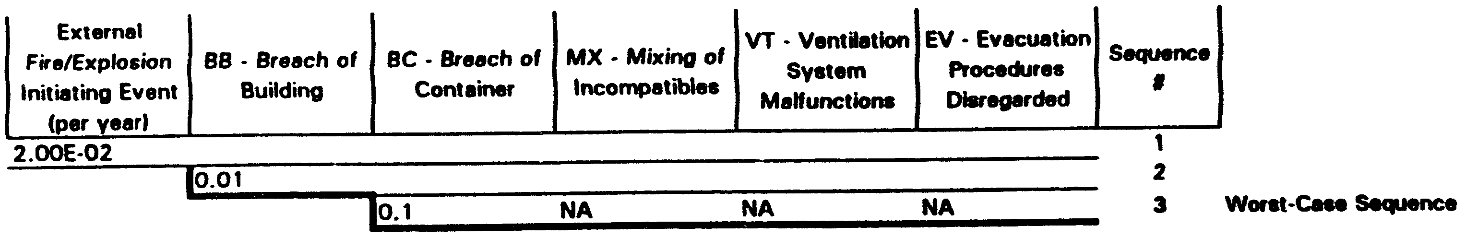
GF - Guaranteed Failure
NA - Not Applicable for Worst-Case Release Frequency Computations

Fig. 4-1. Event tree for seismic event initiator.



NA - Not Applicable for Worst-Case Release Frequency Computations

Fig. 4-2. Event tree for internal fire/explosion initiator.



NA - Not Applicable for Worst-Case Release Frequency Computations

Fig. 4-3. Event tree for external fire/explosion initiator.

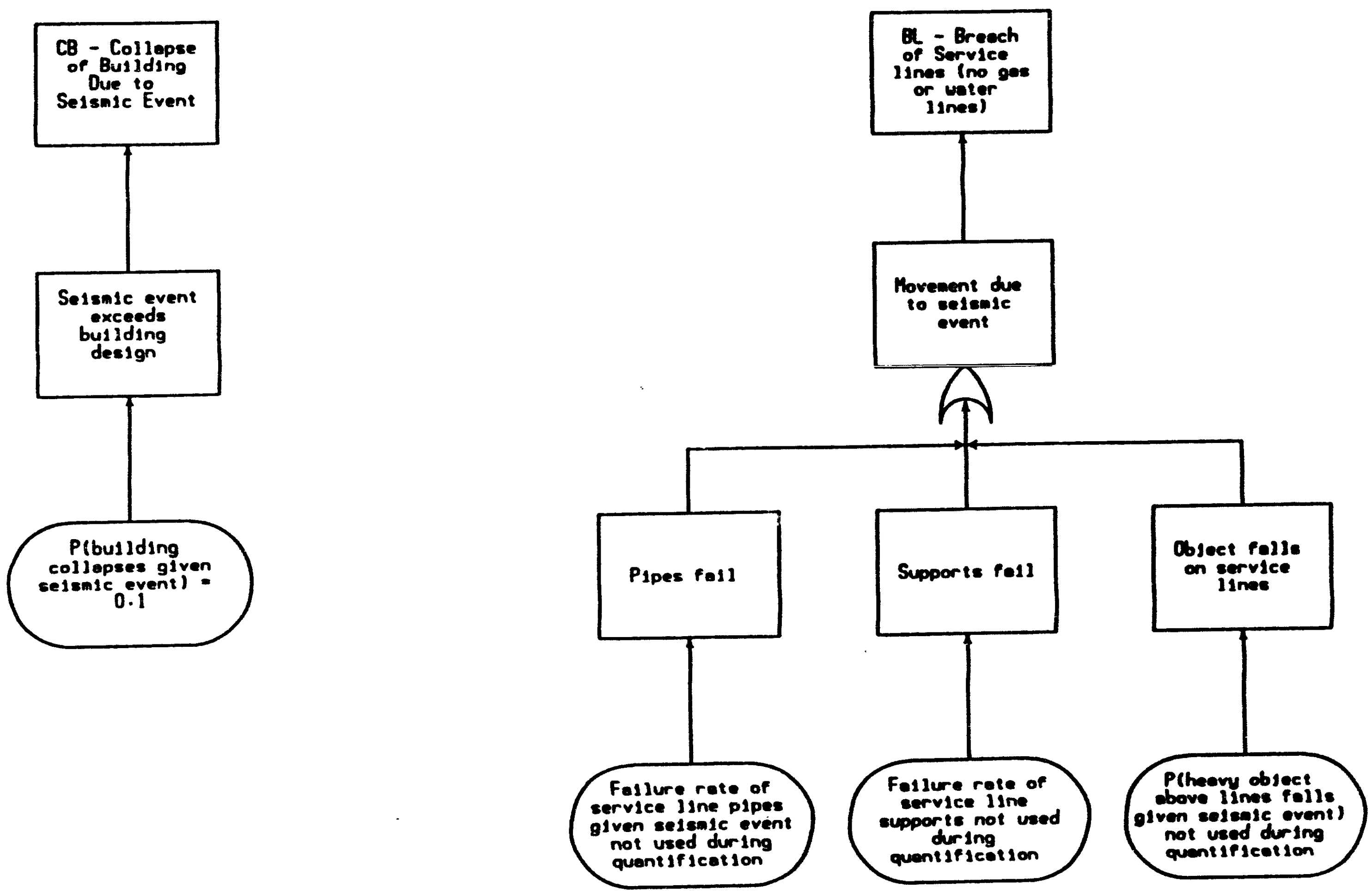


Fig. 4-4. Fault trees for seismic initiator event tree.

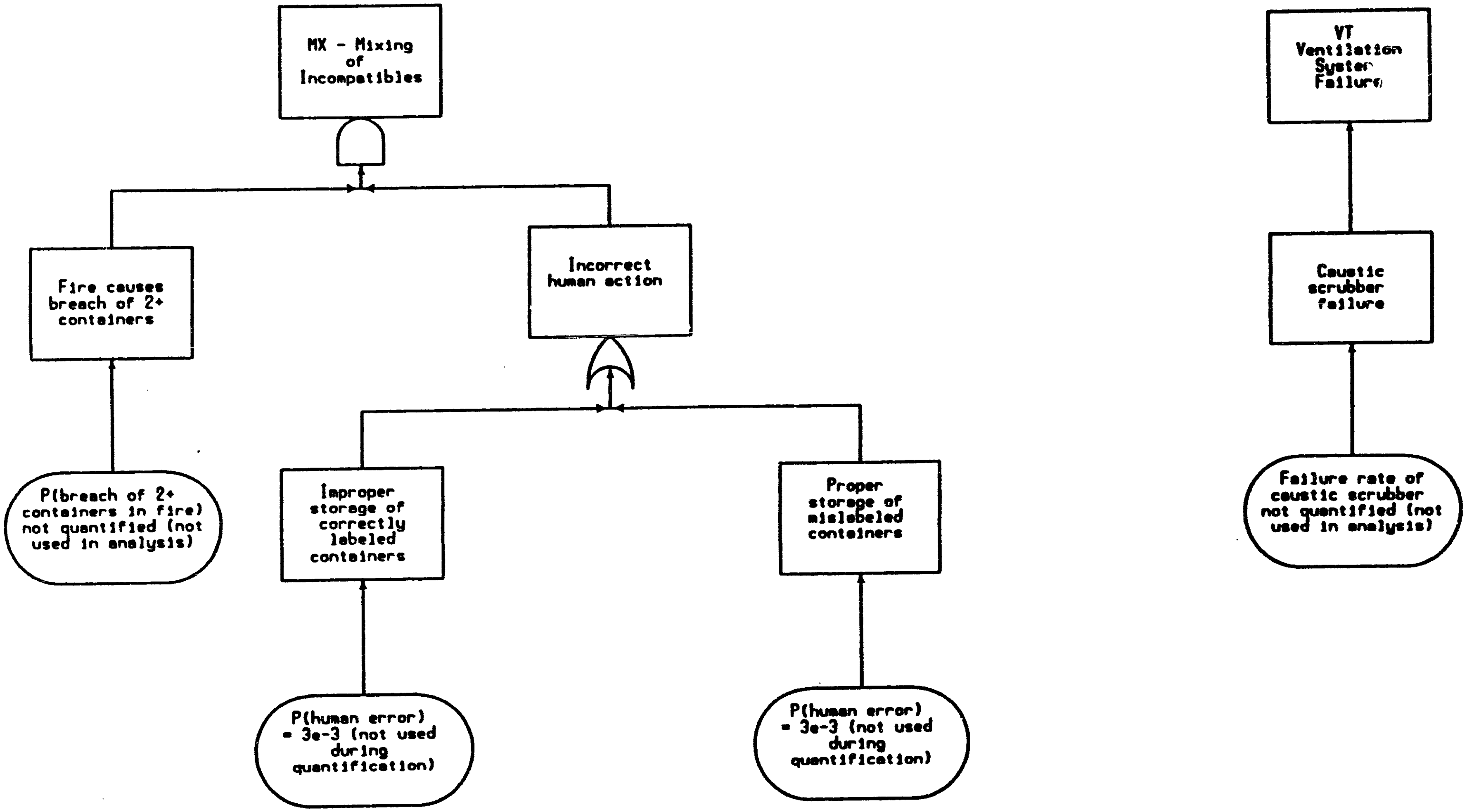


Fig. 4-4. Fault trees for seismic initiator event tree (cont).

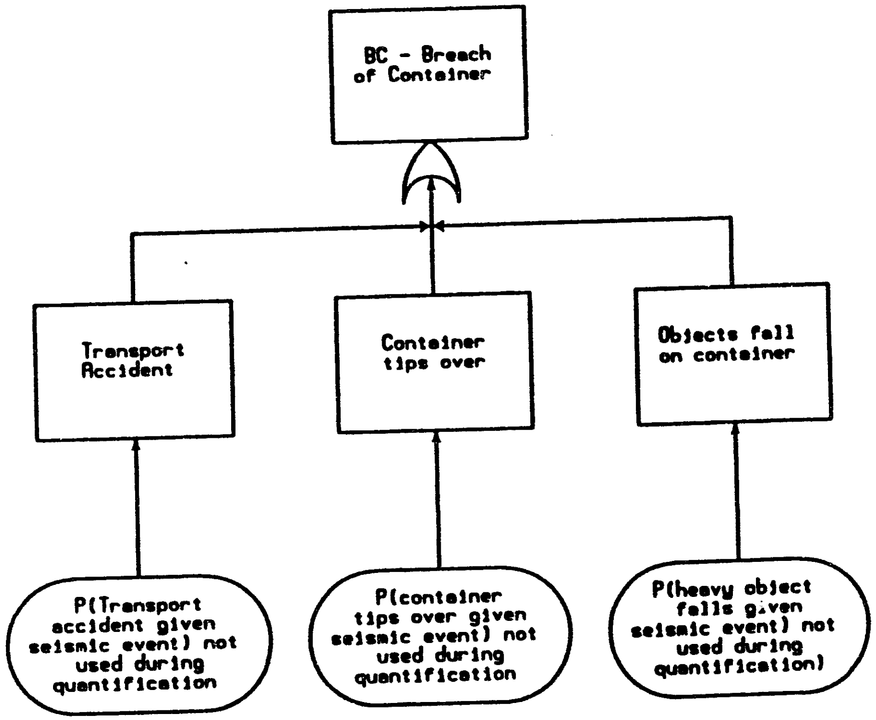


Fig. 4-4. Fault trees for seismic initiator event tree (cont).

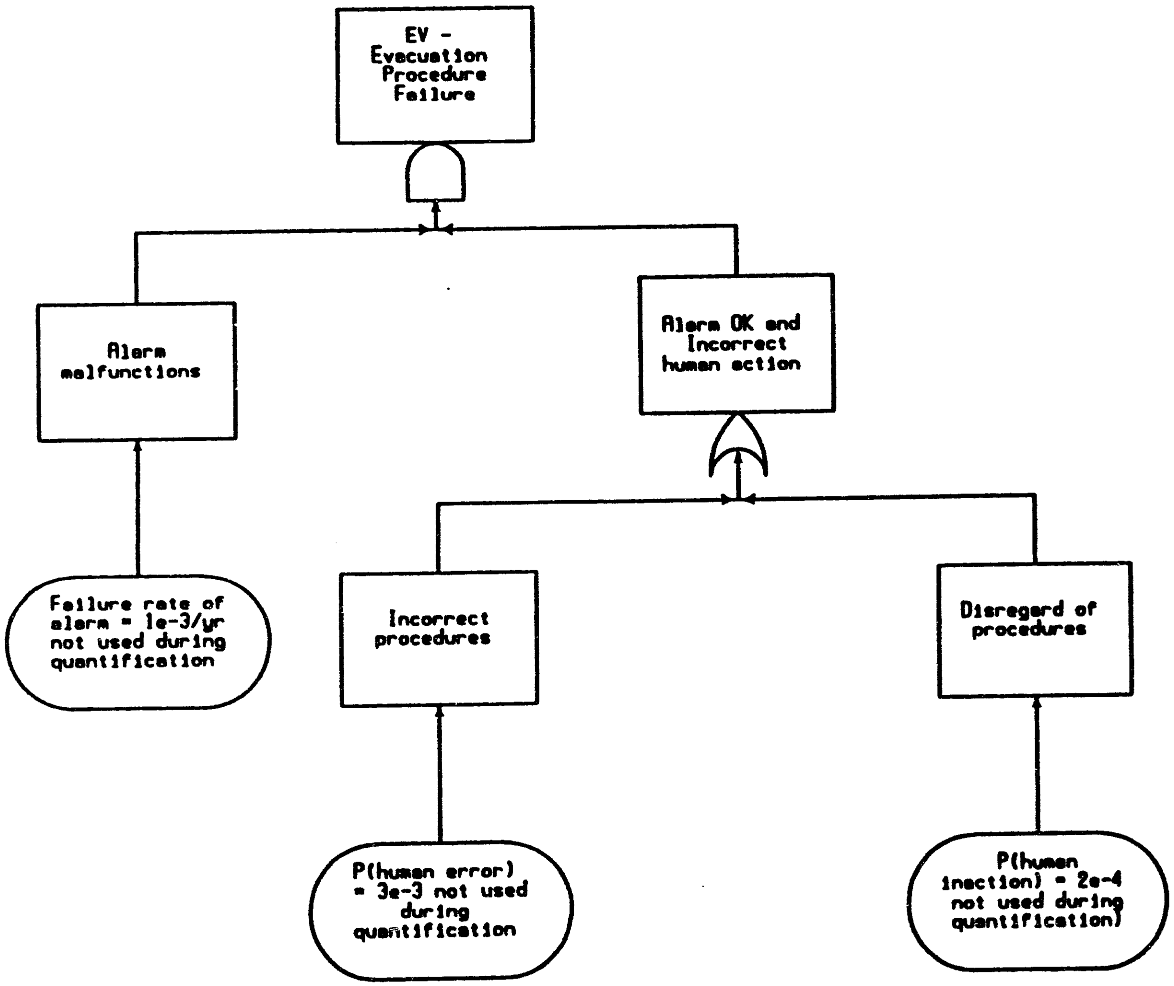


Fig. 4-4. Fault trees for seismic initiator event tree (cont).

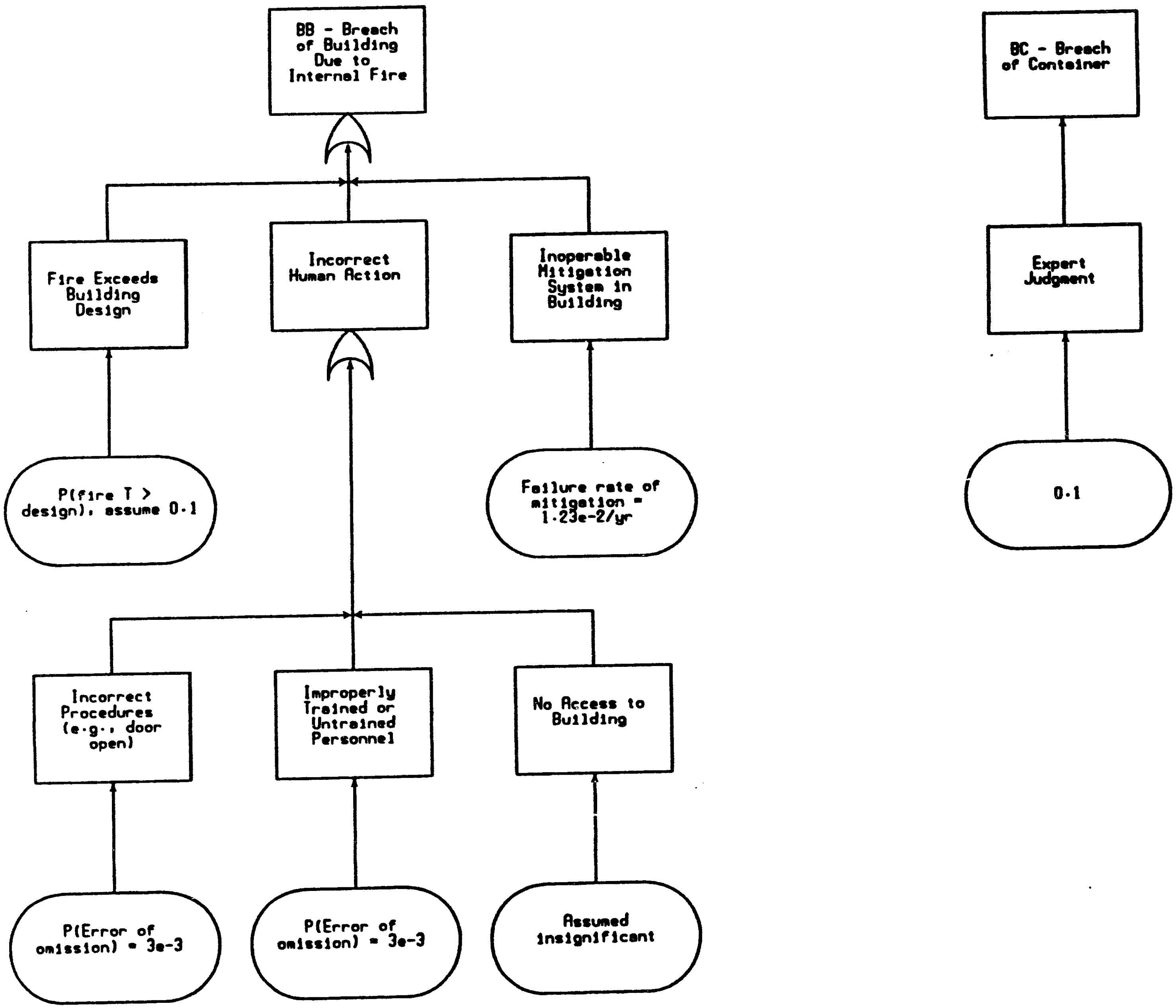


Fig. 4-5. Fault trees for internal fire initiator event tree.

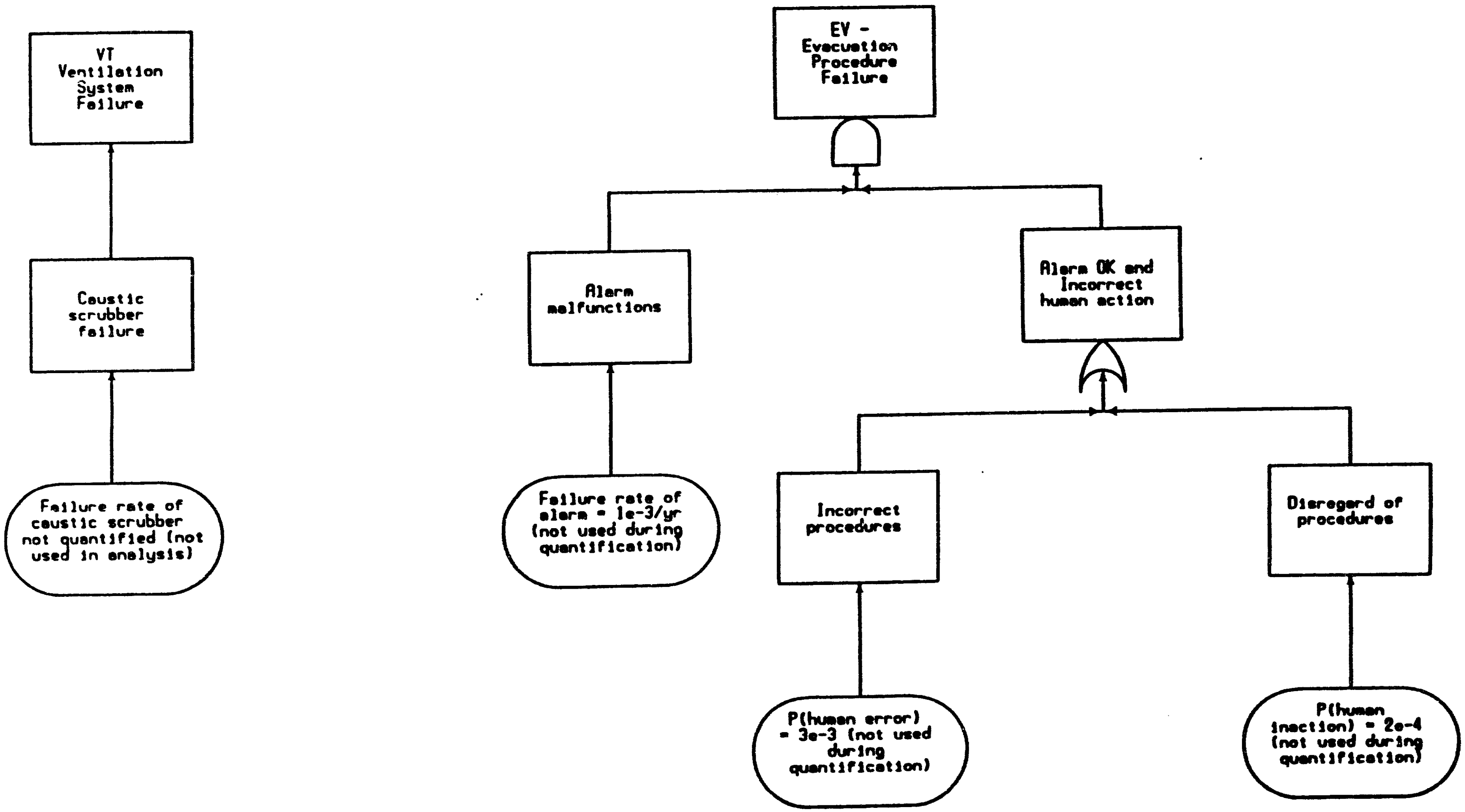


Fig. 4-5. Fault trees for internal fire initiator event tree (cont).

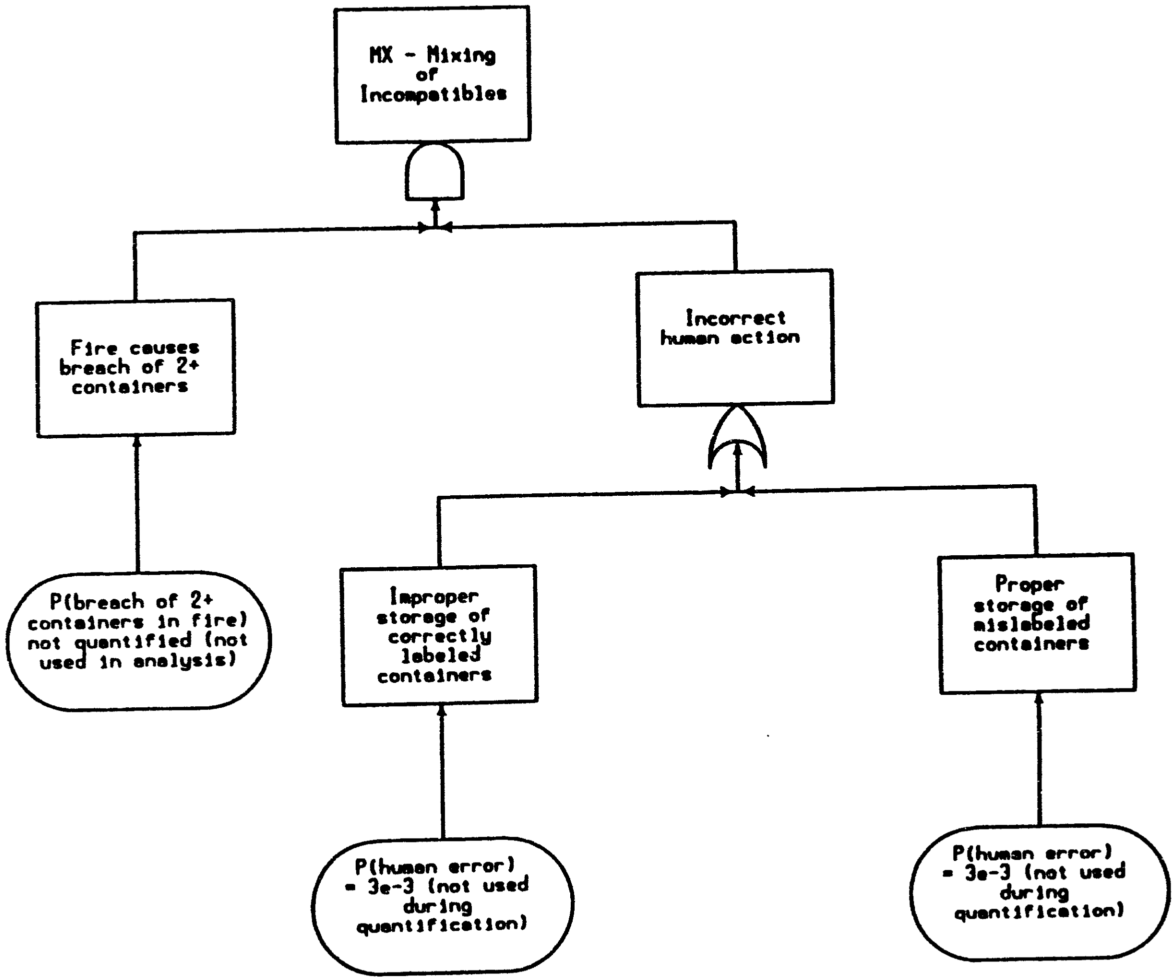


Fig. 4-5. Fault trees for internal fire initiator event tree (cont).

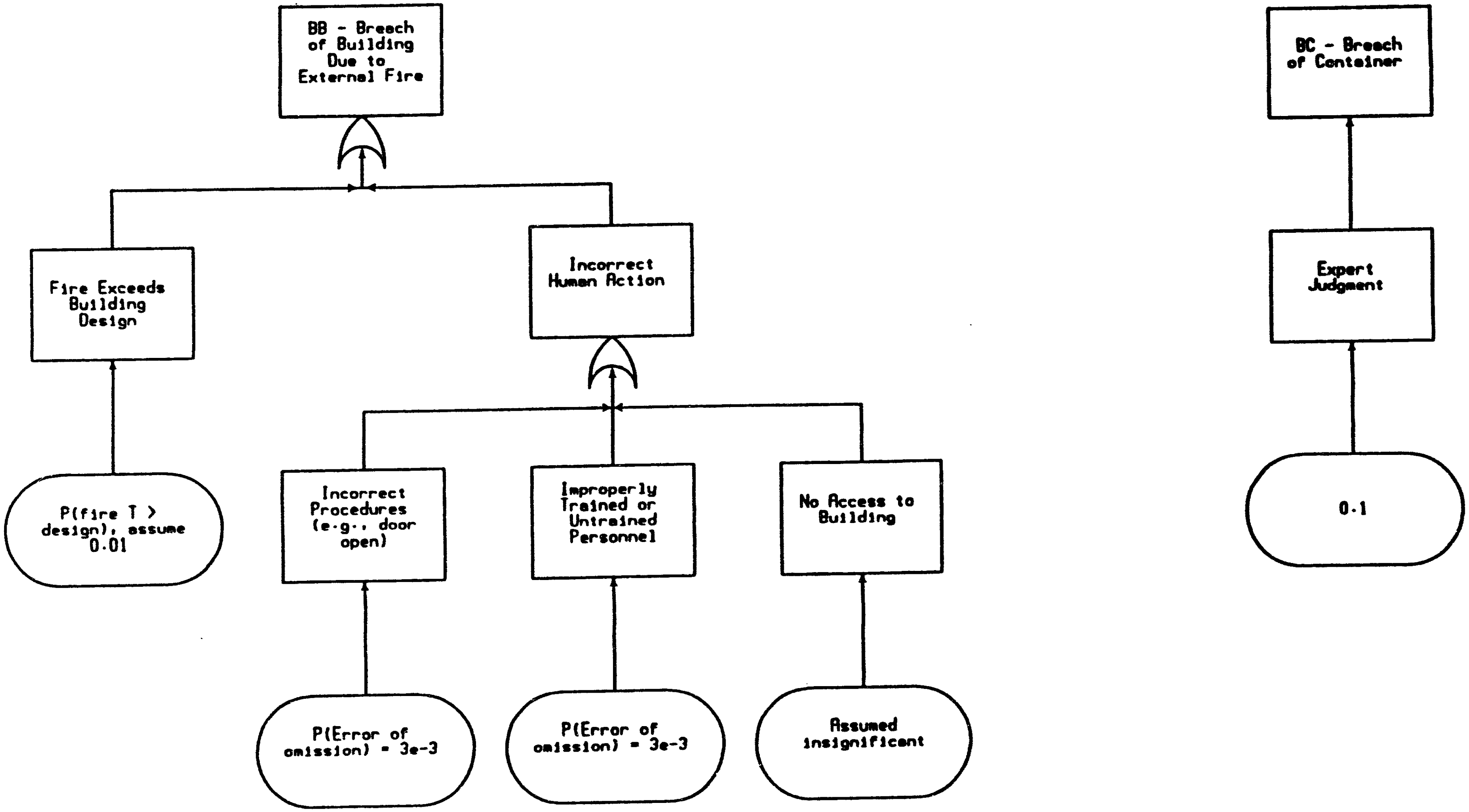


Fig. 4-6. Fault trees for external fire initiator event tree.

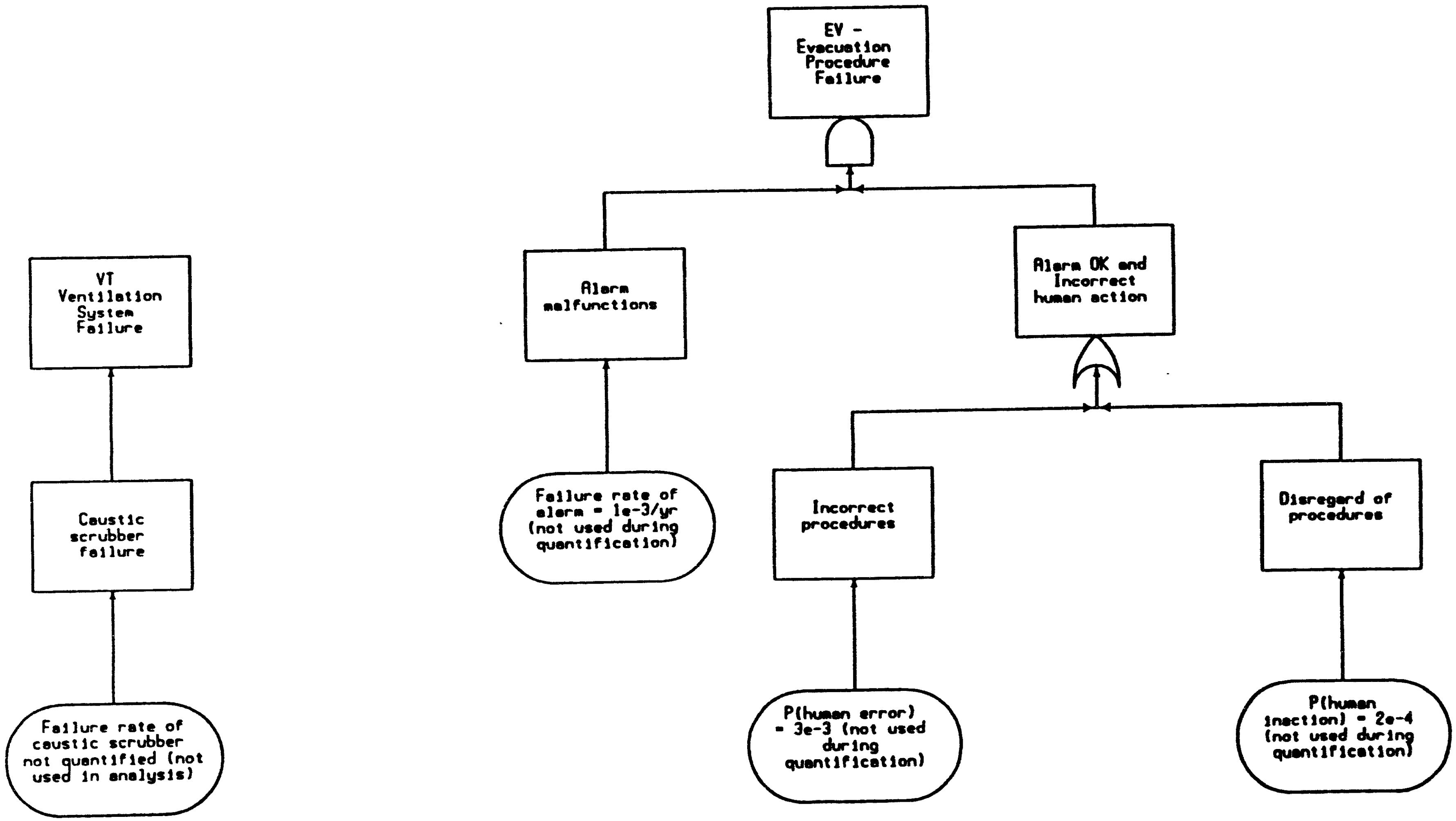


Fig. 4-6. Fault trees for external fire initiator event tree (cont).

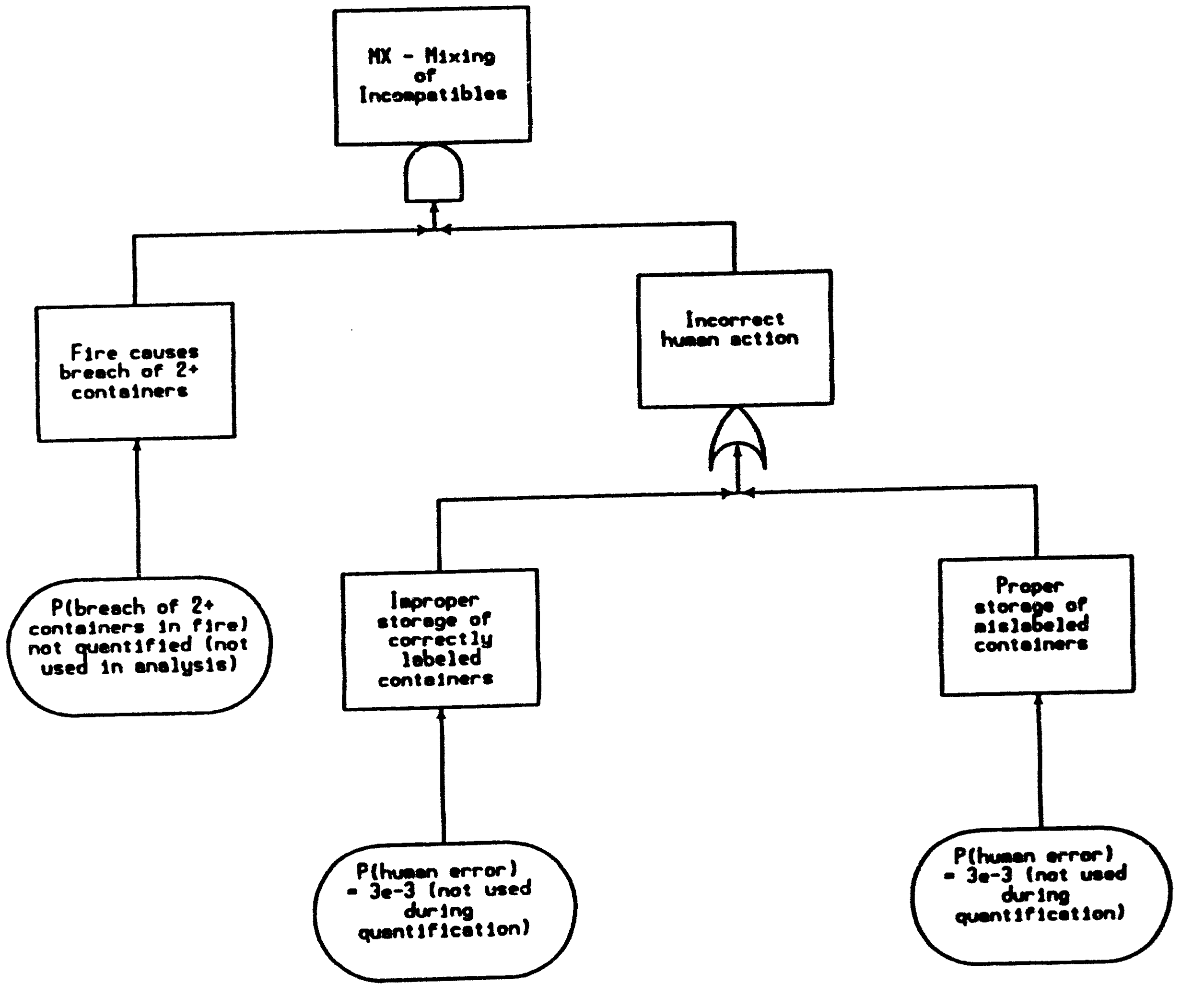


Fig. 4-6. Fault trees for external fire initiator event tree (cont).

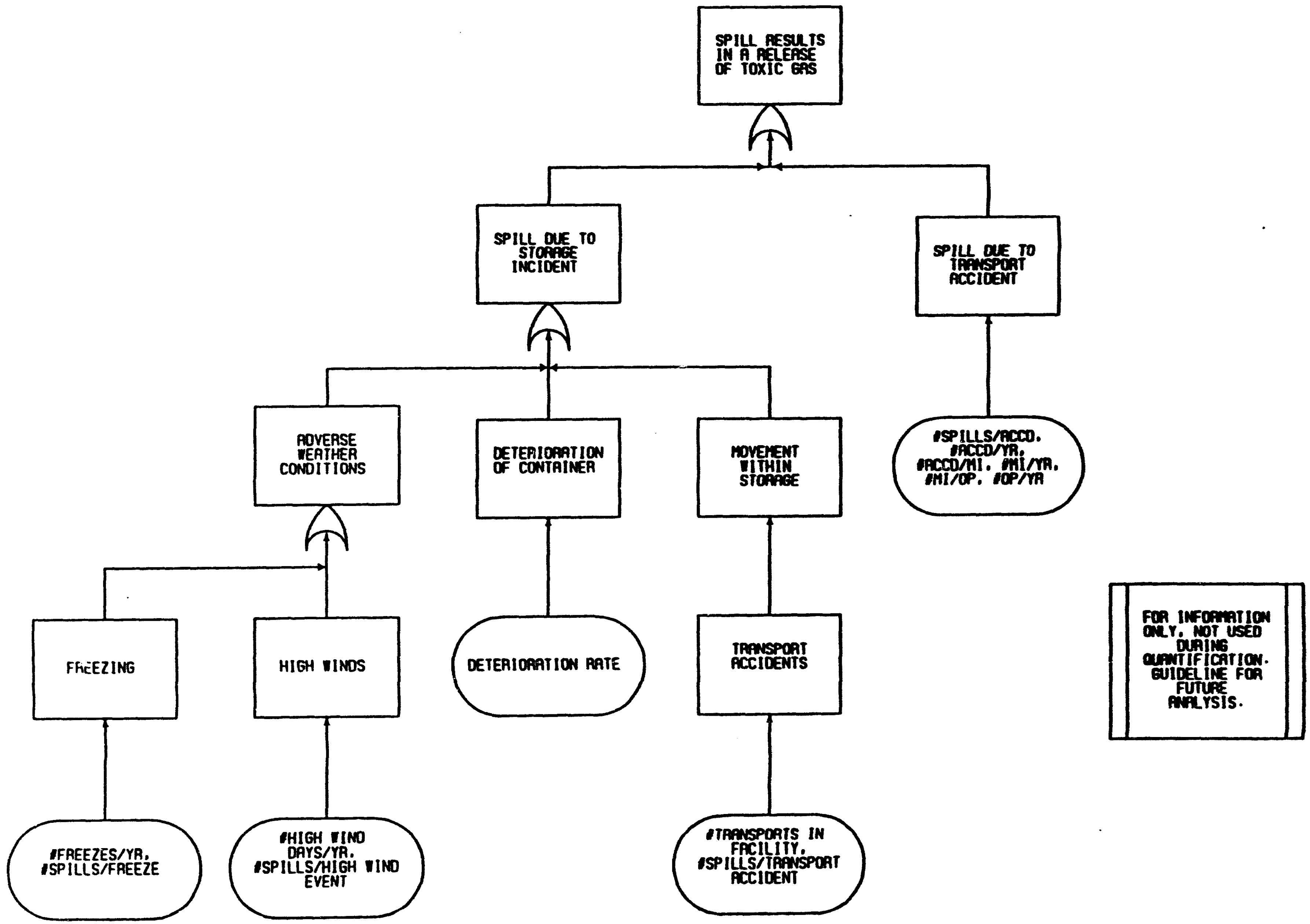


Fig. 4-7. Fault tree for spill of toxic gases.

5.0. ESTIMATION OF MAXIMUM RELEASE INVENTORIES

5.1. Methodology

The team chose six toxic gas releases to be analyzed for this limited-scope PRA.

- Hydrogen fluoride
- Hydrogen sulfide
- Arsine
- Phosgene
- Phosphine
- Cyanogen

Expected toxic gas quantities were estimated using historical data. The current CST-7 data base accounts for all onsite wastes over the last 4 yr from which gas cylinders and their contents can be identified. Because offsite shipment of cylinders occurs annually, the maximum cylinder quantities were evaluated using the inventory just before shipment. The largest volume of cylinders for any one of the 4 yr was selected per chemical for use in the PRA.

The pressure in the cylinders was not recorded in the data base; thus, assumptions were made for this parameter so that mass could be computed. Upon consultation with CST-7 staff, a typical average pressure of 500 psi was assumed for a given cylinder, regardless of chemical contents. This value is based on a survey of the majority of cylinders in the inventory, none of which were above 480 psi. In addition, some containers were empty. Although it is possible that a small number of cylinders could have pressures as high as 1500 psi, the assumption of 500 psi was agreed on as a conservative estimate.

There were instances in which a cylinder contained a chemical of concern as well as other chemicals in unknown concentrations. Thus, the cylinder was assumed conservatively to contain only the chemical of interest. This assumption was applied to cylinders that contain as little as 2% by volume of the toxic gas. The cylinders with a trace contaminant of less than 2% were not included in the toxic gas inventory. This is considered to be a moderately conservative assumption.

5.2. Calculation of Toxic Gas Quantities

The quantities of each toxic gas were determined using the volumes in the data base and the assumptions for pressure. The masses were computed using the perfect gas law. An example calculation is shown below for hydrogen fluoride (HF):

$$PV = nRT \Rightarrow \frac{P_{atm}}{V_{atm}} = \frac{P_2}{V_2} \Rightarrow V_2 = \frac{P_2}{P_{atm}} \times V_{atm} \quad ,$$

where

$$P_{atm} = 14.7 \text{ psi},$$

$$V(HF)_{atm} = 1.91 m^3,$$

$$P_2 = 500 \text{ psi},$$

$$\rho(HR) = 0.8 \, g/\ell \; ,$$

$$\text{mass (HF)} = \rho \times V_2 = \left(0.9 \frac{g}{\ell}\right)\left(\frac{500 \text{ psi}}{14.7 \text{ psi}}\right)\left(1.9 \ell m^3\right)\left(\frac{1000\ell}{m^3}\right) \text{ and}$$

$$\text{mass (HF)} = 58.42 \text{ kg} \; .$$

The same method was used for the other toxic chemicals, and the results are shown in Table 5-1. During the data base search, it was determined that cyanogen was present in very small quantities. It is anticipated that no cylinders of HCN will be stored in future; thus, an estimate of the quantity is unnecessary. The table was reviewed by staff members at the present storage facility; Guy Lussiez of CST-7; Kent Sasser of TSA-11, who was principal investigator for the HWTF/DSB/MWRSF PHA; and other PHA team members and key personnel. All concurred that these quantities are not overly conservative and that they are indicative of the upper bound for future storage needs in the proposed facility.

TABLE 5-1
QUANTITIES OF HAZARDOUS CHEMICALS

CHEMICAL	VOLUME (m^3)	DENSITY (g/l)	QUANTITY (kg)
Hydrogen Fluoride	1.91	0.9	58.42
Hydrogen Sulfide	0.41	1.59	22.37
Arsine	0.07	2.7	6.68
Phosgene	0.11	1.37	5.07
Phosphine	0.06	1.53	2.88
Cyanogen	0.006	0.89	0.18

6.0. CONSEQUENCE ANALYSIS

This section deals with the offsite consequence analysis for the release scenarios identified in Sec. 3. The release frequencies of these scenarios were quantified in Sec. 4, and the source terms (i.e., the maximum release quantities) were estimated in Sec. 5. In this section, dispersion models are used to evaluate zones of vulnerability as a result of a potential release of toxic gases from TA-63. These zones of vulnerability are identified using buoyant- and dense-gas dispersion models. The results of these consequence analyses are presented in the form of concentration isopleths (hazard footprints) and risk contours. The details of the consequence analysis modeling are discussed here. The results of the consequence analysis are presented in Sec. 7.

6.1. Atmospheric Dispersion and Dose Assessment

The consequence analyses were performed using two PLG codes, MIDAS and QCRR. MIDAS (Meteorological Information and Dispersion Analysis System) has been installed at Los Alamos in the Health and Safety Division. The MIDAS system configuration at the Laboratory permits onsite meteorological information to be collected and recorded and allows the dispersion of toxic gas releases from any Los Alamos location to be monitored. Details of the MIDAS program are provided in App. A.

MIDAS was used to provide concentration isopleths for several release scenarios. Concentration isopleths display the area(s) where the Emergency Response Planning Guidelines (ERPG) levels could be exceeded during a release. Because isopleths convey a sense of the dispersion plume size, they can be used to define the potential evacuation area. However, concentration isopleths do not convey the overall risk of a potential release.

The risk depends not only on the amount and toxicity of the release sources but also on their release frequency. The plume size, shape, and path depend on the wind speed, wind direction, and atmospheric stability. The likelihood of occurrence of a certain wind speed, wind direction, and atmospheric stability class can be inferred from the local meteorological data. Therefore, a combination of the release frequency with the likelihood of a specific meteorological condition would be required to define the risk of a potential release.

QCRR (Quantification of Chemical Release Risk) provides this information in the format of risk contours. Risk contours display the risk of exceeding a specific ERPG concentration level at a given location using the dispersion results, local meteorological data, and release frequencies. Detailed description of QCRR is provided in App. B.

The toxic gas release scenarios pose an exposure potential to the workers, co-located workers, and the public. As each toxic gas has different characteristics and toxicity levels, the American Institute of Industrial Hygienists has established ERPGs concentrations for a number of different chemicals. Concentration levels ERPG-2 and ERPG-3 traditionally have been used by various administering agencies, for example, the Fire Department (for State of California's RMPP Act) and Environmental Protection Agency (EPA) (for response planning). These ERPG concentrations levels are defined as follows.

ERPG-2. The ERPG-2 concentration is defined as the maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to 1 h without experiencing or developing irreversible or other serious health effects or symptoms that could impair their ability to take protective action.

ERPG-3. The ERPG-3 concentration is defined as the maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to 1 h without experiencing or developing life-threatening health effects.

The ERPG-2 and ERPG-3 values for the various toxic gas releases evaluated as a part of this limited-scope PRA are listed in Table 6-1.

As can be seen from the ERPG definitions, not only do the ERPG levels have stipulated concentrations, they also have a time of exposure. For example, an ERPG-3 emergency planning guideline for hydrogen fluoride release would be exceeded if an individual is exposed to an airborne concentration of 50 ppm for a period of 60 min. Therefore, to be consistent, the dispersion results should be averaged over a 1-h period. However, to err on the side of caution, some administrative agencies take a conservative approach by insisting on "10-min averaging." This implies that ERPG levels would be exceeded if the concentration were achieved for only 10 min. For the PRA, the dispersion calculations were run for 10 min averaging only.

6.2. Los Alamos Site and Meteorological Data

Dispersion calculations were made using site-specific Los Alamos meteorological (MET) data. The proposed site for TA-63 is given on the Los Alamos site map as shown in Fig. 6-1. It is apparent from the site map that the TA-63 area is in close proximity to TA-52 (approximately 200 ft), a site that would house Laboratory co-located workers. Pajarito Road is the nearest public access road to TA-63 at approximately 100 ft. However, the Laboratory can control and limit access to this road in the event of an emergency. The closest public offsite property for dose calculation purposes is the mobile home park (Royal Crest) located on East Jemez Road. Persons at that location would be more likely to be exposed for longer durations than persons traveling down Pajarito Road. Therefore, potential exposure to the public should be considered seriously only if the mobile home park, which is 1.5 km from TA-63, is in the path of the dispersed chemicals.

MET data for the Los Alamos site were collected through the Los Alamos Environmental Health and Safety Division. The windrose for the Laboratory site is shown in Fig. 6-2. It is apparent that the wind directions are predominantly from the west and south; the average wind speed is 2.5 m/s. Most often, the atmospheric stability is classified as D.

However, a more conservative (worst-case) scenario was analyzed for the offsite consequence modeling. The dispersion scenario considers a wind speed of 0.875 m/s and an atmospheric stability of class F with 10-min averaging. Table 6-2 shows the likelihood of different combinations of wind speeds for stability class F, which is considered to be the most pessimistic condition and occurs about 17% of the time. The dispersion calculations provide concentration isopleths for both ERPG-2 and ERPG-3 values. This scenario results in the maximum plume size, thus indicating the maximum distances at which the ERPG values will be exceeded.

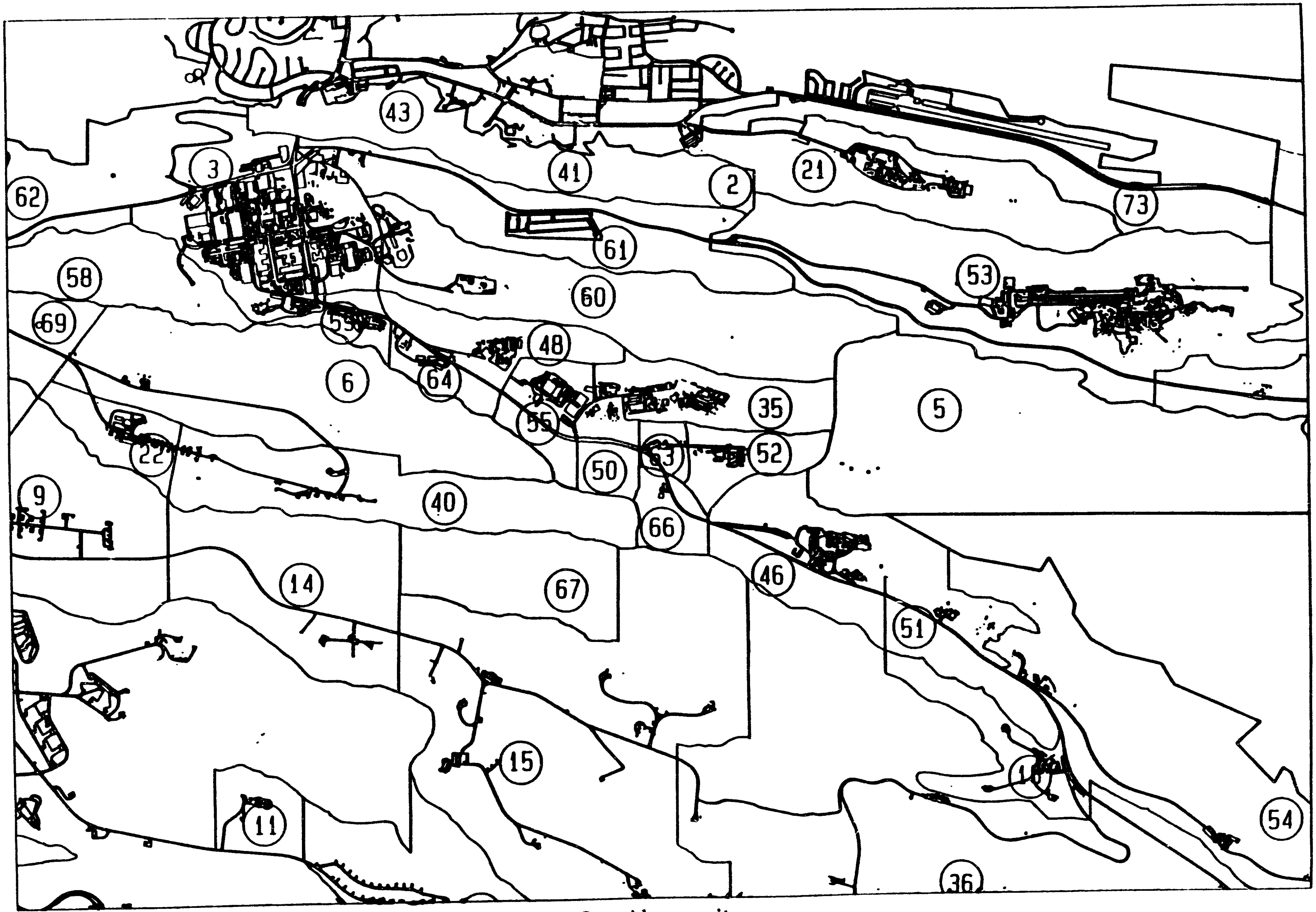
In addition to these MIDAS dispersion calculations, risk contours were developed using QCRR. These contours show the risk of exceeding the ERPG-2 and ERPG-3 values at locations near TA-63.

TABLE 6-1
ERPG VALUES

Gas	ERPG-2 Concentration (PPM)	ERPG-3 Concentration (PPM)
Hydrogen Fluoride	20.0	50
Phosgene	0.2	1
Arsine	1.0	5
Hydrogen Sulfide	30.0	100

TABLE 6-2
NORMALIZED METEORLOGICAL DATA FOR LANL, STABILITY F (7/90–12/92)

Stability F								
Sector	From	Top Wind Speed in meters per second						
Number	Direction	1.75	3.25	5.5	8.5	11.5	200	Total
1	N	0.00651	0.00120	0.00000	0.00000	0.00000	0.00000	0.00771
2	NNE	0.00380	0.00060	0.00000	0.00000	0.00000	0.00000	0.00441
3	NE	0.00240	0.00010	0.00000	0.00000	0.00000	0.00000	0.00250
4	ENE	0.00070	0.00000	0.00000	0.00000	0.00000	0.00000	0.00070
5	E	0.00090	0.00000	0.00000	0.00000	0.00000	0.00000	0.00090
6	ESE	0.00110	0.00010	0.00000	0.00000	0.00000	0.00000	0.00120
7	SE	0.00110	0.00010	0.00000	0.00000	0.00000	0.00000	0.00120
8	SSE	0.00130	0.00000	0.00000	0.00000	0.00000	0.00000	0.00130
9	S	0.00240	0.00020	0.00000	0.00000	0.00000	0.00000	0.00260
10	SSW	0.00360	0.00040	0.00010	0.00000	0.00000	0.00000	0.00410
11	SW	0.00651	0.00140	0.00000	0.00000	0.00000	0.00000	0.00791
12	WSW	0.00841	0.00761	0.00000	0.00000	0.00000	0.00000	0.01602
13	W	0.01061	0.03184	0.00270	0.00000	0.00000	0.00000	0.04515
14	WNW	0.01081	0.03374	0.00400	0.00000	0.00000	0.00000	0.04856
15	NW	0.01151	0.01782	0.00000	0.00000	0.00000	0.00000	0.02934
16	NNW	0.00881	0.00360	0.00000	0.00000	0.00000	0.00000	0.01241
	Total	0.08050	0.09872	0.00681	0.00000	0.00000	0.00000	0.18602



1/2 mile

Fig. 6-1. Los Alamos site map.

Note: Laboratory Technical Areas are noted by numbers in circles.

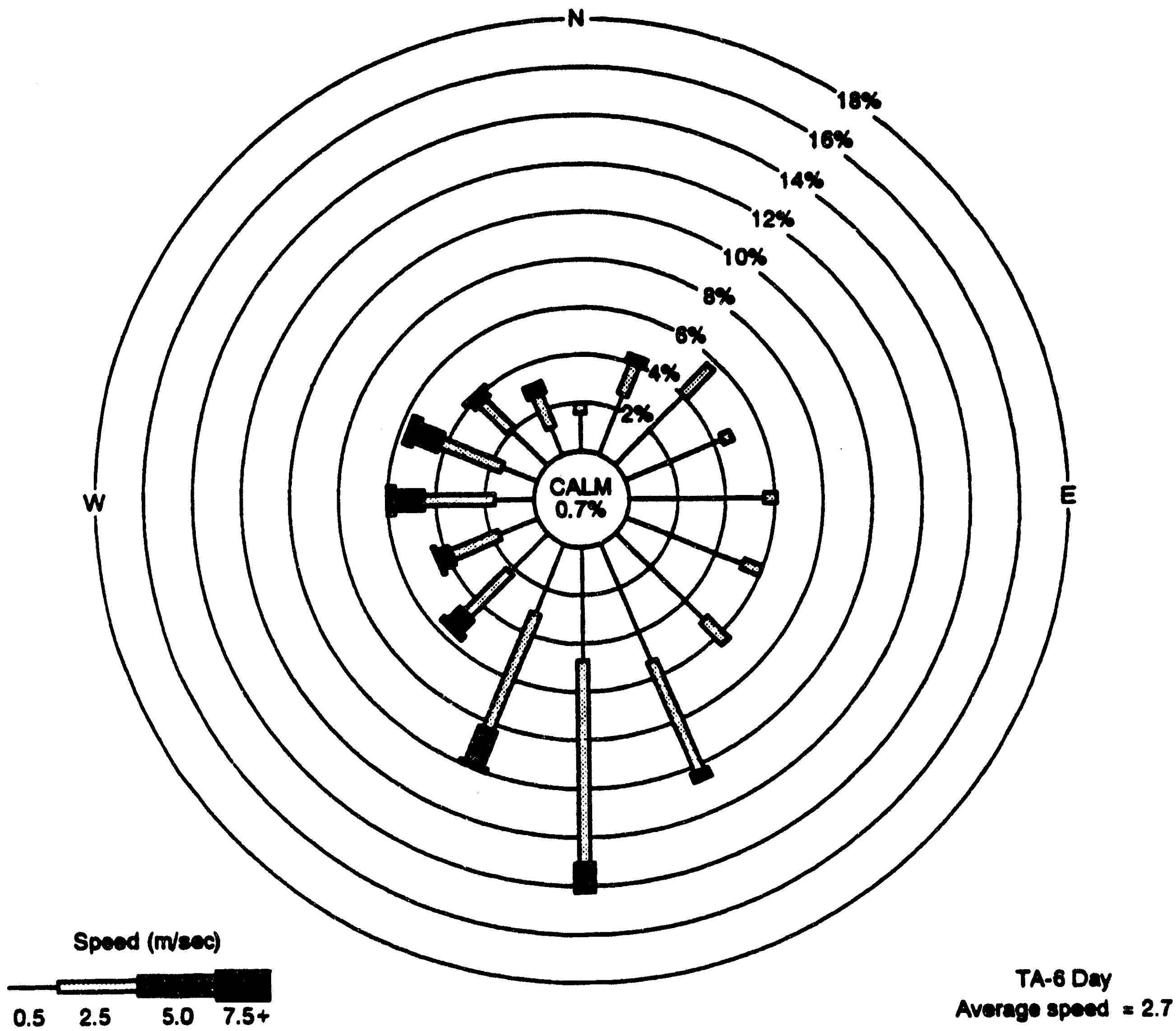


Fig. 6-2. Wind rose for LANL Site.

7.0. RESULTS

7.1. Release Frequencies

Table 7-1 lists the release frequency for each initiating event. These values were determined using the technical approach outlined in Sec. 4. The sum of these annual release frequencies, 3.5E-4/yr, was used in the development of risk contours, the results of which will be discussed in the following section. It is important to note that the release frequency is a conservative number; thus, it represents an upper bound.

7.2. Dispersion Calculations

Dispersion calculations were performed for potential releases of hydrogen fluoride, phosgene, arsine, and hydrogen sulfide gases. Phosphine and cyanogen were not analyzed because the quantities of these gases are small (<3 kg). In addition, no documented dosage values were located for phosphine or cyanogen; ERPG levels have not been developed for either chemical by the American Institute of Industrial Hygienists. As mentioned in Sec. 6, the dispersion calculations were conducted for stability class F and a wind speed of 0.875 m/s with 10-min averaging. This was evaluated for potential release of all four toxic gases. Under these conditions, which represent the worst-case scenario, the maximum plume is generated. Hence, this scenario represents the bounding case.

MIDAS provides concentration isopleths (or hazard footprints) for both ERPG-2 and ERPG-3 values. The dispersion results may be considered "snapshots" at various time intervals. The isopleths were collected at given time intervals after the release. Each snapshot shows the area covered by the plume exceeding the ERPG-2 or ERPG-3 value. The isopleths were plotted at every time interval until the ERPG values were not exceeded. Thus, the maximum distances at which the ERPG values will be exceeded were determined.

In addition to the MIDAS dispersion calculations, risk contours were produced using QCRR. Taking into account the computed release frequency of 3.5E-4/yr, the risk contours were developed by running the dispersion calculations for all combinations of wind speeds and atmospheric stability conditions for averaging the dispersion results. The likelihood of each MET condition was used as a relative weight. The contours depict the risk of exceeding the ERPG-2 and ERPG-3 values based on 10-min averaging at locations near TA-63.

7.2.1. Hydrogen Fluoride Dispersion Results. Hydrogen fluoride release was modeled as a release of 58.42 kg of gas at ambient pressure and temperature conditions. Referring to Sec. 5, this would be the maximum amount of hydrogen fluoride that would be stored at TA-63 in the future. Hydrogen fluoride gas is lighter than air; therefore, the scenario was modeled as a buoyant gas release. The ERPG-2 and ERPG-3 values of hydrogen fluoride are 20 ppm and 50 ppm, respectively. The entire inventory was assumed to be released in the first minute.

7.2.1.1. Hydrogen Fluoride Isopleths. The hydrogen fluoride plume progression for the worst-case scenario is shown in Figs. 7-1 through 7-4. These plots are MIDAS "snapshots," and the time interval between each frame is 10 min. The Los Alamos site map is shown on each plot with the cross-hairs depicting the location of the hydrogen fluoride release. In this calculation, the wind is blowing slowly at 0.875 m/s from the west. The atmospheric stability is F, i.e., it is a very stable condition with very little turbulence to aid dispersion.

Each plot shows both ERPG-3 (in red) and ERPG-2 (in yellow) isopleths. The ERPG-3 area indicates that concentration has exceeded 50 ppm for the last 10 min. Similarly, the ERPG-2 area indicates that concentration has exceeded 20 ppm for the last 10 min. As expected, the ERPG-2 area encompasses the ERPG-3 area. In addition to the ERPG-2 and ERPG-3 isopleths, the profiles that would be expected in the next 10 and 20 min are included. These are shown by the purple- and gray-shaded areas, respectively. These two profiles are not important to the current discussion.

The isopleths become progressively larger in the first four time intervals and then decay; thus, the maximum plume isopleths for ERPG-2 and ERPG-3 were realized 40 min after the release as shown in Fig. 7-4. ERPG-3 levels were exceeded at a number of Laboratory locations, including technical areas and along access roads. The worst-case distances at which the ERPG-2 and ERPG-3 values were exceeded are listed in Table 7-2. These values are obtained from the MIDAS graph of hydrogen fluoride concentration vs distance as shown in Fig. 7-5.

7.2.1.2. Hydrogen Fluoride Risk Contours. Section 7.2.1.1 depicted the worst-case scenario using the most adverse conditions of wind speed, wind direction, and atmospheric stability class. The values of these parameters for the worst-case scenario exist about 1% of the time. If this wind speed and atmospheric stability condition are considered for all wind directions, these adverse conditions would be present about 8% of the time. The risk contours for a hydrogen fluoride release, generated by QCRR using 10-min averaging for all calculations, are shown in Figs. 7-6 and 7-7. The contours account for the release frequency, all combinations of the wind speeds, and atmospheric stability conditions along with their relative likelihoods.

Figure 7-6 displays the risk contours for the case of exceeding ERPG-2 values. The outer contour in magenta depicts the area that has the likelihood of being exposed to ERPG-2 values once in 1 million years (frequency of 1.0E-6/yr). The inner contour in yellow depicts the area that has the likelihood of being exposed to ERPG-2 values once in 100,000 yr (frequency of 1.0E-5/yr). Similarly, Fig. 7-7 displays the risk contours for the case of exceeding ERPG-3 values.

For a frequency of 1.0E-5/yr, the ERPG-2 and ERPG-3 risk contours depict a scenario in which the hydrogen fluoride release is localized to a relatively small footprint. Pajarito Road could be affected, but the likelihood of affecting nearby technical areas is minimal. A wider area, including TA-52, could be affected by a release with a frequency of 1.0E-6/yr. For this low-frequency event, the offsite public consequences of a hydrogen fluoride release are limited to some short-duration exposure to travelers on Pajarito Road. The Royal Crest mobile home park on East Jemez Road is unlikely to experience any adverse effects from such a release.

7.2.2. Phosgene Dispersion Results. Phosgene release was modeled as a release of 5.07 kg of gas at ambient pressure and temperature conditions. Referring to Sec. 5, this would be the maximum amount of phosgene that would be stored at TA-63 in the future. Phosgene gas is heavier than air; therefore, the scenario was modeled as a dense gas release. The ERPG-2 and ERPG-3 values of phosgene are 0.2 ppm and 1 ppm, respectively. The entire inventory was assumed to be released in the first minute.

7.2.2.1. Phosgene Isopleths. The phosgene plume progression for the worst-case scenario is shown in Figs. 7-8 through 7-12. The time interval between each MIDAS snapshot is 10 min. The Los Alamos site map is shown on each plot with the cross-hairs depicting the location of the phosgene release. In this calculation, the wind is blowing slowly at 0.875 m/s from the west, and the atmospheric stability class is F. The color scheme used for ERPG-2 and ERPG-3 is the same as for the hydrogen fluoride isopleths. The ERPG-3 area indicates that concentration has exceeded 1 ppm concentration for the last 10 min. Similarly, the ERPG-2 area indicates that concentration has exceeded 0.2-ppm concentration for the last 10 min. As expected, the ERPG-2 area encompasses the ERPG-3 area. The predictive profiles, shown in purple and gray, are not important to the current discussion.

The maximum plume isopleths for ERPG-2 were realized 60 min after the release as shown in Fig. 7-12. Referring to Fig. 7-9, the maximum isopleths for ERPG-3 occurred 20 min after the release. ERPG-2 and ERPG-3 levels were exceeded at a number of Laboratory locations, including technical areas and along access roads. TA-55 was in close proximity to the dispersion pattern. The worst-case distances at which the ERPG-2 and ERPG-3 values were exceeded are listed in Table 7-2. These values are obtained from the MIDAS graph of phosgene concentration vs distance as shown in Fig. 7-13.

7.2.2.2. Phosgene Risk Contours. Section 7.2.2.1 discussed the worst-case scenario using the most adverse conditions of wind speed, wind direction, and atmospheric stability class. The values of these parameters for the worst-case scenario exist for about 1% of the time (8% of the time if all wind directions are considered). The risk contours for a phosgene release, generated by QCRR using 10-min averaging for all calculations, are shown in Figs. 7-14 and 7-15. The contours account for the release frequency, all combinations of the wind speeds, and atmospheric stability conditions along with their relative likelihoods.

Figure 7-14 displays the risk contours for the case of exceeding ERPG-2 values. Following the same color scheme, the outer contour depicts the area that has a frequency of exposure to ERPG-2 values of 1.0E-6/yr. The inner contour corresponds to a frequency of exposure to ERPG-2 values of 1.0E-5/yr. Similarly, Fig. 7-15 displays the risk contours for the case of exceeding ERPG-3 values.

For a frequency of 1.0E-5/yr, the ERPG-2 and ERPG-3 risk contours depict a scenario in which the phosgene release is localized to a relatively small footprint. However, Pajarito Road could be affected, as could nearby technical areas, including TA-52. A wider area, encompassing several technical areas and Pajarito Road, could be affected by a release with a frequency of 1.0E-6/yr. For this low-frequency event, the offsite public consequences of a phosgene release are limited to some short-duration exposure to travelers on Pajarito Road. The Royal Crest mobile home park on East Jemez Road is unlikely to experience any adverse effects from such a release.

7.2.3. Arsine Dispersion Results. Arsine release was modeled as a release of 6.68 kg of gas at ambient pressure and temperature conditions. As noted in Sec. 5, this would be the maximum amount of arsine that would be stored at TA-63 in the future. Arsine gas is heavier than air; therefore, the scenario was modeled as a dense gas release. The ERPG-2 and ERPG-3 values of arsine are 1 ppm and 5 ppm, respectively. The entire inventory was assumed to be released in the first minute.

7.2.3.1. Arsine Isopleths. The arsine plume progression for the worst-case scenario is shown in Figs. 7-16 through 7-18. The time interval between each MIDAS snapshot is 10 min. The Los Alamos site map is shown on each plot with the cross-hairs depicting the location of the arsine release. In this calculation, the wind is blowing slowly at 0.875 m/s from the west, and the atmospheric stability is F. The color scheme used for ERPG-2 and ERPG-3 is the same as with the hydrogen fluoride and phosgene isopleths. The ERPG-3 area indicates that concentration has exceeded 5 ppm for the last 10 min. Similarly, the ERPG-2 area indicates that concentration has exceeded 1 ppm for the last 10 min. As expected, the ERPG-2 area encompasses the ERPG-3 area. The predictive profiles, shown in purple and gray, are not important to the current discussion.

The maximum plume isopleths for ERPG-2 were realized 20 min after the release as shown in Fig. 7-17. Referring to Fig. 7-16, the maximum isopleths for ERPG-3 occurred 10 min after the release. ERPG-3 levels were exceeded along access roads. ERPG-2 levels were exceeded at a number of Laboratory locations, including technical areas and along access roads. The worst-case distances at which the ERPG-2 and ERPG-3 values were exceeded are listed in Table 7-2. These values are obtained from the MIDAS graph of arsine concentration versus distance as shown in Fig. 7-19.

7.2.3.2. Arsine Risk Contours. Section 7.2.3.1 discussed the worst-case scenario using the most adverse conditions of wind speed, wind direction, and atmospheric stability class. The values of these parameters for the worst-case scenario exist for about 1% of the time (8% of the time if all wind directions are considered). The risk contours for an arsine release, generated by QCRR using 10-min averaging for all calculations, are shown in Figs. 7-20 and 7-21. The contours account for the release frequency, all combinations of the wind speeds, and atmospheric stability conditions along with their relative likelihoods.

Figure 7-20 shows the risk contours for the case of exceeding ERPG-2 values. Following the same color scheme, the outer contour depicts the area that has a frequency of exposure to ERPG-2 values of 1.0E-6/yr. The inner contour corresponds to a frequency of exposure to ERPG-2 values of 1.0E-5/yr. Similarly, Fig. 7-21 displays the risk contours for the case of exceeding ERPG-3 values.

For a frequency of 1.0E-5/yr, the ERPG-2 and ERPG-3 risk contours depict a scenario in which the arsine release is localized to a small footprint. As a result, Pajarito Road still could be affected, but the likelihood of affecting nearby technical areas is minimal. An area encompassing several technical areas, including TA-52 and Pajarito Road, could be affected by a release with a frequency of 1.0E-6/yr. For this low-frequency event, the offsite public consequences of a arsine release are limited to some short-duration exposure to travelers on Pajarito Road. The Royal Crest mobile home park on East Jemez Road is unlikely to experience any adverse effects of such a release.

7.2.4. Hydrogen Sulfide Dispersion Results. Hydrogen sulfide release was modeled as a release of 22.37 kg of gas at ambient pressure and temperature conditions. As noted in Sec. 5, this would be the maximum amount of hydrogen sulfide that would be stored at TA-63 in the future. Hydrogen sulfide gas is heavier than air; therefore, the scenario was modeled as a dense gas release. The ERPG-2 and ERPG-3 values of arsine are 30 ppm and 100 ppm, respectively. The entire inventory was assumed to be released in the first minute.

7.2.4.1. Hydrogen Sulfide Isopleths. The hydrogen sulfide plume progression for the worst-case scenario is shown in Fig. 7-22. The time interval for the MIDAS snapshot is 10 min. The Los Alamos site map is shown on each plot with the cross-hairs depicting the location of the hydrogen sulfide release. In this calculation, the wind is blowing slowly at 0.875 m/s from the west, and the atmospheric stability is F. The color scheme used for ERPG-2 and ERPG-3 is the same as with the hydrogen fluoride, phosgene, and arsine isopleths. The ERPG-3 area indicates that concentration has exceeded 100 ppm for the last 10 min. Similarly, the ERPG-2 area indicates that concentration has exceeded 30 ppm for the last 10 min. As expected, the ERPG-2 area encompasses the ERPG-3 area. The purple and gray shaded areas are not important to the current discussion.

The maximum plume isopleths for ERPG-2 and ERPG-3 were realized 10 min after the release as shown in Fig. 7-22. ERPG-3 levels were exceeded primarily along access roads. ERPG-2 levels were exceeded over technical areas as well as along access roads. The worst-case distances at which the ERPG-2 and ERPG-3 values were exceeded are listed in Table 7-2. These values are obtained from the MIDAS graph of hydrogen sulfide concentration vs distance as shown in Fig. 7-23.

7.2.4.2. Hydrogen Sulfide Risk Contours. Section 7.2.4.1 depicted the worst-case scenario using the most adverse conditions of wind speed, wind direction, and atmospheric stability class. The values of these parameters for the worst case scenario exist for about 1% of the time (8% of the time if all wind directions are considered). The risk contours for a hydrogen sulfide release, generated by QCRR using 10-min averaging for all calculations, are shown in Figs. 7-24 and 7-25. The contours account for the release frequency, all combinations of the wind speeds, and atmospheric stability conditions along with their relative likelihoods.

Figure 7-24 shows the risk contours for the case of exceeding ERPG-2 values. Following the same color scheme, the outer contour depicts the area that has a frequency of exposure to ERPG-2 values of 1.0E-6/yr. The inner contour corresponds to a frequency of exposure to ERPG-2 values of 1.0E-5/yr. Similarly, Fig. 7-25 shows the risk contours for the case of exceeding ERPG-3 values.

For a frequency of 1.0E-5/yr, the ERPG-2 and ERPG-3 risk contours depict a scenario in which the hydrogen sulfide release is localized. The areas affected have the smallest footprints of all the chemicals studied. Nonetheless, the effect on Pajarito Road is a concern. However, the likelihood of affecting nearby technical areas is minimal. A slightly larger area, including technical areas and Pajarito Road, could be affected by a release with a frequency of 1.0E-6/yr. For this low-frequency event, the offsite public consequences of a hydrogen sulfide release are limited to some short-duration exposure to travelers on Pajarito Road. The mobile home park on East Jemez Road is unlikely to experience any adverse effects from such a release.

TABLE 7-1
RELEASE FREQUENCIES FOR WORST-CASE SEQUENCES

INITIATING EVENT	RELEASE FREQUENCY (YR^{-1})
Seismic event of 0.3-g intensity	2.0×10^{-6}
Fire/explosion starting inside facility	3.3×10^{-4}
Fire/explosion starting outside facility	2.0×10^{-5}
TOTAL	3.5×10^{-4}

TABLE 7-2
WORST CASE EXCEEDANCE DISTANCES

Chemical	ERPG-2	ERPG-3
	Worst Case Exceedance Distance (m)	Worst Case Exceedance Distance (m)
Hydrogen Fluoride	3100	2000
Phosgene	1000	110
Arsine	500	150
Hydrogen Sulfide	400	140

Chemical: **Hydrogen Fluoride (HF)**
Quantity: **58.42 KG**

Averaging Time: **10 Min.**
Stability Class: **F**

Snapshot: **10 Min.**
Wind Speed @ 10m: **0.875 m/s**
Wind Direction(From): West
Temperature: 15C
Release Height: 10m
ERPG-3: 50ppm
ERPG-2: 20ppm

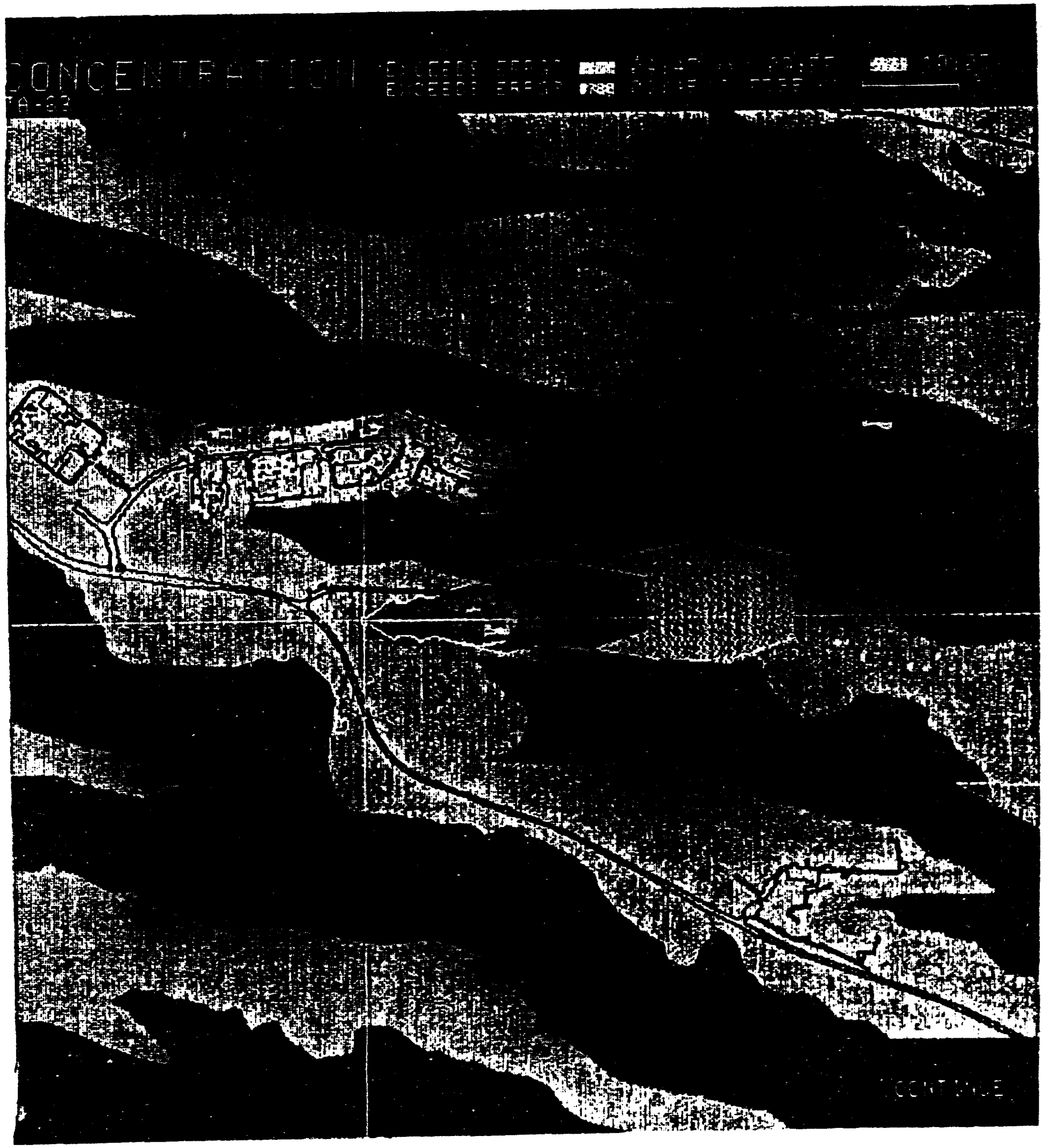


Fig. 7-1. Hydrogen fluoride 10-min snapshot with 10-min averaging and stability f.

Chemical: **Hydrogen Fluoride (HF)**
Quantity: **58.42 KG**

Averaging Time: **10 Min.**
Stability Class: **F**

Snapshot: **20 Min.**
Wind Speed @ 10m: **0.875 m/s**
Wind Direction(From): West
Temperature: 15C
Release Height: 10m
ERPG-3: 50ppm
ERPG-2: 20ppm

Fig. 7-2. Hydrogen fluoride 20-min snapshot with 10-min averaging and stability f.

Chemical: **Hydrogen Fluoride (HF)**
Quantity: **58.42 KG**

Averaging Time: **10 Min.**
Stability Class: **F**

Snapshot: **30 Min.**
Wind Speed @ 10m: **0.875 m/s**
Wind Direction(From): West
Temperature: 15C
Release Height: 10m
ERPG-3: 50ppm
ERPG-2: 20ppm

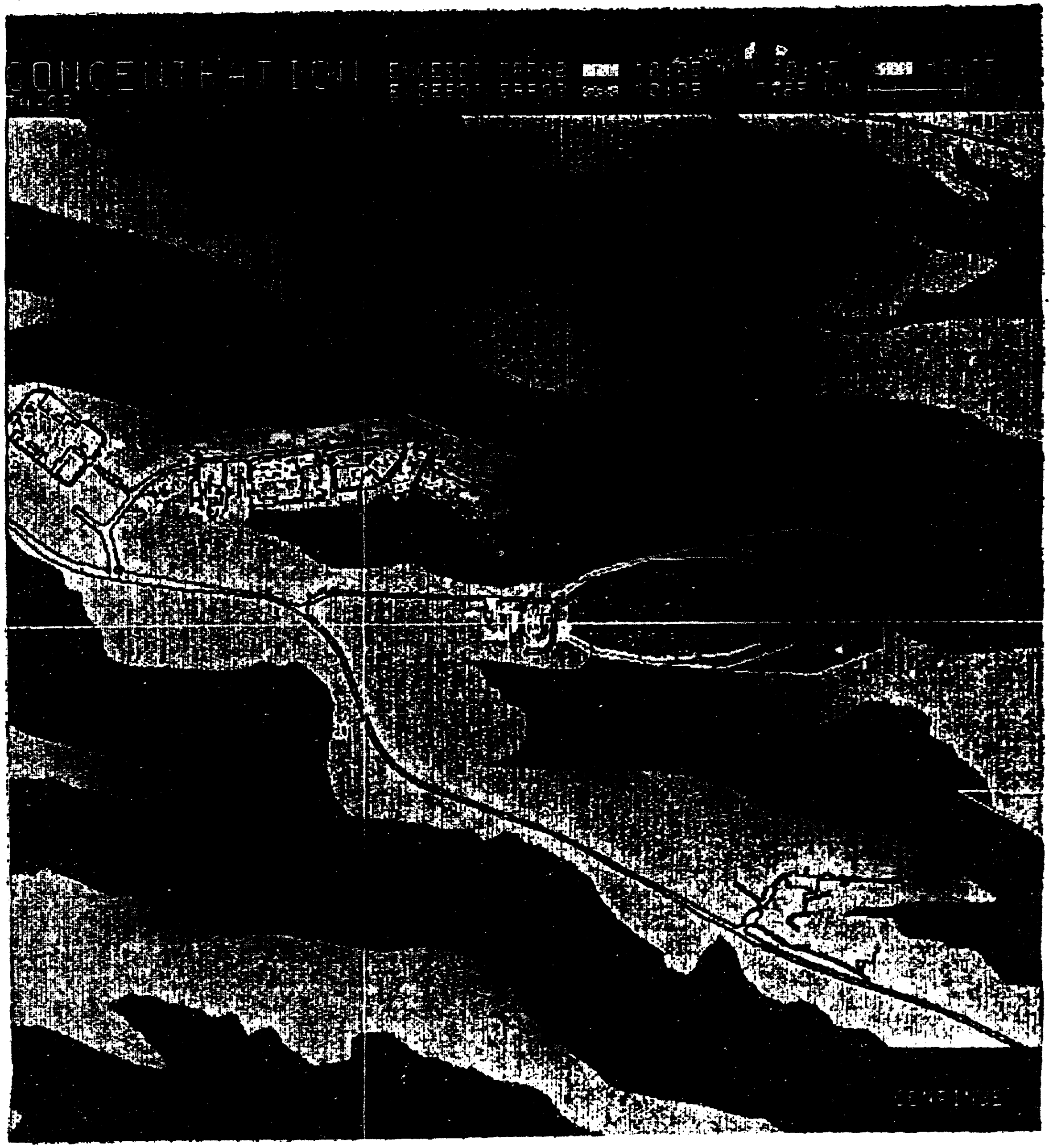


Fig. 7-3. Hydrogen fluoride 30-min snapshot with 10-min averaging and stability f.

Chemical: **Hydrogen Fluoride (HF)**
Quantity: **58.42 KG**

Averaging Time: **10 Min.**
Stability Class: **F**

Snapshot: **40 Min.**
Wind Speed @ 10m: **0.875 m/s**
Wind Direction(From): West
Temperature: 15C
Release Height: 10m
ERPG-3: 50ppm
ERPG-2: 20ppm

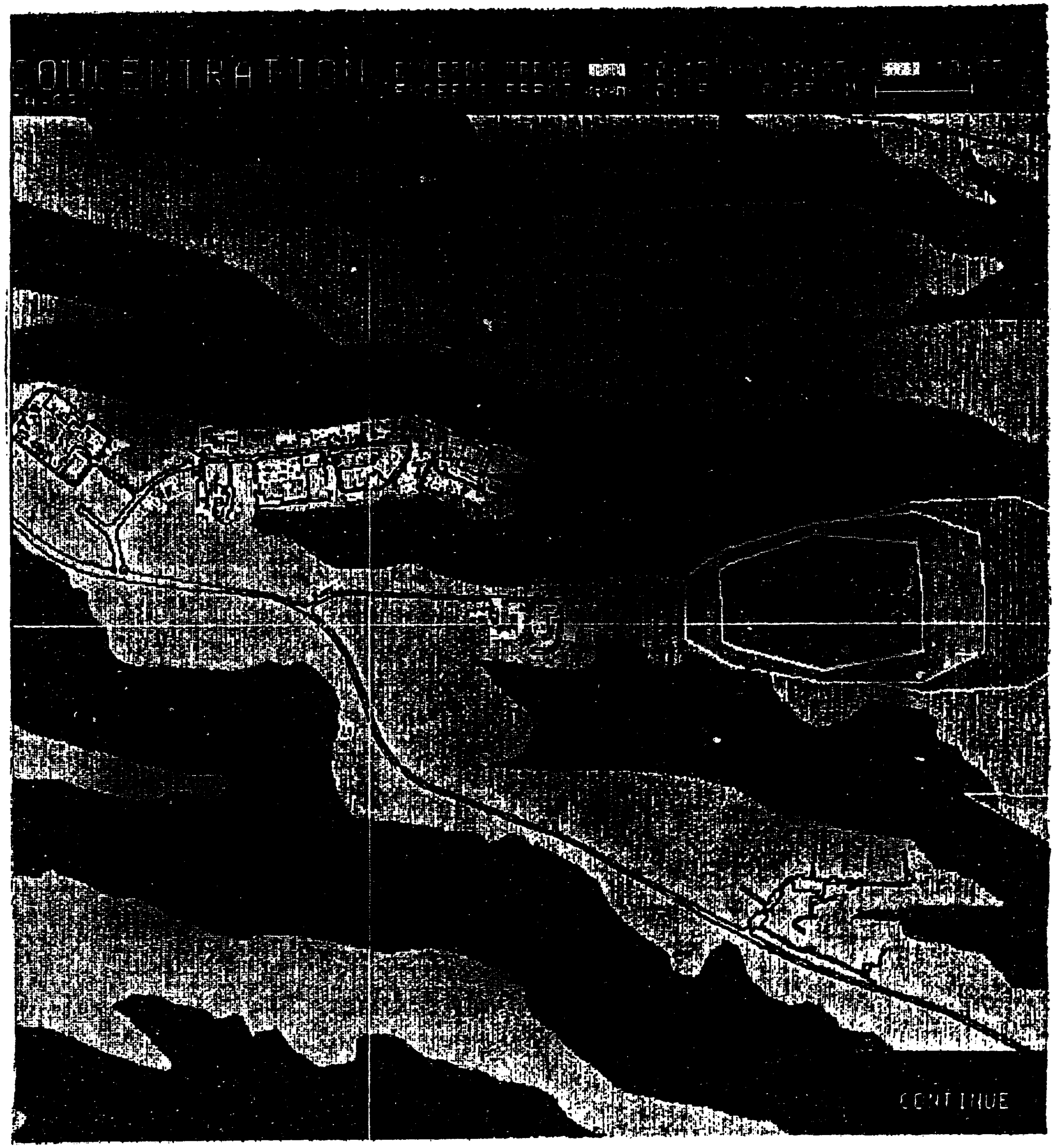


Fig. 7-4. Hydrogen fluoride 40-min snapshot with 10-min averaging and stability f.

Chemical: Hydrogen Fluoride (HF)
Quantity: 58.42 KG

Averaging Time: 10 Min.
Stability Class: F

Wind Speed @ 10m: 0.875 m/s
Wind Direction(From): West
Temperature: 15C
Release Height: 10m
ERPG-3: 50ppm
ERPG-2: 20ppm

DIST. (KM)	SMOOTH (PPM)
.06	7.7E+03
.10	3.8E+03
.30	1.1E+03
.60	2.5E+02
1.00	1.0E+02
3.00	1.7E+01
6.00	2.0E-01
10.00	2.5E-03
	2.1E-07
	5.6E-10

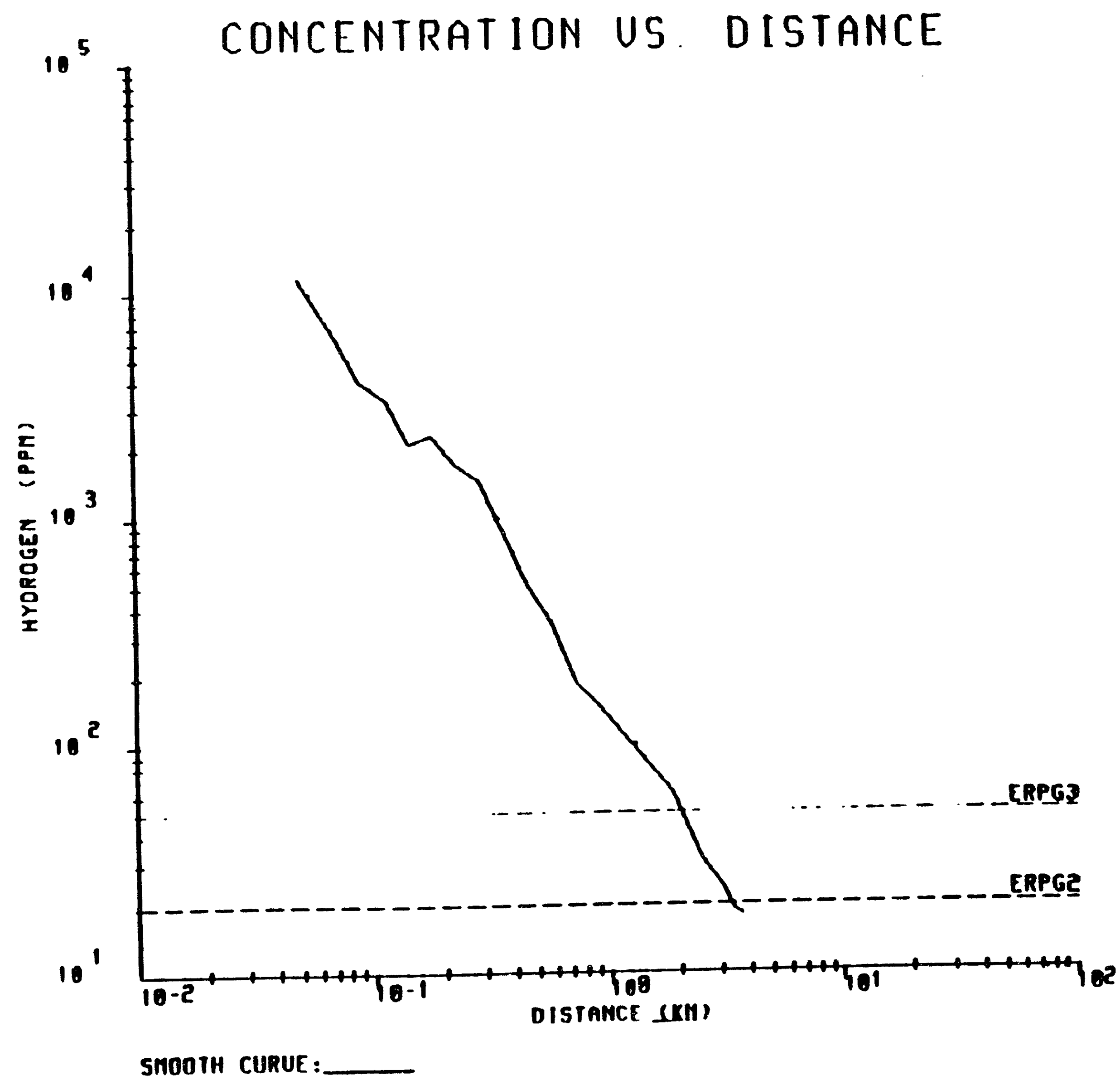


Fig. 7-5. Hydrogen fluoride concentration vs distance plot with 10-min averaging and stability f.

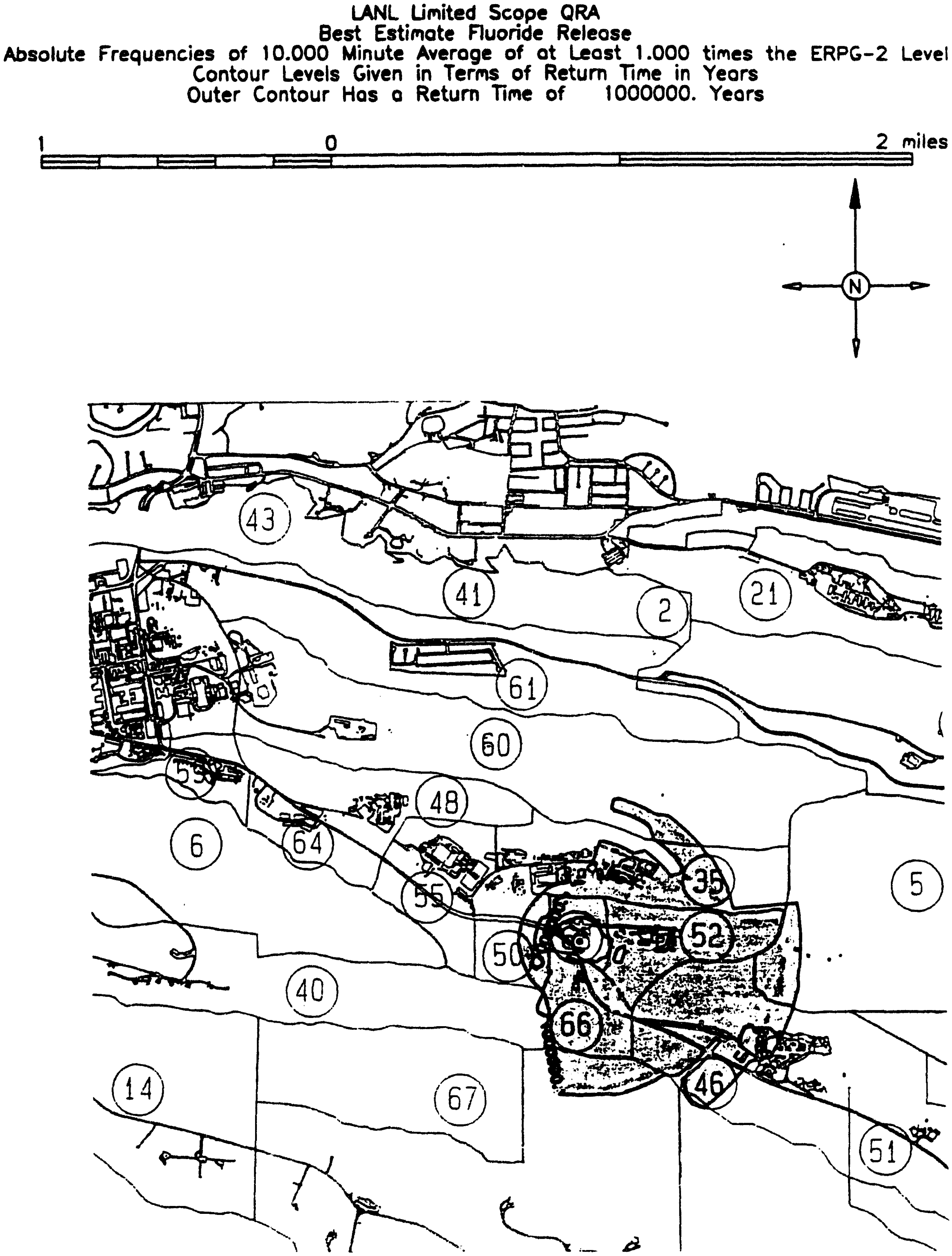


Fig. 7-6. Hydrogen flow in QCRR risk contours, ERPG-2, 10-min average.

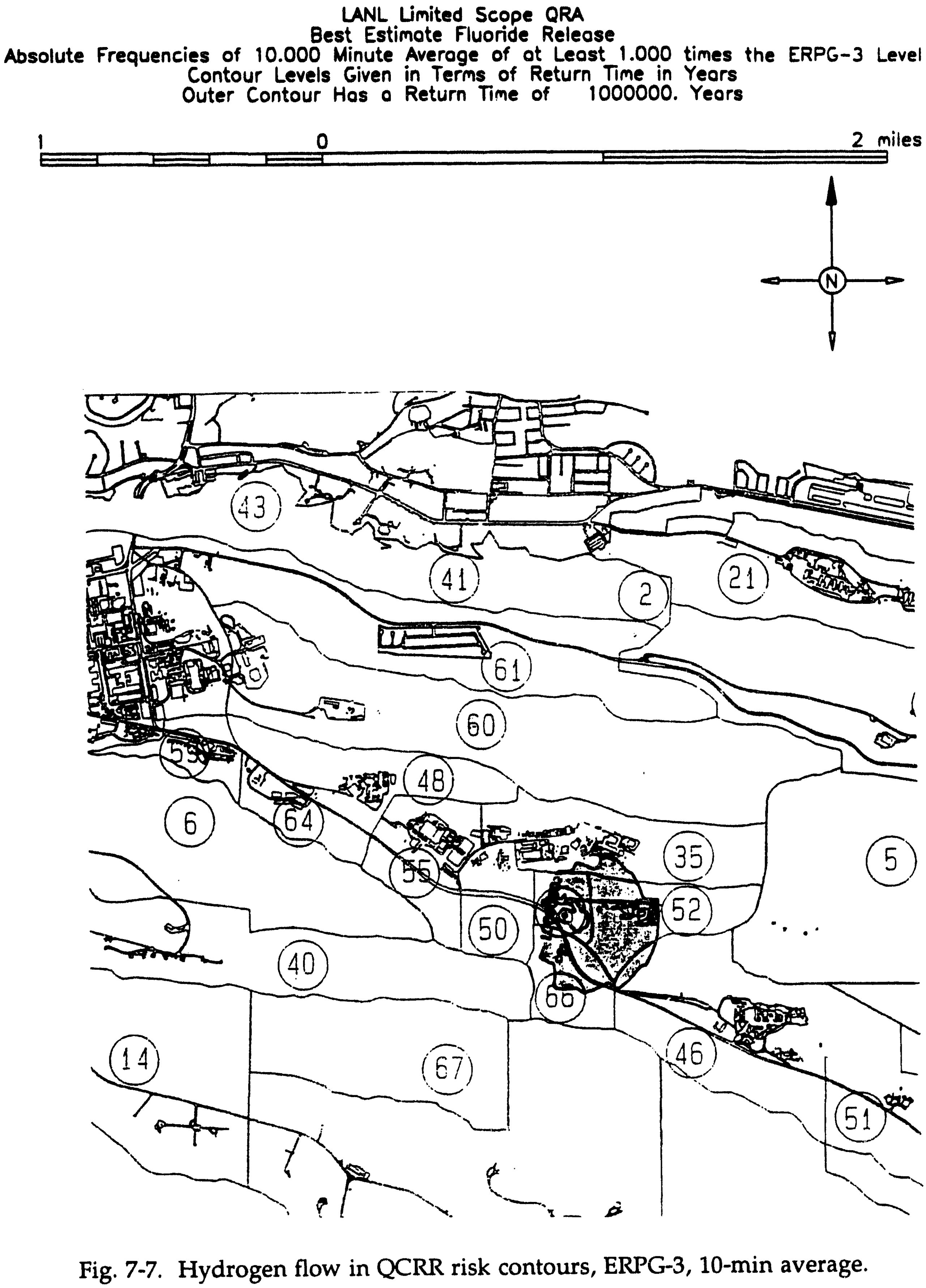


Fig. 7-7. Hydrogen flow in QCRR risk contours, ERPG-3, 10-min average.

Chemical: **Phosgene ($COCl_2$)**
Quantity: **5.07 KG**

Averaging Time: **10 Min.**
Stability Class: **F**

Snapshot: **10 Min.**
Wind Speed @ 10m: **0.875 m/s**
Wind Direction(From): West
Temperature: 15C
Release Height: 10m
ERPG-3: 1ppm
ERPG-2: 0.2ppm

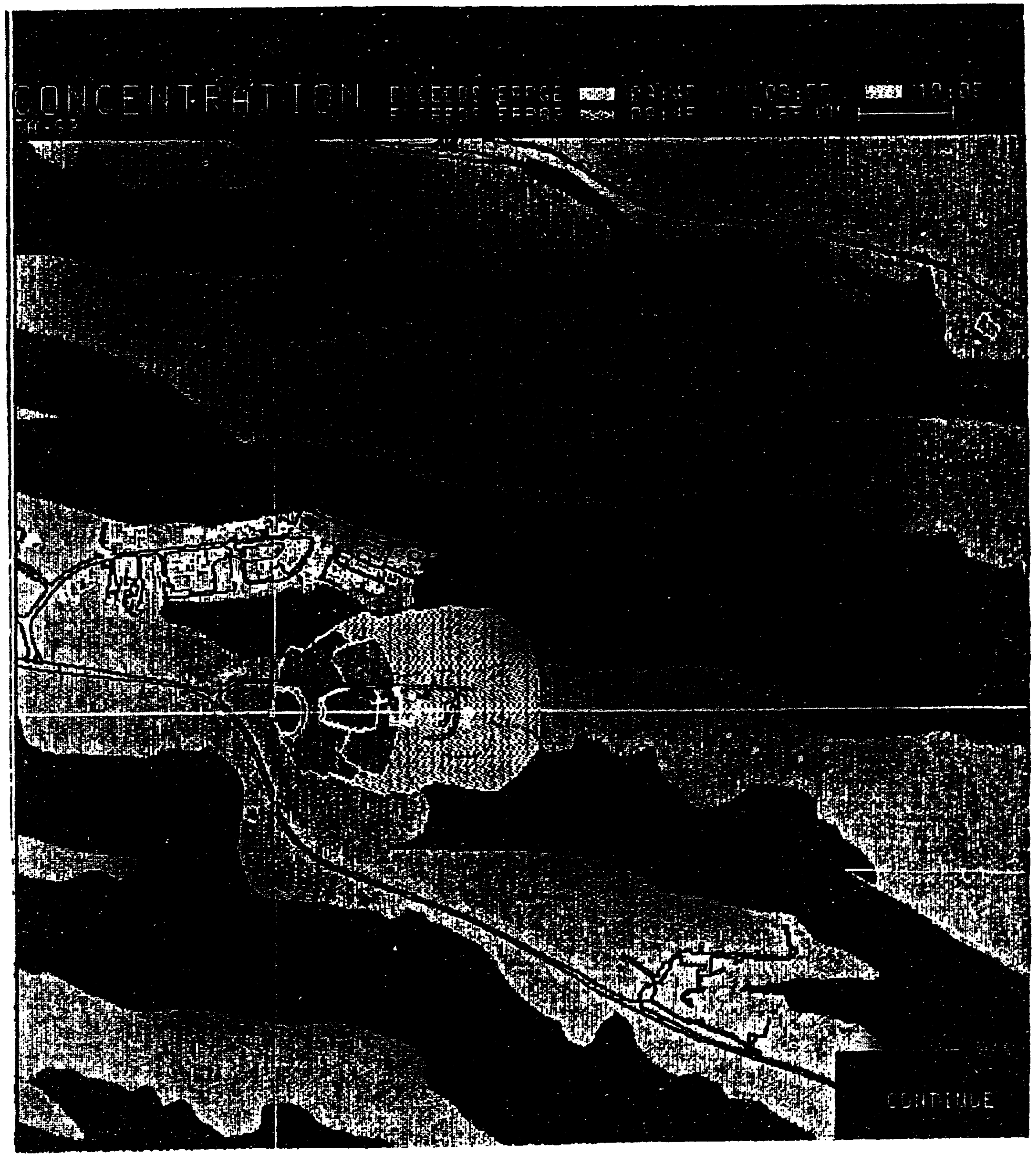


Fig. 7-8. Phosgene 10-min snapshot with 10-min averaging and stability f.

Chemical: **Phosgene ($COCl_2$)**
Quantity: **5.07 KG**

Averaging Time: **10 Min.**
Stability Class: **F**

Snapshot: **20 Min.**
Wind Speed @ 10m: **0.875 m/s**
Wind Direction(From): West
Temperature: 15C
Release Height: 10m
ERPG-3: 1ppm
ERPG-2: 0.2ppm

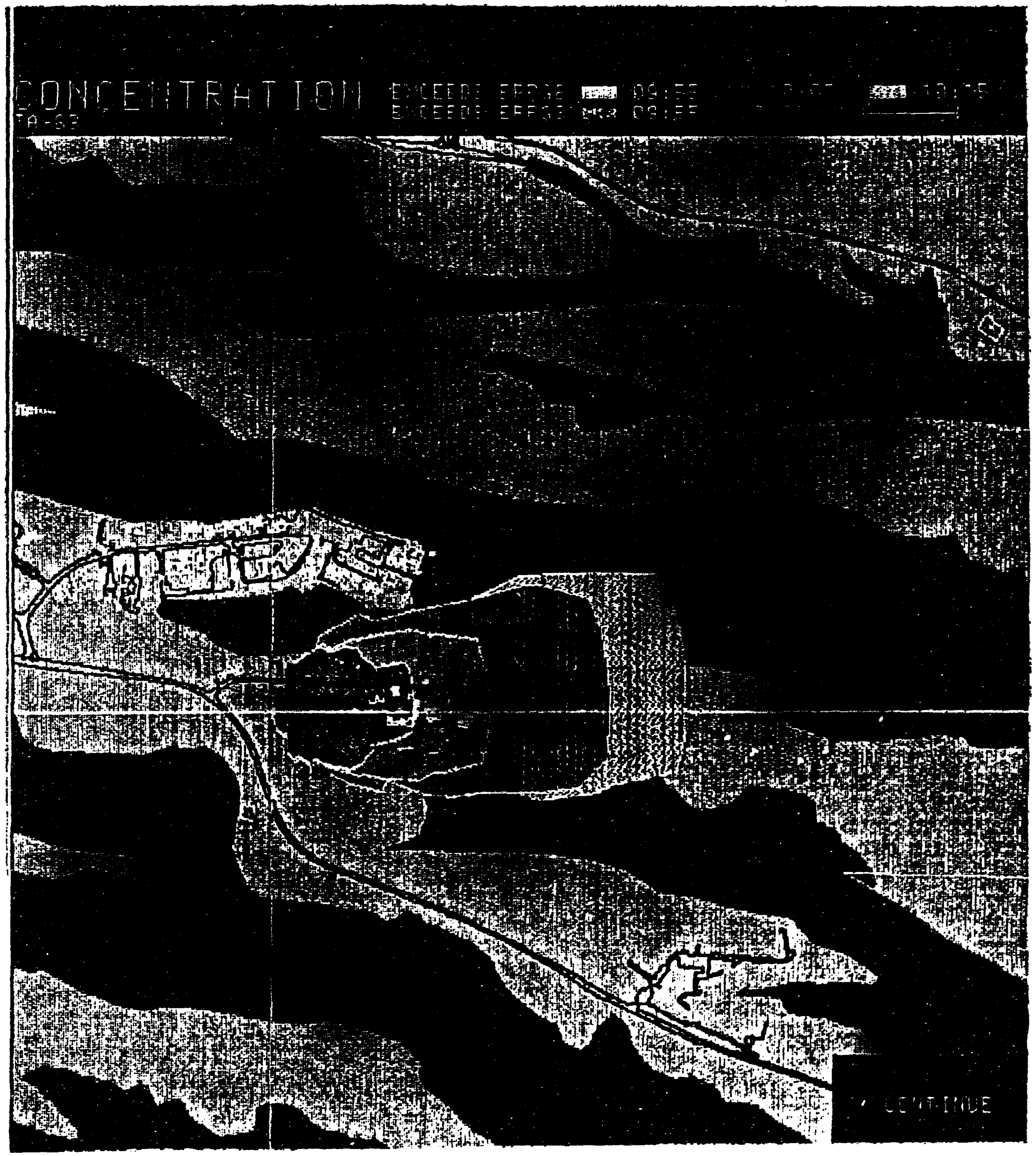


Fig. 7-9. Phosgene 20-min snapshot with 10-min averaging and stability f.

Chemical: **Phosgene ($COCl_2$)**
Quantity: **5.07 KG**

Averaging Time: **10 Min.**
Stability Class: **F**

Snapshot: **30 Min.**
Wind Speed @ 10m: **0.875 m/s**
Wind Direction(From): West
Temperature: 15C
Release Height: 10m
ERPG-3: 1ppm
ERPG-2: 0.2ppm

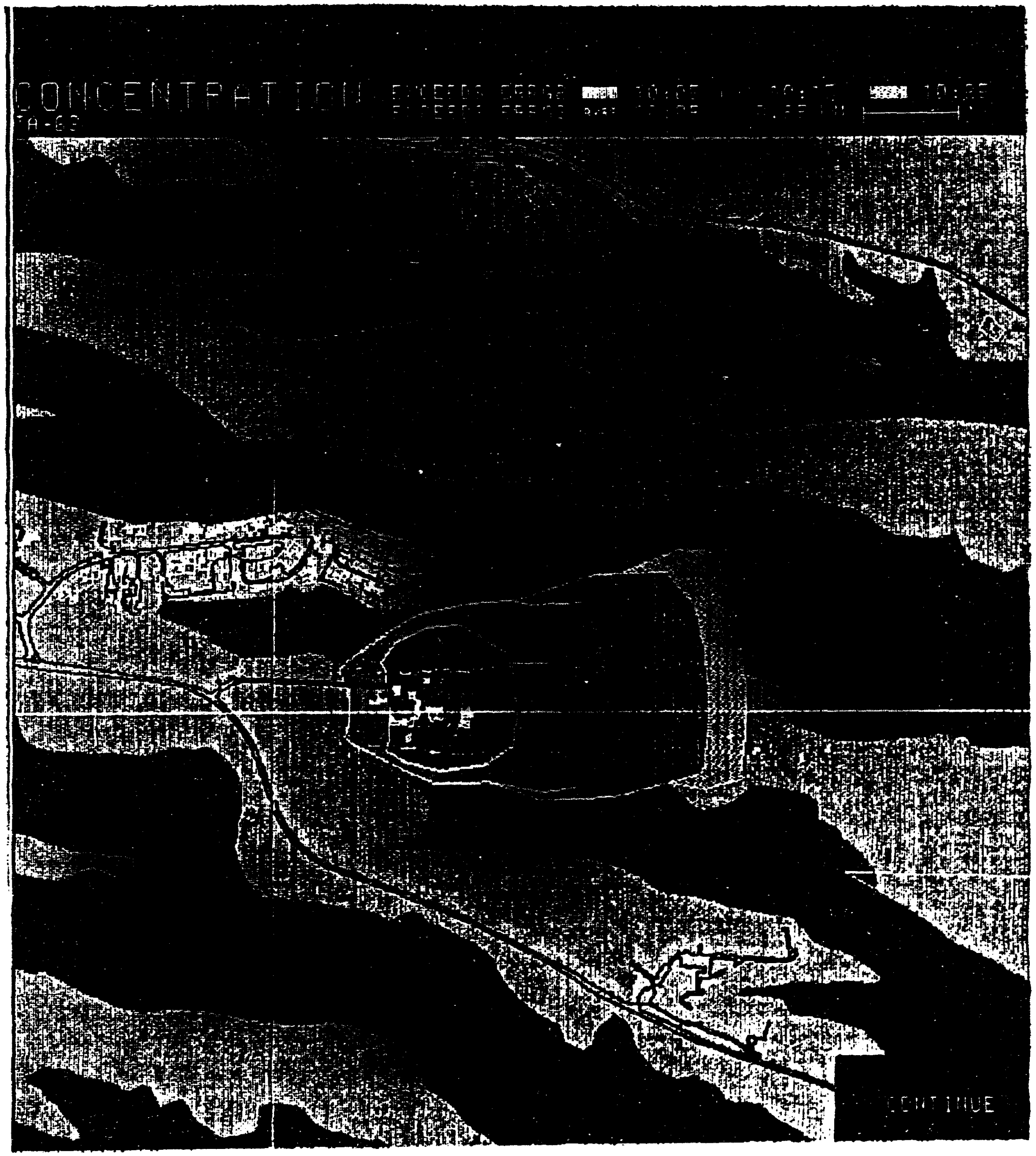


Fig. 7-10. Phosgene 30-min snapshot with 10-min averaging and stability f.

Chemical: **Phosgene ($COCl_2$)**
Quantity: **5.07 KG**

Averaging Time: **10 Min.**
Stability Class: **F**

Snapshot: **40 Min.**
Wind Speed @ 10m: **0.875 m/s**
Wind Direction(From): West
Temperature: 15C
Release Height: 10m
ERPG-3: 1ppm
ERPG-2: 0.2ppm

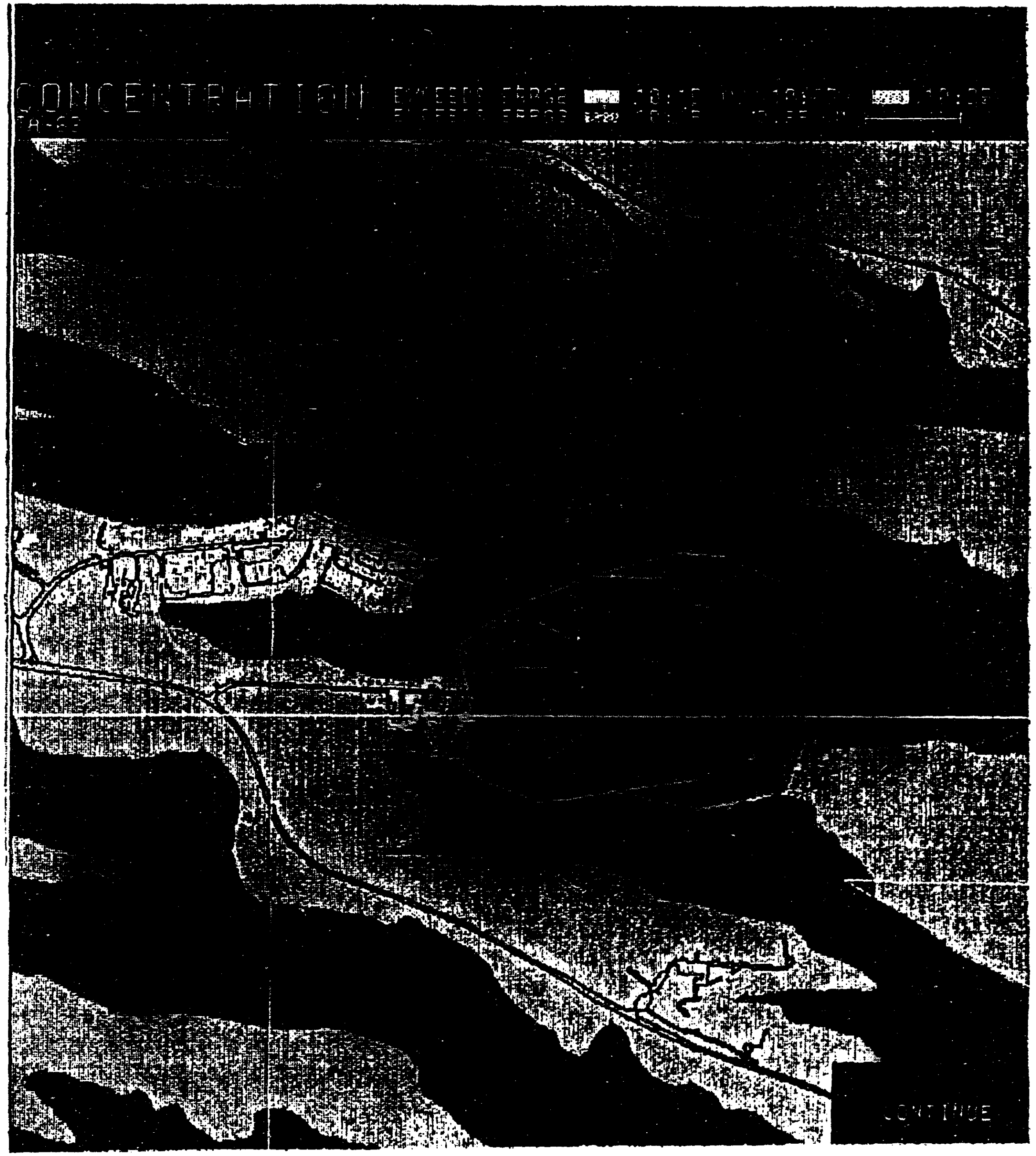


Fig. 7-11. Phosgene 40-min snapshot with 10-min averaging and stability f.

Chemical: **Phosgene ($COCl_2$)**
Quantity: **5.07 KG**

Averaging Time: **10 Min.**
Stability Class: **F**

Snapshot: **60 Min.**
Wind Speed @ 10m: **0.875 m/s**
Wind Direction(From): West
Temperature: 15C
Release Height: 10m
ERPG-3: 1ppm
ERPG-2: 0.2ppm

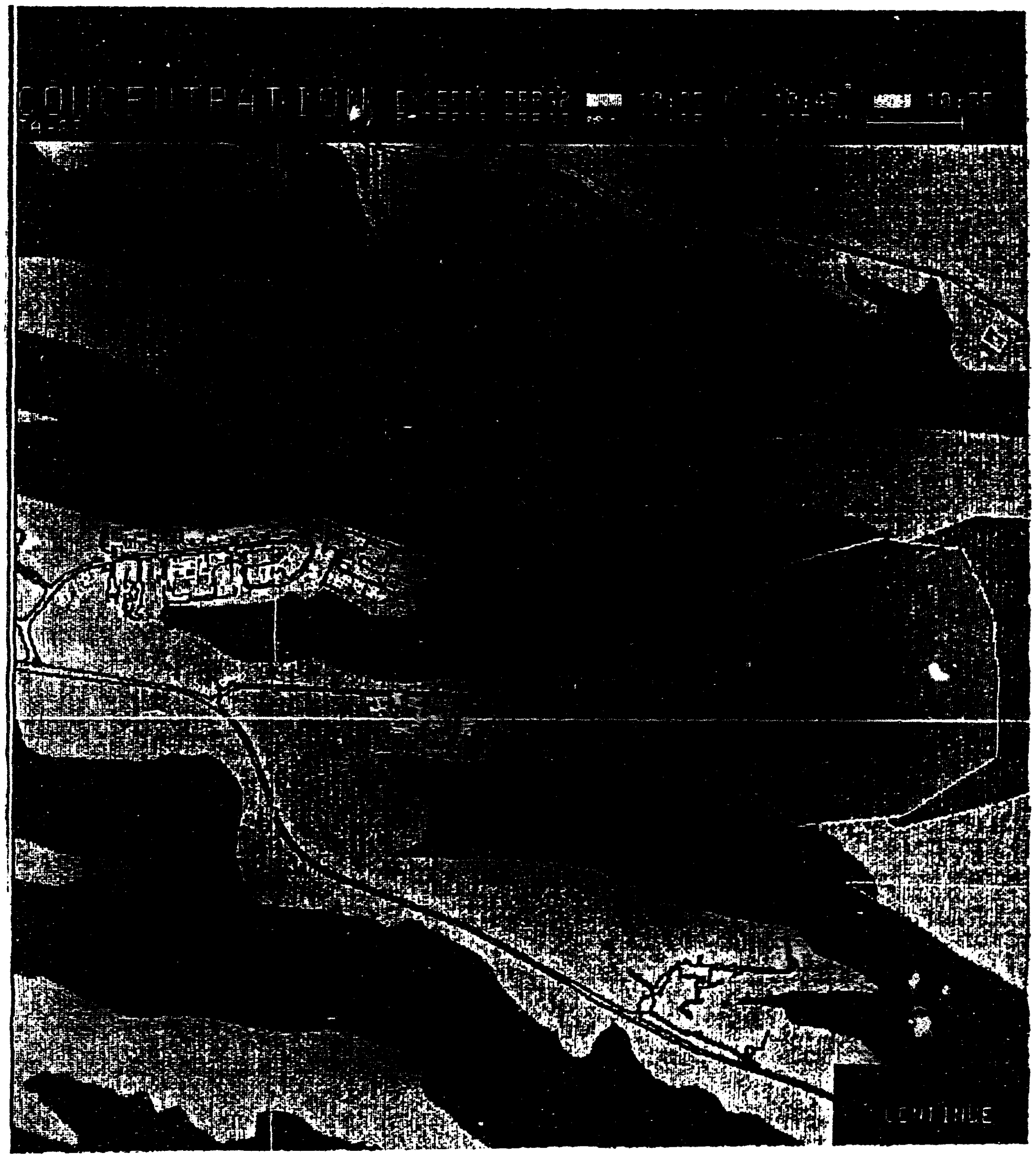


Fig. 7-12. Phosgene 60-min snapshot with 10-min averaging and stability f.

Chemical: Phosgene ($COCl_2$)
Quantity: 5.07 KG

Averaging Time: 10 Min.
Stability Class: F

Wind Speed @ 10m: 0.875 m/s
Wind Direction(From): West
Temperature: 15C
Release Height: 10m
ERPG-3: 1ppm
ERPG-2: 0.2ppm

DIST. (KM)	SMOOTH (PPM)
.06	1.5E+01
.10	4.3E+00
.30	2.6E+00
.60	1.8E-01
1.00	9.7E-06
3.00	6.5E-15
6.00	1.1E-20
10.00	5.7E-25
30.00	1.0E-31
60.00	1.0E-31

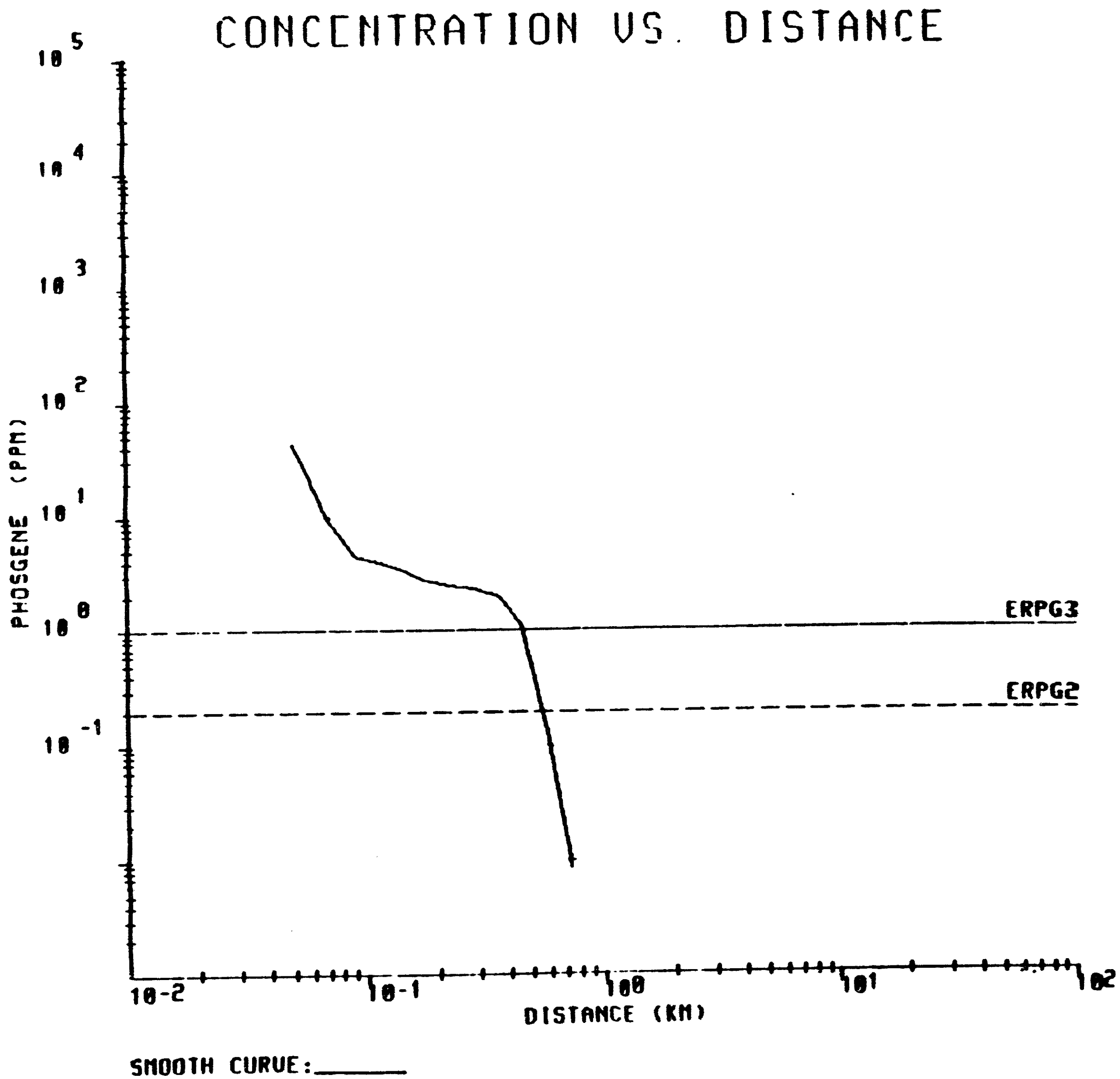


Fig. 7-13. Phosgene concentration vs distance plot with 10-min averaging and stability f.

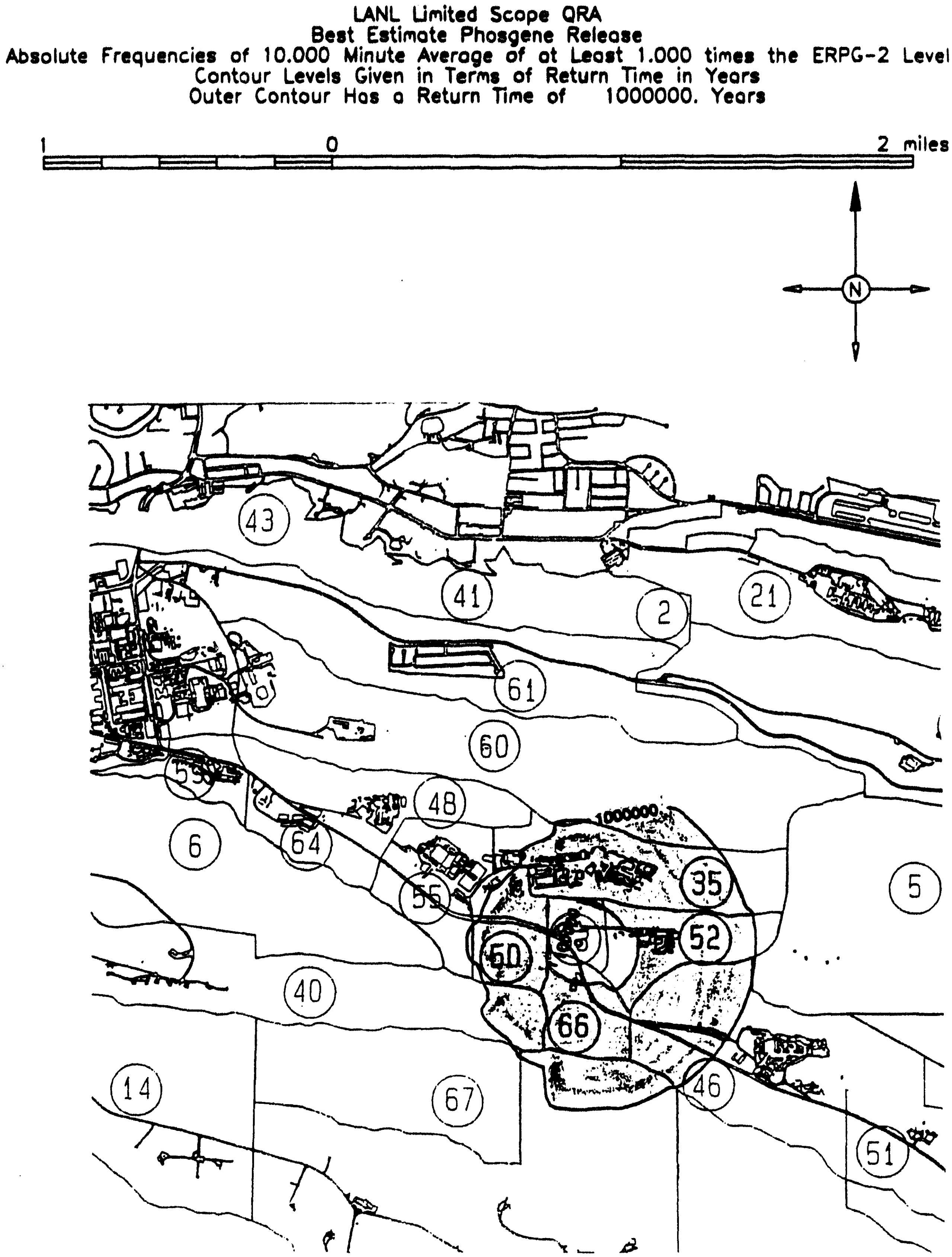


Fig. 7-14. Phosgene QCRR risk contours, ERPG-2, 10-min average.

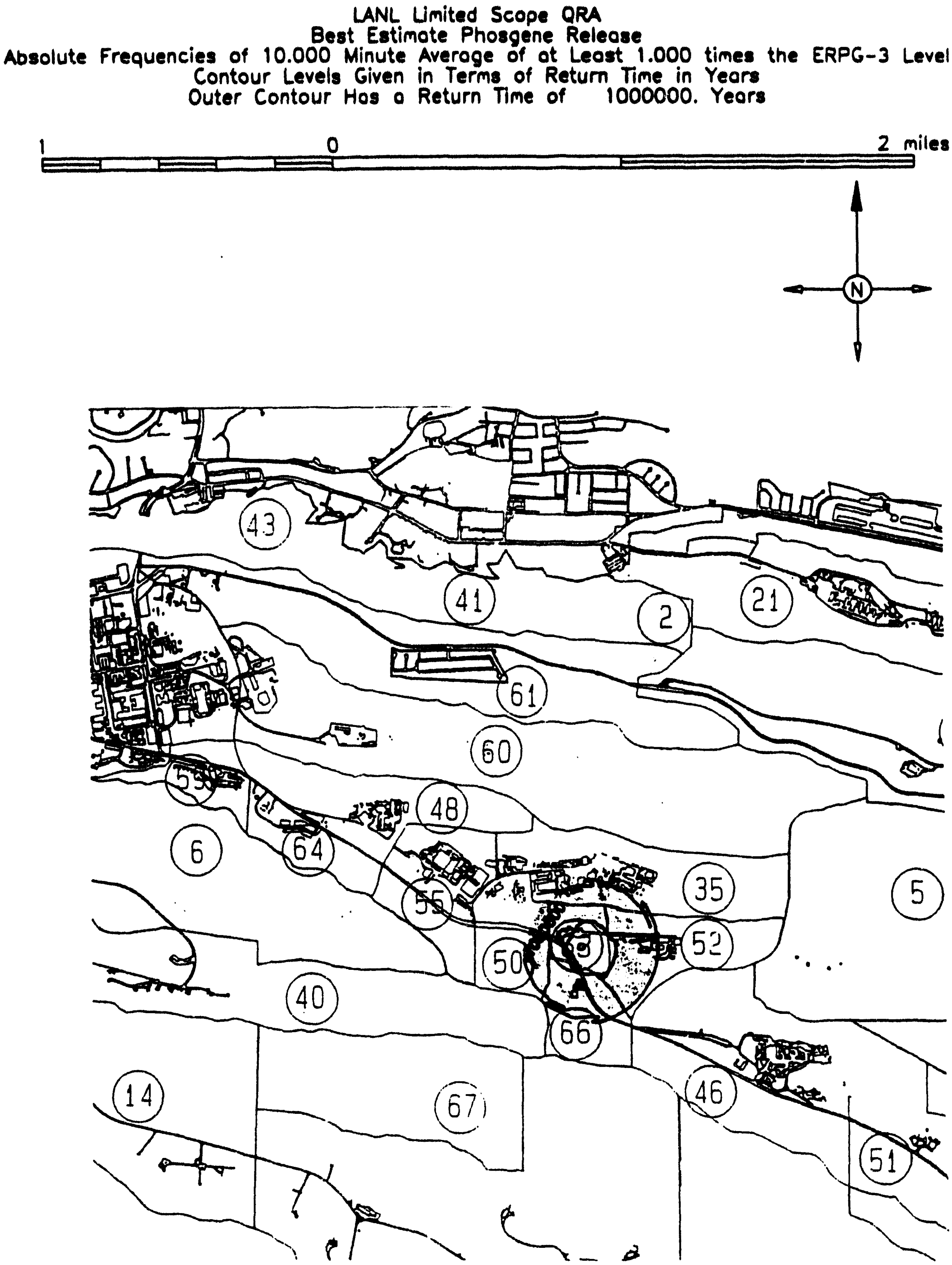


Fig. 7-15. Phosgene QCRR risk contours, ERPG-3, 10-min average.

Chemical: **Arsine (AsH_3)**
Quantity: **6.68 KG**

Averaging Time: **10 Min.**
Stability Class: **F**

Snapshot: **10 Min.**
Wind Speed @ 10m: **0.875 m/s**
Wind Direction(From): West
Temperature: 15C
Release Height: 10m
ERPG-3: 5ppm
ERPG-2: 1ppm

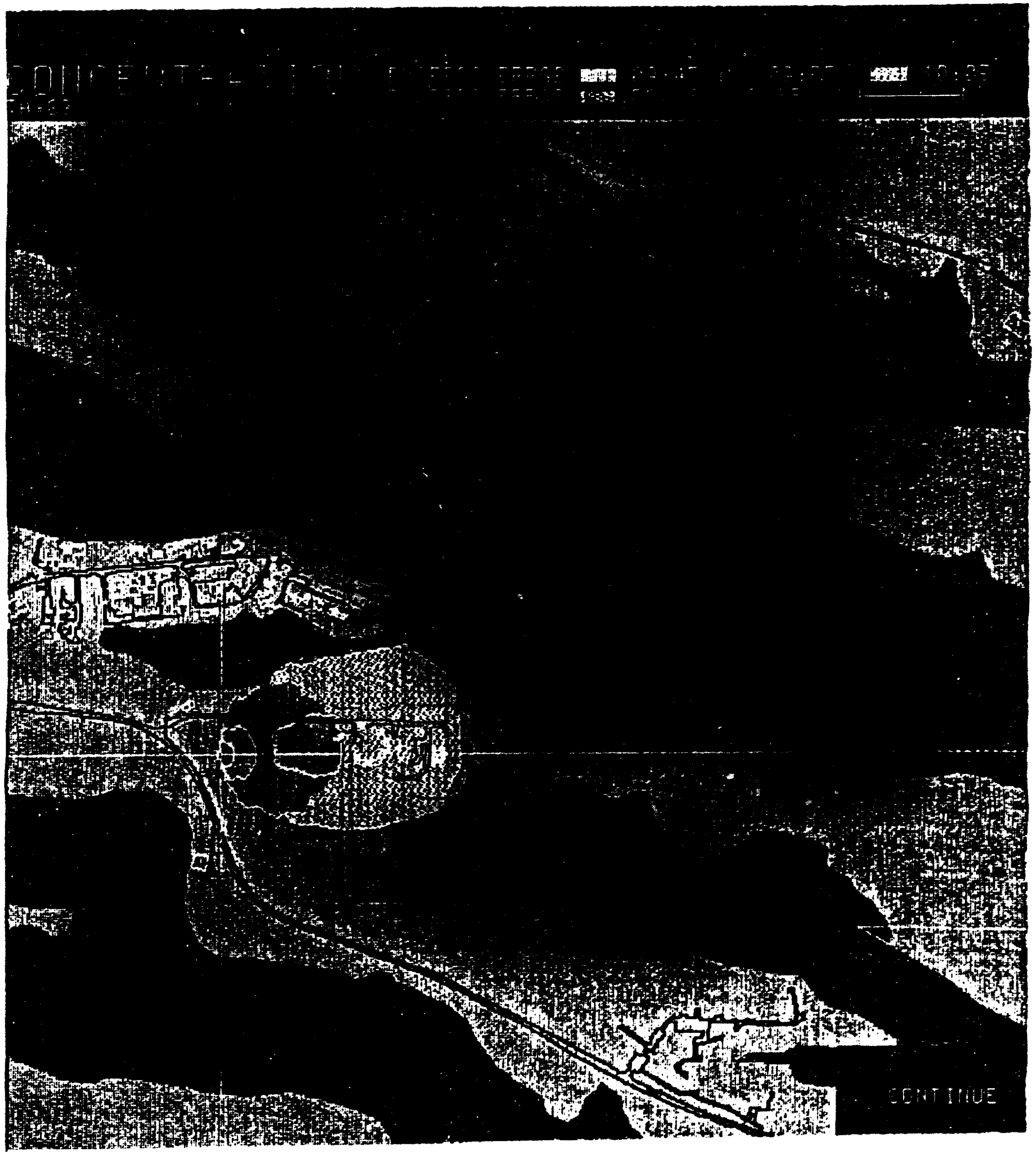


Fig. 7-16. Arsine 10-min snapshot with 10-min averaging and stability f.

Chemical: **Arsine (AsH3)**
Quantity: **6.68 KG**

Averaging Time: **10 Min.**
Stability Class: **F**

Snapshot: **20 Min.**
Wind Speed @ 10m: **0.875 m/s**
Wind Direction(From): West
Temperature: 15C
Release Height: 10m
ERPG-3: 5ppm
ERPG-2: 1ppm

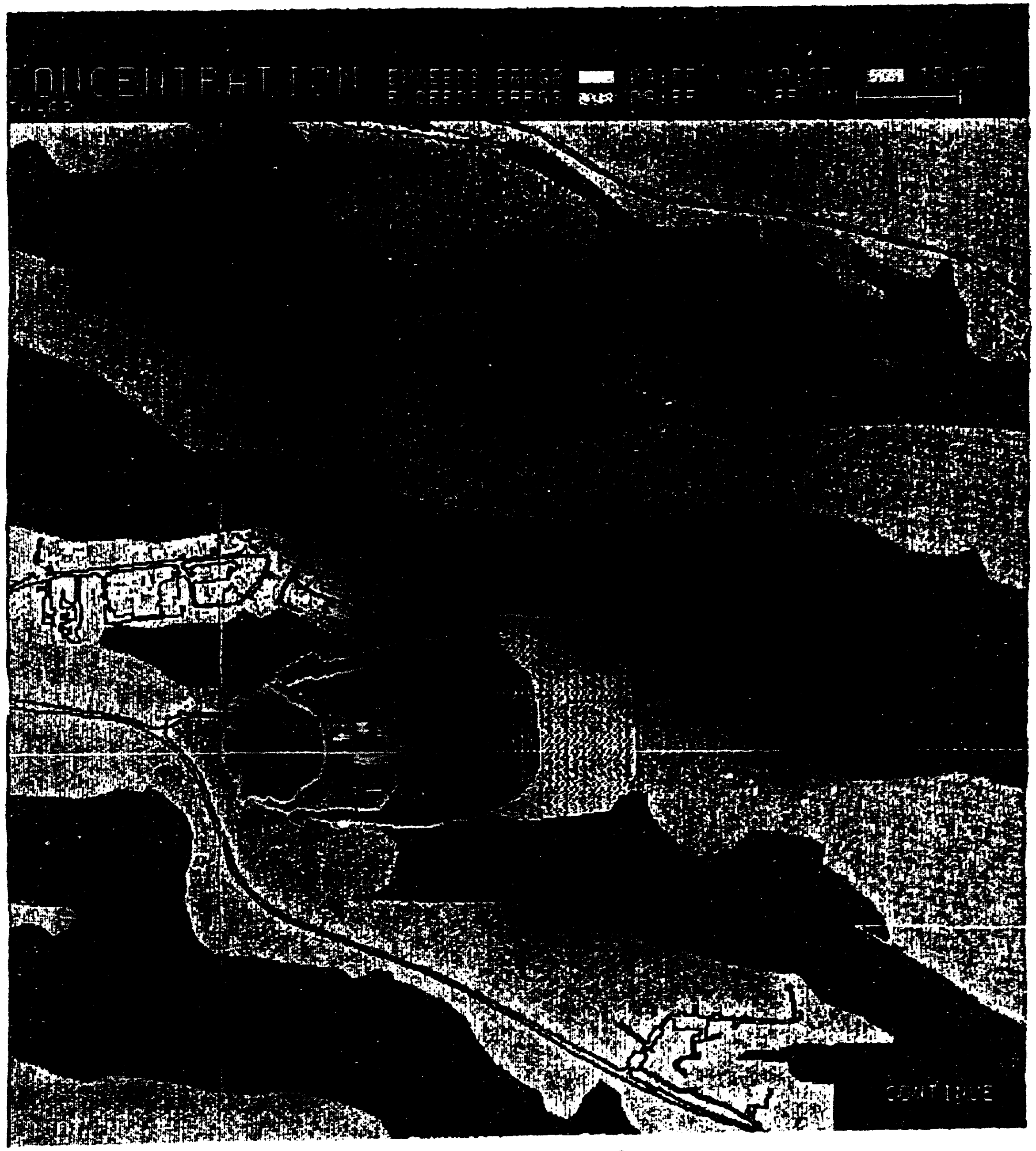


Fig. 7-17. Arsine 20-min snapshot with 10-min averaging and stability f.

Chemical: **Arsine (AsH_3)**
Quantity: **6.68 KG**

Averaging Time: **10 Min.**
Stability Class: **F**

Snapshot: **30 Min.**
Wind Speed @ 10m: **0.875 m/s**
Wind Direction(From): West
Temperature: 15C
Release Height: 10m
ERPG-3: 5ppm
ERPG-2: 1ppm

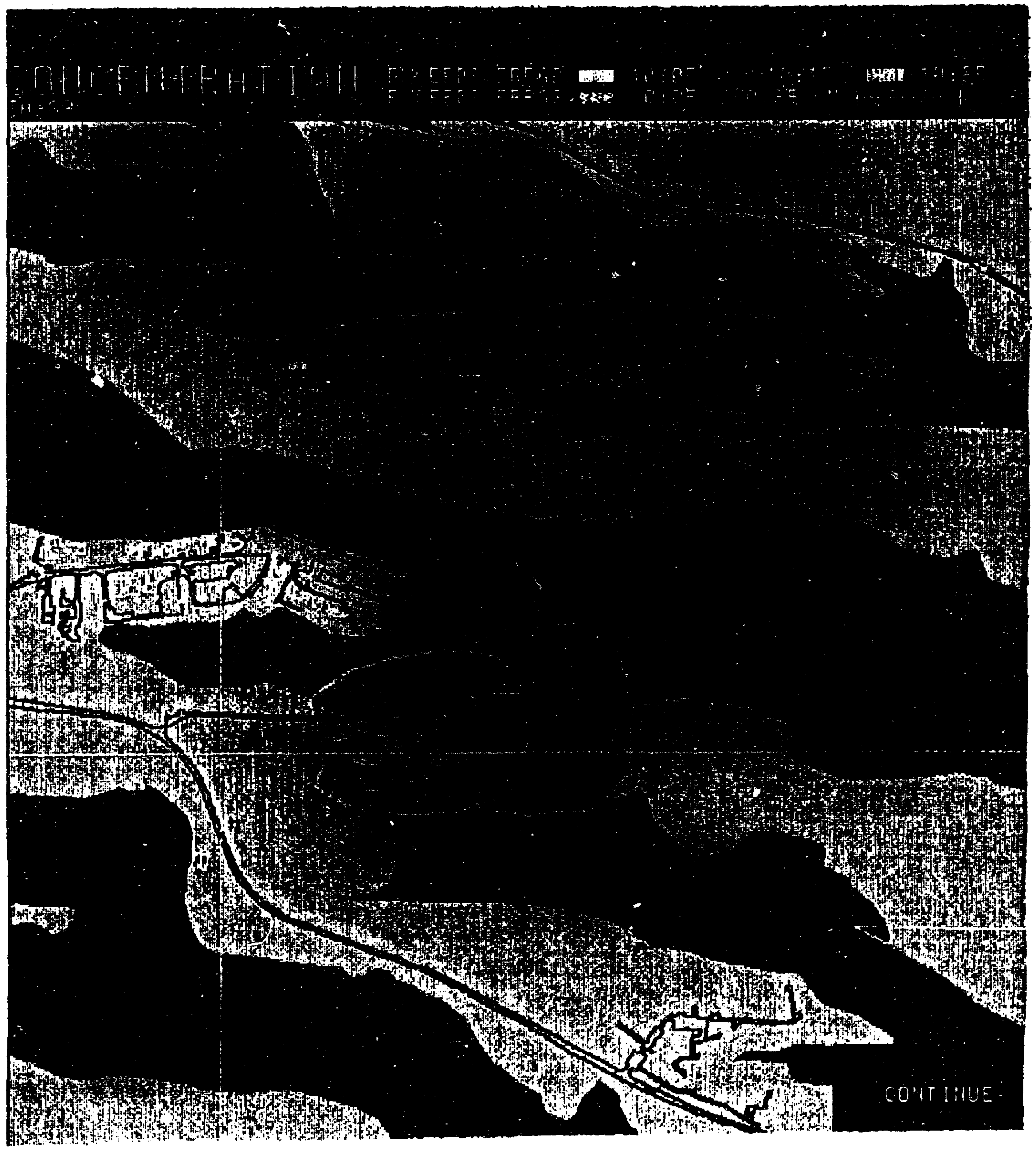


Fig. 7-18. Arsine 30-min snapshot with 10-min averaging and stability f.

Chemical: **Arsine (AsH_3)**
Quantity: **6.68 KG**

Averaging Time: **10 Min.**
Stability Class: **F**

Wind Speed @ 10m: **0.875 m/s**
Wind Direction(From): West
Temperature: 15C
Release Height: 10m
ERPG-3: 5ppm
ERPG-2: 1ppm

DIST. (KM)	SMOOTH (PPM)
.06	3.9E+01
.10	1.2E+01
.30	5.2E+00
.60	2.6E-01
1.00	5.1E-05
3.00	5.4E-13
6.00	5.0E-18
10.00	9.8E-22
30.00	1.0E-29
60.00	1.0E-31

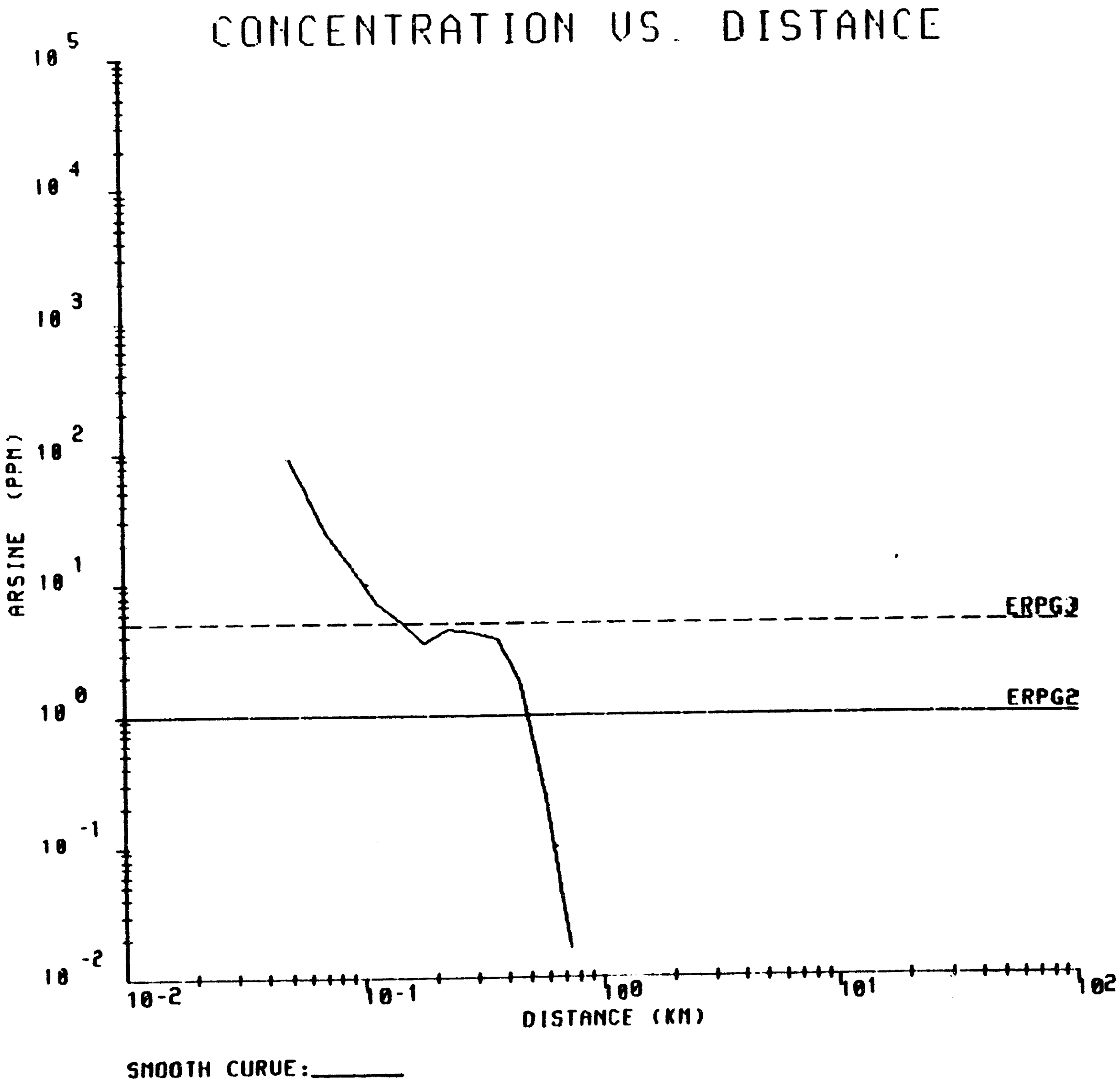


Fig. 7-19. Arsine concentration vs distance plot with 10-min averaging and stability f.

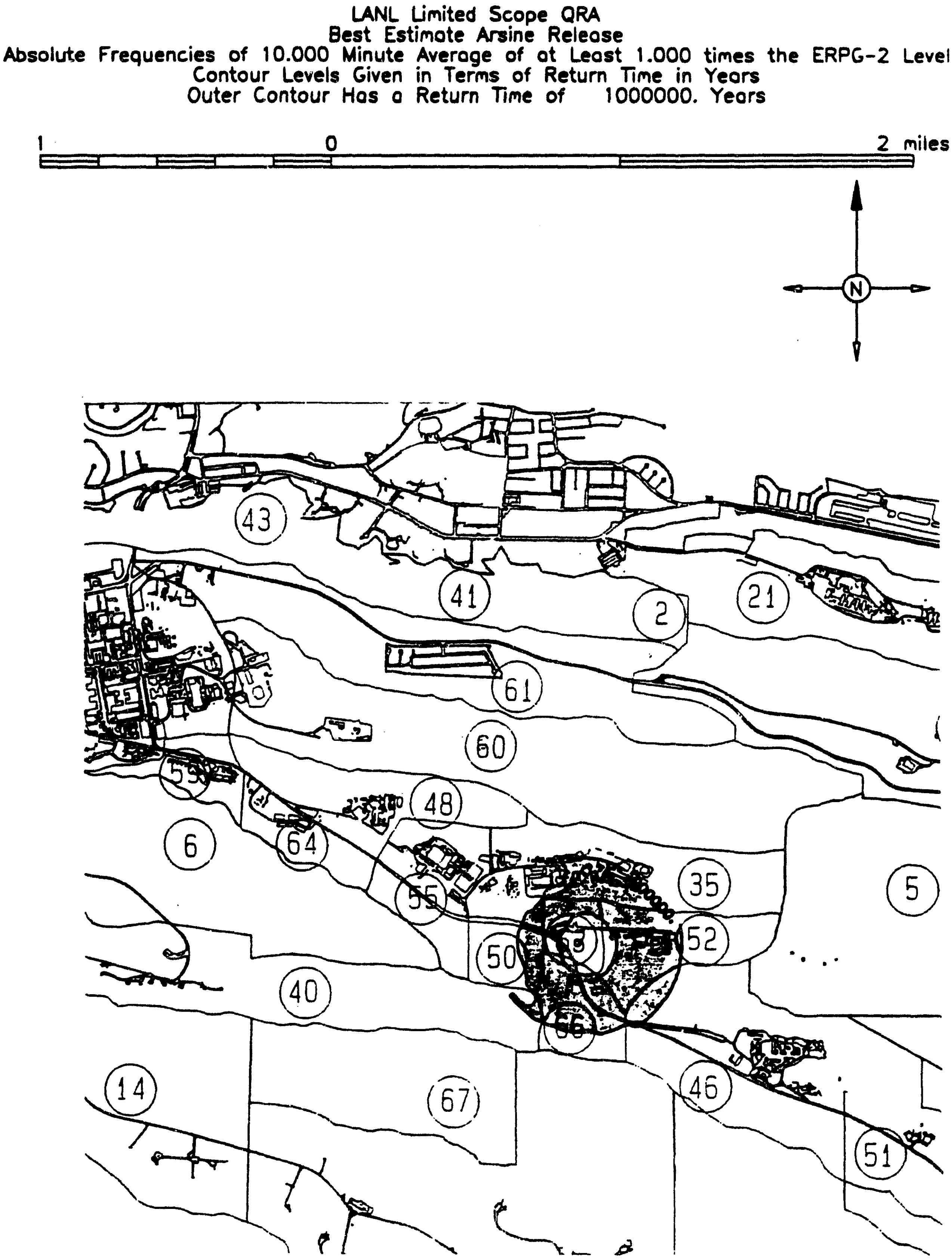


Fig. 7-20. Arsine QCRR risk contours, ERPG-2, 10-min averaging.

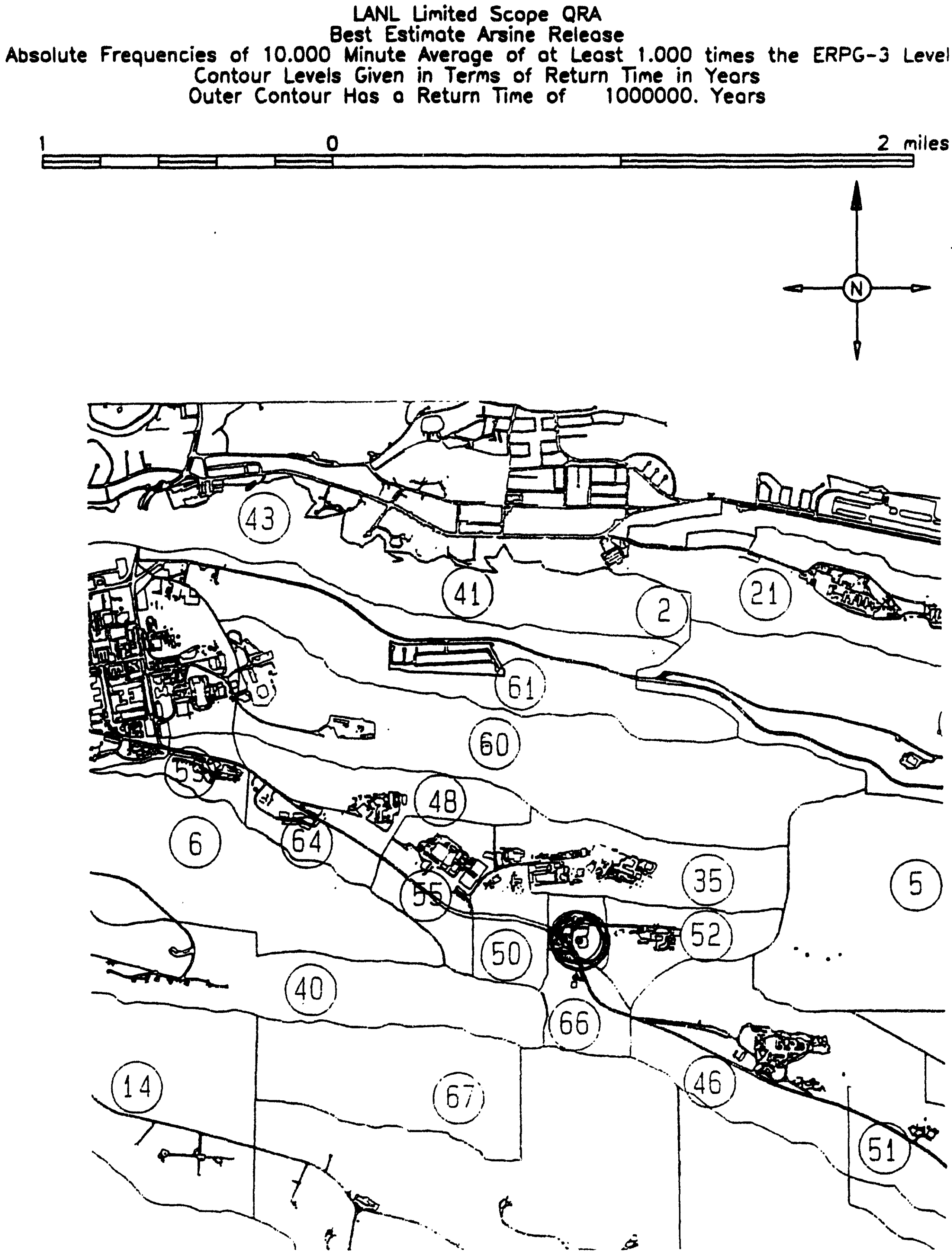


Fig. 7-21. Arsine QCRR risk contours, ERPG-3, 10-min averaging.

Chemical: **Hydrogen Sulfide (H_2S)**
Quantity: **22.37 KG**

Averaging Time: **10 Min.**
Stability Class: **F**

Snapshot: **10 Min.**
Wind Speed @ 10m: **0.875 m/s**
Wind Direction(From): West
Temperature: 15C
Release Height: 10m
ERPG-3: 100ppm
ERPG-2: 30ppm

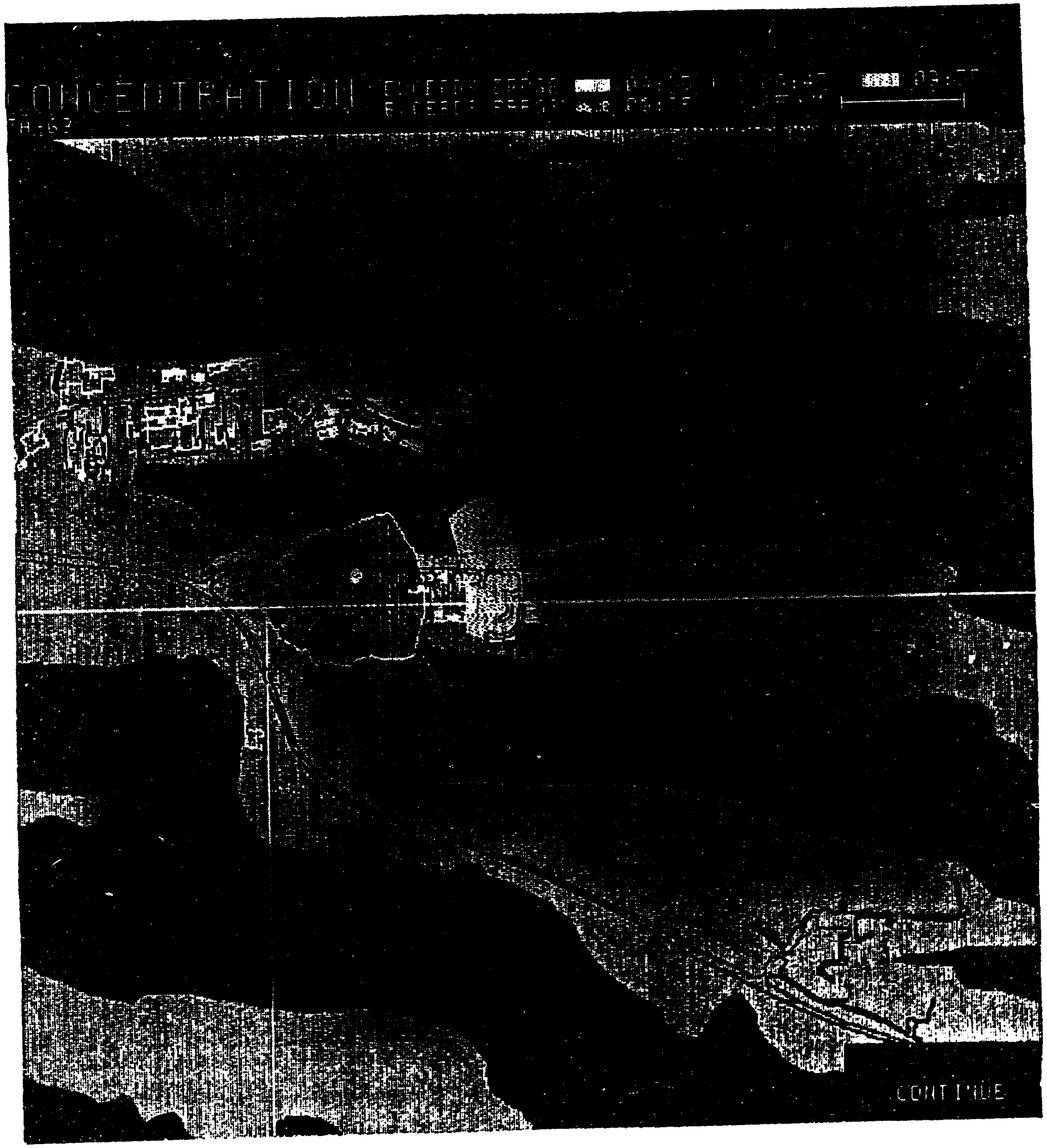


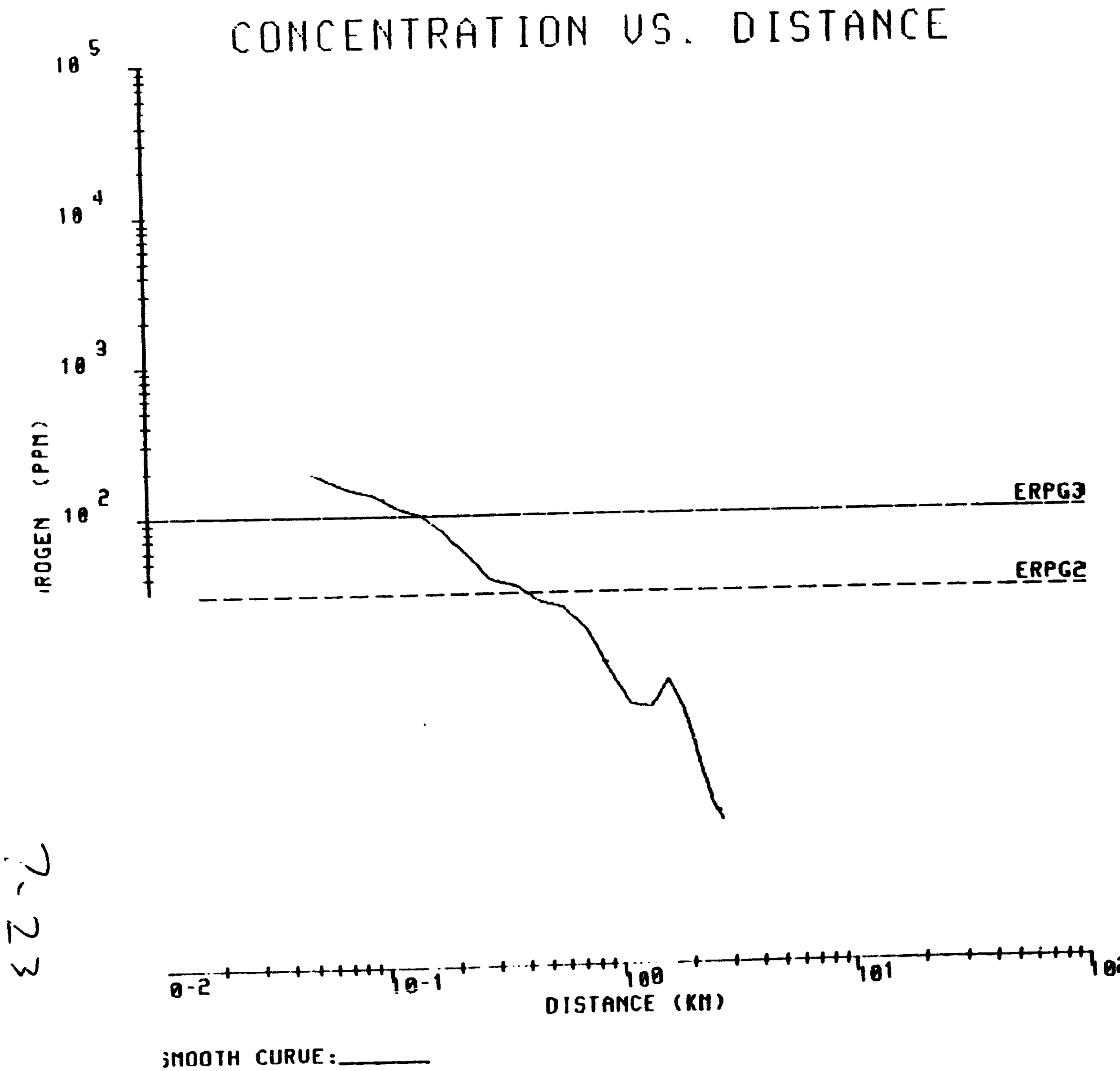
Fig. 7-22. Hydrogen sulfide 10-min snapshot with 10-min averaging and stability f.

Chemical: **Hydrogen Sulfide (H_2S)**
Quantity: **22.37 KG**

Averaging Time: **10 Min.**
Stability Class: **F**

Wind Speed @ 10m: **0.875 m/s**
Wind Direction(From): West
Temperature: 15C
Release Height: 10m
ERPG-3: 100ppm
ERPG-2: 30ppm

DIST. (KM)	SMOOTH (PPM)
.06	1.8E+02
.10	1.2E+02
.30	3.4E+01
.60	1.8E+01
1.00	5.9E+00
3.00	8.6E-01
6.00	4.9E-01
10.00	3.3E-01
30.00	1.4E-01
60.00	7.9E-02



7-23

Fig. 7-23. Hydrogen sulfide concentration vs distance plot with 10-min averaging and stability f.

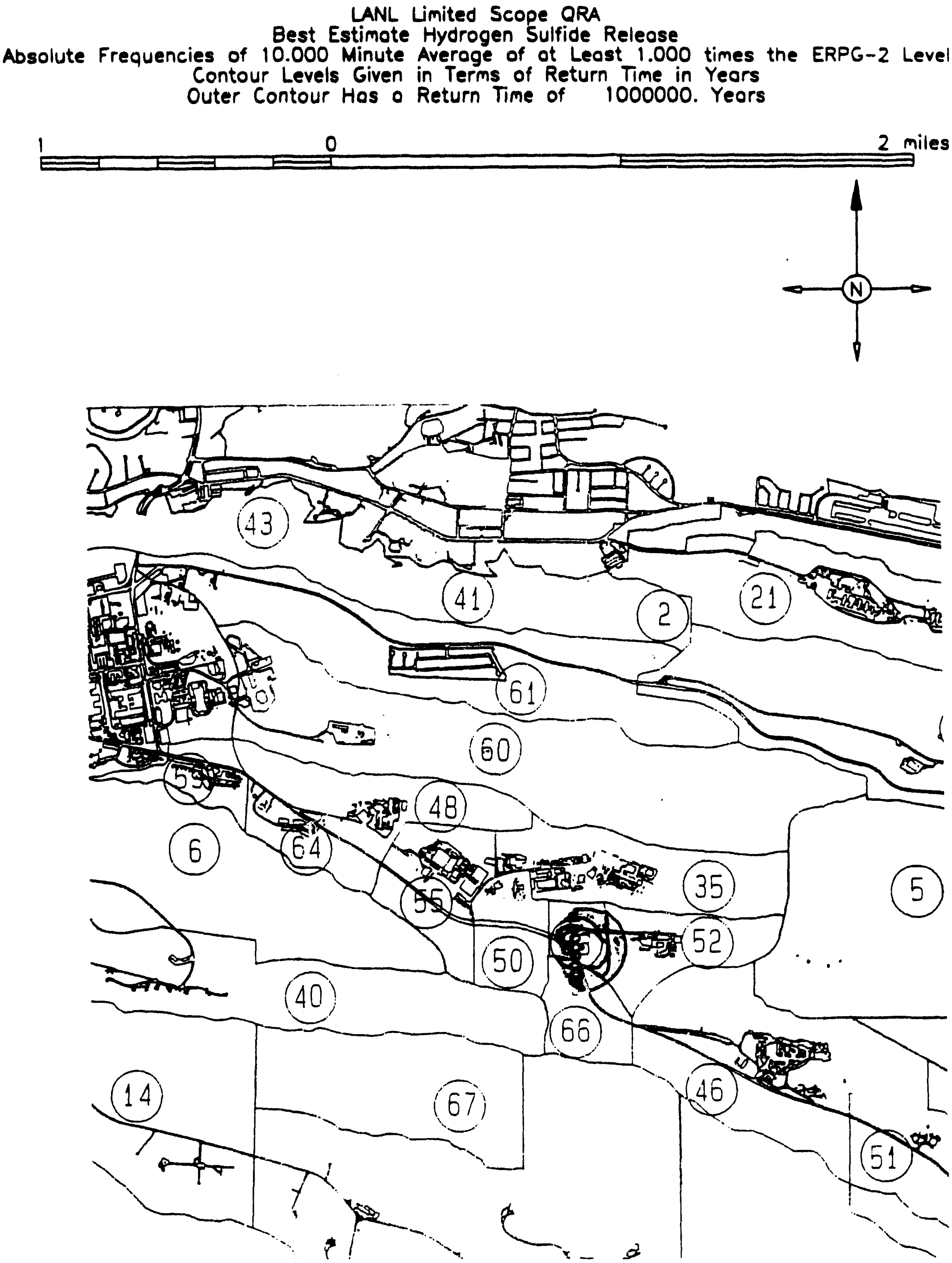


Fig. 7-24. Hydrogen sulfide QCRR risk contours, ERPG-2, 10-min averaging.

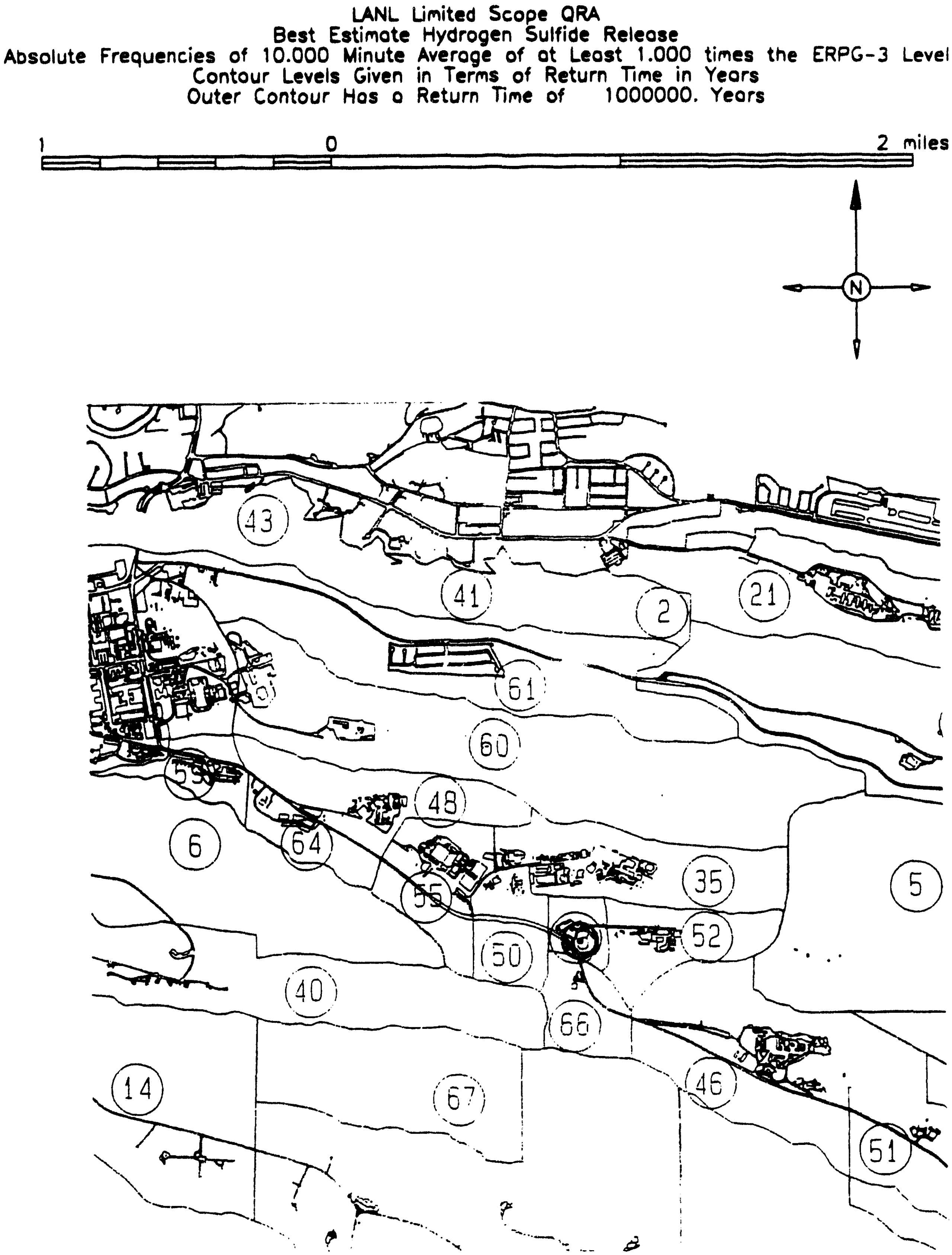


Fig. 7-25. Hydrogen sulfide QCRR risk contours, ERPG-3, 10-min averaging.

8.0. CONCLUSIONS

The results of the PHA were used to define a limited scope of analysis for this PRA of the HWTF/DSB and MWRSF. The effort required to quantify scenarios that present the greatest potential of severe offsite (i.e., public) consequences was reduced significantly by using the PHA recommendations. Those hazards from the PHA that appear to present the most potential to the public (offsite) are the releases of toxic gases from gas cylinders as a result of seismic or fire events. These two events have the capability of releasing a large percentage of the gas in storage. They also bound other scenarios for release of gas, such as the rupture of a single gas cylinder because of accidental conditions or a degraded cylinder.

The results of the event-tree/fault-tree analysis for the large fire and seismic scenarios showed an overall frequency of release on the order of 3.5E-4/yr. The frequency of the initiating events is based on site data or analysis or industry data for facilities of this type. The dependent-failure probabilities (e.g., building breach given a seismic event, building or container breach given a facility fire) are conservative screening-level estimates. These values were assigned to correspond to an upper bound with respect to the uncertainty of the probabilities. Screening-level estimates typically are used in first-order PRAs to determine the degree of importance of accident scenarios.

Consequence calculations were performed for large release of toxic gases, and the six most toxic gases currently stored and planned to be stored in the new facilities were chosen (hydrogen fluoride, hydrogen sulfide, arsine, phosgene, phosphine, and cyanogen). We reviewed the CST-7 current storage inventory to determine an estimate of maximum release inventories. The maximum inventories were judged not to be overly conservative but are indicative of the upper bound for future storage needs for these gases. It was determined that phosphine and cyanogen will be present only in small quantities and thus are not considered to affect the risk of storage. Moreover, ERPG values are not available for these chemicals.

The consequence dispersion analysis was performed using two codes, MIDAS and QCRR. MIDAS was used to predict release paths from postulated accidents. For each chemical, a wind speed of 0.875 m/s and atmospheric stability of class F with 10-min averaging was studied. This represents the worst-case scenario associated with release of the entire toxic gas inventory. The QCRR code was used to calculate a risk contour for each gas release. The results indicate a very short segment of Pajarito Road for which the ERPG levels could be exceeded on a frequency of 1.0E-6/yr. It is important to note that individuals would be required to be exposed to these levels for an hour or more to incur the expected health effect. Additional analysis indicates that individuals traveling this segment of road would traverse the distance in a matter of minutes; therefore, a significant health effect would not be expected.

In addition, DOE and Los Alamos have concluded that Pajarito Road is not considered to be public domain for safety analysis purposes because this highway is

DOE property and under its jurisdiction and therefore can be closed at any time necessary. The mobile home park on the East Jemez Road, 1.5 km from TA-63, is considered to be the closest public offsite property for dose calculation purposes. Persons at that location would be more likely to remain in one location for an hour or more than persons traveling down Pajarito Road. The dispersion analysis indicates the chance of an effect at the mobile home park from a release at TA-63, is well below the 1.0E-6/yr value normally considered as a credible cut-off for safety analysis purposes.

In summary, the PRA indicates that there are a number of hazard scenarios that may affect the worker or have a localized effect to adjacent facilities. Although the analysis does not support any severe offsite public consequences of a credible frequency (1.0E-6/yr), there could be some short-duration exposure to persons traveling the roadway adjacent to TA-63 at a frequency of approximately 1.0E-6/yr. For this reason the facility should ensure a well-developed emergency response capability that is clearly written, reviewed with Los Alamos emergency planning specialists, and practiced during training exercises.

REFERENCES

1. "Guidelines for Hazard Evaluation Procedures," Second Edition with Worked Examples, AIChE, 1992.

2. F. A. Lercari, "Guidance for the Preparation of a Risk Management and Prevention Program," State of California, Office of Emergency Services unnumbered report (November 1989).

3. OSHA "Process Safety Management (PSM) of Highly Hazardous Chemicals," 29 CFR 1910.119.

APPENDIX A
MIDAS DESCRIPTION

MIDAS

MIDAS (the Meteorological Information and Dispersion Assessment System) is a fully integrated software package from Pickard Lowe and Garrick (PLG), designed to assess the environmental and health effects of both routine and accident-related atmospheric releases of hazardous materials. MIDAS enables its users to determine, in real time, the potential effect of actual hazardous material releases, create what-if scenarios to evaluate emergency plans, and train response teams using actual site conditions. During a real or postulated release, MIDAS can quickly answer questions such as the following.

- What are the weather conditions?
- Where is the plume of dispersion material expected to go?
- How is the release rate expected to vary with time?
- Where will the exposures exceed hazardous levels?

Features

MIDAS continuously samples, processes, and stores data from one or more meteorological towers and on-line monitors at and around a site. Using this information, along with other preset characteristics, MIDAS computes release rates to the atmosphere. Current and projected locations where hazardous levels may be exceeded then are quickly displayed on site maps using high-resolution color graphics technology.

User Interface

Simple menus and unique touch-screen features give users access to commands for directing system functions. The MIDAS design enables new users to perform routine calculations with minimum training and instructions while allowing more sophisticated operators to set up and inspect data bases, perform offsite effect calculations, and review results via local or remote terminals.

Because no two applications are alike, built-in edits allow MIDAS users to enter plant-/site-specific information during planning sessions.

Hardware/Software Options

The MIDAS modular design enables easy adaptability to meet the specific needs of a wide variety of users. Whether installed as a full-capability central-system or as a hands-off PC version providing continuous, automatic monitoring, MIDAS can be supplied on existing hardware or as a complete hardware/software package. The system is available in basic configurations.

- The central-system MIDAS is tailored around a shared host computer. Multiple sites can be networked, and calculations can be made at a single processing point.
- The MIDAS workstation incorporates all of the essential functions of MIDAS operating on a high-speed, stand-alone microprocessor or workstation.
- The low-cost PC-MIDAS system provides continuous data collection, real-time plume location, and high-resolution color map displays that are updated every 5 min. PC-MIDAS also is used in the central system MIDAS configuration with the host computer.

Experience

PLG is the leader in providing computer support for emergency response planning and decision-making. The company began MIDAS development in 1973. Since that time, PLG has continued to enhance the system, relying in large part on extensive user feedback. Today MIDAS users benefit from PLG staff services that include training, on-line assistance, software modification, meteorological services, and other ongoing support.

APPENDIX B
QCRR DESCRIPTION

QCRR

QCRR, Quantification of Chemical Release Risk, is a personal computer program for calculating the source evaporation and dispersion of single- and multi-component gases. The QCRR program is available for IBM-PC compatibles and is a subset of PLG's CHEMRISKMAN software package. QCRR is available as a stand-alone package as described below.

Overview

PLG developed the QCRR system of analytical models to determine the risk consequences of releases of chemicals into the atmosphere. QCRR operates in a IBM 80386 or better PC environment and QCRR performs the following functions.

- Determines the release rates of chemicals into the atmosphere.
- Enables input of a user-determined time history of release.
- Develops aerosols from flashing releases.
- Defines dense gas blankets.
- Evaluates dispersion of neutrally buoyant gases, as well as dense gases and aerosols
- Computes plume rise for jets and buoyant vapor releases.
- Treats dispersion of elevated releases.
- Develops building wake and initial plume radius.
- Handles both pure chemicals and mixtures of up to 20 chemical components.

Numerical Results

QCRR can provide the following numerical information in printed format.

- Input data echo
- Chemical properties
- Time history of liquid pool evaporation
- Time history of dense vapor blanket inflow, outflow, and mass

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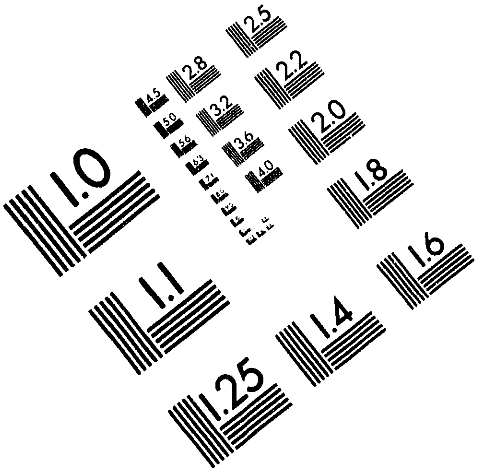

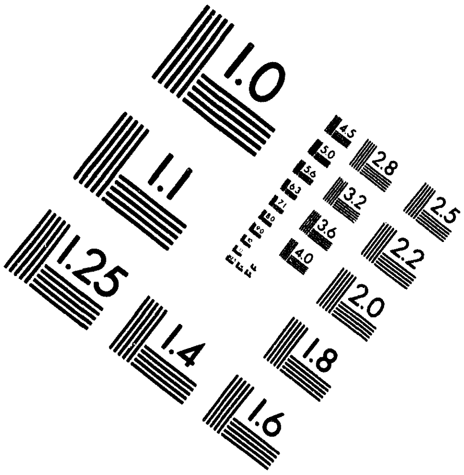

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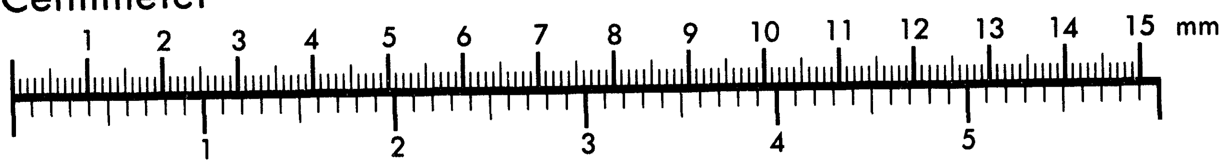

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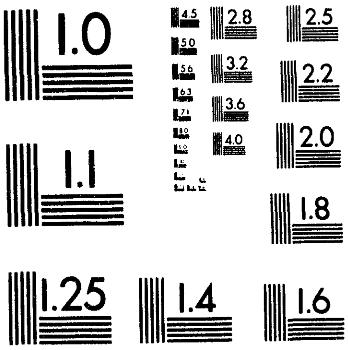

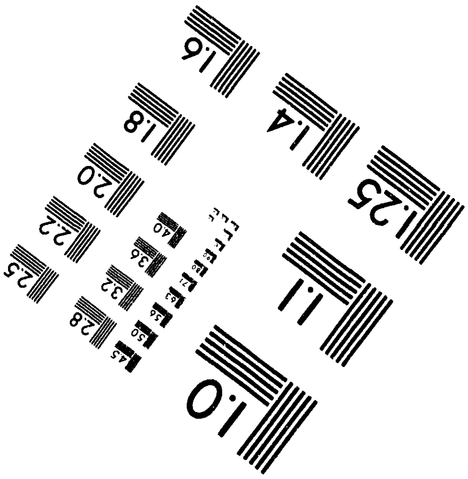

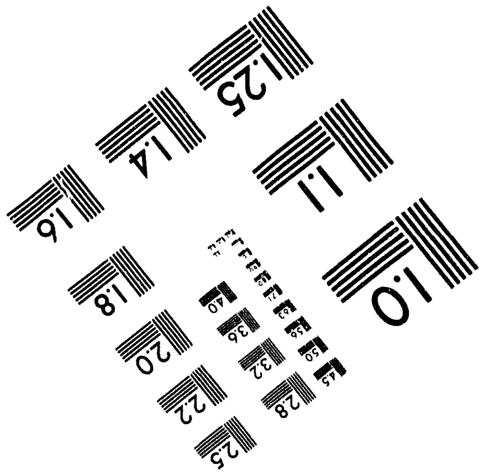

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2 of 5

- Vertical concentration profiles in the vapor blanket
- Time history of plume concentration and location
- Concentration as a function of distance at an instant in time (snap shots)
- Maximum average plume concentrations (for any averaging time)
- Analysis of fires and explosions

Graphical Results

QCRR output files may be used to generate the following as a function of distance downwind from the release point.

- Plots of the concentration of any chemical component in the plume or the total concentration
- Plots of the plume temperature
- Plots of the concentration in the downwind, crosswind, or vertical directions
- Contour plots of equal frequency of exceeding a given concentration
- Plots of affected area vs frequency

VOLUME II:

PRELIMINARY HAZARDS ANALYSIS OF PROPOSED CST-7 WASTE TREATMENT AND STORAGE FACILITIES

Hazardous Waste Treatment Facility (HWTF)
Mixed Waste Receiving and Storage Facility (MWRSF)
HWTF Drum Storage Building (DSB)

CONTENTS

Page

LIST OF TABLES

LIST OF FIGURES

Page

PRELIMINARY HAZARDS ANALYSIS (PHA) OF PROPOSED CST-7 WASTE TREATMENT AND STORAGE FACILITIES

SUMMARY

In FY 1993, the Los Alamos National Laboratory Waste Management Group, CST-7 (formerly EM-7), requested the Probabilistic Risk and Hazards Analysis Group, TSA-11 (formerly N-6), to conduct a study of the hazards associated with several CST-7 facilities. Among these facilities are the Hazardous Waste Treatment Facility (HWTF) and the Mixed Waste Receiving and Storage Facility (MWRSF), which are proposed for construction beginning in 1995. These facilities are needed to upgrade the storage capability for hazardous and mixed wastes and to provide treatment capability for wastes in cases for which offsite treatment is not available or desirable. These facilities will assist Los Alamos in complying with Federal and state regulations and agreements.

Both facilities are currently in the conceptual design stage, and therefore, detailed aspects of the facility structures and systems are not fully developed. The materials available to the hazards analysis team were conceptual design reports and design criteria stating the level of the mitigating systems (e.g., ventilation with filtration and scrubbing) without final details or the final configuration. During the course of the study, numerous design changes were made because of either evolving operational or regulatory considerations or the reduction of risks from hazards identified by this study.

A preliminary hazards analysis (PHA) was chosen for the initial assessment. PHA is an appropriate method because it can identify significant hazards during the conceptual design stage, when design changes can be made cost-effectively. This method is endorsed by various Federal agencies, including the U.S. Department of Energy (DOE), the chemical and nuclear industry, and professional organizations. The PHA method is based on techniques outlined in AIChE,[1] the California Risk Management Prevention Program (RMPP),[2] and the Process Safety Management (PSM) rule.[3] A multidisciplinary team of senior technical personnel was assembled to conduct this study; representatives from TSA-11, CST-7, and PLG, a private consulting firm specializing in chemical and nuclear facility risk assessment, composed the team. The personnel included specialists in nuclear and chemical engineering, process chemistry, risk analysis, environmental issues, human reliability, and facility operations.

A more quantitative analysis, such as a probabilistic risk assessment (PRA), consisting of event and/or fault trees, was judged to be inappropriate for the initial stage. However, PHA results provide input for a limited, but focused, quantitative analysis.

Consistent with other PHAs, a risk ranking was assigned to each accident scenario based on estimates of its consequence and likelihood. Scenarios with a risk ranking of 1 or 2 were considered to be unacceptable. In these cases, actions to reduce the risk for the scenario were identified. The team used the HAZMAN software package, which was developed by PLG, to record the results of the analysis

during the numerous meetings to review facility design and operation. The risks associated with each scenario were evaluated with respect to the public, workers, co-located workers, and the environment (contamination).

We identified four Risk Rank 1 scenarios during our study. These scenarios would be considered unacceptable and would require immediate mitigation if the facilities were in an operating status. Forty-nine scenarios were identified as Risk Rank 2; if the facilities were in operational mode, the risk associated with these scenarios would be judged unacceptable. Mitigation of Risk Rank 2 hazards within a reasonable time frame would be recommended. The Risk Rank 1 and 2 scenarios are listed in Table S-1 according to facility and primary activities. In this list, the storage activities are shown to contribute a disproportionate amount to the overall risk of these facilities. Well over half of the Risk Rank 1 and 2 scenarios are attributed to the storage of the hazardous and mixed wastes. This is consistent with a previous limited study* by TSA-6 that looked at the hazards associated with the storage and treatment of LiH reactive wastes and cyanide plating wastes.

The characterization of each Risk Rank 1 and 2 scenario includes an assessment of consequence and frequency and recommendations to reduce the risk. The consequence, frequency, and ranking of each scenario then are reexamined assuming that the recommendations are implemented. It is significant to note that all of the hazards identified can be minimized successfully by the proposed facility modifications and/or administrative controls. Several engineering insights and recommendations should receive special mention because they are common to a number of hazards or provide a means to significantly reduce risks. They are the following.

1. **Storage Presents Significant Risks.** The hazards associated with treatment are significantly less than storage risks because treatment is carried out in specially designed skids in the HWTF. The risks associated with the treatment building are lower because the HWTF treatment building is designed to contain releases with several redundant levels of filters/ scrubbers. In addition, sampling provisions in the HWTF verify the identity of wastes before treatment, lessening the chances of mislabeling.

2. **Storage of Incompatible Materials Increases Risks.** The risks associated with storage are greater because of the large numbers of various materials in storage, many of which are incompatible. The materials are not independently assayed or sampled before storage, resulting in increased chances for mislabeling.

3. **Storage of Materials in Adverse Weather Conditions Increases Risks.** The Drum Storage Building (DSB) appears to present particular hazards. The DSB is an open building that can be expected to experience problems from weather extremes. Temperature extremes (freezing or heat), high winds, and other environmental conditions have the potential to result in

*Probabilistic Safety Assessment for TA-63, Hazardous Waste Treatment Facility, M. K. Sasser to G. Lussiez, September 29, 1992.

material releases. Because of these weather-related problems, it is recommended that CST-7 consider enclosing the DSB and providing heating and ventilation (HVAC).

Although the additional installation of filters and scrubbers also could help mitigate large releases resulting from accident conditions within the DSB, it is felt that most risk reduction would be achieved by enclosing and heating the facility. Larger releases are expected on a much less frequent basis. In addition, the types of accidents that would result in these large releases (fires, seismic events) also could be expected to breach the facility, which may, in effect, render any filters/scrubbers ineffective because of the existence of direct release paths.

4. **Storage of Shock-Sensitive Materials Increases Risks.** Several chemicals were noted that, if stored in these facilities, would represent significantly higher risks. These materials may be shock or heat sensitive or particularly incompatible with other chemicals. The materials include picric acid, sodium azide, nitromethane, and methyl ethyl ketone peroxide. The resulting hazard is the high potential for an explosion, energetic reactions, or a fire. There appeared to be conflicting views from the several CST-7 specialists interviewed by the PHA team as to the likelihood of future generation of these materials at the Lab and/or the need to store them. However, these materials were included on lists of chemicals generated and/or stored at the Lab in the past.

   The PHA team felt that a specific, restrictive policy should be developed in advance so that CST-7 can deal with these materials properly should there be a request to process such materials. Because of the significant, widespread hazards that these materials represent either alone (from shock, heat, or friction) or in combination with other chemicals, they should not be stored in either facility. If they are required to be handled or stored, then special facilities, compartments, or measures should be in place to place them in remote locations away from incompatible materials. The risks of an explosion or fire that could propagate to surrounding storage compartments or to the entire facility are too great to allow storage of these types of materials without taking special precautions.

5. **Potential for Misrouting of Waste Solutions Increases Risks.** An important design change (inclusion of check valves) was recommended in the cyanide-plating treatment skid in the HWTF. In reviewing the latest design drawings and flow paths of the skid, the team found that misrouting of the waste solution or reagents could result in the generation of highly toxic gases (e.g., HCN) that would threaten the worker. There did not appear to be any check valves in the system to prevent backflow or flow to wrong locations. (Check valves are an effective means of preventing the flow of liquids to the wrong locations.) Without an engineering

method to prevent such misroutings, the process is left entirely to the effectiveness of operators to verify the proper flow path. Human reliability analyses indicate a high frequency of human errors in system valving alignments in similar situations.

6. **Gas Cylinders of Unknown Content or Questionable Integrity Present Significant Risks.** A number of compressed gas cylinders are now stored in an open field at TA-54. Many of these are legacy wastes (generated from past operations), and they may contain unidentified gases or be contained in cylinders of questionable integrity or conformance to standards. Additional high-risk gas cylinders are expected to be identified during the course of future operations and environmental restoration activities. These cylinders represent a substantial hazard during transportation, storage, and treatment. Special precautions are recommended for cylinders containing the most highly toxic gases (e.g., phosgene, phosphine, arsine, etc.) or those that contain unidentified gases. Some of the recommended precautions are as follows.

   a. Double containment of the most highly toxic gases before they are moved and stored.
   b. Special precautions at loading sites; e.g., installation/use of windsocks, training of operators on proper evacuation techniques, availability of self-contained breathing apparatus, etc.
   c. Special transportation restrictions for the most highly toxic or unidentified gases; e.g., escort vehicle, road closure, etc.
   d. Special storage restrictions (e.g., do not store legacy wastes in these buildings) and special enclosed storage compartments for nonlegacy cylinders. At the time of this study, the CST-7 staff were uncertain whether gas cylinders would be stored in the new facilities. The PHA team decided to review the storage facilities as if gas cylinders would be stored in the facility.

7. **Risk Associated with Existing Storage Facilities is a Concern.** Even with improved safety features included in the design of the new facilities, approximately 75% of all high-risk scenarios (Risk Ranks 1 and 2) are attributed to waste storage. The existing storage facilities do not include the latest safety features; therefore, we inferred that the present risk of storage is considerably higher than the anticipated risk associated with the facilities to be built. Figure S-1 shows an estimate of the relative risk, given the current storage capability and progressing to the completion and operation of the new facilities. Until such time that the HWTF and MWRSF are opened, the relative risk associated with storage as it now exists will rise steadily. The relative risk will decrease after the storage facilities are created and the legacy wastes are transferred to the new facilities. Treatment of wastes will reduce the relative risk further.

This document provides a basis for demonstrating compliance with the hazard analysis requirements of DOE Order 5480.23, Topic 5; DOE Standard 1027-92; and DOE Standard 3009. It is anticipated that representative sequences from the PHA will be selected for additional quantitative analysis of their frequency and severity to satisfy the accident analysis requirements of DOE Order 5480.23, Topic 11, necessary for inclusion in a Safety Analysis Report (SAR).

TABLE S-1
SUMMARY OF RESULTS BY FACILITY OR ACTIVITY

Facility or Activity	Number of Risk Rank 1 Scenarios	Number of Risk Rank 2 Scenarios
Storage		
Mixed Waste Storage	1 (25%)	11 (22%)
Hazardous Waste Storage	2 (50%)	22 (45%)
Mixed Waste Bulking	—	2 (4%)
Subtotal	**3 (75%)**	**35 (71%)**
Treatment (HWTF)	1 (25%)	9 (18%)
Transportation*	—	5 (10%)

*Includes transportation outside facilities; e.g., between storage and treatment buildings, or from other locations to TA-63.

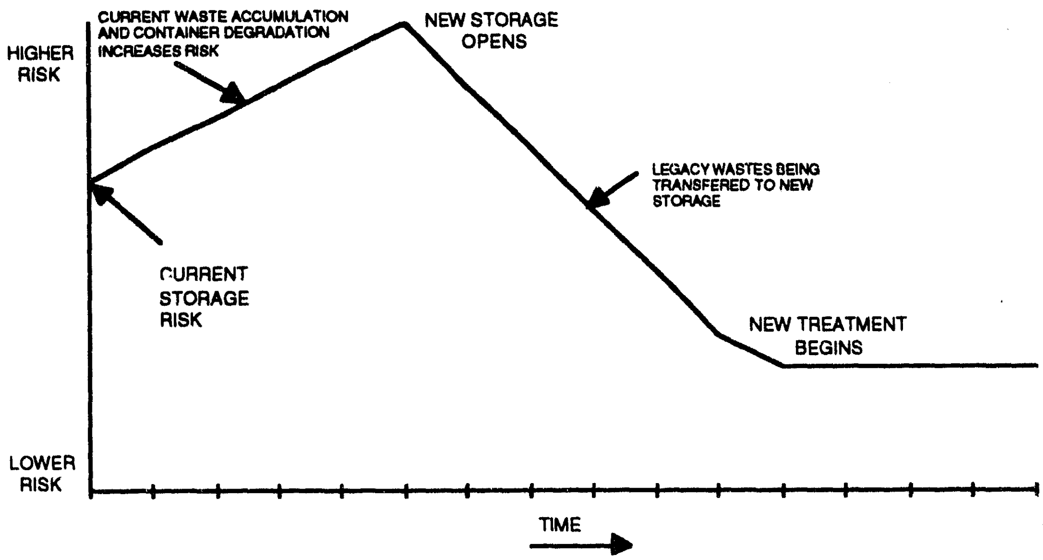

Fig. S-1. Relative risk associated with storage and treatment.

1.0. INTRODUCTION AND PURPOSE

Routine operations and research activities at the Los Alamos National Laboratory generate a variety of radioactive, hazardous, and mixed wastes. By definition, mixed waste contains both a hazardous chemical component and radioactive materials. The types and quantities of wastes generated have varied greatly during the more than 50 yr of Laboratory operations. Los Alamos currently has an aggressive program to minimize new waste generation, thereby reducing the capacity needs for storage. However, significant amounts of existing (or legacy) wastes remain that must be processed and stored appropriately.

Options for treating Laboratory-generated wastes are limited. Some hazardous wastes can be shipped offsite to approved commercial facilities for treatment. For other hazardous wastes and all mixed wastes, no offsite treatment methods are available; Federal and state regulations are restrictive in terms of the storage and treatment of these remaining wastes. Therefore, Los Alamos is evaluating a number of options for treatment and storage of hazardous and mixed wastes to develop a suitable plan that ensures compliance with all Federal and state regulations.

Los Alamos Group CST-7, Waste Management, is responsible for all aspects of waste management at the Laboratory: characterization, storage, offsite shipment, and any onsite treatment. A new technical area, TA-63, is planned as the site for several new facilities to be constructed beginning in FY 1995 or later. These facilities are important to future Laboratory operations to ensure Los Alamos' compliance with regulations regarding the treatment and storage of hazardous and mixed wastes. The primary facilities proposed for TA-63 are the Hazardous Waste Treatment Facility (HWTF) and the Mixed Waste Receiving and Storage Facility (MWRSF). The HWTF will consist of two buildings: (1) a treatment building that is capable of treating both mixed and hazardous wastes and (2) a Drum Storage Building (DSB) for hazardous wastes only. The MWRSF will receive and store mixed wastes; some rebulking or repackaging operations will be performed. Both facilities are currently in the conceptual design stage; a final design has not been accepted, and approval for construction has yet to be granted. It is understood that the designs of the facilities have evolved during the preliminary hazards analysis (PHA) and will continue to change after this study is completed. Any significant design modifications implemented after the PHA is completed should be considered from a hazard standpoint; thus, the PHA should be updated.

The Probabilistic Risk and Hazards Analysis Group (TSA-11) was requested to analyze the various potential hazards associated with these facilities. If a hazards analysis is performed during the conceptual design stage, facility improvements and design changes can be implemented without costly expenditures.

Preliminary Hazards Analysis (PHA) was chosen as the method to use for hazards analysis. PHA is a semiquantitative method for identifying the broad range of potential hazards and accident scenarios, with corresponding estimated frequency and consequences. Because hazards are ranked by qualitative risk measures, PHA allows hazard scenarios to be screened and those that are the least concern to overall risk (either because of low associated consequences or low frequency of occurrence) to be eliminated. The remaining high-risk hazard scenarios can be analyzed further using quantitative techniques; however, this is outside the scope of the current study. Detailed quantitative analyses, in addition to requiring a large expenditure of resources (dollars and time), require a detailed design of the facility with all of the supporting components and systems. PHA is a cost-effective alternative.

The purpose of this PHA is to provide an overall assessment of hazards associated with the HWTF and MWRSF. Because these facilities are currently in the conceptual design stage, such a study is useful to determine if there are hazardous operations or activities that require engineering design changes. This study also is intended to be used as input to CST-7 safety and project documentation. Furthermore, this document will demonstrate that these facilities are in compliance with the hazard analysis requirements of DOE Order 5480.23, Topic 5, DOE Standard 1027-92, and DOE Standard 3009.

The scope of the PHA with respect to hazardous and mixed waste treatment and storage is described in Sec. 2. The PHA methodology used in this study is presented in Sec. 3, and the results of the PHA are discussed in Sec. 4. Section 5 presents insights and recommendations, and Sec. 6 lists the references used in the PHA. Appendices A through C provide a facility description, design changes made during the PHA, and the results of the PHA for the HWTF (treatment only), the MWRSF, and the HWTF DSB. Appendix D presents the overall results of the CST-7 PHA. Appendix E includes the resumes of the PHA team members.

2.0. PHA SCOPE

2.1. Facilities

This PHA includes analyses of hazards associated with the HWTF, the HWTF DSB, and the MWRSF. The analyzed activities are for both hazardous and mixed wastes and can be classified into the following areas: (1) transportation within the TA-63 complex, (2) storage of the waste containers after arrival at TA-63, (3) rebulking or repackaging of some wastes, and (4) processing or treatment.

2.2. Acutely Hazardous Materials

2.2.1. Storage. The range of waste materials that may be stored in the facilities was reviewed to provide an understanding of their degree of flammability, toxicity, and incompatibility with other wastes. The technical staff from CST-7 completed an exhaustive search for information related to the properties of the materials considered for possible storage in the facilities. The CST-7 search included all those materials that have been generated, stored, and/or treated at Los Alamos in the past. A detailed account of this work is provided in Ref. 4.

Tables 2-1 and 2-2 are abbreviated versions of the hazardous and mixed wastes tables from the CST-7 study. These tables list only those materials in each category considered to be most hazardous from the aspects of flammability, reactivity, or toxicity.

2.2.2. Treatment. A number of treatment skids are available or under development to treat hazardous and/or mixed wastes at the HWTF. (The recently approved Federal Facilities Compliance Agreement (FFCA) requires schedules for developing treatment techniques.) After reviewing the list of available and planned skids, the PHA team chose four for analysis. These were chosen based on their potential for significant hazards because of reactivity, flammability, or the possibility for generating toxic materials.

Four waste treatment skids were analyzed.

- Water Reactives, e.g., Lithium Hydride
- Depleted Uranium Chips
- Chemical (e.g., Cyanide) Plating Wastes
- Gas Cylinder Disposal and Recontainerization

Brief descriptions of the treatment skids and the HWTF are presented in the following sections. A more detailed description of the HWTF can be found in App. A.

The complete PHA results for the HWTF treatment skids also are included in App. A.

2.3. General Description of the Facilities

2.3.1. Hazardous Waste Treatment Facility. The HWTF will be located at TA-63, north of Pajarito Road. It will be composed of a DSB, a treatment building, and an office building. The treatment building will have a treatment room for each of four kinds of waste: nonradioactive characteristic wastes, nonradioactive listed wastes, radioactive characteristic wastes, and radioactive listed wastes. These separate treatment rooms will help workers to avoid mixing waste types and prevent cross-contamination.

Processing equipment will be mounted on a skid dedicated to one waste type; the skid then can be moved in and out of a dedicated treatment area. This approach increases flexibility in treatment methods because new skids can be built for new waste types. Several features will help to mitigate or eliminate hazards associated with spills or other unplanned releases.

- Each treatment skid has its own high-efficiency particulate air (HEPA) filtration/scrubber system.
- Individual spill-containing trays are used for each skid.
- Mobile hoods are used and are connected to the exhaust air treatment systems.
- Building surfaces are coated with acid-resistant material.
- Ventilation air is treated (HEPA/scrubbed) before release up the stack.

The currently planned DSB is an enclosed building with heating and air scrubbing filtration. Eight or more individual storage compartments with 4-ft-high segregating walls are planned. Each storage compartment will have its own sump, which is designed to hold at least 10% of the volume of the materials in storage. A forklift will be used to move materials in and out of storage. More detailed descriptions of the HWTF and DSB, including the complete PHA results, are in Appendices A and C, respectively.

2.3.2. Mixed Waste Receiving and Storage Facility. The MWRSF will be located at TA-63 with the HWTF and will consist of only one building. An enclosed loading dock will allow waste containers to be removed from incoming trucks. The containers then will be transported to the appropriate storage room or compartment using low-impact, walk-behind air pallets. Wastes will be stored in one of eight storage rooms/compartments. Each storage area will be designed with an appropriate fire protection system, depending on the type of waste stored. Individual drainage sumps are to be provided for each location. The heating, ventilating, and air conditioning (HVAC) system in the MWRSF will include HEPA filtration, charcoal filters, and a caustic scrubber.

A separate room will be designed for rebulking or repackaging some types of waste. As this activity is expected to be one of the more dangerous operations, the room will have increased fire protection, exhaust systems (e.g., portable hoods), monitoring, supplied air for respirators, and other safety features.

The facility will include all other service areas necessary for it to be independent: change rooms, decontamination rooms, a mechanical/electrical room, and office areas. A more detailed description of the MWRSF, along with a complete listing of the PHA results for the MWRSF, is presented in App. B.

2.4. General Description of the Processes/Activities

2.4.1. Storage. As described above, hazardous waste containers will be stored in the DSB. A forklift will be used to move the storage containers within the facility to and from storage locations. The MWRSF will store mixed waste containers only and will not have any treatment capability. The MWRSF is an enclosed facility and will use bridge cranes and small walk-behind air pallets for moving waste containers.

The currently planned storage classification system is based on the Environmental Protection Agency (EPA) regulations in 40 CFR 264, Storage of Incompatible Wastes. This classification system has been determined to be the most appropriate way to segregate the various types of waste materials, reducing the hazards associated with mixing of incompatibles. The classification system currently in use at the existing TA-54 storage complex is based on DOT shipping regulations. The DOT system was compared with the EPA system by CST-7 technical staff and found to be somewhat deficient in terms of segregating various waste types. The waste classification areas to be provided in both the HWTF and MWRSF are as follows.

- Group 1A: Caustics
- Group 1B: Acids
- Group 2A: Reactives (Metals, Metal Hydrides)
- Group 4A: Flammables
- Group 5A: Cyanides, Sulfides
- Group 6A: Oxidizers
- Group 7A: Compressed Gases
- Group 8: Polychlorinated Biphenyls (PCBs)
- Group 9: Unregulated

2.4.2. Treatment

2.4.2.1. Water Reactives. Relatively small quantities of water-reactive wastes are generated at Los Alamos. The most common is lithium hydride (LiH) mixed with depleted uranium, the total inventory of which is in the range of several thousand pounds. Lithium hydride is stored in a variety of forms; the most abundant form consists of chunky to powdery LiH contaminated with pieces of depleted uranium. Other drums contain clean-up items: paper, rags, used parts, and some LiH. Another form of LiH is produced during machining of LiH and is a sand-like powder.

These wastes react exothermically with moisture and violently with water, producing hydrogen, a flammable and explosive gas. The treatment consists of controlled hydration in a humid atmosphere. The product of hydration is a caustic hydroxide that requires neutralization because of its corrosivity. Any depleted uranium left after treatment of the LiH may be treated using the depleted uranium treatment process.

2.4.2.2. Depleted Uranium Chips. Depleted uranium chips from machining operations are stored in drums with a cover of oil. The treatment process consists of draining the oil from the chips in an inert atmosphere of nitrogen and then adding bleach to oxidize the depleted uranium in a controlled manner. The resulting uranium hydroxide slurry is reduced to a uranium dioxide sediment by adding sodium thiosulfate. The sediment then is cemented and transferred to storage until final disposition.

2.4.2.3. Plating Wastes (Cyanides). Electroplating baths with various compositions are used at the Laboratory. The resulting plating wastes may contain the following material.

- Acids such as $HC\ell$, HNO_3, and H_2SO_4.
- Metals remaining in the bath after electroplating, up to 100 g/L, including nickel, copper, chromium, and, in some cases, depleted uranium.
- Ammonia and metal cyanides in nonacidic or low acidic baths, with concentrations up to 30 g/L and 80 g/L, respectively.

Radioactive plating baths are generated at the rate of two to three 55-gal. drums every 2 to 3 yr, whereas nonradioactive plating wastes are generated at a substantially higher rate (10 to 20 drums per year).

The best-developed available technology (BDAT) for treating these wastes involves a number of steps during which various reagents are introduced as needed.

- Neutralization of acids, if any, with a base; e.g., sodium hydroxide.
- Oxidation of the cyanides (and ammonia) to produce innocuous gases. The most common oxidizing agent is sodium hypochlorite (bleach), with the resulting formation of CO_2 and N_2.
- Reduction of the hexavalent chromium to the trivalent state using sulfites.
- Precipitation of metals with a base to precipitate hydroxides or with H_2S to precipitate metal sulfides.

2.4.2.4. Gas Cylinder Disposal and Recontainerization. Currently, there are a number of gas cylinders (legacy and nonlegacy) stored in an open area. The range of possible contents varies from inert gases (e.g., N_2 and welding cover gases) to highly toxic (e.g., phosgene and arsine). Most cylinders are fully characterized or identified, but approximately 10% contain unknown gases.

The recontainerization skid involves transferring a cylinder to the skid, where it is enclosed in a pressure vessel with an inert or evacuated atmosphere. The cylinder then is purposely breached so the contents are released into the containment vessel, where the gas is sampled and analyzed. The identification of the gas determines its disposition. Inert gas may be vented to the atmosphere. If the gas is radioactive, it will be recontainered in a new cylinder for storage and disposition as mixed waste. Hazardous gases may be recontainered for future treatment offsite or onsite. There is a possibility that a future design modification may include some potential for treatment of gases to minimize wastes and reduce costs.

TABLE 2-1
HAZARDOUS WASTES

Chemical Name	MSDS	Incompatibilities: Light Heat	H2O Moist	Acids	Bases	Oxides	Reduce	Flammability: Flash Point	CERCLA	NFPA	Reactivity: CERCLA	NFPA	HW Storage Class
sodium azide	2			Y					1	1	3	3	1A
sodium hydroxide	2		Y	Y					0	0	1	1	1A
arsenic pentoxide	2			Y		Y			0	0	0	0	1A
arsenic trioxide	1,2	Y	Y	Y		Y			0	0	0	0	1A
arsenic metal	2			Y		Y			0	0	0	0	1A
sulfuric acid			Y		Y				0	0	2	2	1B
hydrofluoric acid	2	Y	Y		Y	Y			0	0	1	0	1B
hydrochloric acid	1		Y		Y	Y				0		0	1B
carbon tetrachloride	1				Y	Y				0		0	1B
arsenic acid	2								0	0	0	0	1B
1,1,2,2-tetrachloroethylyene wastes	1				Y			250F		0		0	1B
trichlorotrifluorethane	1	Y			Y								1B
lithium hydride	1		Y	Y		Y				4		2	2A
Barium	2		Y	Y		Y			3	3	2	2	2A
magnesium			Y	Y		Y			3	1	3	3	2A
sodium	1		Y	Y		Y				1		2	2A
Calcium	2		Y	Y		Y			3	1	2	2	2A
Lithium in oil				Y		Y			3	1	1	1	2A
picric acid	2	Y			Y	Y	Y		4	4	4	4	4A
nitromethane	1	Y		Y	Y	Y	Y	95F		3		3	4A
methyl isocyanate	1	Y	Y	Y	Y	Y		20F		3		3	4A
acethalhehyde	2	Y		Y	Y		Y	(-38)F	3	4	2	2	4A
acrylonitrile	1	Y		Y	Y	Y		32F		3		2	4A
Acetonitrile			Y	Y	Y	Y	Y	42F		3		2	4A
hydrazine	2					Y		100F		3		2	4A
furan	2			Y		Y		(-32)F	3	4	1	1	4A
anhydrous ethyl ether	2					Y		(-49)F	3	4	1	1	4A
formaldehyde	2			Y	Y	Y		185F	3	4	0	0	4A
Benzyl Chloride	2	Y	Y			Y		153F	2	2	1	1	4A
Toluene diisocyanate				Y	Y	Y		260F		1		1	4A
2 Pentene	2		Y			Y		(-4F)	3	4	0	0	4A
chlorobenzene analytical solutions	2					Y		82F	3	3	0	0	4A
1,2-dichloroethane	1					Y		56F		3		0	4A
2,4 dichlorophenoxyacetic acid	2					Y			1	1	0	0	4A
dichloromethane	1	Y				Y		no data		1		0	4A
1,1,2,2 tetrachloroethane	2				Y			more 235F	1	1	0	0	4A
pentachlorophenol	2					Y		190 F	0	0	0	0	4A
mercury oxycyanide	2			Y				0		0	3	3	5A
cyanogen bromide	2			Y		Y		0		0	2	2	5A

TABLE 2-1 (CONT)

Gold cyanide stripper	1,2		Y	Y	Y	Y				0	0	0	5A
ammonium perchlorate	1	Y		Y			Y			0		4	6A
methyl ethyl ketone peroxide	CTX	Y					Y	125.6F		2		3	6A
perchloric acid	1		Y	Y	Y		Y			0		3	6A
Hydrogen pyroxide							Y		0	0	3	3	6A
calcium hypochlorite	1			Y			Y			0		2	6A
nitric acid			Y	Y	Y	Y	Y		0	0	0	0	6A
Ammonium Persulfate	1		Y				Y			3		0	6A
Aluminum Nitrate	1,2		Y	Y			Y		0	0	0	1	6A
cyanogen	2	Y	Y	Y		Y			3	4	2	2	7A
phosphine	DPIM					Y				4		1	7A
hydrogen sulfide	2								3	4	0	0	7A
arsine gas cylinders	2	Y	Y			Y			3	3	0	0	7A
carbon disulfide	1,2	Y				Y		(-22F)	3	3	0	0	7A
nitrogen oxide	2						Y		0	0	3	3	7A
Phosgene	2			Y		Y			0	0	1	1	7A
fluorine	DPIM	Y	Y							0		3	7A

TABLE 2-2
MIXED WASTES

Chemical Name	MSDS	Incompatibilities						Flammability			Reactivity			HW Storage Class
		Light Heat	H2O Moist	Acids	Bases	Oxidizers	Reducers	Flash Point	CERCLA	NFPA	CERCLA	NFPA	Persistance	
chromium										3		2		1A
selenium	1			Y		Y				3		0		1A
chromium	2		Y						3	3	0	0	3	1A
chromium	2		Y						3	3	0	0	3	1A
silver	1	Y		Y	Y				3	3	0	0	3	1A
arsenic	3	Y				Y			0	0	0	0	3	1A
lead	5					Y			0	0	0	0	3	1A
mercury	6	Y				Y			0	0	0	0	3	1A
arsenic	1	Y		Y		Y			0	0	0	0	0	1A
lead	5					Y			0	0	0	0	3	1A
mercury	6	Y				Y			0	0	0	0	3	1A
thallium chloride	1	Y				Y			0	0	0	0	3	1A
thioacetamide	1			Y	Y	Y			0	0	0	0	0	1A
thiourea	1			Y		Y			0	0	0	0	0	1A
cadmium	4			Y	Y					0		0		1A
cadmium	4			Y						0		0		1A
vanadium oxide	1								0	0	0	0	3	1A
lead acetate	1			Y	Y				0	0	0	0	3	1A
selenium dioxide	1		Y	Y					0	0	0	0	3	1A
mercury		Y			Y				0	0	0	0	3	1A
lead									0	0	0	0	3	1A
lead									0	0	0	0	3	1A
arsenic oxide	1	Y	Y	Y		Y								1A
thallium oxide	1					Y								1A
hydroxide salts solutions														1A
mercury														1A
nitric acid; hydro sulfuric acid; sulfuric acid; HF, HP3O4; acetic acid	10	Y	Y		Y	Y			3	3	1	0	3	1B
hydrofluoric acid	2	Y	Y		Y	Y			0	0	1	0	0	1B
hydrogen fluoride	1	Y			Y				0	0	1	0	0	1B
phosphoric acid					Y				0	0	1	0	0	1B
acetic acid	1	Y	Y		Y			104F	1	1	0	0	0	1B
hydrosulfuric acid	1													1B
sulfuric acid	1		Y		Y									1B

TABLE 2-2 (CONT)

Chemical Name	MSDS	Incompatibilities						Flammability			Reactivity			HW Storage Class
		Light Heat	H2O Moist	Acids	Bases	Oxidizers	Reducers	Flash Point	CERCLA	NFPA	CERCLA	NFPA	Persistance	
lithium (hydride), potassium & sodium			Y	Y		Y			3	4	2	2	0	2A
lithium hydride	1		Y	Y		Y				4		2		2A
barium	2		Y	Y					3	3	2	2		2A
barium	2		Y	Y					3	3	2	2		2A
barium									3	3	2	2		2A
sodium	1		Y	Y		Y				1		2		2A
sodium	1		Y	Y		Y				1		2		2A
potassium	2			Y		Y			3	1	2	2	0	2A
ethyl ether	1	Y				Y				4		1		4A
formaldehyde	2			Y	Y	Y		185F	3	4	0	0	0	4A
chloromethane	1		Y			Y				4		0		4A
1,2-dichloroethane	1					Y				3		2		4A
hydrazine	1					Y				3		2		4A
1,1,1, trichloroethane; trichloroehtylene; methylene chloride; chlorinated flourocarbons; toluene		Y			Y	Y			3	3	0	1	1	4A
chromium, 1,1,1; trichloroethane; trichloroethylene; methylene chloride; toluene		Y	Y		Y	Y			3	3	0	1	3	4A
tetrahydrofuran	1			Y	Y	Y				3		1		4A
1,1,1 trichloroethane; trichloroethylene; methylene chloride; toluene; f-solv/dioxin	2					Y			3	3	0	1	1	4A
ethyl acetate	1	Y	Y	Y	Y	Y				3		0		4A

TABLE 2-2 (CONT)

Chemical Name	MSDS	Incompatibilities						Flammability			Reactivity			HW Storage Class
		Light Heat	H2O Moist	Acids	Bases	Oxidizers	Reducers	Flash Point	CERCLA	NFPA	CERCLA	NFPA	Persistance	
pyridine waste	2	Y		Y		Y		68F	3	3	0	0	1	4A
methanol	7	Y				Y			3	3	0	0		4A
acetone	7					Y				3		0		4A
xylene	8					Y				3		0		4A
benzene	1		Y			Y				3		0		4A
acetone	7					Y				3		0		4A
toluene	2					Y		40 F	3	3	0	0	1	4A
methyl ethyl ketone peroxide	1	Y		Y	Y		Y			3		0		4A
acetone; methanol; xylene		Y			Y				3	3	0	0		4A
methanol										3		0		4A
xylene										3		0		4A
aniline	1			Y	Y	Y				2		0		4A
creasol	2			Y	Y	Y		178 F		2		0		4A
phenol	1			Y	Y	Y				2		0		4A
formic acid	1		Y		Y	Y				2		0		4A
cyclohexanone	1					Y	Y	116 F		2		0		4A
napthalene	1					Y				2		0		4A
1,1,1 trichloroethane; trichloroethylene		Y			Y	Y				1		1		4A
1,1,1 trichloroethane	1	Y			Y	Y				1		1		4A
1,1,1 trichlorethane; trichloroethylene; methylene chloride; chlorinated fluorocarbons						Y			1	1	0	1	1	4A
1,1,2, trichloroethane	1	Y			Y	Y	Y		1	1	0	0	3	4A
phthalic anhydride	1		Y	Y	Y	Y	Y			1		0		4A
methylene chloride	1					Y			1	1	0	0	1	4A

3.0. PRELIMINARY HAZARDS ANALYSIS METHODOLOGY

3.1. Overview

PHA is a systematic approach for identifying hazards* associated with a process** and assessing qualitatively the risk of those hazards. The methodology is recognized by various Federal agencies, the chemical and nuclear industry, and professional organizations. A PHA is performed to answer three questions.

- What can happen?
- How likely is it?
- What is the damage?

A PHA can be conducted during a number of phases: research and development, conceptual design, initial operations, detailed engineering, or modification of a process. It is preferable to perform a PHA during the early stages of conceptual design and R&D development phase because risk-reduction measures can be implemented cost-effectively.

PHA is a formal, systematic, and in-depth method for assessing the entire set of possible accident scenarios for a given facility. Frequency estimates of occurrence for all scenarios are assessed along with estimates of the damage level. Credit is taken for any existing protective features for reducing the likelihood of occurrence of each accident scenario. Each accident scenario is assigned a "risk rank" based on the estimates of the frequency of occurrence and the damage level. The entire set of accident scenarios then can be sorted by the severity of the risk rank.

Those accident scenarios identified by the PHA to be of relatively high risk can be studied in more detail or be subjected to a quantitative analysis. The results of the PHA can be used to develop or modify guidelines and policies for the process operations.

The reasons for performing a PHA for the proposed CST-7 facilities include the following.

- Can be performed with general process information.
- Permits design review before P&IDs are developed.
- Requires relatively small investments of time and money.

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*A hazard is an inherent physical or chemical characteristic that has the potential for causing harm to people, property, or the environment.
**The term "process" is used here to generically represent a structure, system, or process.

- Provides qualitative ranking of hazardous situations for focusing design development.

The primary concern/limitation of a PHA is the dependence on subjective information because expert experience and judgment are used in significant amounts.

3.2. PHA Preparation

The success of a PHA relies on the composition of the analysis team and the team's access to any data that clarify various aspects of the process being studied. These factors must be considered before the start of a PHA. Each team member must be knowledgeable in some facet of the operations and maintenance of the process being studied. Regular participation in the PHA sessions is necessary to have a successful PHA; thus, availability of key personnel must be considered when choosing team members.

Many questions that arise during the PHA sessions can be resolved by gathering information related to the topic of the PHA. This includes a process description, hazard studies on similar processes, and incident histories and other empirical information. This is supplemented by expert judgment throughout the PHA.

A thorough understanding of basic process information is necessary, and the chemicals involved in any step of the process must be identified. In addition, data are required for appropriate process parameters, such as pressure, temperature, and chemical reactions, given the state of the process. Major equipment, safety-related equipment, and component interfaces must be noted. Knowledge of the operating environments (e.g., earthquakes, winds, flooding, and transportation systems) provides insight into potential hazards and guidance on how to reduce the risk. Existing or draft procedures relating to operation, maintenance, inspection, and emergencies also are required. A facility layout places the process in the context of other processes and the external surroundings. Acquiring the basic process information before beginning the PHA allows the sessions to be very productive.

A recording medium must be established to systematically evaluate hazard scenarios. One PHA team member, the scribe, is assigned the responsibility to record all data associated with each hazard scenario using a defined format. It is most convenient to use a computer program, such as PLG's HAZMAN, to store the information, although a handwritten log is also acceptable. The goal is to create a complete record of the PHA sessions.

3.3. The PHA Review

The principal steps to be followed in performing a PHA are shown in Fig. 3-1. Each step is described below.

- **Identify Processes/Equipment To Be Analyzed and Construct Flow Charts.** The facilities, processes, and equipment analyzed in a PHA are identified based on (1) a review of written descriptions of the facilities and (2) discussions among the PHA team members. Flow charts depicting the relevant processing, handling, and storage steps are prepared and reviewed by the PHA team members. The flow charts are organized into study segments or "activities" to facilitate the hazard analysis process.

- **Examine Each Activity for Possible Hazards and Assess Impacts.** A PHA focuses on identifying accident scenarios by asking the fundamental question "What can go wrong?" For each activity, a predefined set of possible hazards is reviewed for applicability, a sample of which is shown in Fig. 3-2. For example, the question "What if there is a spill?" is considered for each activity where applicable. If the PHA team agrees that the spill does create a problem, then the team assesses the problem in terms of its consequences, causes, and expected frequency of occurrence.

- **Assign Hazard Severity Category, Frequency, and Risk Ranking.** For those accident scenarios deemed by the PHA team to pose a potential problem in terms of consequences, causes, and/or expected frequency of occurrence, a qualitative assessment of risk is performed based on team consensus judgment and using predefined criteria. Specifically, Figs. 3-3 and 3-4 present a summary of the criteria used to select consequence severity ranking and frequency ranking for those hazard scenarios considered to have significant consequence or frequency. Based on these severity and frequency rankings, Fig. 3-5 presents the risk-ranking matrix that is used to assign a qualitative risk measure to each significant accident scenario.

- **Review Risk Rankings and Recommend Possible Mitigation Actions.** The final risk rankings determine which further actions, if any, should be taken to mitigate or eliminate selected scenarios. Referring to the Risk Decision Criteria in Fig. 3-5, we reviewed accident scenarios with a risk ranking of 1 or 2 to identify if immediate or near-term mitigation actions are warranted. Accident scenarios with lower risk rankings also were reviewed, and recommendations were made for possible risk reduction wherever appropriate. As part of the PHA, estimates of the consequence severity, likelihood, and risk can be assigned, given that the recommended actions are implemented.

After all of the accident scenarios are identified, the results are organized into reports. The results can be prioritized by risk, consequence severity, and/or frequency of occurrence. Each ranking parameter provides a unique perspective on how hazards affect the process being studied. These results are the basis for determining if a more detailed, quantitative risk assessment of one or more accident scenarios is required to better assess the risk of possible onsite or offsite consequences associated with selected hazard scenarios.

3.4. CST-7 PHA Preparation

Mr. M. Kent Sasser and Dr. Mohsen Sharirli (Group TSA-6) coordinated collection of all documentation relevant to the process designs/systems reviewed by the PHA in each phase of the hazards assessment. This documentation included process design specifications, equipment drawings and specifications, drawings showing intended locations of equipment, piping and instrument drawings, and process/activity descriptions.

In accordance with the work plan for the CST-7 facilities, the following activities/operations were considered during the course of the PHA reviews.

- Transportation
- Routine Storage
- Treatment Skid Batch Operations
- Sampling/Testing

Activity diagrams for the PHA review were developed from process descriptions and documentation made available to the team members.

3.4.1. CST-7 PHA Team. Detailed resumes for all full-time PHA team members are in App. E. These persons are identified in the schedule for the various phases of the PHA along with part-time participants and observers. Resumes for part-time participants and observers are not provided.

The schedule of attendance for the PHA is given in Table 3-1. For the PHA reviews, the team primarily consisted of a PHA team leader/facilitator, a PHA scribe, one or more Los Alamos staff members from CST-7, and one or more unit process/design engineers who are intimately familiar with the activity or system being reviewed. These persons consulted, as needed, with other members of the Laboratory staff who are responsible for maintenance and operation of various storage and processing facilities. A summary of participant expertise is given in Table 3-2.

3.4.2. Training and Information Gathering. Before the PHA sessions, all full-time team members who had not participated previously in a PHA were given a brief training session on the methodology by the PLG PHA team leader/facilitator. This brief course was designed to introduce course participants to the PHA approach, which forms the basis for evaluating process designs and procedures.

Before the start of the CST-7 PHA, a brief PHA orientation was conducted during the first day of each series of PHA sessions. This orientation training was used to refresh all full-time team members on key steps in the PHA methodology and to confirm ground rules for conducting the study. Topics included the following.

1. Method of conducting the PHA

2. Schedule for the PHA

3. Processes within CST-7 to be evaluated

4. Hazards present in each section of the process, design, and operating conditions

5. Identification and recording of recommendations

6. Assignment of likelihood and severity rankings for consequences so that all significant hazards can be listed in an ordered ranking

7. Resolution of recommended actions

In addition to the PHA methodology presentation, team members participated in a detailed discussion of the activity or system to be reviewed, which resulted in the construction of detailed flow charts depicting individual steps/activities. These flow charts were used to reinforce the team members' familiarity with the process, activity sequences and the location and design of the proposed equipment and facilities.

3.5. The PHA Review for CST-7

The sequence of tasks outlined in Fig. 3-1 was followed by the CST-7 PHA team. HAZMAN, PLG's PC-based hazard analysis code, was used to record the CST-7 PHA sessions.

The data collected for each accident scenario can be reported in several different formats by HAZMAN. The standard activity report produced by HAZMAN contains all scenarios associated with an activity. An example is shown in Fig. 3-6. HAZMAN also allows for the scenarios to be reported by risk ranking, frequency of occurrence, and/or consequence severity. The key attributes of a scenario, which are stored in the HAZMAN database, are the following.

- Activity number, an identifier used for sorting the activities
- Activity name
- Activity description
- R, the risk rank of the scenario as determined using Fig. 3-5
- F, the frequency of the scenario as determined using Fig. 3-4
- C, the consequence of the scenario as determined using Fig. 3-3
- Cause/scenario, the cause of the hazard scenario

- Consequences, the specific consequences of the given scenario, including the severity of the consequences for the public, co-located worker, worker, and environment
- Protective features, mitigation currently available
- Plans/actions, recommendations to reduce the risk of the scenario

TABLE 3-1
PHA ATTENDANCE

Name/ Organization	LANL 8/2	PLG 8/16	LANL 9/27	PLG 10/11	PLG 11/8
Subodh R. Medhekar, PLG	nXXXn	nnXXX	nXXXX	naXXX	nXXXn
Thomas J. Mikschl, PLG	nXXXn	nnXXX	nXXXX	nXXXX	nXXXn
M. Kent Sasser, TSA-6, LANL	nXXXn	nnXXX	nXXaa	nXXXX	nXXXn
Mohsen Sharirli, TSA-6, LANL	nXXXn	nnXXX	nXXXX	nXXXX	nXXan
Guy Lussiez, CST-7, LANL	nXXXn	nnaaa	naaPP	naaaa	naaan
Krystyna Dziewinska, CST-7, LANL	nXXXn	nnaaa	naxxP	naaaa	naaan
Jacek Dziewinski, CST-7, LANL	nXXXn	nnaaa	naxxP	naaaa	naaan
James Stanton, CST-7, LANL	naaaa	nnaaa	naaPa	naaaa	naaan
Tim Sloan, CST-7, LANL	naaaa	nnaaa	naaaP	naaaa	naaan
Corey McDaniel, TSA-6, LANL	naaaa	nnaaa	naaaa	nXXXa	nXXan
John P. Kindinger, PLG	naaaa	nnXXX	naaaa	nXPPP	nXXXn

Notes: P = Part Time
X = Full Time
a = Absent
n = No Meeting

TABLE 3-2
PHA PARTICIPANTS AND SUMMARY OF EXPERTISE

Attendees	Organization	Function/Expertise
Subodh R. Medhekar	PLG	PHA Facilitator
Thomas J. Mikschl	PLG	PHA Recorder
M. Kent Sasser	TSA-6 LANL	LANL Principal Investigator, PHA Participant
Mohsen Sharirli	TSA-6 LANL	PHA Participant
Guy Lussiez	CST-7 LANL	PHA Participant
Krystyna Dziewinska	CST-7 LANL	PHA Participant
Jacek Dziewinski	CST-7 LANL	PHA Participant
James Stanton	CST-7 LANL	PHA Participant
Tim Sloan	CST-7 LANL	PHA Participant
Corey McDaniel	TSA-6 LANL	PHA Participant
John P. Kindinger	PLG	PLG Project Manager, PHA Participant

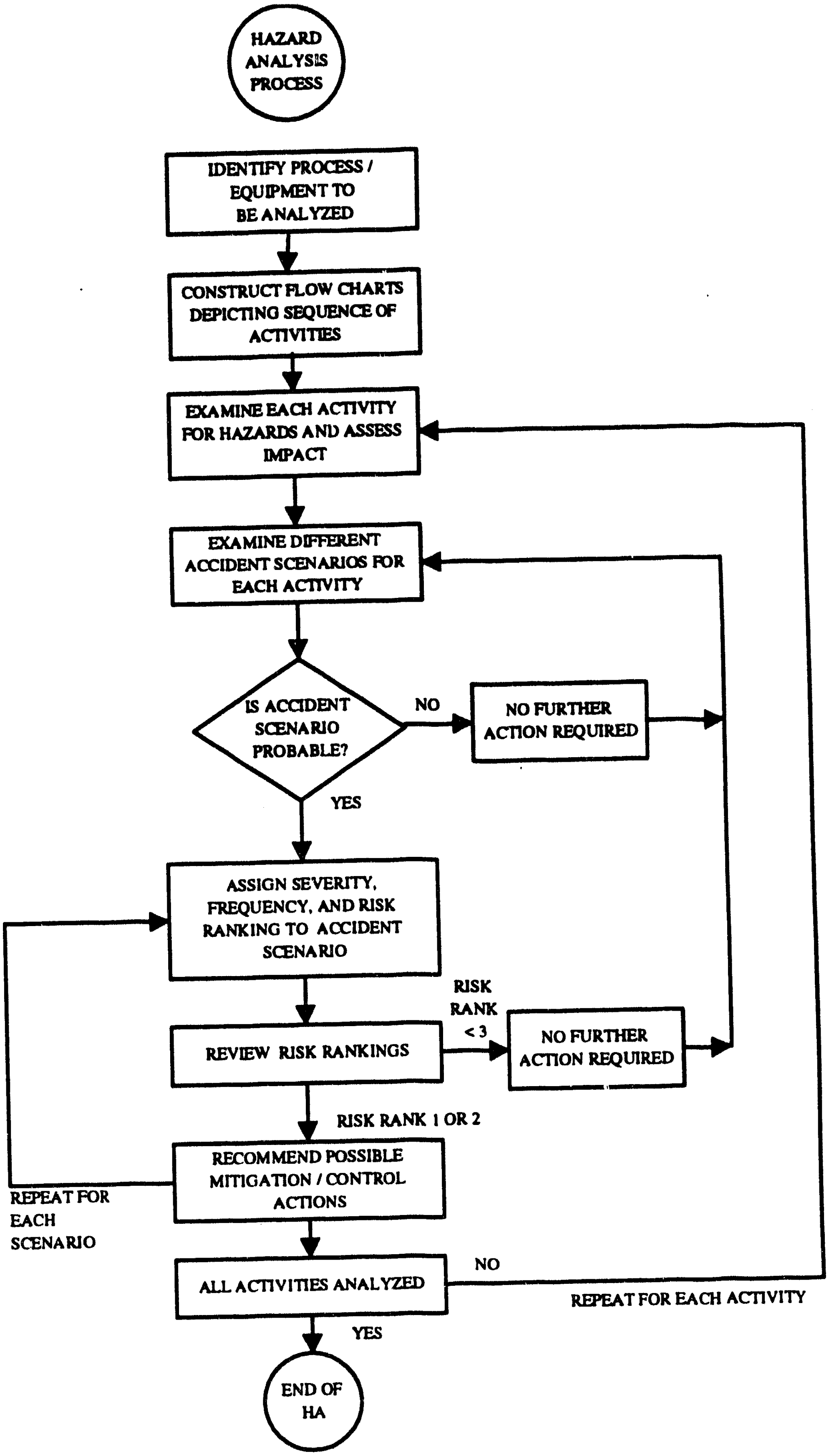

Fig. 3-1. PHA review sequence.

Hazard Sources	Examples
Electric Sources	High-Voltage and Current Sources Transformers Batteries Static Electricity
Motion Sources	Shears, Sharp Edges, Pinch Points, Machinery Vehicles/Forklifts and Trucks Mass in Motion
Gravity-Mass Sources	Falling Falling Objects Lifting Tripping, Slipping Earthquakes
Pressure Sources	Chemical Reactions Noise Confined Gases Extreme Wind
Chemical Sources	Corrosive Materials Flammable Materials Toxic Materials Reactive Materials Carcinogenic Materials Oxygen Deficiency
Heat Sources	Electrical Plasma Torch Natural Gas Friction Spontaneous Combustion
Cold Sources	Cryogenic Materials Ice, Snow, Wind, Rain
Radiant Sources	Radioactive Materials Ionizing Radiation RF Fields Infrared Sources Ultraviolet Plasma Beam Chemical Reactions

Fig. 3-2. Potential hazard sources.

Category	Maximum Possible Consequences			
	Public	Co-Located	Worker	Environment
A	Immediate health effects	Immediate health effects	Loss of life.	Significant offsite contamination.
B	Long-term health effects	Long-term health effects	Severe injury or disability. Radiation > MPBB uptake.	Moderate-to-significant onsite-only contamination and/or minor offsite contamination.
C	Irritation or discomfort but no permanent health effects	Irritation or discomfort but no permanent health effects	Lost-time injury but no disability. Radiation uptake or dose causing temporary radiation worker restriction.	Significant contamination of originating facility/activity, minor onsite contamination. No offsite contamination.
D	No significant offsite effect	No significant offsite effect	Minor or no injury and no disability.	Minor or no contamination of originating facility/activity; no onsite contamination. No offsite contamination.

Notes:

Offsite: Public, private, or Indian lands that are not a part of Laboratory property.

Onsite: Laboratory property but not necessarily the originating technical area.

Facility: Originating technical area of the Laboratory.

Temporary Radiation Worker Restriction: Restrictive work duty for worker who receives a dose that is a large enough dose to place him/her in jeopardy of exceeding the annual dose limits (5 rem per year). This restriction ensures that the worker does not exceed the dose limits.

Fig. 3-3. Consequence severity categories.

I (1 to 0.1)	**Normal Operations:** Frequency as often as once in 10 operating years or at least once in 10 similar facilities operated for 1 yr.
II (0.1 to .01)	**Anticipated Events:** Frequency between 1 in 100 yr and 1 in 10 operating years or at least once in 100 similar facilities operated for 1 yr.
III (10^{-2} to 10^{-4})	**Unlikely:** Frequency between 1 in 100 yr and 1 in 10,000 operating years or at least once in 10,000 similar facilities operated for 1 yr.
IV (10^{-4} to 10^{-6})	**Very Unlikely:** Frequency between 1 in 10,000 yr and once in 1 million years or at least once in a million similar facilities operated for 1 yr.
V	**Improbable:** Frequency of less than once in a million years.

Fig. 3-4. Consequence likelihood categories.

Risk Ranking Matrix					
Severity of Consequence	**Likelihood of Consequence**				
	I	**II**	**III**	**IV**	**V**
A	1	1	2	3	3
B	1	2	2*	3	4
C	2	3	3	4	4
D	3	4	4	4	4

*Assign risk rank of 3 if severity category rank of B is based on worker injury and offsite consequence severity is less than B.

Risk Rank	Recommendation
1	**Unacceptable:** Should be mitigated to risk rank 3 or lower as soon as possible.
2	**Undesirable:** Should be mitigated to risk rank 3 or lower within a reasonable time period.
3	**Acceptable with Controls:** Verify that procedures, controls, and safeguards are in place.
4	**Acceptable As Is:** No action necessary.

Fig. 3-5. Risk ranking matrix.

PRELIMINARY HAZARD/RISK ANALYSIS RECORED BY ACTIVITY FOR MWRSF
ACTIVITY NUMBER: DU3
ACTIVITY NAME: WALK BEHIND FORKLIFT MOVES DRUM OF DEPLETED URANIUM WASTE TO DOCK
ACTIVITY DESCRIPTION: WALK BEHIND FORKLIFT MOVES WASTE DRUM FROM STORAGE ROOM TO LOADING DOCK.

R--F--C	CAUSE/SCENARIO	CONSEQUENCE	PROTECTIVE FEATURES	ACTIONS
3 III C	DRUM PUNCTURED BY FORKLIFT.	CONTAINER BREACH, MINOR WORK EXPOSURE. (D;D;C;D)	NONE	NONE
3 III C	FORKLIFT DRIVES OFF DOCK WHILE TRANSPORTING DURM, WITH SPRINKLER SYSTEM OPERABLE.	CONTAINER BREACH IGNITION OF URANIUM CHIPS IN DOCK AREA. MINOR FIRE, WORKER INJURY AND EXPOSURE TO DEPLETED URANIUM. (D;D;C;D)	NONE	CONSIDER ISTALLATION OF A CURB TO PREVENT DRIVING THE FORKLIFT OFF DOCK.
3 IV B	FORKLIFT DRIVES OFF DOCK WHILE TRANSPORTING DURN, WITH FAILURE OF SPRINKLER SYSTEM.	CONTAINER BREACH, IGNITION OF URANIUM CHIPS IN DOCK AREA. SIGNIFICANT FIRE, WORK INJURIES AND EXPOSURE TO DEPLETED URANIUM, AND FACILITY CONTAMINATION. (D;D;B;C)	NONE	CONSIDER INSTALLATION OF A CURB TO PREVENT DRIVING THE FORKLIFT OFF DOCK.
4 IV D	DRUM PUSHED OFF DOCK BY FORKLIFT.	CONTAINER BREACH, URANIUM CHIP SPILL IN DOCK AREA, NO WORK EXPOSURE DUE TO DISTANCE FROM SPILL. (D;D;D;D)	NONE	NONE

Fig. 3-6. Example of HAZMAN activity report.

4.0. RESULTS

4.1. Summary of Results

The PHA, which was conducted over a 15-week period, provided benefits and insights into the design of the treatment and storage facilities.

A significant benefit of performing the PHA was the scrutiny of the treatment and storage facilities and all of their processes from a safety perspective. Detailed flow charts that defined each activity in the sequence of operations were prepared by the PHA team. These flow charts allowed the PHA to focus on safety issues and provided guidance in a format that did not previously exist.

With the flow charts as a starting point, the PHA review process resulted in a number of design modifications that were adopted as part of the current design. Some of these changes were decided by participating CST-7 staff during the course of PHA meetings; others were developed outside PHA meetings by CST-7 and design staff. These changes specifically affected the safety aspects of the treatment and storage operations. They did not involve major changes to the facility or operations. When the design changes were confirmed, a PHA review continued with this change as part of the facility baseline. This reflects the systematic approach of a PHA to identify safety concerns, address the possible solutions, and implement modifications. One of the significant design changes proposed during the PHA review was revising the conceptual floor plan of the MWRSF, which is now based on EPA classifications. To reduce the risk of puncturing a waste container during transport, motorized forklifts were replaced with walk-behind forklifts in both the HWTF and the MWRSF. Loading dock procedures were modified to reduce the risk of crane accidents. In addition, numerous minor modifications that are not formally presented in this report were proposed and accepted by the participants. Consequently, the list of potential hazards has been reduced substantially.

Over the course of the review sessions, we documented more than 200 scenarios that could lead to unfavorable consequences. Included in the definition of each scenario are its description, its likely cause, a description of the consequences, an estimate of the scenario likelihood, and suggested recommendations that could reduce the likelihood and/or consequences. As opposed to an FSAR or a PSAR report, which identifies only a handful of scenarios, the PHA process extensively detailed potential accident scenarios in every activity or sequence. Each of the more than 200 scenarios was associated with an estimate of likelihood and consequence. This allowed the scenarios to be sorted according to a common measure of risk. An effort of this type is crucial in identifying the overall risk of the individual treatment/storage facilities. Furthermore, it identifies the dominant risk contributor sequences in the entire system or within each individual facility.

With a thorough set of documented accident scenarios sorted according to risk, the PHA provided a basis for serious discussions on issues of safety in the treatment and storage facilities. Allocation of resources, prioritization of design modifications, and additional quantification of risk can now be studied based on risk reduction payback and cost effectiveness. Efforts in the areas of low or minimal risk can be deferred until high-risk scenarios attain acceptable risk levels. Thus, the PHA guided CST-7 to focus their efforts on the high-risk scenarios as well as indicated where further quantitative risk assessment is warranted and could benefit risk reduction.

The full HAZMAN printouts identifying all of the scenarios are presented in appendices for each facility or process of interest. Scenarios with a risk rank of 1 or 2 are the focus of the remainder of this section. A risk rank of 1 implies that the PHA team determined that the risk is unacceptable and that immediate actions should be taken to reduce the consequence and likelihood of such a scenario. A risk rank of 2 implies that the PHA team deemed that the risk is also unacceptable but allows for a reasonable time frame to implement actions to reduce the consequence and likelihood of such a scenario. This "reasonable" amount of time is applicable for normally operating plants where the next "shutdown" or "turnaround" would be the appropriate time to implement the suggested modifications. However, because the facility being evaluated exists purely as a design, all of these recommended actions should be implemented before the actual construction or operation. Scenarios with a lower risk ranking were not considered or included in the interpretation of the results because of the minimal effect and/or less severe consequences posed by those scenarios.

The Risk Rank 1 and 2 scenarios are tallied in Table 4-1 according to facility and primary activities. Interestingly, the storage activities contribute a disproportionate amount to the overall risk of these facilities. Well over half of the Risk Rank 1 and 2 scenarios are attributed to the storage of the hazardous and mixed wastes. This observation is consistent with a previous limited study by TSA-6 (Ref. 5) that looked at the hazards associated with the storage and treatment of LiH reactive wastes and cyanide plating wastes. The following subsections discuss the Risk Rank 1 and 2 scenarios in greater detail to identify and describe the nature of risk involved in the various activities. Based on recommendations associated with each accident scenario, the scenario is reassessed with respect to severity of consequence, frequency, and ranking. It is apparent that all Risk Rank 1 and 2 scenarios can be downgraded to an acceptable level of risk by implementing reasonable facility design modifications and/or administrative controls.

4.2. Discussion of Risk Rank 1 Scenarios

Four scenarios, listed in Table D-1 in App. D, were determined to be Risk Rank 1. There are various ways to study these scenarios, which allows a better understanding of underlying causes, overall environmental impact, or consequence. Table 4-2 presents the Risk Rank 1 scenarios categorized according to the types of incidents that lead to an undesirable condition. The effect on populations, including the worker, co-located workers, and the general public, is also indicative of the severity of these scenarios. The consequences of the Risk Rank 1 scenarios underline the importance of addressing these hazards.

Regardless of the facility, the storage of legacy gas cylinders that are of doubtful integrity is a primary concern. Because of the potential for the release of highly toxic gases, these scenarios can result in worker fatality as well as serious health effects for the general public. Because of the severe consequences, we recommend that the legacy cylinders not be stored in either the HWTF or MWRSF unless a repackaging procedure is adopted. That is, legacy cylinders should be placed in a secondary containment vessel or the contents of a legacy cylinder should be released in a contained environment, and, if necessary, the gas should be repackaged in a cylinder for storage. Again, these recommendations apply to legacy cylinders containing the most highly toxic gases or those with unidentified contents.

The possible mixing of cyanide plating wastes with incompatible materials while transferring reagents during treatment also must be addressed because the scenario can lead to worker fatality. This hazard can be reduced further by using checklists and verification procedures.

The remaining Risk Rank 1 scenario is in the external events category and can yield a release of highly toxic gases and a fire. This hazard can be reduced by strict guidelines preventing the storage of shock-sensitive or highly explosive materials.

4.3. Discussion of Risk Rank 2 Scenarios

The scenarios that require mitigation according to a reasonable schedule (Risk Rank 2) can be categorized into groups by the type of incident leading to adverse consequences, the overall environmental impact, or the direct consequences. All of the Risk Rank 2 scenarios are listed in Table D-1 in App. D. Table 4-3 defines the initiator-type categories and the number of Risk Rank 2 scenarios associated with each one, and Fig. 4-1 presents this categorization graphically. Many of the scenarios reflect the effect of more than one cause category; thus, the total exceeds the number of scenarios listed in Table D-1. The effect of the scenarios, as shown in Table 4-4 and Fig. 4-2, is most often fatal to the worker directly affected by the mishap. Furthermore, significant health risks would affect co-located workers as well as the general public in many of the scenarios. However, in the majority of Risk Rank 2 scenarios, the public would suffer no permanent health effects. As shown in Fig. 4-3 and Table 4-5, the primary consequence of these scenarios is the release of highly toxic gases. When the specific type of chemical is known for a scenario, the hazard of its release is tallied separately. Thus, cyanide, depleted uranium, chlorobenzene, and PCB releases are listed. The gas cylinder (already shown to play a role in some Risk Rank 1 scenarios) also can be hazardous as a potential projectile. Many of the scenarios include a fire or explosion that was induced by exposure to toxic gases; as such, these scenarios were counted for both categories. Therefore, the total in Table 4-5 exceeds the number of Risk Rank 2 scenarios.

The significant contributors to risk are applicable to both the DSB and the MWRSF. The most prominent cause of incidents is the transportation accident—forklift, crane, truck, or manual transport. The situation often is exacerbated by the mislabeling of containers, which can result in the release of incompatible wastes. In many instances, the lack of sufficient guidelines or procedures for labeling and transport of hazardous or mixed wastes also contributes to the scenario. The most severe scenarios in terms of effect on all populations (severity category A in Table 4-4) concern a breach during transport of waste in the form of toxic gas cylinders or drums from either the HWTF or MWRSF to another facility that requires movement on public roads. Other high-risk scenarios focus on fires that are initiated in either facility, resulting in pressurization and rupture of gas cylinders. These scenarios strongly support the review of design features and procedures to ensure the safe use, movement, and storage of legacy and nonlegacy gas cylinders in the facilities.

Unique to the DSB is the effect of adverse weather conditions, particularly freezing, which facilitate containment breaches. This reflects the design of the DSB, which currently is stipulated to be an open structure. This design also poses more severe hazards to co-located workers and the general public than the MWRSF for comparable scenarios. For example, the breach of a nonlegacy cylinder as a result of an accidental drop in the MWRSF can result in worker fatality but no permanent health effects for co-located workers and the public. However, the same scenario in the HWTF can yield immediate and severe health effects on co-located workers and possibly the public as well as resulting in worker fatality. Thus, it is recommended that the DSB be constructed as a enclosed building.

4.4. Risk of Public Exposure

Another perspective from which to consider the results is the effect of the hazard scenarios on the general public. For each scenario, the consequences of exposure to the environment, the worker, the co-located worker, and the public are determined using Fig. 3-3. The most severe category dictates the overall consequence of the scenario. Because the most severe consequence usually is associated with the worker, the effect on the public is not directly evident. Table 4-6 lists the hazard scenarios in which the risk to the public was assigned a severity category of A. Many of the scenarios have a risk rank of 3; this indicates that the frequency was sufficiently low to offset the severity. Furthermore, the initiator types associated with the Risk Rank 3 scenarios are variations of Risk Rank 1 and 2 scenarios. The differences lie in the intensity of the events; e.g., a larger fire or more powerful earthquake. A final observation is that the hazard scenarios, regardless of risk rank, are primarily related to storage or storage activities. These are the types of accident sequences that require further quantification to determine if these estimates of high public consequences are real. The further quantification will involve event-tree frequency analyses and dispersion or consequence analysis.

4.5. Risk Ranking Revision

Based on the recommendations provided for each Risk Rank 1 or 2 scenario, some of these scenarios can be downgraded by adjusting design parameters and refining procedures. Tables 4-7 and 4-8 list the PHA parameters (ranking, frequency, and consequence) that were determined by the PHA team for Risk Rank 1 and 2 scenarios, respectively. The tables also include the effect on the risk rankings, frequencies, and consequences of each scenario by implementing the recommendations associated with each hazard scenario. These tables indicate that all Risk Rank 1 and 2 hazard scenarios can be reduced to acceptable levels of risk by applying reasonable facility design modifications and administrative controls. However, to maintain a conservative approach, the initial risk rankings will be retained for further analysis.

TABLE 4-1
SUMMARY OF RISK RANKS 1 AND 2 SCENARIOS BY FACILITY OR ACTIVITY

Facility or Activity	Number of Risk Rank 1 Scenarios	Number of Risk Rank 2 Scenarios
Storage		
Mixed Waste Storage	1 (25%)	11 (22%)
Hazardous Waste Storage	2 (50%)	22 (45%)
Mixed Waste Bulking	—	2 (4%)
Subtotal	**3 (75%)**	**35 (71%)**
Treatment (HWTF)	1 (25%)	9 (18%)
Transportation*		5 (10%)

*Includes only transportation outside facilities; e.g., between storage and treatment buildings, or from other locations to TA-63.

TABLE 4-2
RISK RANK 1 SCENARIOS

Scenario	Types of Incidents	Impact on Public	Impact on Co-Located Worker	Impact on Worker	Consequences
Storage of MW Gases	Breach	No	Yes	Yes	Highly Toxic Gas Release
Storage of HW Gases	Breach	Yes	Yes	Yes	Highly Toxic Gas Release
Inadvertent Transfer of Cyanide Wastes or Reagents	Mixing of Incompatible Wastes	No	No	Yes	Cyanide Release
HW Global Event	Seismic Event; Inadequate Guidelines for Storage of Shock Sensitive Materials	Yes	Yes	Yes	Highly Toxic Gas Release; Fire/Explosion

TABLE 4-3
RISK RANK 2 SCENARIOS CATEGORIZED BY CAUSE

General Category	Types of Incidents	Number of Risk Rank 2 Scenarios
Transportation	Forklift Accidents	14
	Crane Accidents	5
	Truck Transport Accidents	8
	Manual Transport Accidents	2
Mislabeling		13
Guidelines	Inadequate Guidelines or Procedures	11
External Events	Seismic Events, Fire Events, Strong Winds	6
	Freezing	6
Mechanical/Design	Mechanical Failure	3
	Design Failure	2
Chemical Reaction	Incomplete Chemical Reaction	1
	Corrosion	2
General Breach of Containment	Gas Cylinder Drop and Breach	2
	Breach	3

TABLE 4-4
RISK RANK 2 SCENARIOS CATEGORIZED BY EFFECT

Severity Category	Effect on Public	Effect on Co-Located Worker	Effect on Worker
A	7	7	25
B	6	9	19
C	1	1	3

TABLE 4-5
RISK RANK 2 SCENARIOS CATEGORIZED BY CONSEQUENCE

Consequence	Number of Risk Rank 2 Scenarios
Highly Toxic Gas Release	38
Fire/Explosion	21
Cyanide Release	9
Hydrogen Gas Production	3
Depleted Uranium Release	3
Cylinder as Missile	3
Chlorobenzene Release	2
PCB Release	2
Lithium Hydride Release	1
Moderately Toxic Gas Release	1
Ammonium Perchlorate/MEKP Release	1

TABLE 4-6
HAZARD SCENARIOS SORTED BY CONSEQUENCE TO PUBLIC EXPOSURE

Node	Description of Scenario	Risk Rank	Frequency	Consequence	Consequences of Scenario	Recommendations
HW7A	Breach of Legacy Cylinder of Doubtful Integrity during Storage	1	II	A	Release of highly toxic gases (phosphine, phosgene, arsine, and others). Worker fatality, potential co-located worker, and public exposure. (A;A;A;D)	(1) Do not store legacy cylinders in HWTF area, (2) Process legacy cylinders without intermediate storage (3) Provide secondary containment for the cylinders (4) Consider enclosing the HWTF storage and providing HVAC and scrubber
HWG	Low-Intensity Seismic Event with Horizontal Acceleration of 0.1g	1	II	A	Explosion of shock-sensitive materials; e.g., picric acid, nitro methane, sodium azide. Structural damage to building, fire, and release of toxic gases. (A;A;A;A)	(1) Develop and enforce strict policy not to store explosives or shock-sensitive materials in the building (2) Consider storage of shock-sensitive material in a separate building in a remote location.
GC2	Truck Accident on Public Road Between TA-54 and TA-63 with Breach of Gas Cylinder(s)	2	III	A	Potential release of toxic gases with public and worker exposure. (A;C;A;D)	Administrative controls (1) Provide escort for the transport vehicle and consider road closure during transport (2) Driver training (3) Restrict night or poor weather deliveries (4) Consider secondary containment for cylinders of questionable integrity or unknown contents or those containing most highly toxic materials
HW4A	Picric Acid Dropped or Jarred	2	III	A	Detonation, major fire in HWTF storage area, multiple toxic gases (e.g., phosgene, HCN, etc.) released directly to environment, worker fatality, public exposure. (A;A;A;A)	Develop and enforce policy not to store explosives or shock-sensitive materials in this building.
HW7A	Breach of Cylinder (Nonlegacy) from Accidental Causes; e.g., Cylinder Dropped and Regulator Line Breaks	2	III	A	Release of highly toxic gases (phosphine, phosgene, arsine, and others). Worker fatality, potential co-located worker, and public exposure. (A;A;A;D)	(1) Transport and store cylinders securely (2) Consider secondary containment for most hazardous cylinders (3) Gas cylinders to be processed with high priority (4) Work in this area is to be performed with protection (i.e., wear SCBA, operate under the buddy system) (5) Protective cap for cylinder regulators should be in place at all times (6)Consider storing gas cylinders in enclosed room in an enclosed building
HW7A	External Fire (Initiated Within the Building)	2	III	A	Pressurization and rupture of gas cylinders. Highly toxic gas release and potential cylinder missile generation. (A;A;A;A)	(1) Initiate fire suppression sprinklers given fire in adjacent areas (2) Enclose the hazardous waste storage area and store gas cylinders in an enclosed area.
HWG	Accident during Transportation of Waste (Toxic Gas Cylinders or Incompatible Waste Drums) from Hazardous Waste Storage to CAI or Other Facility	2	III	A	Spill leading to the unmitigated release of toxic gases. Public exposure. (A;A;A;A)	(1) Consider road closure while transporting the most hazardous materials between Lab areas (2) Review procedures for securing waste drums during transportation (3) Do not transport incompatible waste drums together.

TABLE 4-6 (CONT)

Node	Description of Scenario	Risk Rank	Frequency	Consequence	Consequences of Scenario	Recommendations
MW7A	External Fire (Initiated Within the MWRSF Building)	2	III	A	Pressurization and rupture of gas cylinders. Highly toxic gas release and potential cylinder missile generation. (A;A;A;A)	Store gas cylinders in an enclosed area with fire door and fire wall
MWG	Accident during Transportation of the Most Toxic Waste Drums (e.g., Toxic Gas Cylinders or Incompatible Wastes) from MWRSF to CAI or Other Facilities	2	III	A	Spill leading to the unmitigated release of toxic gases. Public exposure. (A;A;A;A)	(1) Consider road closure while transporting the most hazardous materials between Laboratory areas (2) Review procedures for securing waste drums during transportation (3) Do not transport incompatible waste drums together
GC4	Breach of Cylinder from Accidental Causes; e.g., Cylinder Dropped and Regulator Line Breaks	3	IV	A	Release of highly toxic gases (phosphine, phosgene, arsine, and others). Worker fatality. (A;A;A;D)	(1) Transport and store cylinders securely (2) Consider secondary containment for most hazardous cylinders (3) Protective cap for cylinder regulators should be in place at all times
HWG	External Fire	3	IV	A	Fire penetrates the MWRSF, major fire releases toxic gas to the environment. (A;A;A;A)	None
HWG	High-Intensity Seismic Event with Horizontal Acceleration of 0.3 g or Greater	3	IV	A	Structural collapse of building, breach of multiple drums, major fire, release of toxic gas to environment. (A;A;A;A)	(1) Review seismic design criteria, (2) Minimize storage time of most flammable/toxic materials
MWG	Low-Intensity Seismic Event with Horizontal Acceleration of 0.1 g	3	IV	A	Explosion of shock-sensitive materials (e.g., nitro methane, sodium azide). Structural damage to building, fire, and release of toxic gases. (A;A;A;A)	(1) Develop and enforce policy not to store explosive or shock sensitive material in this building (2) Process shock sensitive materials immediately
MWG	High-Intensity Seismic Event with Horizontal Acceleration of 0.3 g or Greater	3	IV	A	Structural collapse of building, breach of multiple drums, major fire, release of toxic gas to environment, and radioactive contamination. (A;A;A;A)	(1) Review seismic design criteria (2) Minimize storage time of most flammable/toxic materials
MWG	External Fire	3	IV	A	Fire penetrates the MWRSF, major fire releases toxic gas to the environment, and radioactive contamination. (A;A;A;A)	None

TABLE 4-7
SUMMARY OF RISK RANK 1 SCENARIOS

Node	Description of Scenario	Risk Rank	Frequency	Consequence	Recommendations	Revised Risk Rank	Revised Frequency	Revised Consequence
CY12	Cyanide Plating Waste Pumped to Wrong Location and Mixed with Noncompatible Material (i.e., Waste Drum, Waste Water System, Chemical Mix and Feed Tank, Chemical Feed Drum or the Dry Chemical Feeder); Plating Waste Process	1	II	A	(1) Install check valves on outlet lines of the chemical mix feed tank, chemical feed drum, and chemical plating waste drum (2) Follow valve alignment checklist procedure (3) Valves should have position indicators (4) Operators should be equipped with protective clothing and respirator (5) Have two operators check valve positioning (6) Install interlock that allows opening of one valve at a time	3	III	B (w)
HW7A	Breach of Legacy Cylinder of Doubtful Integrity during Storage	1	II	A	(1) Do not store legacy cylinders in HWTF area (2) Process legacy cylinders without intermediate storage (3) Provide secondary containment for the cylinders (4) Consider enclosing the HWTF storage and providing HVAC and scrubber.	N/A	N/A	N/A
HWG	Low-Intensity Seismic Event with Horizontal Acceleration of 0.1g	1	II	A	(1) Develop and enforce strict policy not to store explosives or shock-sensitive materials in the building (2) Consider storage of shock-sensitive materials in a separate building in a remote location.	N/A	N/A	N/A
MW7A	Major Breach of Legacy Cylinder of Doubtful Integrity during Storage	1	II	A	(1) Do not store legacy cylinders in the MWSRF (2) Process legacy cylinders without intermediate storage (3) Provide secondary containment when transporting legacy cylinders.	N/A	N/A	N/A

TABLE 4-8
SUMMARY OF RISK RANK 2 SCENARIOS

Node	Description of Scenario	Risk Rank	Frequency	Consequence	Recommendations	Revised Risk Rank	Revised Frequency	Revised Consequence
GC6	Saw Jams or Other Mechanical Failures during Cutting, and Gas is Released Into Pressure Vessel. Worker Opens Vessel after Purging To Inspect	2	I	C	(1) Verify atmosphere before opening vessel (2) Wear protective gear (SCBA) when opening vessel	4	II	D
HWG	High Winds	2	I	C	Enclose the hazardous waste storage building.	N/A	N/A	N/A
MWBK	Inadequate Guidelines or Procedures for Mixing and Rebulking Wastes	2	I	C	(1) Guidelines (procedures) for mixing and bulking should be developed and reviewed (2) Worker should wear respirator until determination of possible reactions	4	II	D
GC6	Saw Jams or Other Mechanical Failures during Cutting. Worker Opens Vessel To Inspect, Causing Unexpected Release	2	II	B	(1) Verify atmosphere before opening vessel (2) wear protective gear (SCBA) when opening vessel	4	III	D
GC6	Treatment Skid (Valves for Containment Vessel) Misaligned Before or After Cylinder Breach	2	II	B	(1) Independent verification of system alignment before cutting (2) Use procedure with checklist (3) Provide valve position indication	3	III	B
HW2A	Forklift Accident or Freezing of Waste Causes Spill of Water Reactive Waste with Water Present in the Area	2	II	B	(1) Restrict use of water in the reactives storage area (2) Enclose the building for water control and fire suppression efficiency (3) Install HVAC and scrubber	3	III	B
HW5A	Mislabeled Cyanide Drum is Placed in the Open Storage Area; Drum Freezes, Causing Simultaneous Spill of Cyanides and Noncompatible Waste, Such as Acids	2	II	B	(1) Consider enclosing the HWTF storage building and providing HVAC (2) Install a scrubber system (3) Provide HCN analyzer and alarm	N/A	N/A	M/A
HW6A	Ammonium Perchlorate or Methyl Ethyl Ketone Peroxide (MEKP), Dried Over Time, Subjected to Shock, Friction, or Sunlight	2	II	B	(1) Develop and enforce strict acceptance criteria for sensitive oxidizers (e.g., diluted form, frequent inspection, wetted material) (2) Consider storage of highly sensitive oxidizers in a separate building in a remote location	3	III	B
HWG	Cracks in Storage Containers Propagated by Rain or Snow (Blown Onto Drums) Freezes Over	2	II	B	Enclose the hazardous waste storage building.	N/A	N/A	N/A
HWG	Accidents during Transportation of Waste Within the Hazardous Waste Storage Area (Forklifts or Manual)	2	II	B	(1) Enclose the hazardous waste storage area (2) Maintain physical separation of incompatible wastes during transportation (3) Limit simultaneous operation of multiple forklifts	3	III	B

TABLE 4-8 (CONT)

Node	Description of Scenario	Risk Rank	Frequency	Consequence	Recommendations	Revised Risk Rank	Revised Frequency	Revised Consequence
LIH14	Incomplete Reaction of the Lithium Hydride in the Humidifier	2	II	B	Use diverse methods for verification that the reaction is complete. Continue wearing protective clothing/breathing apparatus while processing reaction products.	4	III	D
MW6A	Ammonium Perchlorate or Methyl Ethyl Ketone Peroxide (Dried Over Time) Subjected to Shock, Friction, or Sunlight (MEKP)	2	II	B	(1) Develop and enforce strict acceptance criteria for sensitive oxidizers (e.g., diluted form, frequent inspection, wetted material) (2) Consider storage of highly sensitive oxidizers in a separate building in a remote location	3	III	B
MWBK	Inadequate Guidelines or Procedures for Mixing and Rebulking Wastes Leads to Violent Reaction, and Fume Hood Failure	2	II	B	(1) Guidelines (procedures) for mixing and bulking should be developed and reviewed (2) Worker should wear repirator until the possibility of violent reactions is passed	4	II	D
MWG	Accidents during Transportation of Waste Within the MWRSF (Forklifts, Cranes, or Manual)	2	II	B	(1) Maintain physical separation of incompatible wastes during transportation (e.g., do not transport drum over incompatible wastes with the crane) (2) Limit simultaneous operation of multiple forklifts	3	III	B
CY1	Truck Accident with Breach of Multiple Waste Containers Leading To Mixing of Incompatible Wastes as a Result of (1) Normal Transport of Incompatibles and (2) Mislabeled Drums	2	III	A	Administrative controls: (1) Announcement of delivery (2) Driver training (3) Restrict other traffic during delivery Consider review of transportation procedures; e.g., (1) Restrict the transportation of incompatible wastes in single truck (2) Consider transport of one drum at a time	3	IV	A
GC1	Handling Accident while Removing Cylinder from Storage; e.g., Cylinder Falls Breaking Valve or Connections or Rupture of a Corroded Cylinder	2	III	A	(1) Consider secondary containment for known highly toxic gas cylinders and all unknown gas cylinders, (2) valve covers should be in place on all cylinders, (3) train workers to evacuate in upwind direction, and locate gas masks in upwind direction, (4) install a wind sock for continuous wind direction indication, (5) consider protective clothing for mixed waste gas release	3	IV	A
GC2	Truck Accident on Public Road Between TA-54 and TA-63 with Breach of Gas Cylinder(s)	2	III	A	Administrative controls: (1) Provide escort for the transport vehicle and consider road closure during transport, (2) Driver training (3) Restrict night or poor weather deliveries (4) Consider secondary containment for cylinders of questionable integrity, unknown contents, or those containing most highly toxic materials	3	IV	A

TABLE 4-8 (CONT)

Node	Description of Scenario	Risk Rank	Frequency	Consequence	Recommendations	Revised Risk Rank	Revised Frequency	Revised Consequence
GC6	Treatment Skid (Valves for Containment Vessel) Misaligned Before or After Cylinder Breach	2	III	A	(1) Independent verification of system alignment before cutting (2) Use procedure with checklist (3) Provide valve position indication	3	IV	A
GC6	Inadvertent Cutting of Cylinder Before Sealing Vessel	2	III	A	(1) Install interlocks to prevent saw operation before sealing and inerting pressure vessel (2) Verify door closure prior to starting saw	3	IV	A
GC6	Pressure Vessel Incorrectly Sealed (Such as Door Seal) or Seal Fails Causing Leakage	2	III	A	(1) Perform check of pressure vessel seal before cutting operation (2) Minimize time between cutting and disposal or recontainerization (3) Locate control panel away from skid	3	IV	A
HW4A	Spill of Low-Flash-Point Chemicals [Acethalhehye (-38°F), Furan (-32°F), Anhydrous Ethyl Ether (-49°F)] as a Result of Forklift Accident or Corrosion. Fire Suppression System Inadequate	2	III	A	(1) Treat highly flammable materials on an priority basis; do not allow accumulations of large inventories (2) Consider specially designed storage configuration for the most hazardous (low flash point) flammable wastes (3) Consider enclosing the building to increase the efficiency of the fire suppression system and install gas detector and alarm	3	IV	A
HW4A	Forklift Accident Causing Dual Spill of Incompatible Flammable Materials Routinely Stored in the Same Area; e.g., Nitromethane with Acetone	2	III	A	(1) Consider enclosing the building to reduce toxic gas exposure to the public and co-located worker (2) Store incompatible flammable materials in separate locations within the flammable storage area, (3) Install scrubbing system	3	IV	A
HW4A	Forklift Accident Causing Dual Spill of Incompatible Materials Because of Mislabeling of Waste Drum; e.g., Flammable Waste Mixed with: (1) NAOH(1A), (2) H_2SO_4 (1B), (3) Lithium Hydride (2A), (4) Nitric Acid (6A), (5) Chlorobenzene	2	III	A	(1) Consider enclosing the building to reduce toxic gas exposure to the public and co-located worker (2) Install scrubbing system (3) Verify drum contents and labeling at waste generator site (4) Develop Laboratory-wide procedure (Lab ES&H manual) for waste identification and labeling of waste containers	3	IV	A
HW4A	Picric Acid Dropped or Jarred	2	III	A	Develop and enforce policy not to store explosives or shock-sensitive materials in this building.	3	IV	A
HW6A	Forklift Accident or Freezing Causing Dual Spill of Incompatible Materials as a Result of Mislabeling of Waste Drum; e.g., Oxidizer Waste Mixed With: (1) NAOH (1A), (2) Acetic Acid (1B), (3) Sodium (2A), (4) Organics Such as Chloro Benzene (4A); (5) Gold Cyanide (5A)	2	III	A	(1) Verify drum contents and labeling at waste generators site (2) Develop Laboratory-wide procedure (Lab ES&H manual) for waste identification and labeling of waste containers (3) Enclose the HWTF storage building and install scrubber system	3	IV	A

TABLE 4-8 (CONT)

Node	Description of Scenario	Risk Rank	Frequency	Consequence	Recommendations	Revised Risk Rank	Revised Frequency	Revised Consequence
HW7A	Breach of Cylinder (Nonlegacy) Because of Accidental Causes; e.g., Cylinder Dropped and Regulator Line Breaks	2	III	A	(1) Transport and store cylinders securely (2) Consider secondary containment for most hazardous cylinders (3) Gas cylinders should be processed with high priority (4) Work in this area should be performed with protection (i.e., wear SCBA, operate under the buddy system) (5) Protective cap for cylinder regulators should be in place at all times (6) Consider storing gas cylinders in enclosed room in an enclosed building	3	IV	A
HW7A	External Fire (Initiated Within the Building)	2	III	A	(1) Initiate fire suppression sprinklers given fire in adjacent areas, (2) Enclose the hazardous waste storage area and store gas cylinders in an enclosed area	3	IV	A
HW9	Spill (due to Freezing or Forklift Accident) of Incompatible Wastes Routinely Stored in Nonregulated Area; e.g., Mislabeled, Temporary Storage, or do not Belong in Other Defined Regulated Areas	2	III	A	(1) Consider eliminating this area (2) Classify and store all nonregulated wastes in compatible regulated areas (3) Enclose the hazardous waste storage building	3	IV	A
HWG	Accident during Transportation of Waste (Toxic Gas Cylinders or Incompatible Waste Drums) from Hazardous Waste Storage to CAI or Other Facility	2	III	A	(1) Consider road closure while transporting the most hazardous materials between Laboratory areas (2) Review procedures for securing waste drums during transportation (3) Do not transport incompatible waste drums together	3	IV	A
HWG	Medium-Intensity Seismic Event with Horizontal Acceleration of 0.17g	2	III	A	(1) Review seismic design criteria (2) Ensure that incompatible wastes are not stored in adjacent areas. see potential MWRSF floorplan developed by PHA team (3) Minimize storage time of most flammable/ toxic materials (4) Enclose the hazardous waste storage area	3	IV	A
MW4A	Overhead Crane Drops Drum Causing Dual Spill of Incompatible Materials as a Result of Mislabeling of Waste Drum; e.g., Flammable Waste Mixed With (1) NAOH (1a), (2) H_2SO_4 (1b), (3) Lithium Hydride (2a), (4) Nitric Acid (6a), (5) Chlorobenzene	2	III	A	(1) Develop procedures to prevent or minimize crane movements over stored wastes (2) Verify drum contents and labeling at waste generator site (3) Develop Laboratory-wide procedure (Lab ES&H manual) for waste identification and labeling of waste containers	3	IV	A

TABLE 4-8 (CONT)

Node	Description of Scenario	Risk Rank	Frequency	Consequence	Recommendations	Revised Risk Rank	Revised Frequency	Revised Consequence
MW4A	Overhead Crane Drops Drum, Causing Dual Spill of Incompatible Flammable Materials Routinely Stored in the Same Area; e.g., Nitromethane with Acetone	2	III	A	(1) Develop procedures to prevent or minimize crane movements over stored wastes (2) Store incompatible flammable materials in separate locations within the flammable storage area	3	IV	A
MW4A	Spill of Low-Flash-Point Chemicals [Acethalhehye (-38°F), Furan (-32°F), Anhydrous Ethyle (-49°F)] from Forklift Accident, Crane Accident or Corrosion. Fire Suppression System Inadequate	2	III	A	(1) Treat highly flammable materials on an priority basis; do not allow accumulations of large inventories (2) Consider specially designed storage configuration for the most hazardous (low flash point) flammable wastes (3) Install gas detector and alarm (4) Consider adding a flare to the scrubber system (5) Consider inert fire suppression system; e.g., inert the room with N_2 when the gas analyzers alarm	3	IV	A
MW5A	Forklift Accident Causes Simultaneous Spill of Cyanide and Other Noncompatible Waste [e.g., H_2SO_4 (1b), or Perchloric Acid (6a)] as a Result of Mislabeling	2	III	A	(1) Provide HCN analyzer and alarm (2) Verify drum contents and labeling at waste generator site (3) Develop Laboratory-wide procedure (Lab ES&H manual) for waste identification and labeling of waste containers	3	IV	A
MW6A	Overhead Crane Drops Drum Causing Dual Spill of Incompatible Materials as a Result of Mislabeling of Waste Drum; e.g., Oxidizer Waste Mixed With (1) NAOH (1a), (2) Acetic Acid (1b), (3) Sodium (2a), (4) Organics (4a) Such as Chloro Benzene, (5) Gold Cyanide (5a)	2	III	A	(1) Develop procedures to prevent or minimize crane movement over stored wastes (2) Verify drum contents and labeling at waste generators site (3) Develop Lab wide procedure (Lab ES&H manual) for waste identification and labeling of waste containers	3	IV	A
MW7A	External Fire (Initiated Within the MWRSF Building)	2	III	A	Store gas cylinders in an enclosed area with fire door and fire wall.	3	IV	A

TABLE 4-8 (CONT)

Node	Description of Scenario	Risk Rank	Frequency	Consequence	Recommendations	Revised Risk Rank	Revised Frequency	Revised Consequence
MW7A	Breach of Cylinder (Nonlegacy) from Accidental Causes; e.g., Cylinder Dropped and Regulator Line Breaks, which Results in Major Cylinder Damage	2	III	A	(1) Transport and store cylinders securely (2) Consider installation of a flare and/or a special scrubber for this facility (3) Install gas detectors and alarms (4) Consider secondary containment for most hazardous cylinders (5) Gas cylinders should be processed with high priority (6) Work in this area should be performed with protection (i.e., wear SCBA, operate under the buddy system) (7) Protective cap for cylinder regulators should be in place at all times (8) Store gas cylinders in an enclosed area	3	IV	A
MWG	Medium-Intensity Seismic Event with Horizontal Acceleration of 0.17g	2	III	A	(1) Review seismic design criteria (2) Ensure that incompatible wastes are not stored in adjacent areas (see potential MWRSF floorplan developed by PHA team) (3) Minimize storage time of most flammable/ toxic materials.	3	IV	A
MWG	Accident during Transportation of the Most Toxic Waste Drums (e.g., Toxic Gas Cylinders or Incompatible Wastes) from MWRSF to CAI or Other Facilities	2	III	A	(1) Consider road closure while transporting the most hazardous materials between Laboratory areas (2) Review procedures for securing waste drums during transportation (3) Do not transport incompatible waste drums together	3	IV	A
DU1	Truck Accident with Fire and Breach of Depleted Uranium Waste Container	2	III	B	Administrative controls such as (1) Announcement of delivery (2) Driver training (3) Restrict other traffic during delivery	3	IV	B
DU4	Forklift Accident during Transport Between Buildings	2	III	B	Move only one pallet or drum at a time; restrict other vehicles during transport.	3	IV	B
GC7	Misrouting of Toxic Gas (e.g., Gas Sent to Atmosphere) Because of Human Error, Scrubber Failed, or Ineffective	2	III	B	(1) Provide sampling procedures with independent verification (2) verify system line-up prior to routing pressure vessel contents	3	IV	B
GC8	Radioactive Container Mislabeled as Hazardous and Sent Offsite for Treatment	2	III	B	Independently verify correct labeling	3	IV	B

TABLE 4-8 (CONT)

Node	Description of Scenario	Risk Rank	Frequency	Consequence	Recommendations	Revised Risk Rank	Revised Frequency	Revised Consequence
HW1B	Forklift Accident or Freezing Causing Simultaneous Spill of Acid Material and Incompatible Material [e.g., NAOH (1A), Nitrobenzene (4A), Hydrogen Peroxide (6A), Metal Cyanide (5A), Lithium Hydride (2A)] Because of Mislabeling	2	III	B	(1) Verify drum contents and labeling at waste generator site (2) Develop Laboratory-wide procedure (Lab ES&H manual) for waste identification and labeling of waste containers (3) Store waste in enclosed building to prevent freezing	3	IV	B
HW2A	Accident Resulting from Human Error Causes Simultaneous Spill of Water Reactive Waste and Incompatible Waste Because of Mislabeling; (e.g., Reactive Waste Mixed With, Sulfuric Acid (1b), NAOH (1a), Perchloric Acid (6a), or Trichlora Ethylene (4a)	2	III	B	(1) Verify drum contents and labeling at waste generator site (2) Develop Laboratory-wide procedure (Lab ES&H manual) for waste identification and labeling of waste containers	3	IV	B
HW5A	Mercury Oxycyanide Detonates as a Result of Heating, from Shock or Friction; e.g., Forklift Accident	2	III	B	Develop and enforce policy not to store explosives or shock-sensitive materials in this building.	N/A	N/A	N/A
HW5A	Accident Causes Simultaneous Spill of Cyanide and Other Noncompatible Waste [e.g., H_2SO_4 (1b), or Perchloric Acid (6a)] Because of Mislabeling	2	III	B	(1) Consider enclosing the HWTF storage building and providing HVAC (2) Install a scrubber system (3) Provide HCN analyzer and alarm (4) Verify drum contents and labeling at waste generators site (5) Develop Laboratory-wide procedure (Lab ES&H manual) for waste identification and labeling of waste containers	3	IV	B
HW8	Mislabeled Drum Results in PCB Drum Being Stored Near Flammable Waste. Accidental Breach of the Containers Leads to Fire and Burning of PCB Waste	2	III	B	(1) Verify drum contents and labeling at waste generator site (2) Develop Laboratory-wide procedure (Lab ES&H manual) for waste identification and labeling of waste containers	3	IV	B
HW8	Spill of PCB Waste Drum Because of Forklift Accident, Release to the Sump	2	III	B	(1) Install procedures to detect sump levels (2) Test sump contents before discharge	3	IV	B

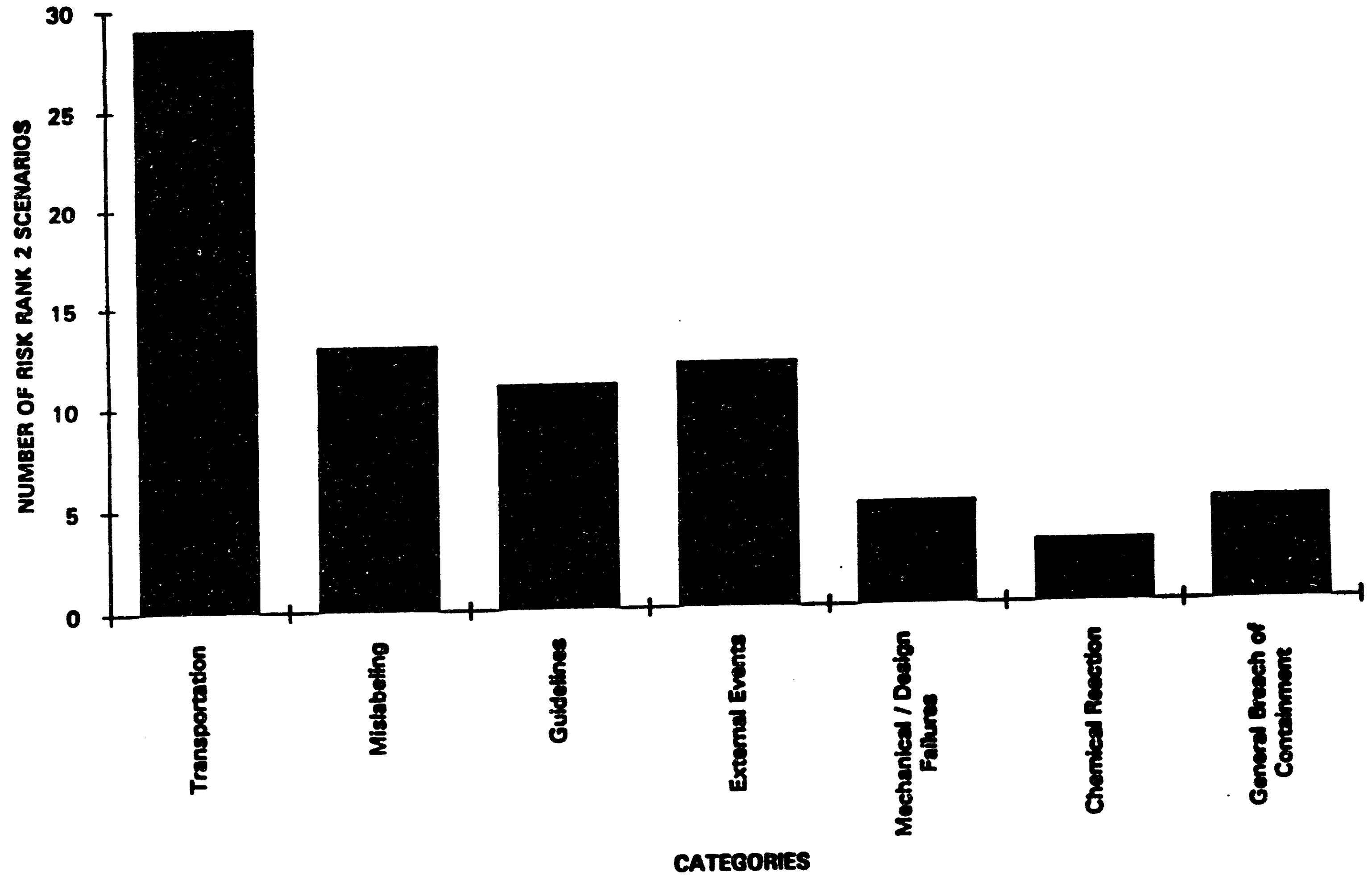

Fig. 4-1. Risk Rank 2 scenarios categorized by cause.

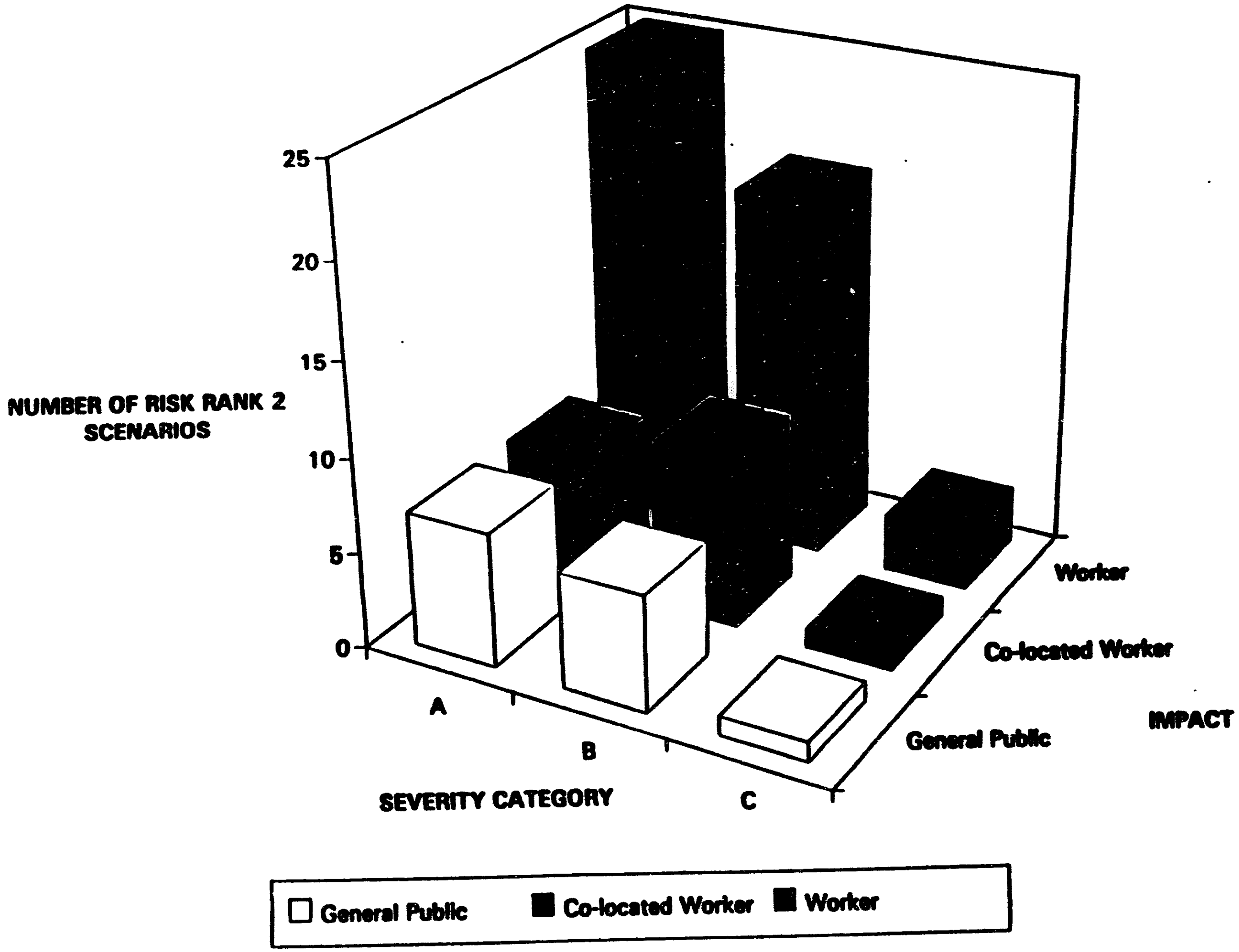

Fig. 4-2. Risk Rank 2 scenarios categorized by effect.

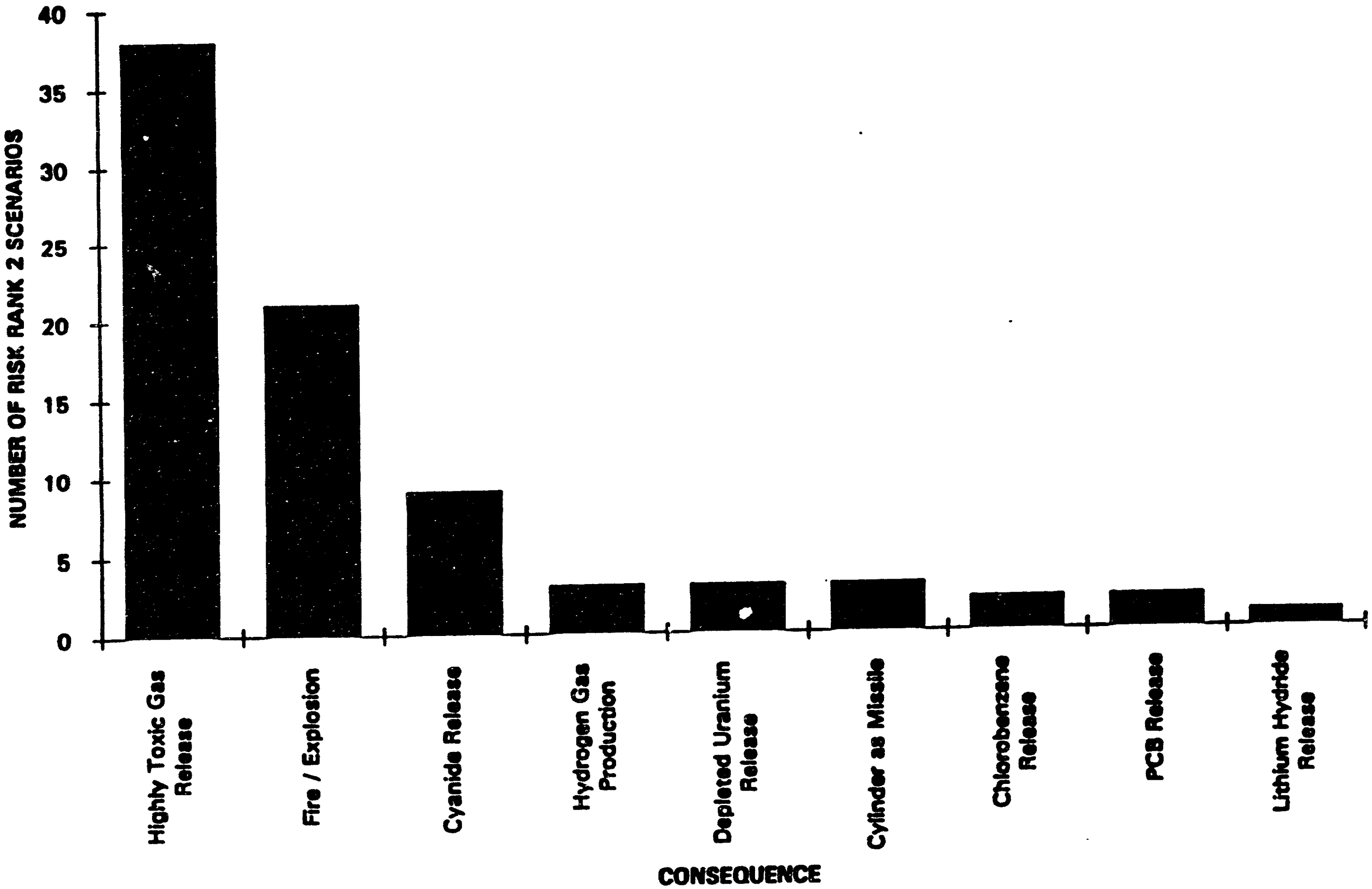

Fig. 4-3. Risk Rank 2 Scenarios categorized by consequence.

5.0. CONCLUSIONS AND RECOMMENDATIONS

5.1. Insights

Several engineering insights and recommendations appear to be appropriate for special mention because they are common to a number of hazards or provide a means to significantly reduce risks.

1. **Storage Presents Significant Risks.** The hazards associated with treatment are significantly less than storage risks because treatment is carried out in specially designed skids in the HWTF. The risks associated with the treatment building are lower as the HWTF treatment building is designed to contain releases with several redundant levels of filters/scrubbers. In addition, sampling provisions in the HWTF verify the identity of wastes before treatment, lessening the chances of mislabeling.

2. **Storage of Incompatible Materials Increases Risks.** The risks associated with storage are greater because of the large numbers of various materials in storage, many of which are incompatible. The materials are not independently assayed or sampled before storage, lending to increased chances for mislabeling.

3. **Storage of Materials in Adverse Weather Conditions Increases Risks.** The DSB appears to present particular hazards. It is an open building that can be expected to experience problems from weather extremes. Temperature extremes (freezing or heat), high winds, and other environmental conditions have the potential to result in material releases. Because of these weather-related problems, it is recommended that CST-7 consider enclosing the DSB and providing heating and ventilation (HVAC).

   Although the installation of additional filters and scrubbers also could help mitigate large releases resulting from accident conditions within the DSB, it is felt that the greatest risk reduction would be achieved by enclosing and heating the facility. Larger releases are expected on a much-less-frequent basis. In addition, the types of accidents that would result in these large releases (fires, seismic events) also could be expected to breach the facility, which may, in effect, render any filters/scrubbers ineffective because of the existence of direct release paths.

4. **Storage of Shock-Sensitive Materials Increases Risks.** Several chemicals were noted, that, if stored in these facilities, would represent significantly higher risks. These are materials that may be shock/heat sensitive or particularly incompatible with other chemicals. The resulting hazard is the high potential for an explosion, energetic reactions, or a fire. These materials include picric acid, sodium azide, nitromethane, and methyl ethyl ketone peroxide, among others. There appeared to be conflicting

views from the several CST-7 specialists interviewed by the PHA team as to the likelihood future generation of these materials at the Laboratory and/or the need to store them.

The PHA team felt that a specific, restrictive policy should be developed in advance so that CST-7 can deal with them properly should there be such a request. Because of the significant widespread hazards that these materials represent either alone (from shock, heat, or friction) or in combination with other chemicals, these materials should not be stored in either facility. If they are required to be handled or stored, then special facilities, compartments, or measures should be in place to place them in remote locations away from incompatible materials. The risks of an explosion or fire that could propagate to surrounding storage compartments or to the entire facility are too great to allow storage of these types of materials without taking special precautions.

5. **Potential for Misrouting of Waste Solutions Increases Risks.** An important design change (inclusion of check valves) was recommended for the cyanide-plating treatment skid. In reviewing the design drawings and flow paths of the skid, it was found that misrouting of the waste solution or reagents could result in the generation of highly toxic gases (e.g., HCN) that would threaten the worker. There did not appear to be any check valves in the system to prevent backflow or flow to wrong locations. Check valves are an effective means of preventing the flow of liquids to the wrong locations. Without an engineering method to prevent such misroutings, the process is left entirely to the effectiveness of operators to verify the proper flow path. Human reliability analyses, in similar situations, indicate the unacceptably high frequency of human errors in system valving alignments.

6. **Gas Cylinders of Unknown Content or Questionable Integrity Present Significant Risks.** A number of compressed gas cylinders are now stored in an open field of TA-54. Many of these are legacy wastes (generated from past operations) and may contain unidentified gases or be contained in cylinders of questionable integrity or conformance to standards. Additional high-risk gas cylinders are expected to be identified during the course of future operations and environmental restoration activities. These cylinders represent a substantial hazard during transportation, storage, and treatment. We recommend special precautions for those cylinders containing the most highly toxic gases (e.g., phosgene, phosphine, arsine, etc.) or those that contain unidentified gases. Some of the precautions are as follows.

   a. Double containment of the most highly toxic gases before movement and storage.

b. Special precautions at loading sites; e.g., installation/use of windsocks, training of operators on proper evacuation techniques, availability of self-contained breathing apparatus, etc.

c. Special transportation restrictions for the most highly toxic or unidentified gases; e.g., escort vehicle, road closure, etc.

d. Special storage restrictions; e.g., do not store legacy wastes in these buildings, special enclosed storage compartments for nonlegacy cylinders, etc.

7. **Risk Associated with Existing Storage Facilities is a Concern.** Even with the inclusion of improved safety features into the design of the new facilities, approximately 75% of all high-risk scenarios (Risk Ranks 1 and 2) are attributed to waste storage. The existing storage facilities do not include the latest safety features; therefore, it is inferred that the present risk of storage is considerably higher than the anticipated risk associated with the facilities to be built. Figure 5-1 shows an estimate of the relative risk given the current storage capability progressing to the completion and operation of the new facilities. Until the HWTF and MWRSF open, relative risk associated with storage as it now exists will steadily rise. The relative risk will decrease after the storage facilities are created and the legacy wastes are transferred to the new facilities. Treatment of wastes will further reduce the relative risk.

5.2. Final Observations

The PHA successfully screened the hazard scenarios into a set of four risk rank categories. Each scenario is associated with one or more cause categories. Furthermore, grouping the scenarios by their effect on the environment provides an alternate perspective. The adverse effects on the worker, co-located workers, and the general public were tabulated (Tables 4-2 and 4-4) to give direction to any subsequent study. This was enhanced by considering the consequences directly.

This document provides the basis for demonstrating compliance with the hazard analysis requirements of DOE Order 5480.23, Topic 5; DOE Standard 1027-92; and DOE Standard 3009-93. After this draft report is reviewed, representative sequences from the PHA will be selected for additional quantitative analysis of their frequency and severity to satisfy the accident analysis requirements of DOE Order 5480.23, Topic 11, necessary for inclusion in a Safety Analysis Report (SAR).

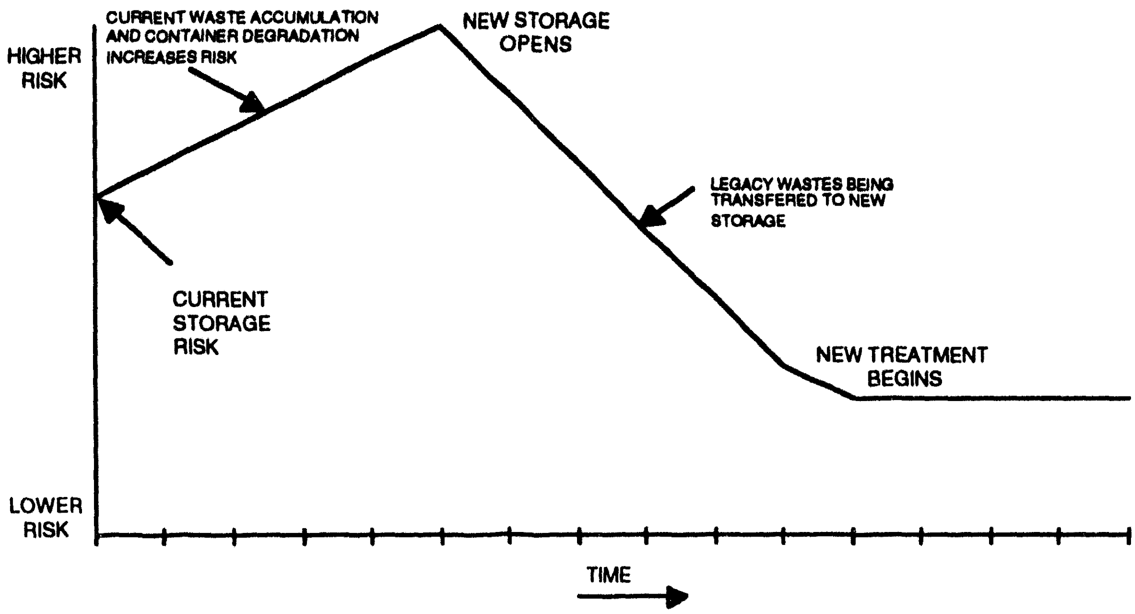

Fig. 5-1. Relative risk associated with storage and treatment.

REFERENCES

1. "Guidelines for Hazard Evaluation Procedures," 2nd Ed. with Worked Examples, AIChE, 1992.

2. F. A. Lercari, "Guidance for the Preparation of a Risk Management and Prevention Program," State of California, Office of Emergency Services unnumbered report (November 1989).

3. OSHA "Process Safety Management (PSM) of Highly Hazardous Chemicals," 29 CFR 1910.119.

4. K. Dziewinska, "Classification of Mixed Wastes and Hazardous Wastes and Selection of the Most Hazardous Wastes at the HWTF Storage Buildings," memo to G. Luissez (October 25, 1993).

5. M. K. Sasser, "Probabilistic Safety Assessment for TA-63, Hazardous Waste Treatment Facility," informal report to G. Luissez (September 29, 1992).

APPENDIX A
HAZARDOUS WASTE TREATMENT FACILITY

FACILITY DESCRIPTION

The Hazardous Waste Treatment Facility (HWTF) design is described in detail in Refs. A-1 and A-2. This appendix provides a brief description of the HWTF and of the treatment processes included in the PHA.

The HWTF will be located at TA-63, north of Pajarito Road. The 12,000-ft^2 treatment building will house treatment rooms for each of four types of waste: nonradioactive characteristic wastes, nonradioactive listed wastes, radioactive characteristic wastes, and radioactive listed wastes. Each treatment room is designed for flammable, ignitable, and reactive wastes or reagents. To avoid contaminating the rest of the building, each treatment room is sealed and under slight negative pressure with its own HEPA filtration. Separate treatment rooms will allow workers to avoid mixing waste types, prevent cross-contamination, and avoid or mitigate other hazards associated with treatment. Figures A-1 and A-2 (from Ref. A-1) show the HWTF floor plan for the ground and mezzanine levels.*

Most processing equipment will be mounted on a skid dedicated to one waste type. The skid then can be moved in and out of a dedicated treatment area. This approach increases flexibility in treatment because new skids can be built to accommodate new waste types and processes. The waste treatment processes analyzed in the PHA are described below.

WATER REACTIVE WASTES TREATMENT PROCESS

Introduction

Relatively small quantities of low-level radioactive and water-reactive wastes are generated at Los Alamos. The most common is lithium hydride mixed with depleted uranium (DU). Much smaller quantities of magnesium metal, and occasionally some calcium metal, have been generated. Lithium hydride is stored in a variety of forms. The most abundant form consists of chunky to powdery lithium hydride contaminated with pieces of DU in such a way as to make separation of the two components impossible or impractical. Other drums contain mostly clean-up items—paper, rags, used parts, and some lithium hydride. These two forms of waste are generally stored in 30- or 55-gal. drums as is or in plastic bags. Another form of lithium hydride is produced during machining and is a sand-like powder. It should contain very little DU. It is generally "suspect" because machining is done next to the room where DU is machined.

*The facility design has changed since the beginning of the PHA.

These wastes react exothermically with moisture and violently with water, producing hydrogen, a flammable and explosive gas. Reactivity increases as the waste is divided more finely. The treatment process consists of controlled hydration in a humid atmosphere to eliminate the RCRA reactivity characteristic. The product of hydrating these reactive wastes is a caustic hydroxide with RCRA corrosivity characteristics, and neutralization will be required. However, lithium hydroxide could be incorporated in the incinerator ash vitrification process, which requires lithium. The DU left after treatment of the reactive waste may be treated according to a process developed for uranium chips and turnings and for which a separate process has been designed (described below)

When the RCRA reactivity characteristics have been eliminated, the resulting waste will be solidified before disposal if it is a low-level waste. Solidification is not mandatory if the waste is not radioactive. A detailed description of this treatment process can be found in Ref. A-3.

Process Description

Lithium hydride is present in various physical forms and packaging configurations. Some chunks mixed with DU will have relatively low reactivity even when exposed to moist air because of the low surface area. However, most of the lithium hydride is in a sandy to powdery form. A powder is much more reactive; it probably is often stored in small, individual bags weighing less than 1 kg, with only a few of these bags stored in each 30-gal. drum, which is placed in a 55-gal. overpack with vermiculite. However, the bulk is stored in drums with plastic liners in quantities up to 75 kg. Lithium hydride also can be found in small quantities mixed with cleaning material and discarded parts. Magnesium and calcium machining debris are probably stored in small bags.

One waste container at the time is brought into the R.C. (radioactive and characteristic) treatment area and introduced into a dry box. Although the probability of gas generation and accumulation in the container is low, the dry box is connected to the room ventilation system. Some of the waste to be treated is spread on a tray in a relatively thin layer. Because of the variety of the waste's physical and chemical forms, the weight and depth on the tray will vary. The tray is introduced into a reactor, which then is sealed. The remaining reactive waste is sealed back in the original container. Piping connections are secured to the reactor. A humidifier provides a water-saturated atmosphere, nitrogen, or some other inert gas, which is introduced into the reactor at a controlled rate. It hydrates the reactive waste according to one of the following exothermic reactions.

$$LiH + H_2O \longrightarrow LiOH + H_2$$

$$Mg + 2H_2O \longrightarrow Mg(OH)_2 + H_2$$

$$Ca + 2H_2O \longrightarrow Ca(OH)_2 + H_2$$

If air were used for the reactive wastes, strongly exothermic and uncontrollable oxidation reactions could take place.

The gas flow rate is adjusted according to the kinetics of the reaction of the waste with water. The gas passes through a scrubber, which will cool it in case of uncontrolled oxidation, and then through the room HEPA filter. A hydrogen analyzer on the exhaust gas indicates the hydrogen concentration and redirects the feed gas to bypass the humidifier if required. The concentration also indicates how fast the reaction is going, whether adjustment is needed, and when it nears or reaches completion.

The hydroxide formed during treatment is removed from the reactor; it is caustic and has the RCRA corrosivity characteristic. It is neutralized in another unit with an acid and filtered to remove any DU and to separate other solid contaminants when present. If not radioactive, the neutralized waste then can be discarded as is or solidified in cement. Finally, if DU is present in a finely divided and/or reactive state, the waste may have to be treated in yet another unit. The uranium will not be very reactive because it will have been exposed to a humid atmosphere, a condition that oxidizes it more readily than air. However, it still may be advisable to treat it. A process devised for treating uranium chips and turnings can be used.

PHA Results

The feed and waste disposal streams for the Water Reactive Waste Treatment Process are shown in Fig. A-3. A process block diagram summarizing the steps in the waste treatment process is shown in Fig. A-4. The blocks or process steps shown in Fig. A-4 are grouped into activities to facilitate the PHA. The activity boundaries and names (i.e., LIH1, LIH2, . . .) also are indicated in Fig. A-4. Each activity was reviewed by the PHA team to identify scenarios contributing to process risk. The results of this risk assessment are presented in Tables A-1 and A-2. Table A-1 presents the scenarios sorted by activity. Scenarios ranked by risk (highest to lowest risk rank) are presented in Table A-2.

DEPLETED URANIUM OXIDATION PROCESS

Introduction

DU chips from machining operations currently are stored at the Laboratory in 30-gal. drums. The drums are filled with uranium chips and covered with diesel oil, and the 30-gal. drum is stored in a 55-gal. overpack filled with vermiculite. A treatment skid has been designed for processing these drums. It consists primarily of the reactor vessel, a surge/settler tank, recirculation pumps, a scrubber system, a cooling water loop, and piping and valves associated with the introduction of reagents and transfer of the uranium dioxide sediment to the cementation drum. The treatment process consists of draining the oil from the chips in an inert atmosphere and oxidizing the uranium in a controlled manner. The resulting uranium hydroxide slurry is reduced to a uranium dioxide sediment by adding sodium thiosulfate. The sediment then is cemented and transferred to storage until final disposition. A detailed description of this treatment process can be found in Ref. A-4.

Process Description

The DU process flow diagram is presented in Fig. A-5 (drawing number 11104-DU-KD-01 from Ref. A-4). One 30-gal. drum of DU waste is processed at a time. The waste drum, in a 55-gal. overpack, is transferred from the MWRSF dock to the door of the treatment room where the DU process skid has been installed. The HWTF overhead crane is used to move the drum into the sample room.

In the sample room, the overpack drum is opened and the inner (i.e., primary) drum is removed from the overpack with the overhead crane. The primary drum is opened, and the contents are inspected visually to verify them. The lid then is replaced and clamped on the primary drum. It is estimated that about 200 g of water will be left at the bottom of the drum. This water will react over time with uranium and generate hydrogen. Empty spaces in both the 30-gal. drum and 55-gal. overpack drum may be filled with hydrogen, a flammable and explosive gas. To safeguard against ignition of any hydrogen that may be present, two safety provisions are in place: (1) anti-spark tools are used for opening both the overpack and primary drums and (2) the drums are opened under a ventilation hood to quickly dilute the hydrogen below the flammability limit.

The sealed primary waste drum then is transferred to the treatment skid with the overhead crane. After the drum is placed in the reactor, the reactor lid is closed and the reactor is purged with nitrogen. The drum's lid and bottom are then punctured by hollow, angled spikes. After the oil has been drained to the waste oil drum, closed-loop circulation of water through the reactor is begun.

The oxidation reaction is initiated by adding sodium hypochlorite to the circulating water. The circulating liquid is sampled every 20 min to analyze for depletion of the sodium hypochlorite reactant or for a lack of further reaction even though there is enough active sodium hypochlorite present. During the oxidation process, the pH is adjusted with caustic if necessary.

After the oxidation process is complete, the uranium hydroxide slurry is transferred to the surge/settler tank. After establishing circulation, sodium thiosulfate is added to reduce the uranium hydroxide to uranium dioxide. The reaction is complete when samples show excess thiosulfate content and minimal hypochlorite. The uranium dioxide is allowed to settle, the clear liquid is shipped to TA-50-1, and the sediment is pumped to the cementation drum. After cementation, the cement drum is transferred to TA-54.

PHA Results

The feed and waste disposal streams for the Depleted Uranium Waste Treatment Process are shown in Fig. A-6. Figure A-7 is a process block diagram summarizing the steps in the waste treatment process. The blocks or process steps shown in Fig. A-7 are grouped into activities to facilitate the PHA. The activity boundaries and names (i.e., DU1, DU2, . . .) also are indicated on Fig. A-7. Each activity was reviewed by the PHA team to identify scenarios contributing to process risk. The results of this risk assessment are given in Tables A-3 and A-4. Table A-3 presents the scenarios sorted by activity. Scenarios are ranked by risk (highest to lowest risk rank) in Table A-4.

CHEMICAL PLATING WASTE TREATMENT PROCESS

Introduction

The Chemical Plating Waste (CPW) treatment system is intended to treat listed, characteristic, and mixed aqueous waste solutions to remove the hazardous components. The CPW system will remove hazardous waste constituents to levels several orders of magnitude lower than the original feed by using the EPA-approved BDAT process for electroplating wastes. Typical waste solutions requiring treatment are cyanide plating wastes, chromic acid plating wastes, metals plating wastes, and ammonia-bearing plating wastes or solutions with similar compositions. Any of these wastes may be considered mixed wastes if a DU component is present. A detailed description of this treatment process can be found in Ref. A-5. The treatment process is described briefly below.

Process Description

The CPW process flow diagram is presented in Fig. A-8 (drawing number 11120-CPW-KD-01 from Ref. A-5). The treatment skid consists primarily of the reactor vessel (used for mixing the CPW feed and appropriate reagents), a filter press, a recirculation and transfer pump, a scrubber system, a cooling water system for reactor vessel cooling, and mixing tanks and hoppers for introducing reagents. One or more treatment processes must be used, depending on the waste material being treated. Five main categories of waste treatment are described in Ref. A-5.

1. Elimination of free cyanide and metal-cyanide complexes

2. Elimination of ammonia in solution

3. Reduction of Cr_6 to Cr_3, precipitation, solids separation, and immobilization

4. Heavy-metal precipitation, solids separation, and immobilization

5. Acid or base neutralization

Wastes typically requiring multiple steps will follow the order listed above to minimize hazardous gas formation or to ensure maximum treatment. The steps described below are generic in that they apply to any batch or drum of plating waste introduced to the CPW skid.

The waste drum (in a 55-gal. overpack) is transferred from the MWRSF dock to the door of the treatment room in which the CPW process skid has been installed. The HWTF overhead crane is used to move the drum into the sample room. The overpack drum is opened, and the inner (i.e., primary drum) is removed with the overhead crane. The primary drum then is opened, and the contents are inspected visually and assayed to verify the constituents. The lid then is replaced and clamped on the primary drum. To safeguard against ignition of any hydrogen that may be present in the overpack or the primary drum, there are two safety provisions: (1) anti-spark tools are used for opening the drums and (2) the drums are opened under a ventilation hood to quickly dilute any hydrogen below the flammability limit.

The sealed primary waste drum then is transferred to the treatment skid with the HWTF overhead crane. After the process service systems are started and their operability is verified (e.g., reactor cooling system, monitoring systems, nitrogen purge), a pumping assembly is attached to the top of the drum, and the plating waste is pumped into the reactor.

Reagents are added to the reactor to obtain the desired reaction. For example, if cyanide is found to be present in concentrations above 0.2 mg/L, cyanide destruction treatment must be performed by adding strong oxidizing agents (e.g., sodium hypochlorite). If needed, caustic soda is added to maintain a pH greater than 10. Maintaining this pH level is critical to avoid the formation of cyanogen chloride gas. The scrubbing system treats any vented offgas from the reactor. When the reaction is verified as complete by monitoring temperature and pH and performing sample assays, the treated waste solution is filtered through the plate and frame filter. Any solids recovered will be immobilized in a drum using cement. The liquids will sent to TA-50-1 or cemented with the solids.

PHA Results

The feed and waste disposal streams for the Chemical Plating Waste Treatment Process are indicated in Fig. A-9. A process block diagram summarizing the steps in the waste treatment process is shown in Fig. A-10. The blocks or process steps shown in Fig. A-10 are grouped into activities to facilitate the PHA. The activity boundaries and names (i.e., CY1, CY2, . . .) also are indicated on Fig. A-10. Each activity was reviewed by the PHA team to identify scenarios contributing to process risk. The results of this risk assessment are presented in Tables A-5 and A-6. Table A-5 presents the scenarios sorted by activity. Scenarios are ranked by risk, highest to lowest risk rank, in Table A-6.

GAS CYLINDER DISPOSAL/RECONTAINERIZATION PROCESS

Introduction

The gas cylinder process skid will provide a means to characterize, recontainer, and dispose of gas cylinders (legacy and nonlegacy) currently stored in an open area at Los Alamos. Although the contents of most stored cylinders are fully characterized and identified, the contents of approximately 10% of the cylinders are unknown. Cylinder contents must receive identification and/or verification analyses before offsite shipment and treatment. Some cylinders may be unacceptable for shipment in their present form and may require that the contents be transferred to DOT-approved, shippable containers.

A particular concern exists for the special case of nonoperable/nonshipable cylinders with unknown contents. These cylinders are not amenable to standard sampling techniques and would require some form of intrusive sampling such as provided by the recontainerization process skid.

Process Description

The recontainerization skid consists of a pressure vessel into which a problem cylinder is placed. The pressure vessel can be purged with an inert gas or be evacuated. After the pressure vessel atmosphere is prepared, the cylinder is cut open using a rotary saw, releasing the gas contents of the cylinder into the pressure vessel. The gas is held in the pressure vessel for in-line sampling and analysis (e.g., mass spectrometer, infrared spectrometer, radiation screening), then either compressed into new gas cylinders acceptable for storage and transportation; if the gas is inert, it may be vented to the atmosphere. A scrubbing solution then is sprayed into the empty cylinder after recontainerization to remove residual deposits. The old cylinder then is sent to the landfill (TA-54) for disposition.

A process block diagram summarizing the steps in the gas cylinder recontainerization process is presented in Fig. A-11. The blocks or process steps shown in Fig. A-11 are grouped into activities. The activity boundaries and names (i.e., GC1, GC2, . . .) are also indicated in Fig. A-10.

PHA Results

Each activity was reviewed by the PHA team to identify scenarios contributing to process risk. The results of this risk assessment are presented in Tables A-7 and A-8. Table A-7 presents the scenarios sorted by activity. Scenarios are ranked by risk (highest to lowest risk rank) in Table A-8.

REFERENCES

A-1. "Hazardous Waste Treatment Facility: Description of the Treatment Building," HWTF-EM7-TDF-001-R00.

A-2. "Hazardous Waste Treatment Facility Treatment Room Designs," November 7, 1991, Guy Lussiez, EM-7, E517.

A-3. "Preliminary Hazard Analysis for the Treatment of Low-Level Water Reactive Wastes," November 1991, Evaluator: Guy Lussiez, EM-7.

A-4. "Depleted Uranium Oxidation Process for Mixed Waste Treatment at the HWTF," Detailed Design Volume I, September 29, 1992, Santa Fe Engineering Team, Santa Fe, New Mexico.

A-5. "Chemical Plating Waste Treatment Process at the HWTF," Detailed Design Vol. I; DRAFT, July 30, 1993, Santa Fe Engineering Team, Santa Fe, New Mexico.

TABLE A-1
HAZMAN RESULTS SORTED BY ACTIVITY FOR WATER REACTIVE WASTES

PRELIMINARY HAZARD/RISK ANALYSIS RECORD BY ACTIVITY FOR MWRSF

ACTIVITY NUMBER: LIH1

ACTIVITY NAME: TRUCK ENTERS FACILITY AND DRIVES TO MWRSF DOCK (LIH PROCESS)

ACTIVITY DESCRIPTION: TRUCK ENTERS GATE AT FENCE AND DRIVES TO DOCK

R--F--C	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
3 III B	TRUCK ACCIDENT WITH FIRE AND BREACH OF LITHIUM HYDRIDE WASTE CONTAINER.	LITHIUM HYDRIDE RELEASE TO ATMOSPHERE DUE TO BURNING OF LIH POWDER. TRUCK DRIVER EXPOSURE TO LIH/DU AND MINOR DEPLETED URANIUM CONTAMINATION WITHIN THE FACILITY. (D;D;B;D).		ADMINISTRATIVE CONTROLS SUCH AS (1) ANNOUNCEMENT OF DELIVERY, (2) DRIVER TRAINING, (3) RESTRICT OTHER TRAFFIC DURING DELIVERY, (4) NO WET WEATHER DELIVERIES.
3 III B	TRUCK ACCIDENT AND BREACH OF MULTIPLE CONTAINERS OF INCOMPATIBLE WASTES.	H2 GAS RELEASED AND DISPERSED. POSSIBLE FIRE, DRIVER EXPOSED TO LIH/DU AND MINOR DEPLETED URANIUM CONTAMINATION WITHIN THE FACILITY. (D;D;B;D).		ADMINISTRATIVE CONTROLS SUCH AS (1) ANNOUNCEMENT OF DELIVERY, (2) DRIVER TRAINING, (3) RESTRICT OTHER TRAFFIC DURING DELIVERY, (4) NO WET WEATHER DELIVERIES, (5) DO NOT TRANSPORT INCOMPATIBLE WASTES TOGETHER (6) TRANSPORT ONE DRUM AT A TIME

PRELIMINARY HAZARD/RISK ANALYSIS RECORD BY ACTIVITY FOR HWRSF

ACTIVITY NUMBER: LIH2

ACTIVITY NAME: WALK BEHIND FORKLIFT TRANSFERS LITHIUM HYDRIDE WASTE DRUM TO ENCLOSED STORAGE ROOM.

ACTIVITY DESCRIPTION: WALK BEHIND FORKLIFT PICKS UP DRUM, MOVES TO STORAGE, AND PLACES INTO STORAGE (SINGLE DRUM HIGH IN AN ENCLOSED ROOM).

R--F--C	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
3 III C	LITHIUM HYDRIDE WASTE DRUM PUSHED OFF DOCK OR TRUCK BY FORKLIFT.	CONTAINER BREACH, LIH/DU SPILL IN DOCK AREA, CONTACT WITH WATER, POSSIBLE FIRE AND WORKER INJURY (D;D;C;C).	NONE	ENSURE THAT THE LOADING/UNLOADING AREA, INCLUDING THE SUMP IS DRY PRIOR TO DELIVERY.
3 III C	FORKLIFT DRIVES OFF DOCK OR TRUCK WHILE TRANSPORTING LITHIUM HYDRIDE WASTE DRUM.	CONTAINER BREACH, IGNITION OF LIH/DU SPILLED IN DOCK AREA DUE TO CONTACT WITH WATER OR INCOMPATIBLE WASTES, POSSIBLE FIRE AND WORKER INJURY (D;D;C;C).	NONE	H2O SPRINKLER SYSTEM IS NOT RECOMMENDED.
3 IV A	LITHIUM HYDRIDE WASTE DRUM PUSHED OFF DOCK OR TRUCK BY FORKLIFT.	CONTAINER BREACH, SPILL OF LIH/DU AND CONTACT WITH WATER IN SUMP, EXPLOSION DUE TO EXPLOSIVE MIXTURE, POSSIBLE WORKER FATALITY. (D;D;A;C)	NONE	ENSURE THAT THE LOADING/UNLOADING AREA, INCLUDING THE SUMP IS DRY PRIOR TO DELIVERY.
3 IV A	FORKLIFT DRIVES OFF DOCK OR TRUCK WHILE TRANSPORTING LITHIUM HYDRIDE WASTE DRUM.	CONTAINER BREACH, SPILL OF LIH/DU AND CONTACT WITH WATER IN SUMP, EXPLOSION DUE TO EXPLOSIVE MIXTURE, POSSIBLE WORKER FATALITY. (D;D;A;C)	NONE	ENSURE THAT THE LOADING/UNLOADING AREA, INCLUDING THE SUMP IS DRY PRIOR TO DELIVERY.
4 IV C	LITHIUM HYDRIDE WASTE DRUM PUNCTURED BY FORKLIFT.	POTENTIAL RELEASE/SPILL OF LIH/DU IN THE LOADING DOCK AREA. POTENTIAL WORKER EXPOSURE (LIH AND DU). (D;D;C;D)	NONE	DRIVER SHOULD HAVE BREATHING APPARATUS AVAILABLE (WITHIN REACH), BREATHING OF LIH POWDER IS HAZARDOUS.

PRELIMINARY HAZARD/RISK ANALYSIS RECORD BY ACTIVITY FOR HWRSF

ACTIVITY NUMBER: LIH3

ACTIVITY NAME: WALK BEHIND FORKLIFT MOVES LITHIUM HYDRIDE DRUM TO DOCK FROM ENCLOSED STORAGE ROOM

ACTIVITY DESCRIPTION: WALK BEHIND FORKLIFT TRANSPORTS DRUM FROM STORAGE TO DOCK.

R--F--C	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
3 III C	LITHIUM HYDRIDE WASTE DRUM PUSHED OFF DOCK BY FORKLIFT.	CONTAINER BREACH, LIH SPILL IN DOCK AREA, CONTACT WITH WATER, POSSIBLE FIRE AND WORKER INJURY (D;D;C;C).	NONE	ENSURE THAT THE LOADING/UNLOADING AREA, INCLUDING THE SUMP IS DRY PRIOR TO DELIVERY.
3 III C	FORKLIFT DRIVES OFF DOCK WHILE TRANSPORTING LITHIUM HYDRIDE WASTE DRUM.	CONTAINER BREACH, IGNITION OF LIH SPILLED IN DOCK AREA DUE TO CONTACT WITH WATER OR INCOMPATIBLE WASTES, POSSIBLE FIRE AND WORKER INJURY (D;D;C;C).	NONE	H2O SPRINKLER SYSTEM IS NOT RECOMMENDED.
3 IV A	LITHIUM HYDRIDE WASTE DRUM PUSHED OFF DOCK BY FORKLIFT.	CONTAINER BREACH, SPILL OF LIH AND CONTACT WITH WATER IN SUMP, EXPLOSION DUE TO EXPLOSIVE MIXTURE, POSSIBLE WORKER FATALITY. (D;D;A;C)	NONE	ENSURE THAT THE LOADING/UNLOADING AREA, INCLUDING THE SUMP IS DRY PRIOR TO DELIVERY.
3 IV A	FORKLIFT DRIVES OFF DOCK WHILE TRANSPORTING LITHIUM HYDRIDE WASTE DRUM.	CONTAINER BREACH, SPILL OF LIH AND CONTACT WITH WATER IN SUMP, EXPLOSION DUE TO EXPLOSIVE MIXTURE, POSSIBLE WORKER FATALITY. (D;D;A;C)	NONE	ENSURE THAT THE LOADING/UNLOADING AREA, INCLUDING THE SUMP IS DRY PRIOR TO DELIVERY.
4 IV C	LITHIUM HYDRIDE WASTE DRUM PUNCTURED BY FORKLIFT.	POTENTIAL RELEASE/SPILL OF LIH IN THE LOADING DOCK AREA. POTENTIAL WORKER EXPOSURE (LIH AND DU). (D;D;C;D)	NONE	DRIVER SHOULD HAVE BREATHING APPARATUS AVAILABLE (WITHIN REACH), BREATHING OF LIH POWDER IS HAZARDOUS.

PRELIMINARY HAZARD/RISK ANALYSIS RECORD BY ACTIVITY FOR HWTF

ACTIVITY NUMBER: LIH6

ACTIVITY NAME: YARD FORKLIFT DELIVERS LITHIUM HYDRIDE TO TREATMENT ROOM DOOR.

ACTIVITY DESCRIPTION: YARD FORKLIFT DELIVERS LITHIUM HYDRIDE WASTE DRUM FROM DOCK TO TREATMENT ROOM DOOR.

R--F--C	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
3 II C	FORKLIFT ACCIDENT DURING TRANSPORT BETWEEN BUILDINGS.	SPILL OF DRUM CONTENTS, WORKER CONTAMINATION (LIH AND DEPLETED URANIUM). ALSO FACILITY (TA) CONTAMINATION. (D;D;C;C)	NONE	(1) MOVE ONLY ONE PALLET AT A TIME, (2) RESTRICT OTHER VEHICLE DURING TRANSPORT, (3)BREATHING APPARATUS AVAILABLE TO DRIVER, WITHIN REACH, (4) NO TRANSPORTS DURING WET WEATHER CONDITIONS.
3 III B	FORKLIFT ACCIDENT DURING TRANSPORT BETWEEN BUILDINGS.	SPILL OF DRUM CONTENTS, POSSIBLE FIRE AND LITHIUM HYDRIDE FUMES INHALED BY THE DRIVER. POSSIBLE DRIVER INJURY AND CONTAMINATION WITH DEPLETED URANIUM WASTE. (D;D;B;C)	NONE	(1) MOVE ONLY ONE PALLET AT A TIME, (2) RESTRICT OTHER VEHICLE DURING TRANSPORT, (3)BREATHING APPARATUS AVAILABLE TO DRIVER, WITHIN REACH, (4) NO TRANSPORTS DURING WET WEATHER CONDITIONS.
3 III C	FORKLIFT ACCIDENT NEAR DOCK AREA.	SPILL OF LIH IN THE DOCK AREA MIXED WITH WATER IN THE SUMP, POSSIBLE FIRE AND WORKER INJURY. (D;D;C;C)	NONE	(1) MOVE ONLY ONE PALLET AT A TIME, (2) RESTRICT OTHER VEHICLE DURING TRANSPORT, (3)BREATHING APPARATUS AVAILABLE TO DRIVER, WITHIN REACH, (4) NO TRANSPORTS DURING WET WEATHER CONDITIONS, (5) ENSURE THE SUMP AND DOCK AREA ARE DRY PRIOR TO MOVING WASTE DRUMS.
3 IV A	FORKLIFT ACCIDENT NEAR DOCK AREA.	SPILL OF LIH INTO THE SUMP. EXPLOSION/FIRE DUE TO EXPLOSIVE MIXTURE, POSSIBLE FATALITY. (D;D;A;C)	NONE	(1) MOVE ONLY ONE PALLET AT A TIME, (2) RESTRICT OTHER VEHICLE DURING TRANSPORT, (3)BREATHING APPARATUS AVAILABLE

PRELIMINARY HAZARD/RISK ANALYSIS RECORD BY ACTIVITY FOR HWTF

ACTIVITY NUMBER: LIH4

ACTIVITY NAME: YARD FORKLIFT DELIVERS LITHIUM HYDRIDE TO TREATMENT ROOM DOOR.

ACTIVITY DESCRIPTION: YARD FORKLIFT DELIVERS LITHIUM HYDRIDE WASTE DRUM FROM DOCK TO TREATMENT ROOM DOOR.

R--F--C	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
				TO DRIVER, WITHIN REACH, (4) NO TRANSPORTS DURING WET WEATHER CONDITIONS, (5) ENSURE THE SUMP AND DOCK AREA ARE DRY PRIOR TO MOVING WASTE DRUMS.

PRELIMINARY HAZARD/RISK ANALYSIS RECORD BY ACTIVITY FOR HWTF

ACTIVITY NUMBER: LIH5

ACTIVITY NAME: HWTF OVERHEAD CRANE DELIVERS LITHIUM HYDRIDE DRUM TO SAMPLE ROOM.

ACTIVITY DESCRIPTION: OVERHEAD CRANE DELIVERS LITHIUM HYDRIDE DRUM TO SAMPLE ROOM.

R--F--C	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
3 III B	LITHIUM HYDRIDE WASTE DRUM DROPPED WHILE MOVING INTO SAMPLE ROOM.	CONTAINER BREACH WITH SPILL OF LIH POWDER. WORKER EXPOSURE/INHALATION OF LIH POWDER AND DEPLETED URANIUM. (D;D;B;D).	NONE	WORKER TO WEAR PROTECTIVE CLOTHING AND BREATHING APPARATUS DURING MOVEMENT OF DRUM WITH HOIST.

PRELIMINARY HAZARD/RISK ANALYSIS RECORD BY ACTIVITY FOR MWTF

ACTIVITY NUMBER: LIH6

ACTIVITY NAME: OVERPACK DRUM IS OPENED AND INNER LIH DRUM IS LIFTED WITH CRANE

ACTIVITY DESCRIPTION: OVERPACK DRUM IS GROUNDED, OPENED WITH NON-SPARK TOOLS, AND THE INNER DRUM IS LIFTED WITH THE OVERHEAD CRANE.

R--F--C	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
3 III B	DRUM CONTENTS SPILLED DUE TO: (1) CLAMP COMES LOOSE, OR (2) LID FALLS OFF; AND IGNITION OF LIH POWDER.	SPILL OF DRUM CONTENTS WITH FIRE. WORKER EXPOSURE TO LIH AND DEPLETED URANIUM POWDER AND INHALATION OF FUMES. (D;D;B;D)	NONE	OPERATORS SHOULD USE SELF CONTAINED BREATHING APPARATUS.
3 III C	OPERATOR FAILS TO FOLLOW PROCEDURE WHILE OPENING THE LIH OVERPACK (I.E., USES WRONG TOOLS, DOES NOT GROUND DRUM, MISPOSITIONING OF THE VENT HOOD, ETC...).	SHORT DURATION HYDROGEN FIRE UPON OPENING THE OVERPACK. POSSIBLE WORKER INJURY. (D;D;C;D)	NONE	OPERATORS SHOULD USE SELF CONTAINED BREATHING APPARATUS
3 III C	DRUM CONTENTS SPILLED DUE TO: (1) CLAMP COMES LOOSE, OR (2) LID FALLS OFF.	WORKER EXPOSURE TO LITHIUM HYDRIDE AND DEPLETED URANIUM. (D;D;C;D)	NONE	OPERATORS SHOULD USE SELF CONTAINED BREATHING APPARATUS.
3 IV A	RELEASE OF TOXIC GAS DUE TO UNEXPECTED MATERIALS IN LIH WASTE DRUM (PHOSGEN, HYDROGEN SULFIDE, CHLORINE, ETC...).	WORKER INJURY, POSSIBLE FATALITY. (D;D;A;D)	NONE	OPERATORS SHOULD USE SELF CONTAINED BREATHING APPARATUS.
4 IV C	OPERATOR FAILS TO FOLLOW PROCEDURE (CAUSES SPARK) AND IGNITES HYDROGEN IN THE LIH WASTE DRUM.	EXPLOSION OF SMALL QUANTITY OF AVAILABLE HYDROGEN RESTRICTED TO SPACE UNDER VENTILATION HOOD. (D;D;C;D)	NONE	OPERATORS SHOULD USE SELF CONTAINED BREATHING APPARATUS.

PRELIMINARY HAZARD/RISK ANALYSIS RECORD BY ACTIVITY FOR HWTF

ACTIVITY NUMBER: LIH7

ACTIVITY NAME: OVERPACK DRUM IS DISCARDED TO CRUSHER OR USED FOR CEMENTATION (LIH PROCESS).

ACTIVITY DESCRIPTION: OVERPACK DRUM (LITHIUM HYDRIDE PROCESS) IS DISCARDED TO CRUSHER OR USED FOR CEMENTATION. INVOLVES TRANSPORTATION TO CRUSHER OR CEMENTATION FACILITY.

R--F--C	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
MINIMAL	TRANSPORT OF EMPTY OVERPACK DRUM (LITHIUM HYDRIDE PROCESS) TO CRUSHER OR CEMENTATION FACILITY.	NONE	NONE	NONE

PRELIMINARY HAZARD/RISK ANALYSIS RECORD BY ACTIVITY FOR HWTF

ACTIVITY NUMBER: LIN8

ACTIVITY NAME: VERMICULITE REMOVED AND BAGGED (LIH PROCESS)

ACTIVITY DESCRIPTION: VERMICULITE REMOVED FROM OVERPACK, BAGGED AND SENT TO LANDFILL OR STORAGE.

R--F--C	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
4 II D	VERMICULITE CONTAMINATED WITH LIH AND DEPLETED URANIUM FROM LEAKY INNER PACK.	POSSIBLE CONTAMINATION WITH LIH/DU, AND MINOR WORKER INHALATION. (D;D;D;D)	NONE	IF THERE ARE INDICATIONS OF A LEAK WHEN REMOVING THE INNER DRUM, DONOT REMOVE THE VERMICULITE.

PRELIMINARY HAZARD/RISK ANALYSIS RECORD BY ACTIVITY FOR HWTF

ACTIVITY NUMBER: LIH9

ACTIVITY NAME: PRIMARY WASTE DRUM IS GROUNDED AND OPENED USING NON-SPARK TOOLS

ACTIVITY DESCRIPTION: PRIMARY DRUM CONTAINING LITHIUM HYDRIDE IS GROUNDED AND OPENED WITH NON-SPARK TOOLS. ASSUME SAME HAZARDS AS ACTIVITY 10, EXCEPT LESS H2 GENERATION POSSI

R--F--C	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
3 I D	LITHIUM HYDRIDE ENTRAINMENT IN THE VENT SYSTEM WHEN PRIMARY DRUM OPENED.	HEPA/SCRUBBER CONTAMINATION WITH LIH AND DEPLETED URANIUM. (D;D;D;D)	NONE	DESIGN/OPERATE HOOD VENT SUCH THAT LIH ENTRAINMENT NOT POSSIBLE.
3 III B	OPERATOR FAILS TO FOLLOW PROCEDURE WHILE OPENING LIH INNER WASTE DRUM (I.E., USES WRONG TOOLS, DRUM NOT GROUNDED, MISPOSITIONING OF THE VENT HOOD, ETC...).	SHORT DURATION HYDROGEN FIRE UPON OPENING THE PRIMARY WASTE DRUM. POSSIBLE LIH IGNITION. WORKER EXPOSURE TO LIH AND DEPLETED URANIUM, INHALATION OF FUMES. (D;D;B;C)	NONE	WORKERS SHOULD WEAR PROTECTIVE CLOTHING, AND USE SELF CONTAINED BREATHING APPARATUS.
3 IV A	RELEASE OF TOXIC GAS DUE TO UNEXPECTED MATERIALS IN LIH PRIMARY WASTE DRUM (PHOSGEN, HYDROGEN SULFIDE, CHLORINE, ETC...).	WORKER INJURY, POSSIBLE FATALITY. (D;D;A;C)	NONE	WORKERS SHOULD WEAR PROTECTIVE CLOTHING, AND USE SELF CONTAINED BREATHING APPARATUS.
3 IV B	OPERATOR FAILS TO FOLLOW PROCEDURE (CAUSES SPARK) AND IGNITES HYDROGEN IN LIH WASTE DRUM.	DISPERSAL OF LIH/DEPLETED URANIUM POWDER DUE TO EXPLOSION/FIRE. SEVERE WORKER INJURY. (D;D;B;C)	NONE	WORKERS SHOULD WEAR PROTECTIVE CLOTHING, AND USE SELF CONTAINED BREATHING APPARATUS.

PRELIMINARY HAZARD/RISK ANALYSIS RECORD BY ACTIVITY FOR HWTF

ACTIVITY NUMBER: LIH10

ACTIVITY NAME: CONTENTS OF LIH WASTE DRUM VISUALLY INSPECTED AND SAMPLED

ACTIVITY DESCRIPTION: CONTENTS OF LIH WASTE DRUM VISUALLY INSPECTED AND SAMPLED

R--F--C	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
3 III B	LIH PRIMARY DRUM OPENED AND LEFT OPEN FOR AN EXTENDED PERIOD OF TIME.	POTENTIAL LITHIUM HYDRIDE FIRE WITH SAMPLE ROOM CONTAMINATION AND WORKER INHALATION. (D;D;B;C)	NONE	MINIMIZE THE TIME THAT THE LITHIUM HYDRIDE MAY BE EXPOSED TO AIR. ROOM HUMIDITY SHOULD BE MONITORED/CONTROLLED.

PRELIMINARY HAZARD/RISK ANALYSIS RECORD BY ACTIVITY FOR HWTF

ACTIVITY NUMBER: LIH11

ACTIVITY NAME: PRIMARY LITHIUM HYDRIDE DRUM TRANSFERED TO SKID WITH CRANE.

ACTIVITY DESCRIPTION: PRIMARY LITHIUM HYDRIDE DRUM TRANSFERED TO SKID WITH CRANE.

R--F--C	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
3 III B	DRUM CONTENTS SPILLED DUE TO: (1) CLAMP COMES LOOSE, (2) LID FALLS OFF, (3) CRANE ACCIDENT.	WORKER EXPOSURE/INHALATION OF LITHIUM HYDRIDE POWDER AND DEPLETED URANIUM. (D;D;B;C)	NONE	WORKER TO WEAR PROTECTIVE CLOTHING AND BREATHING APPARATUS DURING MOVEMENT OF DRUM WITH HOIST.
3 IV B	DRUM CONTENTS SPILLED DUE TO: (1) CLAMP COMES LOOSE, (2) LID FALLS OFF, (3) CRANE ACCIDENT.	LIH SPILLED AND CONTACTS WATER IN SUMP, POSSIBLE FIRE, WORKER EXPOSURE AND INHALATION OF FUMES AND DEPLETED URANIUM. (D;D;B;C)	NONE	WORKER TO WEAR PROTECTIVE CLOTHING AND BREATHING APPARATUS DURING MOVEMENT OF DRUM WITH HOIST. ENSURE THAT THE SUMP IN THE TREATMENT ROOM IS PUMPED DRY IF POSSIBLE.

PRELIMINARY HAZARD/RISK ANALYSIS RECORD BY ACTIVITY FOR HWTF

ACTIVITY NUMBER: LIH12

ACTIVITY NAME: MANUALLY LOAD HUMIDIFIER TRAYS WITH LITHIUM HYDRIDE

ACTIVITY DESCRIPTION: MANUALLY LOAD HUMIDIFIER TRAYS WITH LITHIUM HYDRIDE

R--F--C	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
3 III B	SPILL OF LITHIUM HYDRIDE WHILE LOADING HUMIDIFIER TRAYS	POSSIBLE LITHIUM HYDRIDE FIRE, WORKER EXPOSURE/INHALATION. (D;D;B;D)	NONE	(1) WORKER SHOULD WEAR PROTECTIVE CLOTHING AND BREATHING APPARATUS (2) ENCLOSE WORKER AREA (3) PROVIDE VENTILLATION
3 III B	EXCESS LITHIUM HYDRIDE (AFTER HUMIDIFIER TRAYS FILLED) NOT RESEALED IN THE PARTIALLY FILLED DRUM.	POSSIBLE LITHIUM HYDRIDE FIRE, WORKER EXPOSURE/INHALATION. (D;D;B;D)	NONE	(1) WORKER SHOULD WEAR PROTECTIVE CLOTHING AND BREATHING APPARATUS (2) ENCLOSE LOADING AREA (3) PROVIDE VENTILATION

PRELIMINARY HAZARD/RISK ANALYSIS RECORD BY ACTIVITY FOR HWTF

ACTIVITY NUMBER: LIH13

ACTIVITY NAME: LITHIUM HYDRIDE REACTED WITH WATER IN THE HUMIDIFIER

ACTIVITY DESCRIPTION: LITHIUM HYDRIDE REACTED WITH WATER IN THE HUMIDIFIER

R--F--C	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
3 II C	EXCESS MOISTURE INTRODUCED DUE TO HUMIDIFIER MALFUNCTION OR CONTROL FAILURES (E.G., THE INLET VALVE TO THE PACK COLUMN FAILS OPEN).	TEMPERATURE EXCURSION IN THE REACTOR BED. VERY HIGH GENERATION RATE OF HYDROGEN EXCEEDS DILUTION CAPABILITY OF THE EQUIPMENT. FORMATION OF EXPLOSIVE OR FLAMMABLE MIXTURE (H2 & AIR) IN THE EXHAUST DUCT OR THE HUMIDIFIER. POSSIBLE EXPLOSION/FIRE, WORKER INJURY AND FACILITY DAMAGE/CONTAMINATION. (D;D;C;C)	NONE	(1) INCREASE DESIGN HUMIDIFIER SAFETY (2) INSTALL HUMIDITY ANALYZER, TEMPERATURE ANALYZER, AND HYDROGEN ANALYZER
3 II C	OUT OF CONTROL REACTION DUE TO THE USE OF AIR INSTEAD OF INERT GAS IN THE REACTION PROCESS (LIH PROCESS).	LITHIUM HYDRIDE EVAPORATES AND CONTAMINATES THE SCRUBBING SYSTEM. (D;D;D;C)	NONE	(1) PROCESS SAFETY MEASURES ANS ADMINISTRATIVE CONTROLS (2) PROVIDE SPECIAL CONNECTORS FOR NITROGEN GAS

PRELIMINARY HAZARD/RISK ANALYSIS RECORD BY ACTIVITY FOR HWTF

ACTIVITY NUMBER: LIH14

ACTIVITY NAME: LITHIUM OXIDE REMOVED FROM THE HUMIDIFIER AND PLACED IN THE REACTOR

ACTIVITY DESCRIPTION: LITHIUM OXIDE REMOVED FROM THE HUMIDIFIER AND PLACED IN THE REACTOR (LIH PROCESS).

R--F--C	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
2 II B	INCOMPLETE REACTION OF THE LITHIUM HYDRIDE IN THE HUMIDIFIER	POTENTIAL FOR LITHIUM HYDRIDE FIRE AND WORKER EXPOSURE TO LIH/DEPLETED URANIUM WHILE DISPOSING OF PARTIALLY REACTED WASTE. (D;D;B;D)	NONE	USE DIVERSE METHODS FOR VERIFICATION THAT THE REACTION IS COMPLETE. CONTINUE WEARING PROTECTIVE CLOTHING/BREATHING APPARATUS WHILE PROCESSING REACTION PRODUCTS.

PRELIMINARY HAZARD/RISK ANALYSIS RECORD BY ACTIVITY FOR HWTF

ACTIVITY NUMBER: LIH15

ACTIVITY NAME: SULFURIC ACID ADDED TO LITHIUM HYDROXIDE

ACTIVITY DESCRIPTION: SULFURIC ACID ADDED TO LITHIUM HYDROXIDE

R--F--C	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
3 II C	HUMAN ERROR LEADS TO H2SO4 SPILL.	WORKER INJURY DUE TO ACID BURN. (D;D;C;D)	NONE	NONE
3 III B	MIXING OF ACID (H2SO4) WITH PARTIALLY REACTED LIH (UNREACTED).	GENERATION OF HYDROGEN, POSSIBLE FIRE/EXPLOSION WITH WORKER INJURY AND FACILITY CONTAMINATION. (D;D;B;C)	NONE	MIX UNDER NITROGEN ATMOSPHERE

PRELIMINARY HAZARD/RISK ANALYSIS RECORD BY ACTIVITY FOR HWTF

ACTIVITY NUMBER: LIH16

ACTIVITY NAME: LISO4 SOLUTIONS FILTERED (LITHIUM HYDRIDE PROCESS)

ACTIVITY DESCRIPTION: LISO4 SOLUTIONS FILTERED (LITHIUM HYDRIDE PROCESS)

R--F--C	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
4 II D	LEAK OF SOLUTIONS FILTERED FROM LIH PROCESS.	MINOR WORKER EXPOSURE. (D;D;D;D)	NONE	NONE

TABLE A-2
HAZMAN RESULTS SORTED BY RISK RANK FOR WATER REACTIVE WASTES

HAZARD ANALYSIS REPORT BY RISK

R---F---C	ACT/FAC	ACTIVITY NAME	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
2 II B	LIN14 / HWTF	LITHIUM OXIDE REMOVED FROM THE HUMIDIFIER AND PLACED IN THE REACTOR	INCOMPLETE REACTION OF THE LITHIUM HYDRIDE IN THE HUMIDIFIER	POTENTIAL FOR LITHIUM HYDRIDE FIRE AND WORKER EXPOSURE TO LIH/DEPLETED URANIUM WHILE DISPOSING OF PARTIALLY REACTED WASTE. (D;D;B;D)	NONE	USE DIVERSE METHODS FOR VERIFICATION THAT THE REACTION IS COMPLETE. CONTINUE WEARING PROTECTIVE CLOTHING/BREATHING APPARATUS WHILE PROCESSING REACTION PRODUCTS.
3 I D	LIH9 / HWTF	PRIMARY WASTE DRUM IS GROUNDED AND OPENED USING NON-SPARK TOOLS	LITHIUM HYDRIDE ENTRAINMENT IN THE VENT SYSTEM WHEN PRIMARY DRUM OPENED.	HEPA/SCRUBBER CONTAMINATION WITH LIH AND DEPLETED URANIUM. (D;D;D;D)	NONE	DESIGN/OPERATE HOOD VENT SUCH THAT LIH ENTRAINMENT NOT POSSIBLE.
3 II C	LIH4 / HWTF	YARD FORKLIFT DELIVERS LITHIUM HYDRIDE TO TREATMENT ROOM DOOR.	FORKLIFT ACCIDENT DURING TRANSPORT BETWEEN BUILDINGS.	SPILL OF DRUM CONTENTS, WORKER CONTAMINATION (LIH AND DEPLETED URANIUM). ALSO FACILITY (TA) CONTAMINATION. (D;D;C;C)	NONE	(1) MOVE ONLY ONE PALLET AT A TIME, (2) RESTRICT OTHER VEHICLE DURING TRANSPORT, (3)BREATHING APPARATUS AVAILABLE TO DRIVER, WITHIN REACH, (4) NO TRANSPORTS DURING WET WEATHER CONDITIONS.
3 II C	LIH13 / HWTF	LITHIUM HYDRIDE REACTED WITH WATER IN THE HUMIDIFIER	EXCESS MOISTURE INTRODUCED DUE TO HUMIDIFIER MALFUNCTION OR CONTROL FAILURES (E.G., THE INLET VALVE TO THE PACK COLUMN FAILS OPEN).	TEMPERATURE EXCURSION IN THE REACTOR BED. VERY HIGH GENERATION RATE OF HYDROGEN EXCEEDS DILUTION CAPABILITY OF THE EQUIPMENT. FORMATION OF EXPLOSIVE OR FLAMMABLE MIXTURE (H2 & AIR) IN THE EXHAUST DUCT OR THE HUMIDIFIER. POSSIBLE EXPLOSION/FIRE, WORKER INJURY AND FACILITY DAMAGE/CONTAMINATION. (D;D;C;C)	NONE	(1) INCREASE DESIGN HUMIDIFIER SAFETY (2) INSTALL HUMIDITY ANALYZER, TEMPERATURE ANALYZER, AND HYDROGEN ANALYZER
3 II C	LIH13 / HWTF	LITHIUM HYDRIDE REACTED WITH WATER IN THE HUMIDIFIER	OUT OF CONTROL REACTION DUE TO THE USE OF AIR INSTEAD OF INERT GAS IN THE REACTION PROCESS (LIH PROCESS).	LITHIUM HYDRIDE EVAPORATES AND CONTAMINATES THE SCRUBBING SYSTEM. (D;D;D;C)	NONE	(1) PROCESS SAFETY MEASURES ANS ADMINISTRATIVE CONTROLS (2) PROVIDE SPECIAL CONNECTORS FOR NITROGEN GAS
3 II C	LIH15 / HWTF	SULFURIC ACID ADDED TO LITHIUM HYDROXIDE	HUMAN ERROR LEADS TO H2SO4 SPILL.	WORKER INJURY DUE TO ACID BURN. (D;D;C;D)	NONE	NONE
3 III B	LIH4 / HWTF	YARD FORKLIFT DELIVERS LITHIUM HYDRIDE TO TREATMENT ROOM DOOR.	FORKLIFT ACCIDENT DURING TRANSPORT BETWEEN BUILDINGS.	SPILL OF DRUM CONTENTS, POSSIBLE FIRE AND LITHIUM HYDRIDE FUMES INHALED BY THE DRIVER. POSSIBLE DRIVER INJURY AND CONTAMINATION WITH DEPLETED URANIUM WASTE. (D;D;B;C)	NONE	(1) MOVE ONLY ONE PALLET AT A TIME, (2) RESTRICT OTHER VEHICLE DURING TRANSPORT, (3)BREATHING APPARATUS AVAILABLE TO DRIVER, WITHIN REACH, (4) NO TRANSPORTS DURING WET WEATHER CONDITIONS.

HAZARD ANALYSIS REPORT BY RISK

R---F---C	ACT/FAC	ACTIVITY NAME	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
3 III B	LIH5 / HWTF	HWTF OVERHEAD CRANE DELIVERS LITHIUM HYDRIDE DRUM TO SAMPLE ROOM.	LITHIUM HYDRIDE WASTE DRUM DROPPED WHILE MOVING INTO SAMPLE ROOM.	CONTAINER BREACH WITH SPILL OF LIH POWDER. WORKER EXPOSURE/INHALATION OF LIH POWDER AND DEPLETED URANIUM. (D;D;B;D).	NONE	WORKER TO WEAR PROTECTIVE CLOTHING AND BREATHING APPARATUS DURING MOVEMENT OF DRUM WITH HOIST.
3 III B	LIH15 / HWTF	SULFURIC ACID ADDED TO LITHIUM HYDROXIDE	MIXING OF ACID (H2SO4) WITH PARTIALLY REACTED LIH (UNREACTED).	GENERATION OF HYDROGEN, POSSIBLE FIRE/EXPLOSION WITH WORKER INJURY AND FACILITY CONTAMINATION. (D;D;B;C)	NONE	MIX UNDER NITROGEN ATMOSPHERE
3 III B	LIH10 / HWTF	CONTENTS OF LIH WASTE DRUM VISUALLY INSPECTED AND SAMPLED	LIH PRIMARY DRUM OPENED AND LEFT OPEN FOR AN EXTENDED PERIOD OF TIME.	POTENTIAL LITHIUM HYDRIDE FIRE WITH SAMPLE ROOM CONTAMINATION AND WORKER INHALATION. (D;D;B;C)	NONE	MINIMIZE THE TIME THAT THE LITHIUM HYDRIDE MAY BE EXPOSED TO AIR. ROOM HUMIDITY SHOULD BE MONITORED/CONTROLLED.
3 III B	LIH12 / HWTF	MANUALLY LOAD HUMIDIFIER TRAYS WITH LITHIUM HYDRIDE	SPILL OF LITHIUM HYDRIDE WHILE LOADING HUMIDIFIER TRAYS	POSSIBLE LITHIUM HYDRIDE FIRE, WORKER EXPOSURE/INHALATION. (D;D;B;D)	NONE	(1) WORKER SHOULD WEAR PROTECTIVE CLOTHING AND BREATHING APPARATUS (2) ENCLOSE WORKER AREA (3) PROVIDE VENTILLATION
3 III B	LIH12 / HWTF	MANUALLY LOAD HUMIDIFIER TRAYS WITH LITHIUM HYDRIDE	EXCESS LITHIUM HYDRIDE (AFTER HUMIDIFIER TRAYS FILLED) NOT RESEALED IN THE PARTIALLY FILLED DRUM.	POSSIBLE LITHIUM HYDRIDE FIRE, WORKER EXPOSURE/INHALATION. (D;D;B;D)	NONE	(1) WORKER SHOULD WEAR PROTECTIVE CLOTHING AND BREATHING APPARATUS (2) ENCLOSE LOADING AREA (3) PROVIDE VENTILATION
3 III B	LIH1 / MWRSF	TRUCK ENTERS FACILITY AND DRIVES TO MWRSF DOCK (LIH PROCESS)	TRUCK ACCIDENT WITH FIRE AND BREACH OF LITHIUM HYDRIDE WASTE CONTAINER.	LITHIUM HYDRIDE RELEASE TO ATMOSPHERE DUE TO BURNING OF LIH POWDER. TRUCK DRIVER EXPOSURE TO LIH/DU AND MINOR DEPLETED URANIUM CONTAMINATION WITHIN THE FACILITY. (D;D;B;D).		ADMINISTRATIVE CONTROLS SUCH AS (1) ANNOUNCEMENT OF DELIVERY, (2) DRIVER TRAINING, (3) RESTRICT OTHER TRAFFIC DURING DELIVERY, (4) NO WET WEATHER DELIVERIES.
3 III B	LIH1 / MWRSF	TRUCK ENTERS FACILITY AND DRIVES TO MWRSF DOCK (LIH PROCESS)	TRUCK ACCIDENT AND BREACH OF MULTIPLE CONTAINERS OF INCOMPATIBLE WASTES.	H2 GAS RELEASED AND DISPERSED. POSSIBLE FIRE, DRIVER EXPOSED TO LIH/DU AND MINOR DEPLETED URANIUM CONTAMINATION WITHIN THE FACILITY. (D;D;B;D).		ADMINISTRATIVE CONTROLS SUCH AS (1) ANNOUNCEMENT OF DELIVERY, (2) DRIVER TRAINING, (3) RESTRICT OTHER TRAFFIC DURING DELIVERY, (4) NO WET WEATHER DELIVERIES, (5) DO NOT TRANSPORT INCOMPATIBLE WASTES TOGETHER (6) TRANSPORT ONE DRUM AT A TIME
3 III B	LIH6 / HWTF	OVERPACK DRUM IS OPENED AND INNER LIH DRUM IS LIFTED WITH CRANE	DRUM CONTENTS SPILLED DUE TO: (1) CLAMP COMES LOOSE, OR (2) LID FALLS OFF; AND IGNITION OF LIH POWDER.	SPILL OF DRUM CONTENTS WITH FIRE. WORKER EXPOSURE TO LIH AND DEPLETED URANIUM POWDER AND INHALATION OF FUMES. (D;D;B;D)	NONE	OPERATORS SHOULD USE SELF CONTAINED BREATHING APPARATUS.

HAZARD ANALYSIS REPORT BY RISK

R---F---C	ACT/FAC	ACTIVITY NAME	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
3 III B	LIH9 / HWTF	PRIMARY WASTE DRUM IS GROUNDED AND OPENED USING NON-SPARK TOOLS	OPERATOR FAILS TO FOLLOW PROCEDURE WHILE OPENING LIH INNER WASTE DRUM (I.E., USES WRONG TOOLS, DRUM NOT GROUNDED, MISPOSITIONING OF THE VENT HOOD, ETC...).	SHORT DURATION HYDROGEN FIRE UPON OPENING THE PRIMARY WASTE DRUM. POSSIBLE LIH IGNITION. WORKER EXPOSURE TO LIH AND DEPLETED URANIUM, INHALATION OF FUMES. (D;D;B;C)	NONE	WORKERS SHOULD WEAR PROTECTIVE CLOTHING, AND USE SELF CONTAINED BREATHING APPARATUS.
3 III B	LIH11 / HWTF	PRIMARY LITHIUM HYDRIDE DRUM TRANSFERED TO SKID WITH CRANE.	DRUM CONTENTS SPILLED DUE TO: (1) CLAMP COMES LOOSE, (2) LID FALLS OFF, (3) CRANE ACCIDENT.	WORKER EXPOSURE/INHALATION OF LITHIUM HYDRIDE POWDER AND DEPLETED URANIUM. (D;D;B;C)	NONE	WORKER TO WEAR PROTECTIVE CLOTHING AND BREATHING APPARATUS DURING MOVEMENT OF DRUM WITH HOIST.
3 III C	LIH2 / HWRSF	WALK BEHIND FORKLIFT TRANSFERS LITHIUM HYDRIDE WASTE DRUM TO ENCLOSED STORAGE ROOM.	LITHIUM HYDRIDE WASTE DRUM PUSHED OFF DOCK OR TRUCK BY FORKLIFT.	CONTAINER BREACH, LIH/DU SPILL IN DOCK AREA, CONTACT WITH WATER, POSSIBLE FIRE AND WORKER INJURY (D;D;C;C).	NONE	ENSURE THAT THE LOADING/UNLOADING AREA, INCLUDING THE SUMP IS DRY PRIOR TO DELIVERY.
3 III C	LIH2 / HWRSF	WALK BEHIND FORKLIFT TRANSFERS LITHIUM HYDRIDE WASTE DRUM TO ENCLOSED STORAGE ROOM.	FORKLIFT DRIVES OFF DOCK OR TRUCK WHILE TRANSPORTING LITHIUM HYDRIDE WASTE DRUM.	CONTAINER BREACH, IGNITION OF LIH/DU SPILLED IN DOCK AREA DUE TO CONTACT WITH WATER OR INCOMPATIBLE WASTES, POSSIBLE FIRE AND WORKER INJURY (D;D;C;C).	NONE	H2O SPRINKLER SYSTEM IS NOT RECOMMENDED.
3 III C	LIH3 / HWRSF	WALK BEHIND FORKLIFT MOVES LITHIUM HYDRIDE DRUM TO DOCK FROM ENCLOSED STORAGE ROOM	LITHIUM HYDRIDE WASTE DRUM PUSHED OFF DOCK BY FORKLIFT.	CONTAINER BREACH, LIH SPILL IN DOCK AREA, CONTACT WITH WATER, POSSIBLE FIRE AND WORKER INJURY (D;D;C;C).	NONE	ENSURE THAT THE LOADING/UNLOADING AREA, INCLUDING THE SUMP IS DRY PRIOR TO DELIVERY.
3 III C	LIH3 / HWRSF	WALK BEHIND FORKLIFT MOVES LITHIUM HYDRIDE DRUM TO DOCK FROM ENCLOSED STORAGE ROOM	FORKLIFT DRIVES OFF DOCK WHILE TRANSPORTING LITHIUM HYDRIDE WASTE DRUM.	CONTAINER BREACH, IGNITION OF LIH SPILLED IN DOCK AREA DUE TO CONTACT WITH WATER OR INCOMPATIBLE WASTES, POSSIBLE FIRE AND WORKER INJURY (D;D;C;C).	NONE	H2O SPRINKLER SYSTEM IS NOT RECOMMENDED.
3 III C	LIH4 / HWTF	YARD FORKLIFT DELIVERS LITHIUM HYDRIDE TO TREATMENT ROOM DOOR.	FORKLIFT ACCIDENT NEAR DOCK AREA.	SPILL OF LIH IN THE DOCK AREA MIXED WITH WATER IN THE SUMP, POSSIBLE FIRE AND WORKER INJURY. (D;D;C;C)	NONE	(1) MOVE ONLY ONE PALLET AT A TIME, (2) RESTRICT OTHER VEHICLE DURING TRANSPORT, (3)BREATHING APPARATUS AVAILABLE TO DRIVER, WITHIN REACH, (4) NO TRANSPORTS DURING WET WEATHER CONDITIONS, (5) ENSURE THE SUMP AND DOCK AREA ARE DRY PRIOR TO MOVING WASTE DRUMS.

HAZARD ANALYSIS REPORT BY RISK

R---F---C	ACT/FAC	ACTIVITY NAME	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
3 III C	LIN6 / HWTF	OVERPACK DRUM IS OPENED AND INNER LIH DRUM IS LIFTED WITH CRANE	OPERATOR FAILS TO FOLLOW PROCEDURE WHILE OPENING THE LIH OVERPACK (I.E., USES WRONG TOOLS, DOES NOT GROUND DRUM, MISPOSITIONING OF THE VENT HOOD, ETC...).	SHORT DURATION HYDROGEN FIRE UPON OPENING THE OVERPACK. POSSIBLE WORKER INJURY. (D;D;C;D)	NONE	OPERATORS SHOULD USE SELF CONTAINED BREATHING APPARATUS
3 III C	LIN6 / HWTF	OVERPACK DRUM IS OPENED AND INNER LIH DRUM IS LIFTED WITH CRANE	DRUM CONTENTS SPILLED DUE TO: (1) CLAMP COMES LOOSE, OR (2) LID FALLS OFF.	WORKER EXPOSURE TO LITHIUM HYDRIDE AND DEPLETED URANIUM. (D;D;C;D)	NONE	OPERATORS SHOULD USE SELF CONTAINED BREATHING APPARATUS.
3 IV A	LIN2 / HWRSF	WALK BEHIND FORKLIFT TRANSFERS LITHIUM HYDRIDE WASTE DRUM TO ENCLOSED STORAGE ROOM.	LITHIUM HYDRIDE WASTE DRUM PUSHED OFF DOCK OR TRUCK BY FORKLIFT.	CONTAINER BREACH, SPILL OF LIH/DU AND CONTACT WITH WATER IN SUMP, EXPLOSION DUE TO EXPLOSIVE MIXTURE, POSSIBLE WORKER FATALITY. (D;D;A;C)	NONE	ENSURE THAT THE LOADING/UNLOADING AREA, INCLUDING THE SUMP IS DRY PRIOR TO DELIVERY.
3 IV A	LIN2 / HWRSF	WALK BEHIND FORKLIFT TRANSFERS LITHIUM HYDRIDE WASTE DRUM TO ENCLOSED STORAGE ROOM.	FORKLIFT DRIVES OFF DOCK OR TRUCK WHILE TRANSPORTING LITHIUM HYDRIDE WASTE DRUM.	CONTAINER BREACH, SPILL OF LIH/DU AND CONTACT WITH WATER IN SUMP, EXPLOSION DUE TO EXPLOSIVE MIXTURE, POSSIBLE WORKER FATALITY. (D;D;A;C)	NONE	ENSURE THAT THE LOADING/UNLOADING AREA, INCLUDING THE SUMP IS DRY PRIOR TO DELIVERY.
3 IV A	LIN3 / HWRSF	WALK BEHIND FORKLIFT MOVES LITHIUM HYDRIDE DRUM TO DOCK FROM ENCLOSED STORAGE ROOM	LITHIUM HYDRIDE WASTE DRUM PUSHED OFF DOCK BY FORKLIFT.	CONTAINER BREACH, SPILL OF LIH AND CONTACT WITH WATER IN SUMP, EXPLOSION DUE TO EXPLOSIVE MIXTURE, POSSIBLE WORKER FATALITY. (D;D;A;C)	NONE	ENSURE THAT THE LOADING/UNLOADING AREA, INCLUDING THE SUMP IS DRY PRIOR TO DELIVERY.
3 IV A	LIN3 / HWRSF	WALK BEHIND FORKLIFT MOVES LITHIUM HYDRIDE DRUM TO DOCK FROM ENCLOSED STORAGE ROOM	FORKLIFT DRIVES OFF DOCK WHILE TRANSPORTING LITHIUM HYDRIDE WASTE DRUM.	CONTAINER BREACH, SPILL OF LIH AND CONTACT WITH WATER IN SUMP, EXPLOSION DUE TO EXPLOSIVE MIXTURE, POSSIBLE WORKER FATALITY. (D;D;A;C)	NONE	ENSURE THAT THE LOADING/UNLOADING AREA, INCLUDING THE SUMP IS DRY PRIOR TO DELIVERY.
3 IV A	LIN4 / HWTF	YARD FORKLIFT DELIVERS LITHIUM HYDRIDE TO TREATMENT ROOM DOOR.	FORKLIFT ACCIDENT NEAR DOCK AREA.	SPILL OF LIH INTO THE SUMP. EXPLOSION/FIRE DUE TO EXPLOSIVE MIXTURE, POSSIBLE FATALITY. (D;D;A;C)	NONE	(1) MOVE ONLY ONE PALLET AT A TIME, (2) RESTRICT OTHER VEHICLE DURING TRANSPORT, (3)BREATHING APPARATUS AVAILABLE TO DRIVER, WITHIN REACH, (4) NO TRANSPORTS DURING WET WEATHER CONDITIONS, (5) ENSURE THE SUMP AND DOCK AREA ARE DRY PRIOR TO MOVING WASTE DRUMS.

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R---F---C	ACT/FAC	ACTIVITY NAME	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
3 IV A	LIH6 / HWTF	OVERPACK DRUM IS OPENED AND INNER LIH DRUM IS LIFTED WITH CRANE	RELEASE OF TOXIC GAS DUE TO UNEXPECTED MATERIALS IN LIH WASTE DRUM (PHOSGEN, HYDROGEN SULFIDE, CHLORINE, ETC...).	WORKER INJURY, POSSIBLE FATALITY. (D;D;A;D)	NONE	OPERATORS SHOULD USE SELF CONTAINED BREATHING APPARATUS.
3 IV A	LIH9 / HWTF	PRIMARY WASTE DRUM IS GROUNDED AND OPENED USING NON-SPARK TOOLS	RELEASE OF TOXIC GAS DUE TO UNEXPECTED MATERIALS IN LIH PRIMARY WASTE DRUM (PHOSGEN, HYDROGEN SULFIDE, CHLORINE, ETC...).	WORKER INJURY, POSSIBLE FATALITY. (D;D;A;C)	NONE	WORKERS SHOULD WEAR PROTECTIVE CLOTHING, AND USE SELF CONTAINED BREATHING APPARATUS.
3 IV B	LIH9 / HWTF	PRIMARY WASTE DRUM IS GROUNDED AND OPENED USING NON-SPARK TOOLS	OPERATOR FAILS TO FOLLOW PROCEDURE (CAUSES SPARK) AND IGNITES HYDROGEN IN LIH WASTE DRUM.	DISPERSAL OF LIH/DEPLETED URANIUM POWDER DUE TO EXPLOSION/FIRE. SEVERE WORKER INJURY. (D;D;B;C)	NONE	WORKERS SHOULD WEAR PROTECTIVE CLOTHING, AND USE SELF CONTAINED BREATHING APPARATUS.
3 IV B	LIH11 / HWTF	PRIMARY LITHIUM HYDRIDE DRUM TRANSFERED TO SKID WITH CRANE.	DRUM CONTENTS SPILLED DUE TO: (1) CLAMP COMES LOOSE, (2) LID FALLS OFF, (3) CRANE ACCIDENT.	LIH SPILLED AND CONTACTS WATER IN SUMP, POSSIBLE FIRE, WORKER EXPOSURE AND INHALATION OF FUMES AND DEPLETED URANIUM. (D;D;B;C)	NONE	WORKER TO WEAR PROTECTIVE CLOTHING AND BREATHING APPARATUS DURING MOVEMENT OF DRUM WITH HOIST. ENSURE THAT THE SUMP IN THE TREATMENT ROOM IS PUMPED DRY IF POSSIBLE.
4 II D	LIH16 / HWTF	LISO4 SOLUTIONS FILTERED (LITHIUM HYDRIDE PROCESS)	LEAK OF SOLUTIONS FILTERED FROM LIH PROCESS.	MINOR WORKER EXPOSURE. (D;D;D;D)	NONE	NONE
4 II D	LIH8 / HWTF	VERMICULITE REMOVED AND BAGGED (LIH PROCESS)	VERMICULITE CONTAMINATED WITH LIH AND DEPLETED URANIUM FROM LEAKY INNER PACK.	POSSIBLE CONTAMINATION WITH LIH/DU, AND MINOR WORKER INHALATION. (D;D;D;D)	NONE	IF THERE ARE INDICATIONS OF A LEAK WHEN REMOVING THE INNER DRUM, DONOT REMOVE THE VERMICULITE.
4 IV C	LIH2 / HWRSF	WALK BEHIND FORKLIFT TRANSFERS LITHIUM HYDRIDE WASTE DRUM TO ENCLOSED STORAGE ROOM.	LITHIUM HYDRIDE WASTE DRUM PUNCTURED BY FORKLIFT.	POTENTIAL RELEASE/SPILL OF LIH/DU IN THE LOADING DOCK AREA. POTENTIAL WORKER EXPOSURE (LIH AND DU). (D;D;C;D)	NONE	DRIVER SHOULD HAVE BREATHING APPARATUS AVAILABLE (WITHIN REACH), BREATHING OF LIH POWDER IS HAZARDOUS.
4 IV C	LIH3 / HWRSF	WALK BEHIND FORKLIFT MOVES LITHIUM HYDRIDE DRUM TO DOCK FROM ENCLOSED STORAGE ROOM	LITHIUM HYDRIDE WASTE DRUM PUNCTURED BY FORKLIFT.	POTENTIAL RELEASE/SPILL OF LIH IN THE LOADING DOCK AREA. POTENTIAL WORKER EXPOSURE (LIH AND DU). (D;D;C;D)	NONE	DRIVER SHOULD HAVE BREATHING APPARATUS AVAILABLE (WITHIN REACH), BREATHING OF LIH POWDER IS HAZARDOUS.
4 IV C	LIH6 / HWTF	OVERPACK DRUM IS OPENED AND INNER LIH DRUM IS LIFTED WITH CRANE	OPERATOR FAILS TO FOLLOW PROCEDURE (CAUSES SPARK) AND IGNITES HYDROGEN IN THE LIH WASTE DRUM.	EXPLOSION OF SMALL QUANTITY OF AVAILABLE HYDROGEN RESTRICTED TO SPACE UNDER VENTILATION HOOD. (D;D;C;D)	NONE	OPERATORS SHOULD USE SELF CONTAINED BREATHING APPARATUS.
	LIH7 / HWTF	OVERPACK DRUM IS DISCARDED TO CRUSHER OR USED FOR CEMENTATION (LIH PROCESS).	TRANSPORT OF EMPTY OVERPACK DRUM (LITHIUM HYDRIDE PROCESS) TO CRUSHER OR CEMENTATION FACILITY.	NONE	NONE	NONE

TABLE A-3
HAZMAN RESULTS SORTED BY ACTIVITY BY DU WASTE TREATMENT PROCESS

PRELIMINARY HAZARD/RISK ANALYSIS RECORD BY ACTIVITY FOR MWRSF

ACTIVITY NUMBER: DU1

ACTIVITY NAME: TRUCK ENTERS AND DRIVES TO DOCK

ACTIVITY DESCRIPTION: DELIVERY OF URANIUM WASTE TO THE MWRSF LOADING DOCK AND TRANSFER TO STORAGE

R--F--C	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
2 III B	TRUCK ACCIDENT WITH FIRE AND BREACH OF DEPLETED URANIUM WASTE CONTAINER.	RADIOACTIVE RELEASE TO ATMOSPHERE DUE TO BURNING OF DEPLETED URANIUM. TRUCK DRIVER INCAPACITATED DUE TO ACCIDENT, IS EXPOSED TO FUMES AND DEPLETED URANIUM. CONTAMINATION OF FACILITY (TA) AND MINOR OFFSITE CONTAMINATION. (C;C;B;B).	NONE	ADMINISTRATIVE CONTROLS SUCH AS (1) ANNOUNCEMENT OF DELIVERY, (2) DRIVER TRAINING, (3) RESTRICT OTHER TRAFFIC DURING DELIVERY.

PRELIMINARY HAZARD/RISK ANALYSIS RECORD BY ACTIVITY FOR MWRSF

ACTIVITY NUMBER: DU2

ACTIVITY NAME: WALK BEHIND FORKLIFT TRANSFERS DRUM TO ENCLOSED STORAGE ROOM

ACTIVITY DESCRIPTION: WALK BEHIND FORKLIFT TRANSFERS DRUM TO ENCLOSED STORAGE ROOM

R--F--C	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
3 III C	FORKLIFT DRIVES OFF DOCK WHILE TRANSPORTING DEPLETED URANIUM WASTE DRUM. SPRINKLER SYSTEM IS OPERABLE.	CONTAINER BREACH, IGNITION OF URANIUM CHIPS IN DOCK AREA. MINOR FIRE, POSSIBLE WORKER INJURY AND EXPOSURE TO DEPLETED URANIUM. (D;D;C;D)	NONE	NONE
3 IV B	FORKLIFT DRIVES OFF DOCK WHILE TRANSPORTING DEPLETED URANIUM WASTE DRUM. SPRINKLER SYSTEM FAILS TO OPERATE.	CONTAINER BREACH, IGNITION OF URANIUM CHIPS IN DOCK AREA. SIGNIFICANT FIRE AND POSSIBLE WORKER INJURIES, EXPOSURE TO DEPLETED URANIUM AND FACILITY CONTAMINATION. (D;D;B;C)		NONE
4 III D	DEPLETED URANIUM DRUM PUSHED OFF DOCK BY FORKLIFT.	CONTAINER BREACH, URANIUM CHIP SPILL IN DOCK AREA. (D;D;D;D)		NONE
4 IV C	DEPLETED URANIUM DRUM PUNCTURED BY FORKLIFT.	CONTAINER BREACH, MINOR WORKER EXPOSURE. (D;D;C;D)		NONE

PRELIMINARY HAZARD/RISK ANALYSIS RECORD BY ACTIVITY FOR MWRSF

ACTIVITY NUMBER: DU3

ACTIVITY NAME: WALK BEHIND FORKLIFT MOVES DRUM OF DEPLETED URANIUM WASTE TO DOCK

ACTIVITY DESCRIPTION: WALK BEHIND FORKLIFT MOVES WASTE DRUM FROM STORAGE ROOM TO LOADING DOCK.

R--F--C	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
3 III C	DRUM PUNCTURED BY FORKLIFT.	CONTAINER BREACH, MINOR WORKER EXPOSURE. (D;D;C;D)	NONE	NONE
3 III C	FORKLIFT DRIVES OFF DOCK WHILE TRANSPORTING DRUM, WITH SPRINKLER SYSTEM OPERABLE.	CONTAINER BREACH, IGNITION OF URANIUM CHIPS IN DOCK AREA. MINOR FIRE, WORKER INJURY AND EXPOSURE TO DEPLETED URANIUM. (D;D;C;D)	NONE	CONSIDER INSTALLATION OF A CURB TO PREVENT DRIVING THE FORKLIFT OFF DOCK.
3 IV B	FORKLIFT DRIVES OFF DOCK WHILE TRANSPORTING DRUM, WITH FAILURE OF SPRINKLER SYSTEM.	CONTAINER BREACH, IGNITION OF URANIUM CHIPS IN DOCK AREA. SIGNIFICANT FIRE, WORKER INJURIES AND EXPOSURE TO DEPLETED URANIUM, AND FACILITY CONTAMINATION. (D;D;B;C)	NONE	CONSIDER INSTALLATION OF A CURB TO PREVENT DRIVING THE FORKLIFT OFF DOCK.
4 IV D	DRUM PUSHED OFF DOCK BY FORKLIFT.	CONTAINER BREACH, URANIUM CHIP SPILL IN DOCK AREA, NO WORKER EXPOSURE DUE TO DISTANCE FROM SPILL. (D;D;D;D)	NONE	NONE

PRELIMINARY HAZARD/RISK ANALYSIS RECORD BY ACTIVITY FOR HWTF

ACTIVITY NUMBER: DU6

ACTIVITY NAME: YARD FORKLIFT DELIVERS DEPLETED URANIUM WASTE DRUM TO TREATMENT ROOM DOOR

ACTIVITY DESCRIPTION: YARD FORKLIFT DELIVERS DRUM FROM LOADING DOCK TO TREATMENT ROOM DOOR

R--F--C	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
2 III B	FORKLIFT ACCIDENT DURING TRANSPORT BETWEEN BUILDINGS.	SPILL OF DRUM CONTENTS WITH FIRE AND CRASH INFLICTED INJURY TO DRIVER. DRIVER EXPOSED TO FIRE, FUMES AND DEPLETED URANIUM. CONTAMINATION OF FACILITY (TA) WITH MINOR OFFSITE CONTAMINATION. (C;C;B;B)	NONE	MOVE ONLY ONE PALLET OR DRUM AT A TIME, RESTRICT OTHER VEHICLE DURING TRANSPORT.
4 II D	FORKLIFT ACCIDENT DURING TRANSPORT BETWEEN BUILDINGS.	SPILL OF DRUM CONTENTS WITHOUT FIRE. (D;D;D;D)	NONE	MOVE ONLY ONE PALLET OR DRUM AT A TIME, RESTRICT OTHER VEHICLE DURING TRANSPORT.

PRELIMINARY HAZARD/RISK ANALYSIS RECORD BY ACTIVITY FOR HWTF

ACTIVITY NUMBER: DU5

ACTIVITY NAME: CRANE DELIVERS DRUM TO SAMPLE ROOM

ACTIVITY DESCRIPTION: OVERHEAD CRANE PICKS UP AND DELIVERS DRUM TO SAMPLE ROOM

R--F--C	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
4 III D	DRUM DROPPED WHILE MOVING TO HWTF SAMPLE ROOM USING HOIST. SPRINKLER SYSTEM OPERABLE.	CONTAINER BREACH WITH SPILL OF URANIUM CHIPS AND POTENTIAL FIRE. MINOR WORKER EXPOSURE. (D;D;D;D)	NONE	NONE
4 IV C	DRUM DROPPED WHILE MOVING TO HWTF SAMPLE ROOM USING HOIST. SPRINKLER SYSTEM NOT OPERABLE.	CONTAINER BREACH, SPILL OF URANIUM CHIPS WITH POTENTIAL FIRE LIMITED TO CONTENTS OF ONE DRUM. WORKER INJURY AND EXPOSURE TO DEPLETED URANIUM. (D;D;C;D)	NONE	NONE

PRELIMINARY HAZARD/RISK ANALYSIS RECORD BY ACTIVITY FOR HWTF

ACTIVITY NUMBER: DU6

ACTIVITY NAME: OVERPACK DRUM IS OPENED AND DRUM LIFTED WITH CRANE

ACTIVITY DESCRIPTION: OVERPACK DRUM IS GROUNDED, OPENED WITH NON-SPARK TOOLS, AND THE INNER DRUM IS LIFTED WITH THE OVERHEAD CRANE.

R--F--C	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
3 III C	OPERATOR FAILS TO FOLLOW PROCEDURE WHILE OPENING THE DEPLETED URANIUM OVERPACK (I.E., USES WRONG TOOLS, MISPOSITIONING OF THE VENT HOOD, ETC...).	SHORT DURATION HYDROGEN FIRE UPON OPENING THE OVERPACK. POSSIBLE WORKER INJURY. (D;D;C;D)	NONE	NONE
3 IV A	RELEASE OF TOXIC GAS DUE TO UNEXPECTED MATERIALS IN DEPLETED URANIUM WASTE DRUM (PHOSGEN, HYDROGEN SULFIDE, CHLORINE, ETC...).	WORKER INJURY, POSSIBLE FATALITY. (D;D;A;D)	NONE	OPERATORS SHOULD USE SELF CONTAINED BREATHING APPARATUS, LEAVE ROOM IF ANYTHING OUT OF THE ORDINARY IS OBSERVED.
4 II D	DRUM CONTENTS SPILLED DUE TO: (1) CLAMP COMES LOOSE, (2) CORROSION OF INNER DRUM, (3) LID FALLS OFF.	LIMITED SPILL OF DEPLETED URANIUM WASTE DRUM CONTENTS, MINOR CONTAMINATION. (D;D;D;D)	NONE	NONE
4 IV C	OPERATOR FAILS TO FOLLOW PROCEDURE (CAUSES SPARK) AND IGNITES HYDROGEN IN THE DEPLETED URANIUM WASTE DRUM.	EXPLOSION OF SMALL QUANTITY OF HYDROGEN RESTRICTED TO SPACE UNDER VENTILATION HOOD. (D;D;C;D)	NONE	NONE
4 IV C	DRUM CONTENTS SPILLED DUE TO: (1) CLAMP COMES LOOSE, (2) CORROSION OF INNER DRUM, (3) LID FALLS OFF; AND IGNITION OF URANIUM CHIPS.	SPILL OF DRUM CONTENTS WITH URANIUM FIRE. (D;D;C;D)	NONE	NONE

PRELIMINARY HAZARD/RISK ANALYSIS RECORD BY ACTIVITY FOR HWTF

ACTIVITY NUMBER: DU7

ACTIVITY NAME: OVERPACK DRUM IS DISCARDED TO CRUSHER OR USED FOR CEMENTATION.

ACTIVITY DESCRIPTION: OVERPACK DRUM (DEPLETED URANIUM PROCESS) IS DISCARDED TO CRUSHER OR USED FOR CEMENTATION. INVOLVES TRANSPORTATION TO CRUSHER OR CEMENTATION FACILITY.

R--F--C	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
MINIMAL	TRANSPORT OF EMPTY OVERPACK DRUM (DEPLETED URANIUM PROCESS) TO CRUSHER OF CEMENTATION FACILITY.	VERMICULITE IS REMOVED, DRUM IS TESTED FOR CONTAMINATION PRIOR TO DISPOSAL.	NONE	NONE

PRELIMINARY HAZARD/RISK ANALYSIS RECORD BY ACTIVITY FOR HWTF

ACTIVITY NUMBER: DUB

ACTIVITY NAME: VERMICULITE REMOVED AND BAGGED

ACTIVITY DESCRIPTION: VERMICULITE REMOVED FROM OVERPACK, BAGGED AND SENT TO LANDFILL OR STORAGE.

R--F--C	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
3 I D	LEAK FROM THE INNER DRUM (DEPLETED URANIUM IN OIL) TO THE VERMICULITE.	POTENTIAL MINOR CONTAMINATION PROBLEMS. LEAK CONTAINED IN OVERPACK. (D;D;D;D)		IF THERE ARE INDICATIONS OF A LEAK WHEN REMOVING THE INNER DRUM, DONOT REMOVE THE VERMICULITE.

PRELIMINARY HAZARD/RISK ANALYSIS RECORD BY ACTIVITY FOR WWTF

ACTIVITY NUMBER: DU9

ACTIVITY NAME: INNER DRUM IS GROUNDED AND OPENED USING NON-SPARK TOOLS

ACTIVITY DESCRIPTION: INNER DRUM CONTAINING DEPLETED URANIUM AND OIL IS GROUNDED AND OPENED WITH NON-SPARK TOOLS. ASSUME SAME HAZARDS AS ACTIVITY 10, EXCEPT LESS H2 GENERATIO

R--F--C	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
3 III C	OPERATOR FAILS TO FOLLOW PROCEDURE WHILE OPENING DEPLETED URANIUM INNER WASTE DRUM (I.E., USES WRONG TOOLS, MISPOSITIONING OF THE VENT HOOD, ETC...).	SHORT DURATION HYDROGEN FIRE UPON OPENING THE OVERPACK. POSSIBLE WORKER INJURY. (D;D;C;D)	NONE	NONE
3 IV A	RELEASE OF TOXIC GAS DUE TO UNEXPECTED MATERIALS IN DEPLETED URANIUM INNER WASTE DRUM (PHOSGEN, HYDROGEN SULFIDE, CHLORINE, ETC...).	WORKER INJURY, POSSIBLE FATALITY. (D;D;A;D)	NONE	OPERATORS SHOULD USE SELF CONTAINED BREATHING APPARATUS, LEAVE ROOM IF ANYTHING OUT OF THE ORDINARY IS OBSERVED.
4 IV C	OPERATOR FAILS TO FOLLOW PROCEDURE (CAUSES SPARK) AND IGNITES HYDROGEN IN DEPLETED URANIUM WASTE DRUM.	EXPLOSION OF SMALL QUANTITY OF HYDROGEN RESTRICTED TO SPACE UNDER VENTILATION HOOD. (D;D;C;D)	NONE	NONE

PRELIMINARY HAZARD/RISK ANALYSIS RECORD BY ACTIVITY FOR HWTF

ACTIVITY NUMBER: DU10

ACTIVITY NAME: CONTENTS OF DRUM INSPECTED VISUALLY

ACTIVITY DESCRIPTION: CONTENTS OF DEPLETED URANIUM INNER DRUM INSPECTED VISUALLY, LID IS REPLACED AND CLAMPED ON INNER DRUM.

R--F--C	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
MINIMAL	CONTENTS OF DEPLETED URANIUM WASTE INNER DRUM VISUALLY INSPECTED.	POTENTIAL HAZARDS COVERED UNDER ACTIVITIES WHERE OVERPACK AND INNER DRUM ARE OPENED.	NONE	IF UNEXPECTED CONTENTS FOUND, CONTACT SUPERVISOR.

PRELIMINARY HAZARD/RISK ANALYSIS RECORD BY ACTIVITY FOR MWTF

ACTIVITY NUMBER: DU11

ACTIVITY NAME: DEPLETED URANIUM WASTE DRUM TRANSFERED TO TREATMENT SKID WITH OVERHEAD CRANE

ACTIVITY DESCRIPTION: DEPLETED URANIUM WASTE DRUM TRANSFERED TO TREATMENT SKID WITH OVERHEAD CRANE.

R--F--C	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
4 II D	DRUM CONTENTS SPILLED DUE TO: (1) CLAMP COMES LOOSE, (2) CORROSION OF INNER DRUM, (3) LID FALLS OFF.	LIMITED SPILL OF DEPLETED URANIUM WASTE DRUM CONTENTS, MINOR CONTAMINATION. (D;D;D;D)	NONE	NONE
4 IV C	DRUM CONTENTS SPILLED DUE TO: (1) CLAMP COMES LOOSE, (2) CORROSION OF INNER DRUM, (3) LID FALLS OFF; AND IGNITION OF URANIUM CHIPS.	SPILL OF DEPLETED URANIUM WASTE DRUM CONTENTS WITH URANIUM FIRE. WORKER EXPOSURE TO DEPLETED URANIUM. (D;D;C;D)	NONE	NONE

PRELIMINARY HAZARD/RISK ANALYSIS RECORD BY ACTIVITY FOR HWTF

ACTIVITY NUMBER: DU12

ACTIVITY NAME: HYDRAULIC PUNCTURE OF DRUM USING HOLLOW SPIKES

ACTIVITY DESCRIPTION: HYDRAULIC PUNCTURE OF DEPLETED URANIUM DRUM USING HOLLOW SPIKES. THE REACTOR IS INERTED WITH NITROGEN PRIOR TO PUNCTURING THE DRUM.

R--F--C	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
4 III D	FAILURE TO INERT THE REACTOR WITH NITROGEN.	CONTAINED FIRE IN THE REACTOR. NO RELEASE BEYOND FILTERS AND SCRUBBER. (D;D;D;D)	NONE	INTERLOCK THE OXYGEN DETECTION WITH THE HYDRAULIC PRESS, SO DRUM IS NOT PUNCTURED IF OXYGEN IS PRESENT.

PRELIMINARY HAZARD/RISK ANALYSIS RECORD BY ACTIVITY FOR HWTF

ACTIVITY NUMBER: DU13

ACTIVITY NAME: CLOSED LOOP CIRCULATION OF WATER THROUGH REACTOR

ACTIVITY DESCRIPTION: CLOSED LOOP CIRCULATION OF WATER THROUGH REACTOR (DEPLETED URANIUM PROCESS).

R--F--C	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
4 III D	WATER REACTIVE MATERIAL (I.E., LIH) PRESENT DUE TO MISLABELING NOT DETECTED BY VISUAL INSPECTION.	H2 GAS PRODUCTION AND RELEASE TO SCRUBBER. NO FIRE SINCE REACTOR IS INERTED WITH NITROGEN. (D;D;D;D)	NONE	NONE
4 IV C	ADDITION OF WATER OR BLEACH TO WATER REACTIVE MATERIAL (I.E., LIH) PRESENT DUE TO MISLABELING NOT DETECTED BY VISUAL INSPECTION. REACTOR NOT INERTED WITH NITROGEN.	LIMITED EXPLOSION IN REACTOR AND DUCT WORK OF SCRUBBER. LIMITED POTENTIAL FOR WORKER INJURY. FACILITY CONTAMINATION AND SOME RELEASE TO OTHER TECHNICAL AREAS ONSITE. (D;D;C;C)	NONE	ADD WATER VERY SLOWLY AT THE BEGINNING TO DETECT ANY H2 FORMATION.
4 IV D	HUMAN ERROR; BLEACH INTRODUCED WITHOUT CIRCULATION OF WATER (DEPLETED. SCRUBBER FAILURE.	CHLORINE GAS RELEASE THROUGH STACK. (D;D;D;D)	NONE	NONE

PRELIMINARY HAZARD/RISK ANALYSIS RECORD BY ACTIVITY FOR HWTF

ACTIVITY NUMBER: DU14

ACTIVITY NAME: OIL DRAINS TO WASTE OIL DRUM (DEPLETED URANIUM PROCESS)

ACTIVITY DESCRIPTION: OIL DRAINS TO WASTE OIL DRUM (DEPLETED URANIUM PROCESS).

R--F--C	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
4 II D	OVERFILL OF OIL DRUM CAUSED BY OPERATOR ERROR (I.E., INSUFFICIENT VOLUME OR DRUM NOT IN POSITION).	MINOR CONTAMINATION PROBLEM. (D;D;D;D)	NONE	NONE

PRELIMINARY HAZARD/RISK ANALYSIS RECORD BY ACTIVITY FOR HWTF

ACTIVITY NUMBER: DU15

ACTIVITY NAME: BLEACH IS ADDED TO CIRCULATING WATER

ACTIVITY DESCRIPTION: BLEACH IS ADDED TO CIRCULATING WATER (DEPLETED URANIUM PROCESS). INCLUDES OXIDATION REACTION.

R--F--C	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
3 III C	CAUSTIC LINE LEAK DUE TO CORROSION.	POSSIBLE WORKER INJURY. (D;D;C;D)	NONE	NONE
3 III C	CIRCULATING LINE RUPTURE DUE TO CORROSION, PUMP DIAPHRAM LEAK OR CONNECTIONS.	URANIUM SLURRY RELEASED IN THE TREATMENT ROOM. POSSIBLE WORKER CONTACT BY SPRAY AND ROOM CONTAMINATION. (D;D;C;C)	NONE	NONE
4 III D	LOSS OF COOLING WATER (DU PROCESS).	INCREASE IN TEMPERATURE AND INCREASED AMOUNT OF CHLORINE GAS DUE TO DECOMPOSITION OF BLEACH. (D;D;D;D)	NONE	NONE
4 III D	LOSS HEPA/SCRUBBING SYSTEM (DU PROCESS).	SMALL CHLORINE GAS RELEASE NEAR STACK OR SCRUBBING SYSTEM. (D;D;D;D)	NONE	NONE
4 IV C	LOSS OF COOLING WATER WITH LOSS OF SUCTION TO THE SCRUBBER (DU PROCESS).	INCREASED AMOUNT OF CHLORINE GAS LEAKED INTO THE TREATMENT ROOM DUE TO INCREASE IN TEMPERATURE. WORKER EXPOSURE TO CHLORINE AND DEPLETED URANIUM. (D;D;C;D)	NONE	NONE

PRELIMINARY HAZARD/RISK ANALYSIS RECORD BY ACTIVITY FOR HWTF

ACTIVITY NUMBER: DU16

ACTIVITY NAME: REACTION COMPLETE. SLURRY TRANSFERRED TO REDUCTION/SETTLING TANK (DEPLETED URANIUM PROCESS)

ACTIVITY DESCRIPTION: REACTION COMPLETE. SLURRY TRANSFERRED TO REDUCTION/SETTLING TANK (DEPLETED URANIUM PROCESS)

R--F--C	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
3 II C	HUMAN ERROR (DEPLETED URANIUM PROCESS). MISALIGNMENT OF VALVES DURING TRANSFER OF URANIUM SLURRY TO REDUCTION/SETTLING TANK.	SLURRY ROUTED TO WASTE WATER TANK, CEMENTATION DRUM OR OTHER. FACILITY CONTAMINATION, MINOR WORKER EXPOSURE. (D;D;D;C)	NONE	NONE
MINIMAL	PLUGGING OF CIRCULATION LINE DUE TO ACCUMULATION OF SMALL UNREACTED URANIUM CHIPS (DEPLETED URANIUM PROCESS). MAY BE DUE TO BREACH OF THE PACTICLE SCREEN.	OPERATIONAL PROBLEM. NOT A HAZARD.	NONE	NONE

PRELIMINARY HAZARD/RISK ANALYSIS RECORD BY ACTIVITY FOR HWTF

ACTIVITY NUMBER: DU17

ACTIVITY NAME: REDUCTION OF URANIUM HYDROXIDE BY SODIUM THIOSULFATE TO URANIUM DIOXIDE (DEPLETED URANIUM PROCESS)

ACTIVITY DESCRIPTION: REDUCTION OF URANIUM HYDROXIDE BY SODIUM THIOSULFATE TO URANIUM DIOXIDE (DEPLETED URANIUM PROCESS).

R--F--C	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
3 I D	SPILLS DURING REDUCTION, DECANTING, OR TRANSFER OF LIQUIDS OR SEDIMENT.	MINOR WORKER EXPOSURE AND FACILITY CONTAMINATION. (D;D;D;D)	NONE	NONE
3 I D	SLURRY SPILLED DURING CEMENTATION PROCESS (I.E., OVERFILL, TIPPED OVER, ETC...)	MINOR CONTAMINATION IN TREATMENT ROOM. (D;D;D;D)	NONE	NONE
3 III C	LINE RUPTURE IN THE CIRCULATING SLURRY LOOP DUE TO CORROSION.	CONTAMINATION OF THE TREATMENT ROOM AND POSSIBLE WORKER CONTAMINATION/INJURY. (D;D;C;C)	NONE	NONE

PRELIMINARY HAZARD/RI ANALYSIS RECORD BY ACTIVITY FOR HWTF

ACTIVITY NUMBER: DU18

ACTIVITY NAME: OPEN REACTOR AND WASTE DRUM AND CHECK RESIDUAL CONTENTS

ACTIVITY DESCRIPTION: OPEN REACTOR LID, OPEN WASTE DRUM, CHECK CONTENTS, REMOVE AND BAG DRUM FOR DISPOSITION (DEPLETED URANIUM PROCESS).

R--F--C	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
3 II C	UNREACTED URANIUM FINES IGNITE IN PRESENCE OF OXYGEN WHEN INNER DRUM LID OPENED TO CHECK CONTENTS (DEPLETED URANIUM PROCESS).	FIRE IN DRUM. POSSIBLE WORKER INHALATION. (D;D;C;D)	NONE	WORKER SHOULD BE EQUIPED WITH RESPIRATORY PROTECTION.
4 II D	LOSS OF INERT GAS COVER LEADS TO SLOW BURN OF RESIDUAL URANIUM IN DRUM (DEPLETED URANIUM PROCESS).	POSSIBLE RELEASE OF URANIUM OXIDE TO SCRUBBER SYSTEM. (D;D;D;D)	NONE	INSPECT DRUM FOR RESIDUAL URANIUM AFTER OXIDATION PROCESS BEFORE END OF SHIFT.

TABLE A-4
HAZMAN RESULTS SORTED BY RISK RANK FOR DU WASTE TREATMENT PROCESS

HAZARD ANALYSIS REPORT BY RISK

R---F---C	ACT/FAC	ACTIVITY NAME	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
2 III B	DU4 / HWTF	YARD FORKLIFT DELIVERS DEPLETED URANIUM WASTE DRUM TO TREATMENT ROOM DOOR	FORKLIFT ACCIDENT DURING TRANSPORT BETWEEN BUILDINGS.	SPILL OF DRUM CONTENTS WITH FIRE AND CRASH INFLICTED INJURY TO DRIVER. DRIVER EXPOSED TO FIRE, FUMES AND DEPLETED URANIUM. CONTAMINATION OF FACILITY (TA) WITH MINOR OFFSITE CONTAMINATION. (C;C;B;B)	NONE	MOVE ONLY ONE PALLET OR DRUM AT A TIME, RESTRICT OTHER VEHICLE DURING TRANSPORT.
2 III B	DU1 / MWRSF	TRUCK ENTERS AND DRIVES TO DOCK	TRUCK ACCIDENT WITH FIRE AND BREACH OF DEPLETED URANIUM WASTE CONTAINER.	RADIOACTIVE RELEASE TO ATMOSPHERE DUE TO BURNING OF DEPLETED URANIUM. TRUCK DRIVER INCAPACITATED DUE TO ACCIDENT, IS EXPOSED TO FUMES AND DEPLETED URANIUM. CONTAMINATION OF FACILITY (TA) AND MINOR OFFSITE CONTAMINATION. (C;C;B;B).	NONE	ADMINISTRATIVE CONTROLS SUCH AS (1) ANNOUNCEMENT OF DELIVERY, (2) DRIVER TRAINING, (3) RESTRICT OTHER TRAFFIC DURING DELIVERY.
3 I D	DU8 / HWTF	VERMICULITE REMOVED AND BAGGED	LEAK FROM THE INNER DRUM (DEPLETED URANIUM IN OIL) TO THE VERMICULITE.	POTENTIAL MINOR CONTAMINATION PROBLEMS. LEAK CONTAINED IN OVERPACK. (D;D;D;D)		IF THERE ARE INDICATIONS OF A LEAK WHEN REMOVING THE INNER DRUM, DONOT REMOVE THE VERMICULITE.
3 I D	DU17 / HWTF	REDUCTION OF URANIUM HYDROXIDE BY SODIUM THIOSULFATE TO URANIUM DIOXIDE (DEPLETED URANIUM PROCESS)	SPILLS DURING REDUCTION, DECANTING, OR TRANSFER OF LIQUIDS OR SEDIMENT.	MINOR WORKER EXPOSURE AND FACILITY CONTAMINATION. (D;D;D;D)	NONE	NONE
3 I D	DU17 / HWTF	REDUCTION OF URANIUM HYDROXIDE BY SODIUM THIOSULFATE TO URANIUM DIOXIDE (DEPLETED URANIUM PROCESS)	SLURRY SPILLED DURING CEMENTATION PROCESS (I.E., OVERFILL, TIPPED OVER, ETC...)	MINOR CONTAMINATION IN TREATMENT ROOM. (D;D;D;D)	NONE	NONE
3 II C	DU16 / HWTF	REACTION COMPLETE. SLURRY TRANSFERRED TO REDUCTION/SETTLING TANK (DEPLETED URANIUM PROCESS)	HUMAN ERROR (DEPLETED URANIUM PROCESS). MISALIGNMENT OF VALVES DURING TRANSFER OF URANIUM SLURRY TO REDUCTION/SETTLING TANK.	SLURRY ROUTED TO WASTE WATER TANK, CEMENTATION DRUM OR OTHER. FACILITY CONTAMINATION, MINOR WORKER EXPOSURE. (D;D;D;C)	NONE	NONE
3 II C	DU18 / HWTF	OPEN REACTOR AND WASTE DRUM AND CHECK RESIDUAL CONTENTS	UNREACTED URANIUM FINES IGNITE IN PRESENCE OF OXYGEN WHEN INNER DRUM LID OPENED TO CHECK CONTENTS (DEPLETED URANIUM PROCESS).	FIRE IN DRUM. POSSIBLE WORKER INHALATION. (D;D;C;D)	NONE	WORKER SHOULD BE EQUIPED WITH RESPIRATORY PROTECTION.

HAZARD ANALYSIS REPORT BY RISK

R---F---C	ACT/FAC	ACTIVITY NAME	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
3 III C	DU2 / MWRSF	WALK BEHIND FORKLIFT TRANSFERS DRUM TO ENCLOSED STORAGE ROOM	FORKLIFT DRIVES OFF DOCK WHILE TRANSPORTING DEPLETED URANIUM WASTE DRUM. SPRINKLER SYSTEM IS OPERABLE.	CONTAINER BREACH, IGNITION OF URANIUM CHIPS IN DOCK AREA. MINOR FIRE, POSSIBLE WORKER INJURY AND EXPOSURE TO DEPLETED URANIUM. (D;D;C;D)	NONE	NONE
3 III C	DU3 / MWRSF	WALK BEHIND FORKLIFT MOVES DRUM OF DEPLETED URANIUM WASTE TO DOCK	DRUM PUNCTURED BY FORKLIFT.	CONTAINER BREACH, MINOR WORKER EXPOSURE. (D;D;C;D)	NONE	NONE
3 III C	DU3 / MWRSF	WALK BEHIND FORKLIFT MOVES DRUM OF DEPLETED URANIUM WASTE TO DOCK	FORKLIFT DRIVES OFF DOCK WHILE TRANSPORTING DRUM, WITH SPRINKLER SYSTEM OPERABLE.	CONTAINER BREACH, IGNITION OF URANIUM CHIPS IN DOCK AREA. MINOR FIRE, WORKER INJURY AND EXPOSURE TO DEPLETED URANIUM. (D;D;C;D)	NONE	CONSIDER INSTALLATION OF A CURB TO PREVENT DRIVING THE FORKLIFT OFF DOCK.
3 III C	DU15 / HWTF	BLEACH IS ADDED TO CIRCULATING WATER	CAUSTIC LINE LEAK DUE TO CORROSION.	POSSIBLE WORKER INJURY. (D;D;C;D)	NONE	NONE
3 III C	DU15 / HWTF	BLEACH IS ADDED TO CIRCULATING WATER	CIRCULATING LINE RUPTURE DUE TO CORROSION, PUMP DIAPHRAM LEAK OR CONNECTIONS.	URANIUM SLURRY RELEASED IN THE TREATMENT ROOM. POSSIBLE WORKER CONTACT BY SPRAY AND ROOM CONTAMINATION. (D;D;C;C)	NONE	NONE
3 III C	DU17 / HWTF	REDUCTION OF URANIUM HYDROXIDE BY SODIUM THIOSULFATE TO URANIUM DIOXIDE (DEPLETED URANIUM PROCESS)	LINE RUPTURE IN THE CIRCULATING SLURRY LOOP DUE TO CORROSION.	CONTAMINATION OF THE TREATMENT ROOM AND POSSIBLE WORKER CONTAMINATION/INJURY. (D;D;C;C)	NONE	NONE
3 III C	DU9 / HWTF	INNER DRUM IS GROUNDED AND OPENED USING NON-SPARK TOOLS	OPERATOR FAILS TO FOLLOW PROCEDURE WHILE OPENING DEPLETED URANIUM INNER WASTE DRUM (I.E., USES WRONG TOOLS, MISPOSITIONING OF THE VENT HOOD, ETC...).	SHORT DURATION HYDROGEN FIRE UPON OPENING THE OVERPACK. POSSIBLE WORKER INJURY. (D;D;C;D)	NONE	NONE
3 III C	DU6 / HWTF	OVERPACK DRUM IS OPENED AND DRUM LIFTED WITH CRANE	OPERATOR FAILS TO FOLLOW PROCEDURE WHILE OPENING THE DEPLETED URANIUM OVERPACK (I.E., USES WRONG TOOLS, MISPOSITIONING OF THE VENT HOOD, ETC...).	SHORT DURATION HYDROGEN FIRE UPON OPENING THE OVERPACK. POSSIBLE WORKER INJURY. (D;D;C;D)	NONE	NONE
3 IV A	DU6 / HWTF	OVERPACK DRUM IS OPENED AND DRUM LIFTED WITH CRANE	RELEASE OF TOXIC GAS DUE TO UNEXPECTED MATERIALS IN DEPLETED URANIUM WASTE DRUM (PHOSGEN, HYDROGEN SULFIDE, CHLORINE, ETC...).	WORKER INJURY, POSSIBLE FATALITY. (D;D;A;D)	NONE	OPERATORS SHOULD USE SELF CONTAINED BREATHING APPARATUS, LEAVE ROOM IF ANYTHING OUT OF THE ORDINARY IS OBSERVED.

HAZARD ANALYSIS REPORT BY RISK

R---F---C	ACT/FAC	ACTIVITY NAME	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
3 IV A	DU9 / HWTF	INNER DRUM IS GROUNDED AND OPENED USING NON-SPARK TOOLS	RELEASE OF TOXIC GAS DUE TO UNEXPECTED MATERIALS IN DEPLETED URANIUM INNER WASTE DRUM (PHOSGEN, HYDROGEN SULFIDE, CHLORINE, ETC...).	WORKER INJURY, POSSIBLE FATALITY. (D;D;A;D)	NONE	OPERATORS SHOULD USE SELF CONTAINED BREATHING APPARATUS, LEAVE ROOM IF ANYTHING OUT OF THE ORDINARY IS OBSERVED.
3 IV B	DU2 / HWRSF	WALK BEHIND FORKLIFT TRANSFERS DRUM TO ENCLOSED STORAGE ROOM	FORKLIFT DRIVES OFF DOCK WHILE TRANSPORTING DEPLETED URANIUM WASTE DRUM. SPRINKLER SYSTEM FAILS TO OPERATE.	CONTAINER BREACH, IGNITION OF URANIUM CHIPS IN DOCK AREA. SIGNIFICANT FIRE AND POSSIBLE WORKER INJURIES, EXPOSURE TO DEPLETED URANIUM AND FACILITY CONTAMINATION. (D;D;B;C)		NONE
3 IV B	DU3 / HWRSF	WALK BEHIND FORKLIFT MOVES DRUM OF DEPLETED URANIUM WASTE TO DOCK	FORKLIFT DRIVES OFF DOCK WHILE TRANSPORTING DRUM, WITH FAILURE OF SPRINKLER SYSTEM.	CONTAINER BREACH, IGNITION OF URANIUM CHIPS IN DOCK AREA. SIGNIFICANT FIRE, WORKER INJURIES AND EXPOSURE TO DEPLETED URANIUM, AND FACILITY CONTAMINATION. (D;D;B;C)	NONE	CONSIDER INSTALLATION OF A CURB TO PREVENT DRIVING THE FORKLIFT OFF DOCK.
4 II D	DU6 / HWTF	OVERPACK DRUM IS OPENED AND DRUM LIFTED WITH CRANE	DRUM CONTENTS SPILLED DUE TO: (1) CLAMP COMES LOOSE, (2) CORROSION OF INNER DRUM, (3) LID FALLS OFF.	LIMITED SPILL OF DEPLETED URANIUM WASTE DRUM CONTENTS, MINOR CONTAMINATION. (D;D;D;D)	NONE	NONE
4 II D	DU4 / HWTF	YARD FORKLIFT DELIVERS DEPLETED URANIUM WASTE DRUM TO TREATMENT ROOM DOOR	FORKLIFT ACCIDENT DURING TRANSPORT BETWEEN BUILDINGS.	SPILL OF DRUM CONTENTS WITHOUT FIRE. (D;D;D;D)	NONE	MOVE ONLY ONE PALLET OR DRUM AT A TIME, RESTRICT OTHER VEHICLE DURING TRANSPORT.
4 II D	DU11 / HWTF	DEPLETED URANIUM WASTE DRUM TRANSFERED TO TREATMENT SKID WITH OVERHEAD CRANE	DRUM CONTENTS SPILLED DUE TO: (1) CLAMP COMES LOOSE, (2) CORROSION OF INNER DRUM, (3) LID FALLS OFF.	LIMITED SPILL OF DEPLETED URANIUM WASTE DRUM CONTENTS, MINOR CONTAMINATION. (D;D;D;D)	NONE	NONE
4 II D	DU14 / HWTF	OIL DRAINS TO WASTE OIL DRUM (DEPLETED URANIUM PROCESS)	OVERFILL OF OIL DRUM CAUSED BY OPERATOR ERROR (I.E., INSUFFICIENT VOLUME OR DRUM NOT IN POSITION).	MINOR CONTAMINATION PROBLEM. (D;D;D;D)	NONE	NONE
4 II D	DU18 / HWTF	OPEN REACTOR AND WASTE DRUM AND CHECK RESIDUAL CONTENTS	LOSS OF INERT GAS COVER LEADS TO SLOW BURN OF RESIDUAL URANIUM IN DRUM (DEPLETED URANIUM PROCESS).	POSSIBLE RELEASE OF URANIUM OXIDE TO SCRUBBER SYSTEM. (D;D;D;D)	NONE	INSPECT DRUM FOR RESIDUAL URANIUM AFTER OXIDATION PROCESS BEFORE END OF SHIFT.
4 III D	DU2 / HWRSF	WALK BEHIND FORKLIFT TRANSFERS DRUM TO ENCLOSED STORAGE ROOM	DEPLETED URANIUM DRUM PUSHED OFF DOCK BY FORKLIFT.	CONTAINER BREACH, URANIUM CHIP SPILL IN DOCK AREA. (D;D;D;D)		NONE

HAZARD ANALYSIS REPORT BY RISK

R---F---C	ACT/FAC	ACTIVITY NAME	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
4 III D	DU12 / HWTF	HYDRAULIC PUNCTURE OF DRUM USING HOLLOW SPIKES	FAILURE TO INERT THE REACTOR WITH NITROGEN.	CONTAINED FIRE IN THE REACTOR. NO RELEASE BEYOND FILTERS AND SCRUBBER. (D;D;D;D)	NONE	INTERLOCK THE OXYGEN DETECTION WITH THE HYDRAULIC PRESS, SO DRUM IS NOT PUNCTURED IF OXYGEN IS PRESENT.
4 III D	DU13 / HWTF	CLOSED LOOP CIRCULATION OF WATER THROUGH REACTOR	WATER REACTIVE MATERIAL (I.E., LIH) PRESENT DUE TO MISLABELING NOT DETECTED BY VISUAL INSPECTION.	H2 GAS PRODUCTION AND RELEASE TO SCRUBBER. NO FIRE SINCE REACTOR IS INERTED WITH NITROGEN. (D;D;D;D)	NONE	NONE
4 III D	DU15 / HWTF	BLEACH IS ADDED TO CIRCULATING WATER	LOSS OF COOLING WATER (DU PROCESS).	INCREASE IN TEMPERATURE AND INCREASED AMOUNT OF CHLORINE GAS DUE TO DECOMPOSITION OF BLEACH. (D;D;D;D)	NONE	NONE
4 III D	DU15 / HWTF	BLEACH IS ADDED TO CIRCULATING WATER	LOSS HEPA/SCRUBBING SYSTEM (DU PROCESS).	SMALL CHLORINE GAS RELEASE NEAR STACK OR SCRUBBING SYSTEM. (D;D;D;D)	NONE	NONE
4 III D	DU5 / HWTF	CRANE DELIVERS DRUM TO SAMPLE ROOM	DRUM DROPPED WHILE MOVING TO HWTF SAMPLE ROOM USING HOIST. SPRINKLER SYSTEM OPERABLE.	CONTAINER BREACH WITH SPILL OF URANIUM CHIPS AND POTENTIAL FIRE. MINOR WORKER EXPOSURE. (D;D;D;D)	NONE	NONE
4 IV C	DU6 / HWTF	OVERPACK DRUM IS OPENED AND DRUM LIFTED WITH CRANE	OPERATOR FAILS TO FOLLOW PROCEDURE (CAUSES SPARK) AND IGNITES HYDROGEN IN THE DEPLETED URANIUM WASTE DRUM.	EXPLOSION OF SMALL QUANTITY OF HYDROGEN RESTRICTED TO SPACE UNDER VENTILATION HOOD. (D;D;C;D)	NONE	NONE
4 IV C	DU6 / HWTF	OVERPACK DRUM IS OPENED AND DRUM LIFTED WITH CRANE	DRUM CONTENTS SPILLED DUE TO: (1) CLAMP COMES LOOSE, (2) CORROSION OF INNER DRUM, (3) LID FALLS OFF; AND IGNITION OF URANIUM CHIPS.	SPILL OF DRUM CONTENTS WITH URANIUM FIRE. (D;D;C;D)	NONE	NONE
4 IV C	DU2 / HWRSF	WALK BEHIND FORKLIFT TRANSFERS DRUM TO ENCLOSED STORAGE ROOM	DEPLETED URANIUM DRUM PUNCTURED BY FORKLIFT.	CONTAINER BREACH, MINOR WORKER EXPOSURE. (D;D;C;D)		NONE
4 IV C	DU11 / HWTF	DEPLETED URANIUM WASTE DRUM TRANSFERED TO TREATMENT SKID WITH OVERHEAD CRANE	DRUM CONTENTS SPILLED DUE TO: (1) CLAMP COMES LOOSE, (2) CORROSION OF INNER DRUM, (3) LID FALLS OFF; AND IGNITION OF URANIUM CHIPS.	SPILL OF DEPLETED URANIUM WASTE DRUM CONTENTS WITH URANIUM FIRE. WORKER EXPOSURE TO DEPLETED URANIUM. (D;D;C;D)	NONE	NONE

HAZARD ANALYSIS REPORT BY RISK

R---F---C	ACT/FAC	ACTIVITY NAME	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
4 IV C	DU13 / HWTF	CLOSED LOOP CIRCULATION OF WATER THROUGH REACTOR	ADDITION OF WATER OR BLEACH TO WATER REACTIVE MATERIAL (I.E., LIH) PRESENT DUE TO MISLABELING NOT DETECTED BY VISUAL INSPECTION. REACTOR NOT INERTED WITH NITROGEN.	LIMITED EXPLOSION IN REACTOR AND DUCT WORK OF SCRUBBER. LIMITED POTENTIAL FOR WORKER INJURY. FACILITY CONTAMINATION AND SOME RELEASE TO OTHER TECHNICAL AREAS ONSITE. (D;D;C;C)	NONE	ADD WATER VERY SLOWLY AT THE BEGINNING TO DETECT ANY H2 FORMATION.
4 IV C	DU15 / HWTF	BLEACH IS ADDED TO CIRCULATING WATER	LOSS OF COOLING WATER WITH LOSS OF SUCTION TO THE SCRUBBER (DU PROCESS).	INCREASED AMOUNT OF CHLORINE GAS LEAKED INTO THE TREATMENT ROOM DUE TO INCREASE IN TEMPERATURE. WORKER EXPOSURE TO CHLORINE AND DEPLETED URANIUM. (D;D;C;D)	NONE	NONE
4 IV C	DU5 / HWTF	CRANE DELIVERS DRUM TO SAMPLE ROOM	DRUM DROPPED WHILE MOVING TO HWTF SAMPLE ROOM USING HOIST. SPRINKLER SYSTEM NOT OPERABLE.	CONTAINER BREACH, SPILL OF URANIUM CHIPS WITH POTENTIAL FIRE LIMITED TO CONTENTS OF ONE DRUM. WORKER INJURY AND EXPOSURE TO DEPLETED URANIUM. (D;D;C;D)	NONE	NONE
4 IV C	DU9 / HWTF	INNER DRUM IS GROUNDED AND OPENED USING NON-SPARK TOOLS	OPERATOR FAILS TO FOLLOW PROCEDURE (CAUSES SPARK) AND IGNITES HYDROGEN IN DEPLETED URANIUM WASTE DRUM.	EXPLOSION OF SMALL QUANTITY OF HYDROGEN RESTRICTED TO SPACE UNDER VENTILATION HOOD. (D;D;C;D)	NONE	NONE
4 IV D	DU3 / HWRSF	WALK BEHIND FORKLIFT MOVES DRUM OF DEPLETED URANIUM WASTE TO DOCK	DRUM PUSHED OFF DOCK BY FORKLIFT.	CONTAINER BREACH, URANIUM CHIP SPILL IN DOCK AREA, NO WORKER EXPOSURE DUE TO DISTANCE FROM SPILL. (D;D;D;D)	NONE	NONE
4 IV D	DU13 / HWTF	CLOSED LOOP CIRCULATION OF WATER THROUGH REACTOR	HUMAN ERROR; BLEACH INTRODUCED WITHOUT CIRCULATION OF WATER (DEPLETED. SCRUBBER FAILURE.	CHLORINE GAS RELEASE THROUGH STACK. (D;D;D;D)	NONE	NONE
	DU10 / HWTF	CONTENTS OF DRUM INSPECTED VISUALLY	CONTENTS OF DEPLETED URANIUM WASTE INNER DRUM VISUALLY INSPECTED.	POTENTIAL HAZARDS COVERED UNDER ACTIVITIES WHERE OVERPACK AND INNER DRUM ARE OPENED.	NONE	IF UNEXPECTED CONTENTS FOUND, CONTACT SUPERVISOR.

HAZARD ANALYSIS REPORT BY RISK

R---F---C	ACT/FAC	ACTIVITY NAME	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
	DU16 / HWTF	REACTION COMPLETE. SLURRY TRANSFERRED TO REDUCTION/SETTLING TANK (DEPLETED URANIUM PROCESS)	PLUGGING OF CIRCULATION LINE DUE TO ACCUMULATION OF SMALL UNREACTED URANIUM CHIPS (DEPLETED URANIUM PROCESS). MAY BE DUE TO BREACH OF THE PACTICLE SCREEN.	OPERATIONAL PROBLEM. NOT A HAZARD.	NONE	NONE
	DU7 / HWTF	OVERPACK DRUM IS DISCARDED TO CRUSHER OR USED FOR CEMENTATION.	TRANSPORT OF EMPTY OVERPACK DRUM (DEPLETED URANIUM PROCESS) TO CRUSHER OF CEMENTATION FACILITY.	VERMICULITE IS REMOVED, DRUM IS TESTED FOR CONTAMINATION PRIOR TO DISPOSAL.	NONE	NONE

TABLE A-5
HAZMAN RESULTS SORTED BY ACTIVITY FOR CHEMICAL PLATING WASTE TREA ГMENT PROCESS

PRELIMINARY HAZARD/RISK ANALYSIS RECORD BY ACTIVITY FOR MWRSF

ACTIVITY NUMBER: CY1

ACTIVITY NAME: TRUCK ENTERS FACILITY AND DRIVES TO DOCK (PLATING WASTES).

ACTIVITY DESCRIPTION: TRUCK ENTERS GATE AT FENCE AND DRIVES TO DOCK

R--F--C	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
2 III A	TRUCK ACCIDENT WITH BREACH OF MULTIPLE WASTE CONTAINERS LEADING TO MIXING OF INCOMPATIBLE WASTES. DUE TO (1) NORMAL TRANSPORT OF INCOMPATIBLES, (2) MISLABELED DRUMS.	POSSIBLE PRODUCTION OF HCN. WORKER(S) EXPOSED TO HCN GAS WITH POSSIBLE FATALITIES, AND INJURY TO COLOCATED WORKERS. MINOR ONSITE CONTAMINATION. (B;B;A;C)	NONE	ADMINISTRATIVE CONTROLS; (1) ANNOUNCEMENT OF DELIVERY, (2) DRIVER TRAINING, (3) RESTRICT OTHER TRAFFIC DURING DELIVERY. CONSIDER REVIEW OF TRANSPORTATION PROCEDURES, E.G., (1) RESTRICT THE TRANSPORTATION OF INCOMPATIBLE WASTES IN SINGLE TRUCK, (2) CONSIDER TRANSPORT OF ONE DRUM AT A TIME.
3 III C	TRUCK ACCIDENT WITH THE SPILL OF A SINGLE DRUM OF PLATING WASTE. RELEASE OF 55 GALLONS.	WORKER EXPOSURE TO CYANIDE AND POSSIBLE INJURY, RADIATION CONTAMINATION, MINOR ONSITE CONTAMINATION. (D;D;C;C)	NONE	ADMINISTRATIVE CONTROLS; (1) ANNOUNCEMENT OF DELIVERY, (2) DRIVER TRAINING, (3) RESTRICT OTHER TRAFFIC DURING DELIVERY.

PRELIMINARY HAZARD/RISK ANALYSIS RECORD BY ACTIVITY FOR MWRSF

ACTIVITY NUMBER: CY2

ACTIVITY NAME: WALK BEHIND FORKLIFT TRANSFERS WASTE DRUM TO STORAGE AREA (PLATING WASTES)

ACTIVITY DESCRIPTION: FORKLIFT PICKS UP CYANIDE PLATING WASTE DRUM (CARBOY, POLYPACK OR OTHER) AND MOVES TO STORAGE AREA.

R--F--C	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
3 III C	FORKLIFT DRIVES OFF DOCK WHILE TRANSPORTING CYANIDE PLATING WASTE CONTAINER (CARBOY, POLYPACK OR OTHER).	CARBOY, POLYPACK OR OTHER CONTAINER BREACH IN DOCK AREA, WORKER EXPOSURE TO CYANIDE. (D;D;C;D).	NONE	NONE
3 IV A	FORKLIFT ACCIDENT BREACHES DRUMS OF INCOMPATIBLE WASTES ON THE TRUCK OR IN THE DOCK AREA.	CYANIDE AND ACID WASTES CAUSE LETHAL HCN MIXTURE. POSSIBLE WORKER FATALITY. MINOR ONSITE CONTAMINATION. (D;D;A;C)	DRUMS NOT STORED IN DOCK AREA. ONLY MATERIAL AT RISK IS ON THE TRUCK.	NONE
4 II D	CARBOY, POLYPACK OR OTHER PLATING WASTE CONTAINER PUSHED OFF DOCK OR TRUCK BY FORKLIFT.	CONTAINER BREACH, PLATING WASTE SPILL IN DOCK AREA. MINOR WORKER EXPOSURE AND FACILITY CONTAMINATION. (D;D;D;D)	NONE	NONE
4 III D	CARBOY, POLYPACK OR OTHER PLATING WASTE CONTAINER PUNCTURED BY FORKLIFT.	CONTAINER BREACH, PLATING WASTE SPILL IN DOCK AREA. (D;D;D;D)	NONE	NONE

PRELIMINARY HAZARD/RISK ANALYSIS RECORD BY ACTIVITY FOR HWRSF

ACTIVITY NUMBER: CY3

ACTIVITY NAME: WALK BEHIND FORKLIFT MOVES CYANIDE WASTE DRUM TO DOCK

ACTIVITY DESCRIPTION: WALK BEHIND FORKLIFT MOVES CYANIDE WASTE DRUM FROM STORAGE ROOM TO DOCK

R--F--C	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
3 III C	FORKLIFT DRIVES OFF DOCK WHILE TRANSPORTING CYANIDE PLATING WASTE CONTAINER (CARBOY, POLYPACK OR OTHER).	CARBOY, POLYPACK OR OTHER CONTAINER BREACH IN DOCK AREA, WORKER EXPOSURE. (D;D;C;C)	NONE	NONE
3 IV A	FORKLIFT ACCIDENT BREACHES DRUMS OF INCOMPATIBLE WASTES ON THE TRUCK OR IN THE DOCK AREA.	CYANIDE AND ACID WASTES CAUSE LETHAL HCN MIXTURE. POSSIBLE WORKER FATALITY. (D;D;A;C)	DRUMS NOT STORED IN DOCK AREA. ONLY MATERIAL AT RISK IS ON THE TRUCK.	NONE
4 II D	CARBOY, POLYPACK OR OTHER PLATING WASTE CONTAINER PUSHED OFF DOCK BY FORKLIFT.	CONTAINER BREACH, PLATING WASTE SPILL IN DOCK AREA. (D;D;D;D)	NONE	NONE
4 III D	CARBOY, POLYPACK OR OTHER PLATING WASTE CONTAINER PUNCTURED BY FORKLIFT.	CONTAINER BREACH, PLATING WASTE SPILL IN DOCK AREA. (D;D;D;D)	NONE	NONE

PRELIMINARY HAZARD/RISK ANALYSIS RECORD BY ACTIVITY FOR HWTF

ACTIVITY NUMBER: CY4

ACTIVITY NAME: YARD FORKLIFT TRANSPORTS CYANIDE PLATING WASTE TO TREATMENT ROOM DOOR

ACTIVITY DESCRIPTION: YARD FORKLIFT TRANSPORTS CYANIDE PLATING WASTE TO TREATMENT ROOM DOOR

R--F--C	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
3 III C	FORKLIFT ACCIDENT WITH THE SPILL OF A SINGLE DRUM OF PLATING WASTE. RELEASE OF 55 GALLONS.	WORKER EXPOSURE TO CYANIDE, POSSIBLE INJURY, MINOR FACILITY CONTAMINATION. (D;D;C;D)	NONE	NONE
3 IV A	FORKLIFT ACCIDENT WITH BREACH OF MULTIPLE WASTE CONTAINERS LEADING TO MIXING OF NONCOMPATIBLE WASTE MATERIALS. MISLABELED WASTE RESULTS IN MOVEMENT OF INCOMPATIBLE ACIDS WITH CYANIDE WASTES.	POSSIBLE PRODUCTION OF HCN. WORKER(S) EXPOSED TO HCN GAS WITH POSSIBLE FATALITIES, AND SEVERE INJURY TO COLOCATED WORKERS. FACILITY AND ONSITE CONTAMINATION. (C;B;A;C)	NONE	(1) MOVE ONLY ONE PALLET AT A TIME, (2) CONSIDER MOVING ONLY ONE DRUM AT A TIME.

PRELIMINARY HAZARD/RISK ANALYSIS RECORD BY ACTIVITY FOR HWTF

ACTIVITY NUMBER: CY5

ACTIVITY NAME: HWTF CRANE DELIVERS CYANIDE PLATING WASTE DRUM TO SAMPLE ROOM

ACTIVITY DESCRIPTION: CRANE DELIVERS CYANIDE PLATING WASTE DRUM TO SAMPLE ROOM

R--F--C	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
3 III C	PLATING WASTE DRUM DROPPED WHILE MOVING TO HWTF SAMPLE ROOM USING CRANE.	CARBOY, POLYPACK OR OTHER CONTAINER BREACH IN SAMPLE ROOM, POSSIBLE WORKER EXPOSURE. (D;D;C;D)	NONE	NONE

PRELIMINARY HAZARD/RISK ANALYSIS RECORD BY ACTIVITY FOR HWTF

ACTIVITY NUMBER: CY6

ACTIVITY NAME: OVERPACK DRUM IS OPENED AND INNER CYANIDE DRUM IS LIFTED WITH CRANE

ACTIVITY DESCRIPTION: OVERPACK DRUM IS GROUNDED, OPENED WITH NON-SPARK TOOLS, AND THE INNER DRUM IS LIFTED WITH THE OVERHEAD CRANE.

R--F--C	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
3 III C	OPERATOR FAILS TO FOLLOW PROCEDURE WHILE OPENING THE CYANIDE OVERPACK (I.E., USES WRONG TOOLS, DOES NOT GROUND DRUM, MISPOSITIONING OF THE VENT HOOD, ETC...).	SHORT DURATION HYDROGEN FIRE UPON OPENING THE OVERPACK. POSSIBLE WORKER INJURY. (D;D;C;D)	NONE	OPERATORS SHOULD USE SELF CONTAINED BREATHING APPARATUS
3 III C	DRUM CONTENTS SPILLED DUE TO: (1) CLAMP COMES LOOSE, OR (2) LID FALLS OFF.	SPILL OF DRUM CONTENTS. WORKER EXPOSURE TO CYANIDE WASTE. (D;D;C;D)	NONE	OPERATORS SHOULD USE SELF CONTAINED BREATHING APPARATUS.
3 IV A	RELEASE OF TOXIC GAS DUE TO UNEXPECTED MATERIALS IN CYANIDE WASTE DRUM (PHOSGEN, HYDROGEN SULFIDE, CHLORINE, ETC...).	WORKER INJURY, POSSIBLE FATALITY. (D;D;A;D)	NONE	OPERATORS SHOULD USE SELF CONTAINED BREATHING APPARATUS.
4 IV C	OPERATOR FAILS TO FOLLOW PROCEDURE (CAUSES SPARK) AND IGNITES HYDROGEN IN THE CYANIDE WASTE DRUM.	EXPLOSION OF SMALL QUANTITY OF AVAILABLE HYDROGEN RESTRICTED TO SPACE UNDER VENTILATION HOOD. (D;D;C;D)	NONE	OPERATORS SHOULD USE SELF CONTAINED BREATHING APPARATUS.

PRELIMINARY HAZARD/RISK ANALYSIS RECORD BY ACTIVITY FOR WWTF

ACTIVITY NUMBER: CY7

ACTIVITY NAME: OVERPACK DRUM IS DISCARDED TO CRUSHER OR USED FOR CEMENTATION (PLATING WASTE PROCESS).

ACTIVITY DESCRIPTION: OVERPACK DRUM (PLATING WASTE PROCESS) IS DISCARDED TO CRUSHER OR USED FOR CEMENTATION. INVOLVES TRANSPORTATION TO CRUSHER OR CEMENTATION FACILITY.

R--F--C	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
MINIMAL	TRANSPORT OF EMPTY OVERPACK DRUM (PLATING WASTE PROCESS) TO CRUSHER OR CEMENTATION FACILITY.	NONE	NONE	NONE

PRELIMINARY HAZARD/RISK ANALYSIS RECORD BY ACTIVITY FOR HWTF

ACTIVITY NUMBER: CY8

ACTIVITY NAME: VERMICULITE REMOVED AND BAGGED (PLATING WASTE PROCESS)

ACTIVITY DESCRIPTION: VERMICULITE REMOVED FROM OVERPACK, BAGGED AND SENT TO LANDFILL OR STORAGE.

R--F--C	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
4 11 D	VERMICULITE CONTAMINATED WITH CYANIDE PLATING WASTE FROM LEAKY INNER PACK.	POSSIBLE CONTAMINATION WITH CYANIDE PLATING WASTE, MINOR WORKER EXPOSURE. (D;D;D;D)	NONE	IF THERE ARE INDICATIONS OF A LEAK WHEN REMOVING THE INNER DRUM, DO NOT REMOVE THE VERMICULITE.

PRELIMINARY HAZARD/RISK ANALYSIS RECORD BY ACTIVITY FOR MWTF

ACTIVITY NUMBER: CY9

ACTIVITY NAME: PRIMARY WASTE DRUM IS GROUNDED AND OPENED USING NON-SPARK TOOLS (PLATING WASTES).

ACTIVITY DESCRIPTION: PRIMARY WASTE DRUM IS GROUNDED AND OPENED USING NON-SPARK TOOLS (PLATING WASTES).

R--F--C	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
3 IV A	RELEASE OF TOXIC GAS DUE TO UNEXPECTED MATERIALS IN CYANIDE WASTE DRUM (PHOSGEN, HYDROGEN SULFIDE, CHLORINE, ETC...).	WORKER INJURY, POSSIBLE FATALITY. (D;D;A;D)	NONE	OPERATORS SHOULD USE SELF CONTAINED BREATHING APPARATUS.
4 IV C	OPERATOR FAILS TO FOLLOW PROCEDURE WHILE OPENING CYANIDE PRIMARY WASTE DRUM (I.E., USES WRONG TOOLS, MISPOSITIONING OF THE VENT HOOD, ETC...). RELEASE OF FLAMMABLE GAS DUE TO UNEXPECTED CONTENTS.	SHORT DURATION FIRE UPON OPENING THE WASTE CONTAINER. POSSIBLE WORKER INJURY AND MINOR CONTAMINATION. (D;D;C;D)	NONE	NONE

PRELIMINARY HAZARD/RISK ANALYSIS RECORD BY ACTIVITY FOR HWTF

ACTIVITY NUMBER: CY10

ACTIVITY NAME: CONTENTS OF PLATING WASTE DRUM INSPECTED VISUALLY

ACTIVITY DESCRIPTION: CONTENTS OF PLATING WASTE DRUM INSPECTED VISUALLY AND SAMPLED

R--F--C	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
4 II D	SPILL OF CYANIDE LIQUID DURING SAMPLING AND VISUAL INSPECTION.	MINOR WORKER INJURY/EXPOSURE. (D;D;D;D)	NONE	IF UNEXPECTED CONTENTS FOUND, CONTACT SUPERVISOR.

PRELIMINARY HAZARD/RISK ANALYSIS RECORD BY ACTIVITY FOR HWTF

ACTIVITY NUMBER: CY11

ACTIVITY NAME: PLATING WASTE CONTAINER TRANSFERED TO SKID WITH CRANE OR MANUALLY.

ACTIVITY DESCRIPTION: PLATING WASTE CONTAINER TRANSFERED TO SKID WITH CRANE OR MANUALLY.

R--F--C	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
3 III C	CONTAINER CONTENTS SPILLED DUE TO: (1) CLAMP COMES LOOSE, (2) CAP FALLS OFF, OR (3) CONTAINER IS DROPPED. (PLATING WASTES)	SPILL OF WASTE CONTAINER CONTENTS. POTENTIAL WORKER EXPOSURE AND INJURY. (D;D;C;D)	NONE	NONE
3 V A	CRANE ACCIDENT SPILLS CYANIDE WASTE DRUM CONTENTS WITH INCOMPATIBLE WASTE(ACIDS). BOTH DRUMS BREACHED.	MIXING OF INCOMPATIBLE WASTES RESULTS IN LETHAL HCN GAS. (D;D;A;D)	NONE	NONE

PRELIMINARY HAZARD/RISK ANALYSIS RECORD BY ACTIVITY FOR HWTF

ACTIVITY NUMBER: CY12

ACTIVITY NAME: INSTALL PUMPING ASSEMBLY TO THE TOP OF THE CYANIDE WASTE DRUM

ACTIVITY DESCRIPTION: INSTALL PUMPING ASSEMBLY TO THE TOP OF THE CYANIDE WASTE DRUM (PLATING WASTE PROCESS).

R--F--C	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
1 II A	CYANIDE PLATING WASTE PUMPED TO WRONG LOCATION AND MIXED WITH NONCOMPATIBLE MATERIAL (I.E., WASTE DRUM, WASTE WATER SYSTEM, CHEMICAL MIX AND FEED TANK, CHEMICAL FEED DRUM OR THE DRY CHEMICAL FEEDER.) PLATING WASTE PROCESS.	HCN, H2S, NH3 OR OTHER TOXIC GAS PRODUCED AND RELEASED IN THE TREATMENT ROOM. WORKER EXPOSURE AND INJURY. (D;D;A;D)	NONE	(1) INSTALL CHECK VALVES ON OUTLET LINES OF THE CHEMICAL MIX FEED TANK, CHEMICAL FEED DRUM AND CHEMICAL PLATING WASTE DRUM (2) FOLLOW VALVE ALIGNMENT CHECKLIST PROCEDURE (3) VALVES SHOULD HAVE POSITION INDICATORS (4) OPERATORS SHOULD BE EQUIPED WITH PROTECTIVE CLOTHING AND RESPIRATOR (5) HAVE TWO OPERATORS CHECK VALVE POSITIONING (6) INSTALL INTERLOCK WHICH ALLOWS OPENING OF ONE VALVE AT A TIME
4 II D	RESIDUAL PLATING WASTE/REAGENTS LEFT IN PROCESS LINES DUE TO IMPROPER PURGE AFTER LOADING OF PREVIOUS WASTE CONTAINER. PLATING WASTE PROCESS.	HCN, H2S OR NH3 GAS GENERATED AND RELEASED TO SCRUBBER. (D;D;D;D)	NONE	ENSURE SCRUBBER OPERATION DURING ALL PHASES OF TREATMENT.

PRELIMINARY HAZARD/RISK ANALYSIS RECORD BY ACTIVITY FOR HWTF

ACTIVITY NUMBER: CY13

ACTIVITY NAME: INTRODUCTION OF REAGENTS TO THE REACTOR

ACTIVITY DESCRIPTION: INTRODUCTION OF REAGENTS TO THE REACTOR (PLATING WASTE PROCESS).

R--F--C	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
3 III C	REAGENTS ADDED TO THE PROCESS IN THE WRONG SEQUENCE (PLATING WASTE PROCESS).	UNPLANNED REACTIONS LEAD TO EXCESSIVE GENERATION OF GASES. CAN OVERLOAD SKID SCRUBBER BUT WILL VENT TO ROOM SCRUBBER. MINOR LEAK OF TOXIC GASES TO ROOM THROUGH LEAKS IN PIPING AND DUCTWORK. POTENTIAL FOR MINOR WORKER INJURY. (D;D;C;D)	NONE	NONE
3 III C	INSTRUMENTATION FAILURE LEADS TO INCORRECT REAGENT/AMOUNTS OF REAGENTS ADDED TO REACTOR (PLATING WASTE PROCESS).	UNPLANNED REACTIONS LEAD TO RELEASE OF TOXIC GAS TO THE SCRUBBER. (D;D;C;D)	NONE	NONE

PRELIMINARY HAZARD/RISK ANALYSIS RECORD BY ACTIVITY FOR MWTF

ACTIVITY NUMBER: CY14

ACTIVITY NAME: LIQUIDS PACKAGED AND SENT TO TA-50-1

ACTIVITY DESCRIPTION: LIQUIDS PACKAGED AND SENT TO TA-50-1 (PLATING WASTE PROCESS).

R--F--C	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
3 III C	THE REACTION IS INCOMPLETE DUE TO INSTRUMENTATION FAILURE OR HUMAN ERROR (PLATING WASTE PROCESS).	UNTREATED MIXED WASTE SENT TO TA-50-1. (D;D;D;C)	PHYSICALLY SAMPLE LIQUID PRIOR TO TRANSPORTATION TO TA-50-1.	NONE

TABLE A-6
HAZMAN RESULTS SORTED BY RISK RANK FOR CHEMICAL PLATING WASTE TREATMENT PROCESS

HAZARD ANALYSIS REPORT BY RISK

R---F---C	ACT/FAC	ACTIVITY NAME	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
1 II A	CY12 / HWTF	INSTALL PUMPING ASSEMBLY TO THE TOP OF THE CYANIDE WASTE DRUM	CYANIDE PLATING WASTE PUMPED TO WRONG LOCATION AND MIXED WITH NONCOMPATIBLE MATERIAL (I.E., WASTE DRUM, WASTE WATER SYSTEM, CHEMICAL MIX AND FEED TANK, CHEMICAL FEED DRUM OR THE DRY CHEMICAL FEEDER.) PLATING WASTE PROCESS.	HCN, H2S, NH3 OR OTHER TOXIC GAS PRODUCED AND RELEASED IN THE TREATMENT ROOM. WORKER EXPOSURE AND INJURY. (D;D;A;D)	NONE	(1) INSTALL CHECK VALVES ON OUTLET LINES OF THE CHEMICAL MIX FEED TANK, CHEMICAL FEED DRUM AND CHEMICAL PLATING WASTE DRUM (2) FOLLOW VALVE ALIGNMENT CHECKLIST PROCEDURE (3) VALVES SHOULD HAVE POSITION INDICATORS (4) OPERATORS SHOULD BE EQUIPED WITH PROTECTIVE CLOTHING AND RESPIRATOR (5) HAVE TWO OPERATORS CHECK VALVE POSITIONING (6) INSTALL INTERLOCK WHICH ALLOWS OPENING OF ONE VALVE AT A TIME
2 III A	CY1 / HWRSF	TRUCK ENTERS FACILITY AND DRIVES TO DOCK (PLATING WASTES).	TRUCK ACCIDENT WITH BREACH OF MULTIPLE WASTE CONTAINERS LEADING TO MIXING OF INCOMPATIBLE WASTES. DUE TO (1) NORMAL TRANSPORT OF INCOMPATIBLES, (2) MISLABELED DRUMS.	POSSIBLE PRODUCTION OF HCN. WORKER(S) EXPOSED TO HCN GAS WITH POSSIBLE FATALITIES, AND INJURY TO COLOCATED WORKERS. MINOR ONSITE CONTAMINATION. (B;B;A;C)	NONE	ADMINISTRATIVE CONTROLS; (1) ANNOUNCEMENT OF DELIVERY, (2) DRIVER TRAINING, (3) RESTRICT OTHER TRAFFIC DURING DELIVERY. CONSIDER REVIEW OF TRANSPORTATION PROCEDURES, E.G., (1) RESTRICT THE TRANSPORTATION OF INCOMPATIBLE WASTES IN SINGLE TRUCK, (2) CONSIDER TRANSPORT OF ONE DRUM AT A TIME.
3 III C	CY11 / HWTF	PLATING WASTE CONTAINER TRANSFERED TO SKID WITH CRANE OR MANUALLY.	CONTAINER CONTENTS SPILLED DUE TO: (1) CLAMP COMES LOOSE, (2) CAP FALLS OFF, OR (3) CONTAINER IS DROPPED. (PLATING WASTES)	SPILL OF WASTE CONTAINER CONTENTS. POTENTIAL WORKER EXPOSURE AND INJURY. (D;D;C;D)	NONE	NONE
3 III C	CY2 / HWRSF	WALK BEHIND FORKLIFT TRANSFERS WASTE DRUM TO STORAGE AREA (PLATING WASTES)	FORKLIFT DRIVES OFF DOCK WHILE TRANSPORTING CYANIDE PLATING WASTE CONTAINER (CARBOY, POLYPACK OR OTHER).	CARBOY, POLYPACK OR OTHER CONTAINER BREACH IN DOCK AREA, WORKER EXPOSURE TO CYANIDE. (D;D;C;D).	NONE	NONE
3 III C	CY3 / HWRSF	WALK BEHIND FORKLIFT MOVES CYANIDE WASTE DRUM TO DOCK	FORKLIFT DRIVES OFF DOCK WHILE TRANSPORTING CYANIDE PLATING WASTE CONTAINER (CARBOY, POLYPACK OR OTHER).	CARBOY, POLYPACK OR OTHER CONTAINER BREACH IN DOCK AREA, WORKER EXPOSURE. (D;D;C;C)	NONE	NONE

HAZARD ANALYSIS REPORT BY RISK

R---F---C	ACT/FAC	ACTIVITY NAME	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
3 III C	CY4 / HWTF	YARD FORKLIFT TRANSPORTS CYANIDE PLATING WASTE TO TREATMENT ROOM DOOR	FORKLIFT ACCIDENT WITH THE SPILL OF A SINGLE DRUM OF PLATING WASTE. RELEASE OF 55 GALLONS.	WORKER EXPOSURE TO CYANIDE, POSSIBLE INJURY, MINOR FACILITY CONTAMINATION. (D;D;C;D)	NONE	NONE
3 III C	CY5 / HWTF	HWTF CRANE DELIVERS CYANIDE PLATING WASTE DRUM TO SAMPLE ROOM	PLATING WASTE DRUM DROPPED WHILE MOVING TO HWTF SAMPLE ROOM USING CRANE.	CARBOY, POLYPACK OR OTHER CONTAINER BREACH IN SAMPLE ROOM, POSSIBLE WORKER EXPOSURE. (D;D;C;D)	NONE	NONE
3 III C	CY6 / HWTF	OVERPACK DRUM IS OPENED AND INNER CYANIDE DRUM IS LIFTED WITH CRANE	OPERATOR FAILS TO FOLLOW PROCEDURE WHILE OPENING THE CYANIDE OVERPACK (I.E., USES WRONG TOOLS, DOES NOT GROUND DRUM, MISPOSITIONING OF THE VENT HOOD, ETC...).	SHORT DURATION HYDROGEN FIRE UPON OPENING THE OVERPACK. POSSIBLE WORKER INJURY. (D;D;C;D)	NONE	OPERATORS SHOULD USE SELF CONTAINED BREATHING APPARATUS
3 III C	CY6 / HWTF	OVERPACK DRUM IS OPENED AND INNER CYANIDE DRUM IS LIFTED WITH CRANE	DRUM CONTENTS SPILLED DUE TO: (1) CLAMP COMES LOOSE, OR (2) LID FALLS OFF.	SPILL OF DRUM CONTENTS. WORKER EXPOSURE TO CYANIDE WASTE. (D;D;C;D)	NONE	OPERATORS SHOULD USE SELF CONTAINED BREATHING APPARATUS.
3 III C	CY13 / HWTF	INTRODUCTION OF REAGENTS TO THE REACTOR	REAGENTS ADDED TO THE PROCESS IN THE WRONG SEQUENCE (PLATING WASTE PROCESS).	UNPLANNED REACTIONS LEAD TO EXCESSIVE GENERATION OF GASES. CAN OVERLOAD SKID SCRUBBER BUT WILL VENT TO ROOM SCRUBBER. MINOR LEAK OF TOXIC GASES TO ROOM THROUGH LEAKS IN PIPING AND DUCTWORK. POTENTIAL FOR MINOR WORKER INJURY. (D;D;C;D)	NONE	NONE
3 III C	CY13 / HWTF	INTRODUCTION OF REAGENTS TO THE REACTOR	INSTRUMENTATION FAILURE LEADS TO INCORRECT REAGENT/AMOUNTS OF REAGENTS ADDED TO REACTOR (PLATING WASTE PROCESS).	UNPLANNED REACTIONS LEAD TO RELEASE OF TOXIC GAS TO THE SCRUBBER. (D;D;C;D)	NONE	NONE
3 III C	CY14 / HWTF	LIQUIDS PACKAGED AND SENT TO TA-50-1	THE REACTION IS INCOMPLETE DUE TO INSTRUMENTATION FAILURE OR HUMAN ERROR (PLATING WASTE PROCESS).	UNTREATED MIXED WASTE SENT TO TA-50-1. (D;D;D;C)	PHYSICALLY SAMPLE LIQUID PRIOR TO TRANSPORTATION TO TA-50-1.	NONE
3 III C	CY1 / MWRSF	TRUCK ENTERS FACILITY AND DRIVES TO DOCK (PLATING WASTES).	TRUCK ACCIDENT WITH THE SPILL OF A SINGLE DRUM OF PLATING WASTE. RELEASE OF 55 GALLONS.	WORKER EXPOSURE TO CYANIDE AND POSSIBLE INJURY, RADIATION CONTAMINATION, MINOR ONSITE CONTAMINATION. (D;D;C;C)	NONE	ADMINISTRATIVE CONTROLS; (1) ANNOUNCEMENT OF DELIVERY, (2) DRIVER TRAINING, (3) RESTRICT OTHER TRAFFIC DURING DELIVERY.
3 IV A	CY9 / HWTF	PRIMARY WASTE DRUM IS GROUNDED AND OPENED USING NON-SPARK TOOLS (PLATING WASTES).	RELEASE OF TOXIC GAS DUE TO UNEXPECTED MATERIALS IN CYANIDE WASTE DRUM (PHOSGEN, HYDROGEN	WORKER INJURY, POSSIBLE FATALITY. (D;D;A;D)	NONE	OPERATORS SHOULD USE SELF CONTAINED BREATHING APPARATUS.

HAZARD ANALYSIS REPORT BY RISK

R---F---C	ACT/FAC	ACTIVITY NAME	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
			SULFIDE, CHLORINE, ETC...).			
3 IV A	CY2 / MWRSF	WALK BEHIND FORKLIFT TRANSFERS WASTE DRUM TO STORAGE AREA (PLATING WASTES)	FORKLIFT ACCIDENT BREACHES DRUMS OF INCOMPATIBLE WASTES ON THE TRUCK OR IN THE DOCK AREA.	CYANIDE AND ACID WASTES CAUSE LETHAL HCN MIXTURE. POSSIBLE WORKER FATALITY. MINOR ONSITE CONTAMINATION. (D;D;A;C)	DRUMS NOT STORED IN DOCK AREA. ONLY MATERIAL AT RISK IS ON THE TRUCK.	NONE
3 IV A	CY3 / MWRSF	WALK BEHIND FORKLIFT MOVES CYANIDE WASTE DRUM TO DOCK	FORKLIFT ACCIDENT BREACHES DRUMS OF INCOMPATIBLE WASTES ON THE TRUCK OR IN THE DOCK AREA.	CYANIDE AND ACID WASTES CAUSE LETHAL HCN MIXTURE. POSSIBLE WORKER FATALITY. (D;D;A;C)	DRUMS NOT STORED IN DOCK AREA. ONLY MATERIAL AT RISK IS ON THE TRUCK.	NONE
3 IV A	CY4 / HWTF	YARD FORKLIFT TRANSPORTS CYANIDE PLATING WASTE TO TREATMENT ROOM DOOR	FORKLIFT ACCIDENT WITH BREACH OF MULTIPLE WASTE CONTAINERS LEADING TO MIXING OF NONCOMPATIBLE WASTE MATERIALS. MISLABELED WASTE RESULTS IN MOVEMENT OF INCOMPATIBLE ACIDS WITH CYANIDE WASTES.	POSSIBLE PRODUCTION OF HCN. WORKER(S) EXPOSED TO HCN GAS WITH POSSIBLE FATALITIES, AND SEVERE INJURY TO COLOCATED WORKERS. FACILITY AND ONSITE CONTAMINATION. (C;B;A;C)	NONE	(1) MOVE ONLY ONE PALLET AT A TIME, (2) CONSIDER MOVING ONLY ONE DRUM AT A TIME.
3 IV A	CY6 / HWTF	OVERPACK DRUM IS OPENED AND INNER CYANIDE DRUM IS LIFTED WITH CRANE	RELEASE OF TOXIC GAS DUE TO UNEXPECTED MATERIALS IN CYANIDE WASTE DRUM (PHOSGEN, HYDROGEN SULFIDE, CHLORINE, ETC...).	WORKER INJURY, POSSIBLE FATALITY. (D;D;A;D)	NONE	OPERATORS SHOULD USE SELF CONTAINED BREATHING APPARATUS.
3 V A	CY11 / HWTF	PLATING WASTE CONTAINER TRANSFERED TO SKID WITH CRANE OR MANUALLY.	CRANE ACCIDENT SPILLS CYANIDE WASTE DRUM CONTENTS WITH INCOMPATIBLE WASTE(ACIDS). BOTH DRUMS BREACHED.	MIXING OF INCOMPATIBLE WASTES RESULTS IN LETHAL HCN GAS. (D;D;A;D)	NONE	NONE
4 II D	CY10 / HWTF	CONTENTS OF PLATING WASTE DRUM INSPECTED VISUALLY	SPILL OF CYANIDE LIQUID DURING SAMPLING AND VISUAL INSPECTION.	MINOR WORKER INJURY/EXPOSURE. (D;D;D;D)	NONE	IF UNEXPECTED CONTENTS FOUND, CONTACT SUPERVISOR.
4 II D	CY2 / MWRSF	WALK BEHIND FORKLIFT TRANSFERS WASTE DRUM TO STORAGE AREA (PLATING WASTES)	CARBOY, POLYPACK OR OTHER PLATING WASTE CONTAINER PUSHED OFF DOCK OR TRUCK BY FORKLIFT.	CONTAINER BREACH, PLATING WASTE SPILL IN DOCK AREA. MINOR WORKER EXPOSURE AND FACILITY CONTAMINATION. (D;D;D;D)	NONE	NONE

HAZARD ANALYSIS REPORT BY RISK

R---F---C	ACT/FAC	ACTIVITY NAME	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
4 II D	CY3 / MWRSF	WALK BEHIND FORKLIFT MOVES CYANIDE WASTE DRUM TO DOCK	CARBOY, POLYPACK OR OTHER PLATING WASTE CONTAINER PUSHED OFF DOCK BY FORKLIFT.	CONTAINER BREACH, PLATING WASTE SPILL IN DOCK AREA. (D;D;D;D)	NONE	NONE
4 II D	CY12 / HWTF	INSTALL PUMPING ASSEMBLY TO THE TOP OF THE CYANIDE WASTE DRUM	RESIDUAL PLATING WASTE/REAGENTS LEFT IN PROCESS LINES DUE TO IMPROPER PURGE AFTER LOADING OF PREVIOUS WASTE CONTAINER. PLATING WASTE PROCESS.	HCN, H2S OR NH3 GAS GENERATED AND RELEASED TO SCRUBBER. (D;D;D;D)	NONE	ENSURE SCRUBBER OPERATION DURING ALL PHASES OF TREATMENT.
4 II D	CY8 / HWTF	VERMICULITE REMOVED AND BAGGED (PLATING WASTE PROCESS)	VERMICULITE CONTAMINATED WITH CYANIDE PLATING WASTE FROM LEAKY INNER PACK.	POSSIBLE CONTAMINATION WITH CYANIDE PLATING WASTE, MINOR WORKER EXPOSURE. (D;D;D;D)	NONE	IF THERE ARE INDICATIONS OF A LEAK WHEN REMOVING THE INNER DRUM, DO NOT REMOVE THE VERMICULITE.
4 III D	CY2 / MWRSF	WALK BEHIND FORKLIFT TRANSFERS WASTE DRUM TO STORAGE AREA (PLATING WASTES)	CARBOY, POLYPACK OR OTHER PLATING WASTE CONTAINER PUNCTURED BY FORKLIFT.	CONTAINER BREACH, PLATING WASTE SPILL IN DOCK AREA. (D;D;D;D)	NONE	NONE
4 III D	CY3 / MWRSF	WALK BEHIND FORKLIFT MOVES CYANIDE WASTE DRUM TO DOCK	CARBOY, POLYPACK OR OTHER PLATING WASTE CONTAINER PUNCTURED BY FORKLIFT.	CONTAINER BREACH, PLATING WASTE SPILL IN DOCK AREA. (D;D;D;D)	NONE	NONE
4 IV C	CY9 / HWTF	PRIMARY WASTE DRUM IS GROUNDED AND OPENED USING NON-SPARK TOOLS (PLATING WASTES).	OPERATOR FAILS TO FOLLOW PROCEDURE WHILE OPENING CYANIDE PRIMARY WASTE DRUM (I.E., USES WRONG TOOLS, MISPOSITIONING OF THE VENT HOOD, ETC...). RELEASE OF FLAMMABLE GAS DUE TO UNEXPECTED CONTENTS.	SHORT DURATION FIRE UPON OPENING THE WASTE CONTAINER. POSSIBLE WORKER INJURY AND MINOR CONTAMINATION. (D;D;C;D)	NONE	NONE
4 IV C	CY6 / HWTF	OVERPACK DRUM IS OPENED AND INNER CYANIDE DRUM IS LIFTED WITH CRANE	OPERATOR FAILS TO FOLLOW PROCEDURE (CAUSES SPARK) AND IGNITES HYDROGEN IN THE CYANIDE WASTE DRUM.	EXPLOSION OF SMALL QUANTITY OF AVAILABLE HYDROGEN RESTRICTED TO SPACE UNDER VENTILATION HOOD. (D;D;C;D)	NONE	OPERATORS SHOULD USE SELF CONTAINED BREATHING APPARATUS.
	CY7 / HWTF	OVERPACK DRUM IS DISCARDED TO CRUSHER OR USED FOR CEMENTATION (PLATING WASTE PROCESS).	TRANSPORT OF EMPTY OVERPACK DRUM (PLATING WASTE PROCESS) TO CRUSHER OR CEMENTATION FACILITY.	NONE	NONE	NONE

TABLE A-7
HAZMAN RESULTS SORTED BY ACTIVITY FOR GAS CYLINDER RECONTAINERIZATION PROCESS

PRELIMINARY HAZARD/RISK ANALYSIS RECORD BY ACTIVITY FOR MWRSF

ACTIVITY NUMBER: GC1

ACTIVITY NAME: LOAD CYLINDER FROM TA-54 ONTO TRANSPORT VEHICLE AND MOVE TO TA-63

ACTIVITY DESCRIPTION: LOAD CYLINDER FROM TA-54 ONTO TRANSPORT VEHICLE AND MOVE TO TA-63

R--F--C	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
2 III A	HANDLING ACCIDENT WHILE REMOVING CYLINDER FROM STORAGE, (E.G., CYLINDER FALLS BREAKING VALVE OR CONNECTIONS OR RUPTURE OF A CORRODED CYLINDER).	RELEASE OF TOXIC GAS FROM A SINGLE CYLINDER (E.G., CYANOGEN, ARSENIC PENTAFLORIDE, HF, PHOSGENE). POSSIBLE WORKER FATALITY. (C;D;A;D)	NONE	(1) CONSIDER SECONDARY CONTAINMENT FOR KNOWN HIGHLY TOXIC GAS CYLINDERS AND ALL UNKNOWN GAS CYLINDERS, (2) VALVE COVERS SHOULD BE IN PLACE ON ALL CYLINDERS, (3) TRAIN WORKERS TO EVACUATE IN UPWIND DIRECTION, AND LOCATE GAS MASKS IN UPWIND DIRECTION, (4) INSTALL A WIND SOCK FOR CONTINUOUS WIND DIRECTION INDICATION, (5) CONSIDER PROTECTIVE CLOTHING FOR MIXED WASTE GAS RELEASE.
3 IV B	RUPTURE OF FLAMMABLE GAS CYLINDER DURING HANDLING NEAR OTHER GAS CYLINDERS.	FLAMMABLE GAS IGNITES AND EXPOSES MULTIPLE CYLINDERS TO HIGH TEMPERATURE RESULTING IN RELEASE OF MULTIPLE GAS CYLINDERS. (C;C;B;C)	(1) WORKER HAS TIME TO RESPOND TO THE FIRE PRIOR TO RUPTURE OF OTHER CYLINDERS, (2) STORAGE FACILITY IS LOCATED AT A REMOTE SITE.	(1) VALVE COVERS SHOULD BE IN PLACE ON ALL CYLINDERS, (2) TRAIN WORKERS TO EVACUATE IN UPWIND DIRECTION, AND LOCATE GAS MASKS IN UPWIND DIRECTION, (3) INSTALL A WIND SOCK FOR CONTINUOUS WIND DIRECTION INDICATION..

PRELIMINARY HAZARD/RISK ANALYSIS RECORD BY ACTIVITY FOR HWRSF

ACTIVITY NUMBER: GC2

ACTIVITY NAME: TRANSPORT OF GAS CYLINDER TO TA-63 HWRSF

ACTIVITY DESCRIPTION: GAS CYLINDER TRANSPORTED TO THE HWRSF DOCK

R--F--C	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
2 III A	TRUCK ACCIDENT ON PUBLIC ROAD BETWEEN TA-54 AND TA-63 WITH BREACH OF GAS CYLINDER(S).	POTENTIAL RELEASE OF TOXIC GASES WITH PUBLIC AND WORKER EXPOSURE. (A;C;A;D)	NONE	ADMINISTRATIVE CONTROLS; (1) PROVIDE ESCORT FOR THE TRANSPORT VEHICLE AND CONSIDER ROAD CLOSURE DURING TRANSPORT, (2) DRIVER TRAINING, (3) RESTRICT NIGHT OR POOR WEATHER DELIVERIES, (4) CONSIDER SECONDARY CONTAINMENT FOR CYLINDERS OF QUESTIONABLE INTEGRITY, UNKNOWN CONTENTS, OR THOSE CONTAINING MOST HIGHLY TOXIC MATERIALS.

PRELIMINARY HAZARD/RISK ANALYSIS RECORD BY ACTIVITY FOR NURSF

ACTIVITY NUMBER: GC3

ACTIVITY NAME: GAS CYLINDER TRANSPORTED FROM NURSF DOCK STORAGE AREA

ACTIVITY DESCRIPTION: GAS CYLINDER TRANSPORTED FROM NURSF DOCK STORAGE AREA

R--F--C	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
3 IV A	BREACH OF CYLINDER DUE TO ACCIDENTAL CAUSES (E.G., CYLINDER DROPPED AND REGULATOR LINE BREAKS).	RELEASE OF HIGHLY TOXIC GASES (PHOSPHINE, PHOSGEN, ARSINE, AND OTHERS), WORKER FATALITY. (C;C;A;D)	HEPA AND SCRUBBING SYSTEM.	(1) TRANSPORT AND STORE CYLINDERS SECURELY, (2) INSTALL GAS DETECTORS AND ALARMS, (3) CONSIDER SECONDARY CONTAINMENT FOR MOST HAZARDOUS CYLINDERS, (4) PROTECTIVE CAP FOR CYLINDER REGULATORS SHOULD BE IN PLACE AT ALL TIMES.
3 IV B	BREACH OF CYLINDER DUE TO ACCIDENTAL CAUSES (E.G., CYLINDER DROPPED AND REGULATOR LINE BREAKS).	RELEASE OF MODERATELY TOXIC GASES (H2S, NO2, AND OTHERS). WORKER EXPOSURE. (C;C;B;D)	HEPA AND SCRUBBING SYSTEM.	(1) TRANSPORT AND STORE CYLINDERS SECURELY, (2) INSTALL GAS DETECTORS AND ALARMS, (3) CONSIDER SECONDARY CONTAINMENT FOR MOST HAZARDOUS CYLINDERS, (4) PROTECTIVE CAP FOR CYLINDER REGULATORS SHOULD BE IN PLACE AT ALL TIMES.

PRELIMINARY HAZARD/RISK ANALYSIS RECORD BY ACTIVITY FOR HWRSF

ACTIVITY NUMBER: GC4

ACTIVITY NAME: TRANSPORT GAS CYLINDER FROM HWRSF STORAGE TO THE HWTF TREATMENT ROOM

ACTIVITY DESCRIPTION: TRANSPORT GAS CYLINDER FROM HWRSF STORAGE TO THE HWTF TREATMENT ROOM

R--F--C	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
3 IV A	BREACH OF CYLINDER DUE TO ACCIDENTAL CAUSES (E.G., CYLINDER DROPPED AND REGULATOR LINE BREAKS).	RELEASE OF HIGHLY TOXIC GASES (PHOSPHINE, PHOSGEN, ARSINE, AND OTHERS), WORKER FATALITY. (A;A;A;D)	NONE	(1) TRANSPORT AND STORE CYLINDERS SECURELY, (2) CONSIDER SECONDARY CONTAINMENT FOR MOST HAZARDOUS CYLINDERS, (4) PROTECTIVE CAP FOR CYLINDER REGULATORS SHOULD BE IN PLACE AT ALL TIMES.
3 IV B	BREACH OF CYLINDER DUE TO ACCIDENTAL CAUSES (E.G., CYLINDER DROPPED AND REGULATOR LINE BREAKS).	RELEASE OF MODERATELY TOXIC GASES (H2S, NO2, AND OTHERS). WORKER EXPOSURE. (C;C;B;D)	NONE	(1) TRANSPORT AND STORE CYLINDERS SECURELY, (2) CONSIDER SECONDARY CONTAINMENT FOR MOST HAZARDOUS CYLINDERS, (4) PROTECTIVE CAP FOR CYLINDER REGULATORS SHOULD BE IN PLACE AT ALL TIMES.

PRELIMINARY HAZARD/RISK ANALYSIS RECORD BY ACTIVITY FOR NWTF

ACTIVITY NUMBER: GC5

ACTIVITY NAME: TRANSFER CYLINDER INTO SKID PRESSURE VESSEL

ACTIVITY DESCRIPTION: TRANSFER CYLINDER INTO SKID PRESSURE VESSEL

R--F--C	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
3 IV A	CYLINDER DROPPED DURING TRANSFER INTO PRESSURE VESSEL.	POTENTIAL RELEASE OF TOXIC GAS, WORKER EXPOSURE AND FATALITY. (D;D;A;D)	CYLINDER IS NOT TRANFERRED USING OVERHEAD CRANE.	(1) WORKER SHOULD WEAR PROTECTIVE EQUIPMENT, INCLUDING RESPIRATOR.

PRELIMINARY HAZARD/RISK ANALYSIS RECORD BY ACTIVITY FOR MWTF

ACTIVITY NUMBER: GC6

ACTIVITY NAME: CYLINDER BREACHED

ACTIVITY DESCRIPTION: CYLINDER BREACHED

R--F--C	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
2 I C	SAW JAMS OR OTHER MECHANICAL FAILURES DURING CUTTING AND GAS IS RELEASED INTO PRESSURE VESSEL, WORKER OPENS VESSEL AFTER PURGING TO INSPECT.	RELEASE OF RESIDUAL TOXIC GAS, MINOR WORKER EXPOSURE. (D;D;C;D)	ONLINE GAS DETECTORS.	(1) VERIFY ATMOSPHERE PRIOR TO OPENING VESSEL. (2) WEAR PROTECTIVE GEAR (SCBA) WHEN OPENING VESSEL.
2 II B	SAW JAMS OR OTHER MECHANICAL FAILURES DURING CUTTING, WORKER OPENS VESSEL TO INSPECT, CAUSING UNEXPECTED RELEASE.	RELEASE OF TOXIC GAS, WORKER EXPOSURE AND SERIOUS INJURY. (D;D;B;D)	ONLINE GAS DETECTORS.	(1) VERIFY ATMOSPHERE PRIOR TO OPENING VESSEL. (2) WEAR PROTECTIVE GEAR (SCBA) WHEN OPENING VESSEL.
2 II B	TREATMENT SKID (VALVES FOR CONTAINMENT VESSEL) MISALIGNED BEFORE OR AFTER CYLINDER BREACH.	RELEASE OF MODERATELY TOXIC GASES (E.G., NO2, H2S, ETC...) TO ATMOSPHERE AND/OR BUILDING. WORKER EXPOSURE. (C;C;B;D)	HEPA AND SCRUBBING SYSTEM.	(1) INDEPENDENT VERIFICATION OF SYSTEM ALIGNMENT BEFORE CUTTING. (2) USE PROCEDURE WITH CHECKLIST, (3) PROVIDE VALVE POSITION INDICATION.
2 III A	TREATMENT SKID (VALVES FOR CONTAINMENT VESSEL) MISALIGNED BEFORE OR AFTER CYLINDER BREACH.	RELEASE OF HIGHLY TOXIC GASES (PHOSPINE, PHOSGEN, ARSINE, AND OTHERS) TO ATMOSPHERE AND/OR BUILDING. WORKER FATALITY, POTENTIAL COLOCATED WORKER AND PUBLIC EXPOSURE. (C;B;A;D)	HEPA AND SCRUBBING SYSTEM.	(1) INDEPENDENT VERIFICATION OF SYSTEM ALIGNMENT BEFORE CUTTING. (2) USE PROCEDURE WITH CHECKLIST, (3) PROVIDE VALVE POSITION INDICATION.
2 III A	INADVERTANT CUTTING OF CYLINDER PRIOR TO SEALING VESSEL.	RELEASE OF TOXIC GAS INTO ROOM, WORKER EXPOSURE AND POSSIBLE FATALITY. (D;D;A;D)	NONE	(1) INSTALL INTERLOCKS TO PREVENT SAW OPERATION BEFORE SEALING AND INERTING PRESSURE VESSEL. (2) VERIFY DOOR CLOSURE PRIOR TO STARTING SAW.
2 III A	PRESSURE VESSEL INCORRECTLY SEALED (SUCH AS DOOR SEAL) OR SEAL FAILS	MINOR LEAK OF HIGHLY TOXIC GAS (PHOSPHINE, PHOSGEN, ARSINE) FROM LEAKY	NONE	(1) PERFORM CHECK OF PRESSURE VESSEL SEAL BEFORE CUTTING OPERATION. (2)

PRELIMINARY HAZARD/RISK ANALYSIS RECORD BY ACTIVITY FOR MWTF

ACTIVITY NUMBER: GC6

ACTIVITY NAME: CYLINDER BREACHED

ACTIVITY DESCRIPTION: CYLINDER BREACHED

R--F--C	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
	CAUSING LEAKAGE.	SEALS, POTENTIAL WORKER FATALITY. (D;D;A;D)		MINIMIZE TIME BETWEEN CUTTING AND DISPOSAL OR RECONTAINERIZATION. (3) LOCATE CONTROL PANEL AWAY FROM SKID.
3 II C	PRESSURE VESSEL INCORRECTLY SEALED (SUCH AS DOOR SEAL) OR SEAL FAILS CAUSING LEAKAGE.	LEAK OF MODERATELY TOXIC GAS FROM LEAKY SEALS. (D;D;C;D)	NONE	(1) PERFORM CHECK OF PRESSURE VESSEL SEAL BEFORE CUTTING OPERATION. (2) MINIMIZE TIME BETWEEN CUTTING AND DISPOSAL OR RECONTAINERIZATION. (3) LOCATE CONTROL PANEL AWAY FROM SKID.
3 IV B	FLAMABLE CYLINDER BREACHED WITOUT INERTING PRESSURE VESSEL ATMOSPHERE.	FIRE OR EXPLOSION, POTENTIAL PRESSURE VESSEL DAMAGE. RELEASE OF GASES TO ATMOSPERE, WORKER INJURY. (D;D;B;C)	VESSEL DESIGNED TO CONTAIN FIRE AND EXPLOSION.	VERIFY PRESSURE VESSEL ATMOSPHERE BEFORE CUTTING CYLINDER.

PRELIMINARY HAZARD/RISK ANALYSIS RECORD BY ACTIVITY FOR NWTF

ACTIVITY NUMBER: GC7

ACTIVITY NAME: SAMPLE, ANALYZE, AND DISPOSE PRESSURE VESSEL CONTENTS

ACTIVITY DESCRIPTION: SAMPLE, ANALYZE, AND DISPOSE OF PRESSURE VESSEL GASES

R--F--C	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
2 III B	MISROUTING OF TOXIC GAS (E.G., GAS SENT TO ATMOSPHERE) DUE TO HUMAN ERROR, SCRUBBER FAILED OR INEFFECTIVE.	TOXIC GASES INADVERTENTLY VENTED TO ATMOSPHERE, EXPOSURE TO PUBLIC, COLOCATED WORKERS AND WORKERS OUTSIDE THE BUILDING. (B;B;B;D)	NONE	(1) PROVIDE SAMPLING PROCEDURES WITH INDEPENDENT VERIFICATION, (2) VERIFY SYSTEM LINE-UP PRIOR TO ROUTING PRESSURE VESSEL CONTENTS.
3 II C	MISROUTING OF TOXIC GAS (E.G., GAS SENT TO ATMOSPHERE) DUE TO HUMAN ERROR OR MISINTERPRETATION OF SAMPLING RESULTS.	TOXIC GASES INADVERTENTLY VENTED TO ATMOSPHERE THROUGH SCRUBBER SYSTEM, MINOR EXPOSURE. (C;C;C;D)	HEPA AND SCRUBBER SYSTEM.	(1) VERIFY SYSTEM LINE-UP PRIOR TO ROUTING PRESSURE VESSEL CONTENTS.
3 II C	INCOMPLETE VENTING OR SCRUBBING OF THE PRESSURE VESSEL DUE TO HUMAN ERROR.	WORKER EXPOSURE TO RESIDUAL TOXIC GASES UPON OPENNING THE PRESSURE VESSEL. (D;D;C;D)	NONE	(1) WORKER TO WEAR PROTECTIVE EQUIPMENT (INCLUDING SCBA) WHEN OPENNING PRESSURE VESSEL.

PRELIMINARY HAZARD/RISK ANALYSIS RECORD BY ACTIVITY FOR HWTF

ACTIVITY NUMBER: GC8

ACTIVITY NAME: SCRUBBING AND DISPOSING OF CYLINDERS

ACTIVITY DESCRIPTION: SCRUBBING AND DISPOSING OF CYLINDERS

R--F--C	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
2 III B	RADIOACTIVE CONTAINER MISLABELED AS HAZARDOUS AND SENT OFF-SITE FOR TREATMENT.	VIOLATION OF REGULATIONS, LOCALIZED MINOR OFFSITE CONTAMINATION. (D;D;D;B)	ONLINE SAMPLING.	INDEPENDENTLY VERIFY CORRECT LABELING.

TABLE A-8
HAZMAN RESULTS SORTED BY RISK RANK FOR GAS CYLINDER RECONTAINERIZATION PROCESS

HAZARD ANALYSIS REPORT BY RISK

R---F---C	ACT/FAC	ACTIVITY NAME	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
2 I C	GC6 / MWTF	CYLINDER BREACHED	SAW JAMS OR OTHER MECHANICAL FAILURES DURING CUTTING AND GAS IS RELEASED INTO PRESSURE VESSEL, WORKER OPENS VESSEL AFTER PURGING TO INSPECT.	RELEASE OF RESIDUAL TOXIC GAS, MINOR WORKER EXPOSURE. (D;D;C;D)	ONLINE GAS DETECTORS.	(1) VERIFY ATMOSPHERE PRIOR TO OPENING VESSEL. (2) WEAR PROTECTIVE GEAR (SCBA) WHEN OPENING VESSEL.
2 II B	GC6 / MWTF	CYLINDER BREACHED	SAW JAMS OR OTHER MECHANICAL FAILURES DURING CUTTING, WORKER OPENS VESSEL TO INSPECT, CAUSING UNEXPECTED RELEASE.	RELEASE OF TOXIC GAS, WORKER EXPOSURE AND SERIOUS INJURY. (D;D;B;D)	ONLINE GAS DETECTORS.	(1) VERIFY ATMOSPHERE PRIOR TO OPENING VESSEL. (2) WEAR PROTECTIVE GEAR (SCBA) WHEN OPENING VESSEL.
2 II B	GC6 / MWTF	CYLINDER BREACHED	TREATMENT SKID (VALVES FOR CONTAINMENT VESSEL) MISALIGNED BEFORE OR AFTER CYLINDER BREACH.	RELEASE OF MODERATELY TOXIC GASES (E.G., NO2, H2S, ETC...) TO ATMOSPHERE AND/OR BUILDING. WORKER EXPOSURE. (C;C;B;D)	HEPA AND SCRUBBING SYSTEM.	(1) INDEPENDENT VERIFICATION OF SYSTEM ALIGNMENT BEFORE CUTTING. (2) USE PROCEDURE WITH CHECKLIST, (3) PROVIDE VALVE POSITION INDICATION.
2 III A	GC1 / MWRSF	LOAD CYLINDER FROM TA-54 ONTO TRANSPORT VEHICLE AND MOVE TO TA-63	HANDLING ACCIDENT WHILE REMOVING CYLINDER FROM STORAGE, (E.G., CYLINDER FALLS BREAKING VALVE OR CONNECTIONS OR RUPTURE OF A CORRODED CYLINDER).	RELEASE OF TOXIC GAS FROM A SINGLE CYLINDER (E.G., CYANOGEN, ARSENIC PENTAFLORIDE, HF, PHOSGENE). POSSIBLE WORKER FATALITY. (C;D;A;D)	NONE	(1) CONSIDER SECONDARY CONTAINMENT FOR KNOWN HIGHLY TOXIC GAS CYLINDERS AND ALL UNKNOWN GAS CYLINDERS, (2) VALVE COVERS SHOULD BE IN PLACE ON ALL CYLINDERS, (3) TRAIN WORKERS TO EVACUATE IN UPWIND DIRECTION, AND LOCATE GAS MASKS IN UPWIND DIRECTION, (4) INSTALL A WIND SOCK FOR CONTINUOUS WIND DIRECTION INDICATION, (5) CONSIDER PROTECTIVE CLOTHING FOR MIXED WASTE GAS RELEASE.

HAZARD ANALYSIS REPORT BY RISK

R---F---C	ACT/FAC	ACTIVITY NAME	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
2 I C	GC6 / MWTF	CYLINDER BREACHED	SAW JAMS OR OTHER MECHANICAL FAILURES DURING CUTTING AND GAS IS RELEASED INTO PRESSURE VESSEL, WORKER OPENS VESSEL AFTER PURGING TO INSPECT.	RELEASE OF RESIDUAL TOXIC GAS, MINOR WORKER EXPOSURE. (D;D;C;D)	ONLINE GAS DETECTORS.	(1) VERIFY ATMOSPHERE PRIOR TO OPENING VESSEL. (2) WEAR PROTECTIVE GEAR (SCBA) WHEN OPENING VESSEL.
2 II B	GC6 / MWTF	CYLINDER BREACHED	SAW JAMS OR OTHER MECHANICAL FAILURES DURING CUTTING, WORKER OPENS VESSEL TO INSPECT, CAUSING UNEXPECTED RELEASE.	RELEASE OF TOXIC GAS, WORKER EXPOSURE AND SERIOUS INJURY. (D;D;B;D)	ONLINE GAS DETECTORS.	(1) VERIFY ATMOSPHERE PRIOR TO OPENING VESSEL. (2) WEAR PROTECTIVE GEAR (SCBA) WHEN OPENING VESSEL.
2 II B	GC6 / MWTF	CYLINDER BREACHED	TREATMENT SKID (VALVES FOR CONTAINMENT VESSEL) MISALIGNED BEFORE OR AFTER CYLINDER BREACH.	RELEASE OF MODERATELY TOXIC GASES (E.G., NO2, H2S, ETC...) TO ATMOSPHERE AND/OR BUILDING. WORKER EXPOSURE. (C;C;B;D)	HEPA AND SCRUBBING SYSTEM.	(1) INDEPENDENT VERIFICATION OF SYSTEM ALIGNMENT BEFORE CUTTING. (2) USE PROCEDURE WITH CHECKLIST, (3) PROVIDE VALVE POSITION INDICATION.
2 III A	GC1 / MWRSF	LOAD CYLINDER FROM TA-54 ONTO TRANSPORT VEHICLE AND MOVE TO TA-63	HANDLING ACCIDENT WHILE REMOVING CYLINDER FROM STORAGE, (E.G., CYLINDER FALLS BREAKING VALVE OR CONNECTIONS OR RUPTURE OF	RELEASE OF TOXIC GAS FROM A SINGLE CYLINDER (E.G., CYANOGEN, ARSENIC PENTAFLORIDE, HF, PHOSGENE). POSSIBLE	NONE	(1) CONSIDER SECONDARY CONTAINMENT FOR KNOWN HIGHLY TOXIC GAS CYLINDERS AND ALL UNKNOWN GAS CYLINDERS, (2) VALVE

HAZARD ANALYSIS REPORT BY RISK

R---F---C	ACT/FAC	ACTIVITY NAME	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
			A CORRODED CYLINDER).	WORKER FATALITY. (C;D;A;D)		COVERS SHOULD BE IN PLACE ON ALL CYLINDERS, (3) TRAIN WORKERS TO EVACUATE IN UPWIND DIRECTION, AND LOCATE GAS MASKS IN UPWIND DIRECTION, (4) INSTALL A WIND SOCK FOR CONTINUOUS WIND DIRECTION INDICATION, (5) CONSIDER PROTECTIVE CLOTHING FOR MIXED WASTE GAS RELEASE.

HAZARD ANALYSIS REPORT BY RISK

R---F---C	ACT/FAC	ACTIVITY NAME	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
2 III A	GC2 / MWRSF	TRANSPORT OF GAS CYLINDER TO TA-63 MWRSF	TRUCK ACCIDENT ON PUBLIC ROAD BETWEEN TA-54 AND TA-63 WITH BREACH OF GAS CYLINDER(S).	POTENTIAL RELEASE OF TOXIC GASES WITH PUBLIC AND WORKER EXPOSURE. (A;C;A;D)	NONE	ADMINISTRATIVE CONTROLS; (1) PROVIDE ESCORT FOR THE TRANSPORT VEHICLE AND CONSIDER ROAD CLOSURE DURING TRANSPORT, (2) DRIVER TRAINING, (3) RESTRICT NIGHT OR POOR WEATHER DELIVERIES, (4) CONSIDER SECONDARY CONTAINMENT FOR CYLINDERS OF QUESTIONABLE INTEGRITY, UNKNOWN CONTENTS, OR THOSE CONTAINING MOST HIGHLY TOXIC MATERIALS.
2 III A	GC6 / MWTF	CYLINDER BREACHED	TREATMENT SKID (VALVES FOR CONTAINMENT VESSEL) MISALIGNED BEFORE OR AFTER CYLINDER BREACH.	RELEASE OF HIGHLY TOXIC GASES (PHOSPINE, PHOSGEN, ARSINE, AND OTHERS) TO ATMOSPHERE AND/OR BUILDING. WORKER FATALITY, POTENTIAL COLOCATED WORKER AND PUBLIC EXPOSURE. (C;B;A;D)	HEPA AND SCRUBBING SYSTEM.	(1) INDEPENDENT VERIFICATION OF SYSTEM ALIGNMENT BEFORE CUTTING. (2) USE PROCEDURE WITH CHECKLIST, (3) PROVIDE VALVE POSITION INDICATION.
2 III A	GC6 / MWTF	CYLINDER BREACHED	INADVERTANT CUTTING OF CYLINDER PRIOR TO SEALING VESSEL.	RELEASE OF TOXIC GAS INTO ROOM, WORKER EXPOSURE AND POSSIBLE FATALITY. (D;D;A;D)	NONE	(1) INSTALL INTERLOCKS TO PREVENT SAW OPERATION BEFORE SEALING AND INERTING PRESSURE VESSEL. (2) VERIFY DOOR CLOSURE PRIOR TO STARTING SAW.
2 III A	GC6 / MWTF	CYLINDER BREACHED	PRESSURE VESSEL INCORRECTLY SEALED (SUCH AS DOOR SEAL) OR SEAL FAILS CAUSING LEAKAGE.	MINOR LEAK OF HIGHLY TOXIC GAS (PHOSPHINE, PHOSGEN, ARSINE) FROM LEAKY SEALS, POTENTIAL WORKER FATALITY. (D;D;A;D)	NONE	(1) PERFORM CHECK OF PRESSURE VESSEL SEAL BEFORE CUTTING OPERATION. (2) MINIMIZE TIME BETWEEN CUTTING AND DISPOSAL OR RECONTAINERIZATION. (3) LOCATE CONTROL PANEL AWAY FROM SKID.
2 III B	GC7 / MWTF	SAMPLE, ANALYZE, AND DISPOSE PRESSURE VESSEL CONTENTS	MISROUTING OF TOXIC GAS (E.G., GAS SENT TO ATMOSPHERE) DUE TO HUMAN ERROR, SCRUBBER FAILED OR INEFFECTIVE.	TOXIC GASES INADVERTENTLY VENTED TO ATMOSPHERE, EXPOSURE TO PUBLIC, COLOCATED WORKERS AND WORKERS OUTSIDE THE BUILDING. (B;B;B;D)	NONE	(1) PROVIDE SAMPLING PROCEDURES WITH INDEPENDENT VERIFICATION, (2) VERIFY SYSTEM LINE-UP PRIOR TO ROUTING PRESSURE VESSEL CONTENTS.
2 III B	GC8 / MWTF	SCRUBBING AND DISPOSING OF CYLINDERS	RADIOACTIVE CONTAINER MISLABELED AS HAZARDOUS AND SENT OFF-SITE FOR TREATMENT.	VIOLATION OF REGULATIONS, LOCALIZED MINOR OFFSITE CONTAMINATION. (D;D;D;B)	ONLINE SAMPLING.	INDEPENDENTLY VERIFY CORRECT LABELING.

R---F---C	ACT/FAC	ACTIVITY NAME	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
3 II C	GC6 / MWTF	CYLINDER BREACHED	PRESSURE VESSEL INCORRECTLY SEALED (SUCH AS DOOR SEAL) OR SEAL FAILS CAUSING LEAKAGE.	LEAK OF MODERATELY TOXIC GAS FROM LEAKY SEALS. (D;D;C;D)	NONE	(1) PERFORM CHECK OF PRESSURE VESSEL SEAL BEFORE CUTTING OPERATION. (2) MINIMIZE TIME BETWEEN CUTTING AND DISPOSAL OR RECONTAINERIZATION. (3) LOCATE CONTROL PANEL AWAY FROM SKID.
3 II C	GC7 / MWTF	SAMPLE, ANALYZE, AND DISPOSE PRESSURE VESSEL CONTENTS	MISROUTING OF TOXIC GAS (E.G., GAS SENT TO ATMOSPHERE) DUE TO HUMAN ERROR OR MISINTERPRETATION OF SAMPLING RESULTS.	TOXIC GASES INADVERTENTLY VENTED TO ATMOSPHERE THROUGH SCRUBBER SYSTEM, MINOR EXPOSURE. (C;C;C;D)	HEPA AND SCRUBBER SYSTEM.	(1) VERIFY SYSTEM LINE-UP PRIOR TO ROUTING PRESSURE VESSEL CONTENTS.
3 II C	GC7 / MWTF	SAMPLE, ANALYZE, AND DISPOSE PRESSURE VESSEL CONTENTS	INCOMPLETE VENTING OR SCRUBBING OF THE PRESSURE VESSEL DUE TO HUMAN ERROR.	WORKER EXPOSURE TO RESIDUAL TOXIC GASES UPON OPENNING THE PRESSURE VESSEL. (D;D;C;D)	NONE	(1) WORKER TO WEAR PROTECTIVE EQUIPMENT (INCLUDING SCBA) WHEN OPENNING PRESSURE VESSEL.
3 IV A	GC3 / MWRSF	GAS CYLINDER TRANSPORTED FROM MWRSF DOCK STORAGE AREA	BREACH OF CYLINDER DUE TO ACCIDENTAL CAUSES (E.G., CYLINDER DROPPED AND REGULATOR LINE BREAKS).	RELEASE OF HIGHLY TOXIC GASES (PHOSPHINE, PHOSGEN, ARSINE, AND OTHERS), WORKER FATALITY. (C;C;A;D)	HEPA AND SCRUBBING SYSTEM.	(1) TRANSPORT AND STORE CYLINDERS SECURELY, (2) INSTALL GAS DETECTORS AND ALARMS, (3) CONSIDER SECONDARY CONTAINMENT FOR MOST HAZARDOUS CYLINDERS, (4) PROTECTIVE CAP FOR CYLINDER REGULATORS SHOULD BE IN PLACE AT ALL TIMES.
3 IV A	GC4 / MWRSF	TRANSPORT GAS CYLINDER FROM MWRSF STORAGE TO THE MWTF TREATMENT ROOM	BREACH OF CYLINDER DUE TO ACCIDENTAL CAUSES (E.G., CYLINDER DROPPED AND REGULATOR LINE BREAKS).	RELEASE OF HIGHLY TOXIC GASES (PHOSPHINE, PHOSGEN, ARSINE, AND OTHERS), WORKER FATALITY. (A;A;A;D)	NONE	(1) TRANSPORT AND STORE CYLINDERS SECURELY, (2) CONSIDER SECONDARY CONTAINMENT FOR MOST HAZARDOUS CYLINDERS, (4) PROTECTIVE CAP FOR CYLINDER REGULATORS SHOULD BE IN PLACE AT ALL TIMES.
3 IV A	GC5 / MWTF	TRANSFER CYLINDER INTO SKID PRESSURE VESSEL	CYLINDER DROPPED DURING TRANSFER INTO PRESSURE VESSEL.	POTENTIAL RELEASE OF TOXIC GAS, WORKER EXPOSURE AND FATALITY. (D;D;A;D)	CYLINDER IS NOT TRANFERRED USING OVERHEAD CRANE.	(1) WORKER SHOULD WEAR PROTECTIVE EQUIPMENT, INCLUDING RESPIRATOR.
3 IV B	GC1 / MWRSF	LOAD CYLINDER FROM TA-54 ONTO TRANSPORT VEHICLE AND MOVE TO TA-63	RUPTURE OF FLAMMABLE GAS CYLINDER DURING HANDLING NEAR OTHER GAS CYLINDERS.	FLAMMABLE GAS IGNITES AND EXPOSES MULTIPLE CYLINDERS TO HIGH TEMPERATURE RESULTING IN RELEASE OF MULTIPLE GAS CYLINDERS. (C;C;B;C)	(1) WORKER HAS TIME TO RESPOND TO THE FIRE PRIOR TO RUPTURE OF OTHER CYLINDERS, (2) STORAGE FACILITY IS LOCATED AT A REMOTE SITE.	(1) VALVE COVERS SHOULD BE IN PLACE ON ALL CYLINDERS, (2) TRAIN WORKERS TO EVACUATE IN UPWIND DIRECTION, AND LOCATE GAS MASKS IN UPWIND DIRECTION, (3) INSTALL A WIND SOCK FOR CONTINUOUS WIND DIRECTION INDICATION..

HAZARD ANALYSIS REPORT BY RISK

R---F---C	ACT/FAC	ACTIVITY NAME	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
3 IV B	GC3 / MWRSF	GAS CYLINDER TRANSPORTED FROM MWRSF DOCK STORAGE AREA	BREACH OF CYLINDER DUE TO ACCIDENTAL CAUSES (E.G., CYLINDER DROPPED AND REGULATOR LINE BREAKS).	RELEASE OF MODERATELY TOXIC GASES (H2S, NO2, AND OTHERS). WORKER EXPOSURE. (C;C;B;D)	HEPA AND SCRUBBING SYSTEM.	(1) TRANSPORT AND STORE CYLINDERS SECURELY, (2) INSTALL GAS DETECTORS AND ALARMS, (3) CONSIDER SECONDARY CONTAINMENT FOR MOST HAZARDOUS CYLINDERS, (4) PROTECTIVE CAP FOR CYLINDER REGULATORS SHOULD BE IN PLACE AT ALL TIMES.
3 IV B	GC4 / MWRSF	TRANSPORT GAS CYLINDER FROM MWRSF STORAGE TO THE HWTF TREATMENT ROOM	BREACH OF CYLINDER DUE TO ACCIDENTAL CAUSES (E.G., CYLINDER DROPPED AND REGULATOR LINE BREAKS).	RELEASE OF MODERATELY TOXIC GASES (H2S, NO2, AND OTHERS). WORKER EXPOSURE. (C;C;B;D)	NONE	(1) TRANSPORT AND STORE CYLINDERS SECURELY, (2) CONSIDER SECONDARY CONTAINMENT FOR MOST HAZARDOUS CYLINDERS, (4) PROTECTIVE CAP FOR CYLINDER REGULATORS SHOULD BE IN PLACE AT ALL TIMES.
3 IV B	GC6 / HWTF	CYLINDER BREACHED	FLAMABLE CYLINDER BREACHED WITOUT INERTING PRESSURE VESSEL ATMOSPHERE.	FIRE OR EXPLOSION, POTENTIAL PRESSURE VESSEL DAMAGE. RELEASE OF GASES TO ATMOSPERE, WORKER INJURY. (D;D;B;C)	VESSEL DESIGNED TO CONTAIN FIRE AND EXPLOSION.	VERIFY PRESSURE VESSEL ATMOSPHERE BEFORE CUTTING CYLINDER.

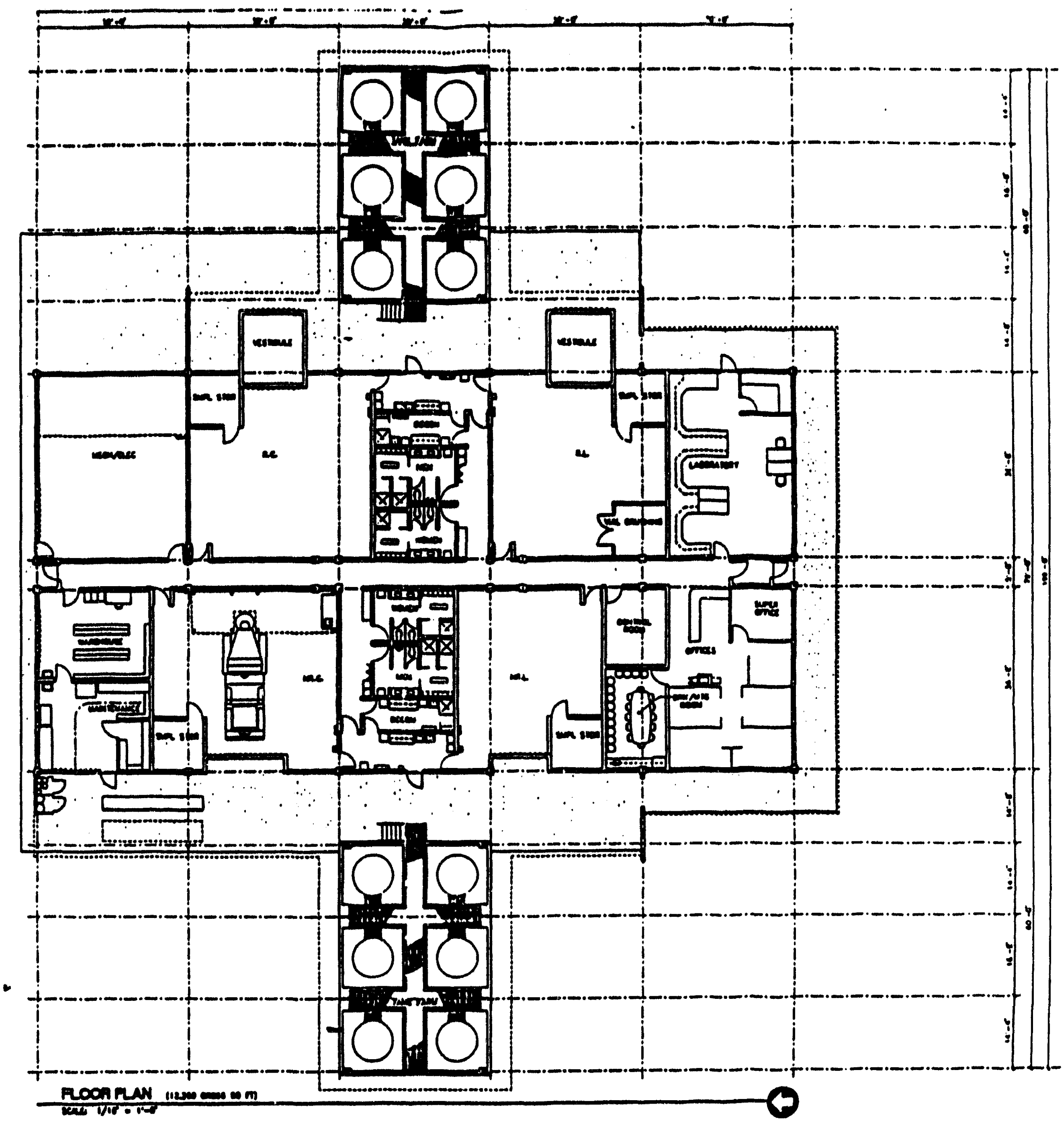

Fig. A-1. Hazardous Waste Treatment Facility floor plan.

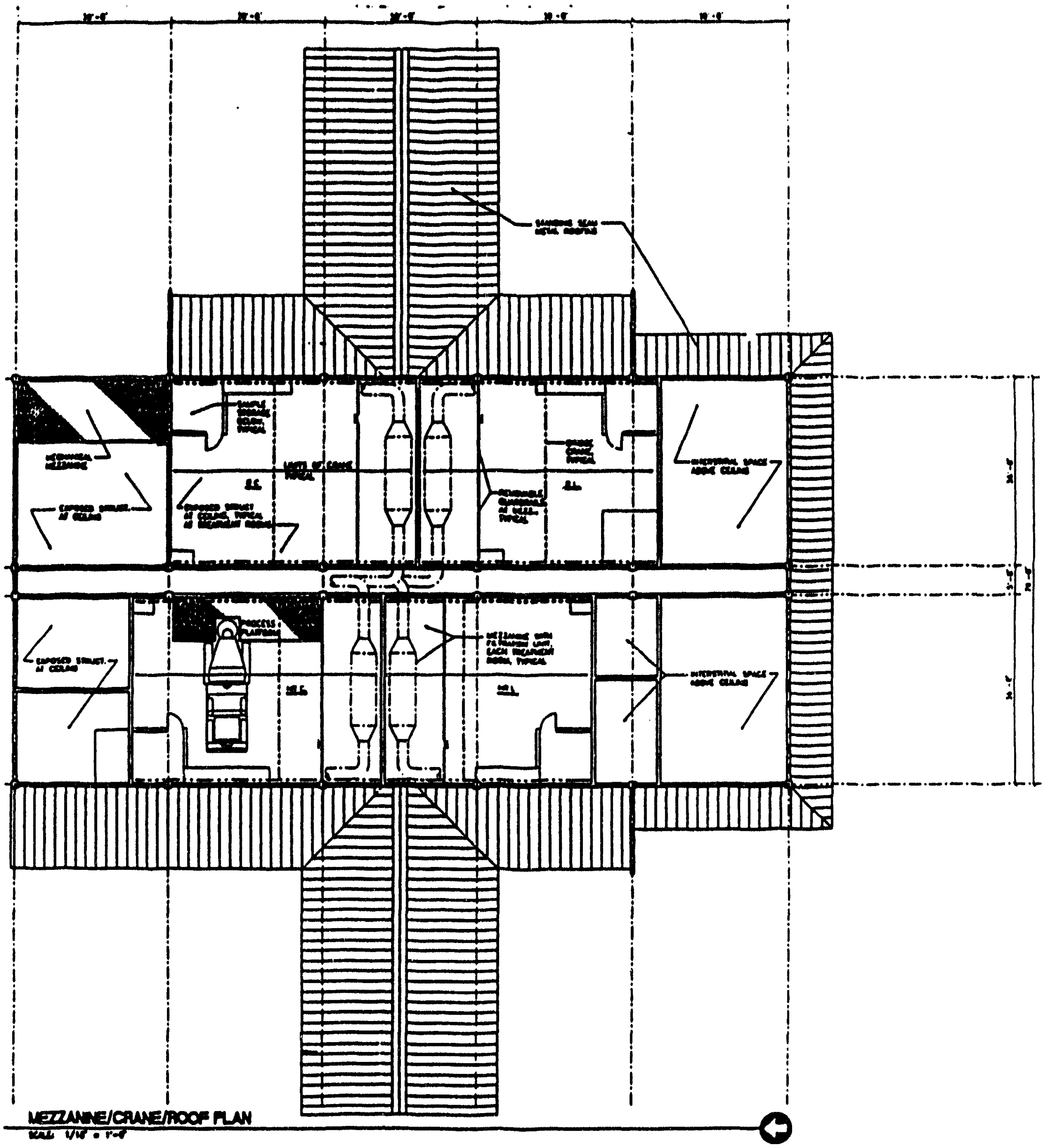

Fig. A-2. Hazardous Waste Treatment Facility mezzanine/crane/floor plan.

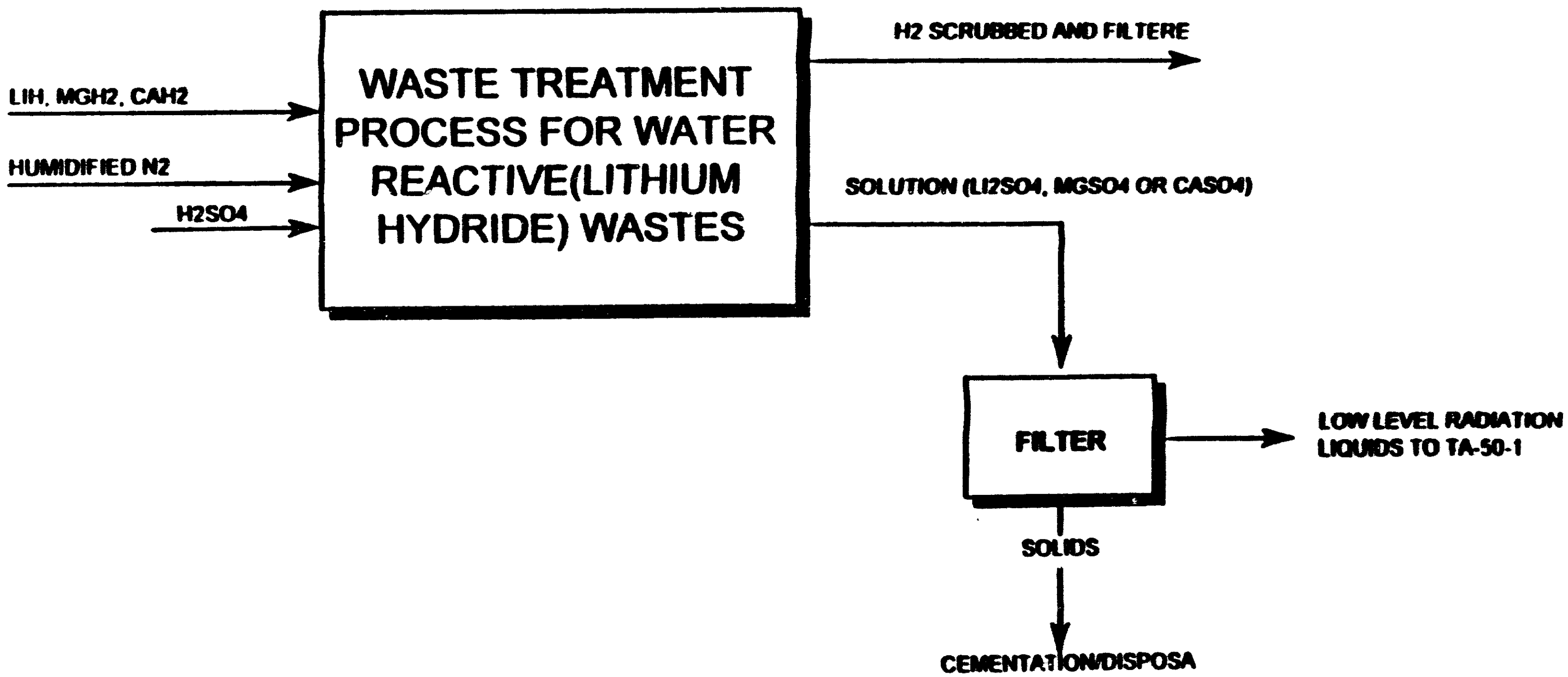

Fig. A-3. Feed/waste streams for the water reactive waste treatment process.

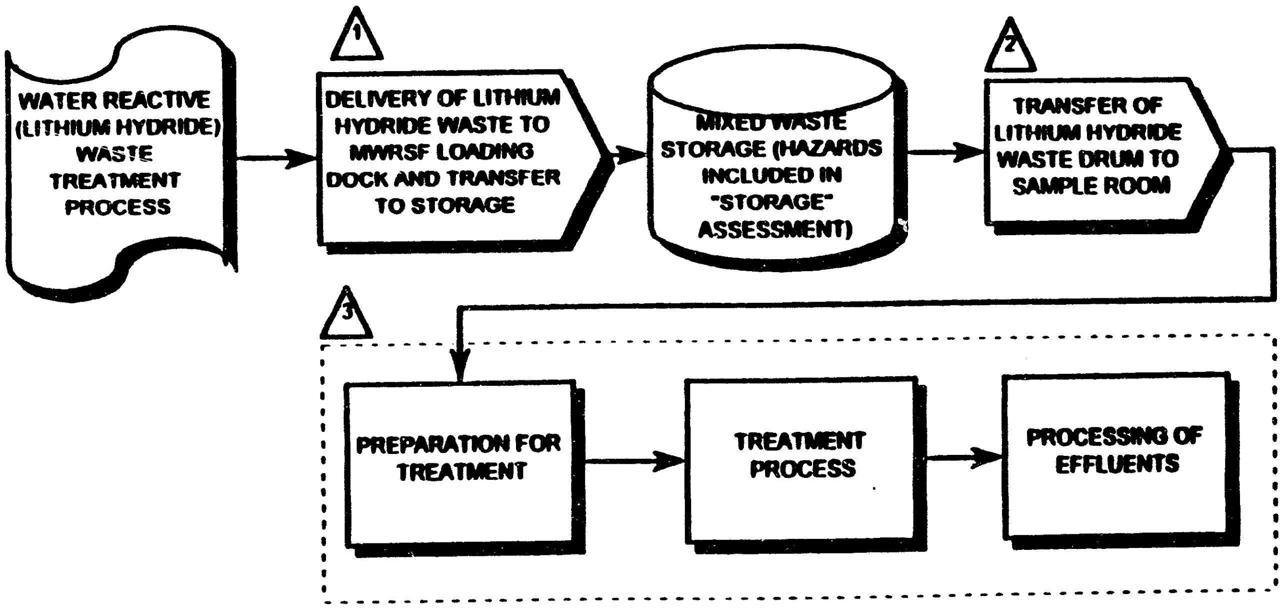

Fig. A-4. Flow diagram for water reactive waste treatment process.

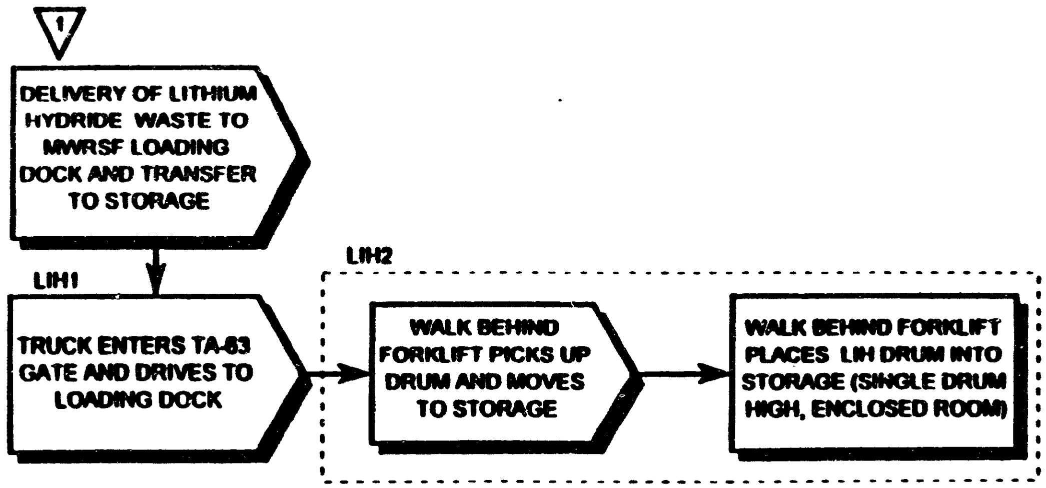

Fig. A-4. Flow diagram for water reactive waste treatment process (cont).

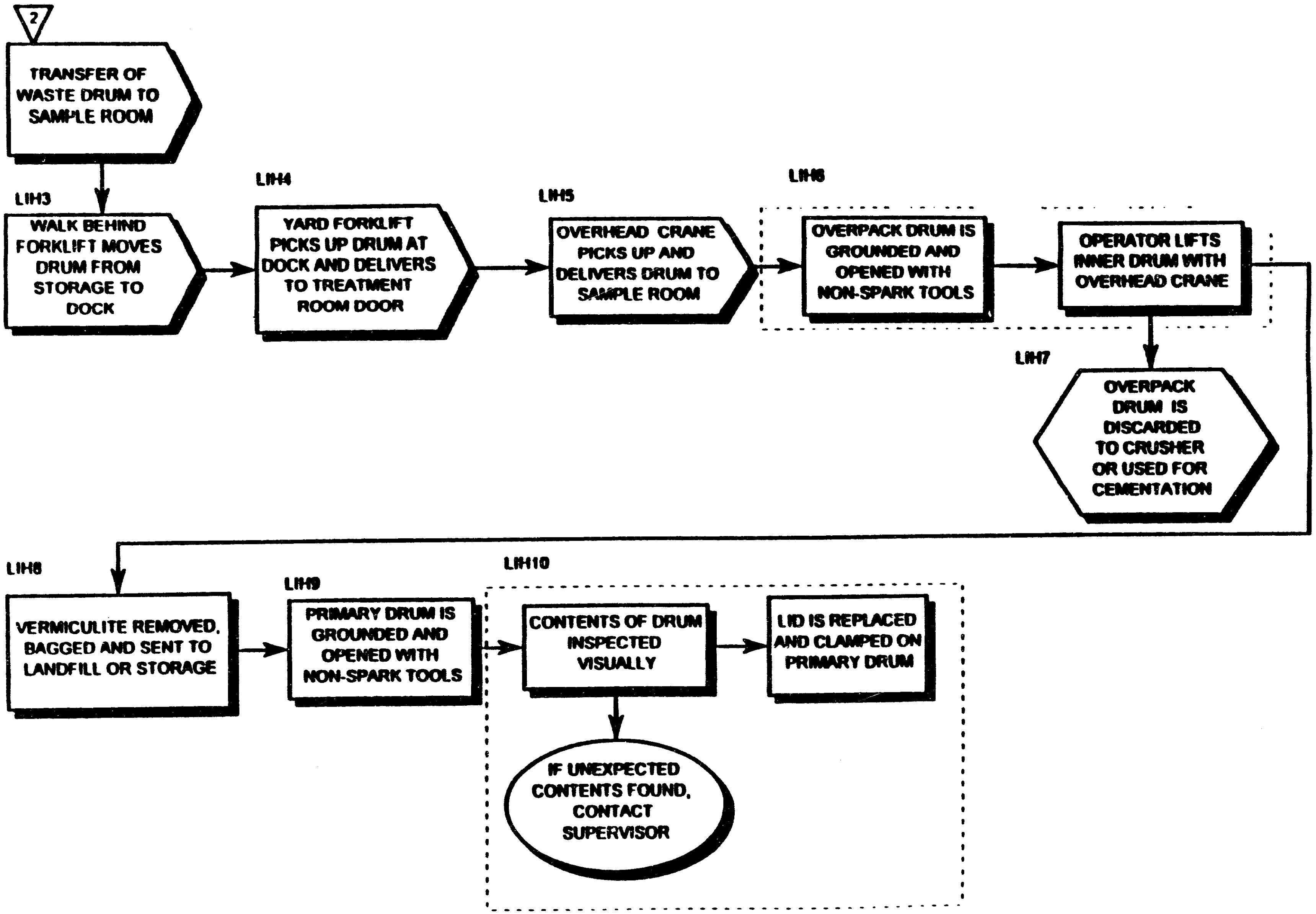

Fig. A-4. Flow diagram for water reactive waste treatment process (cont).

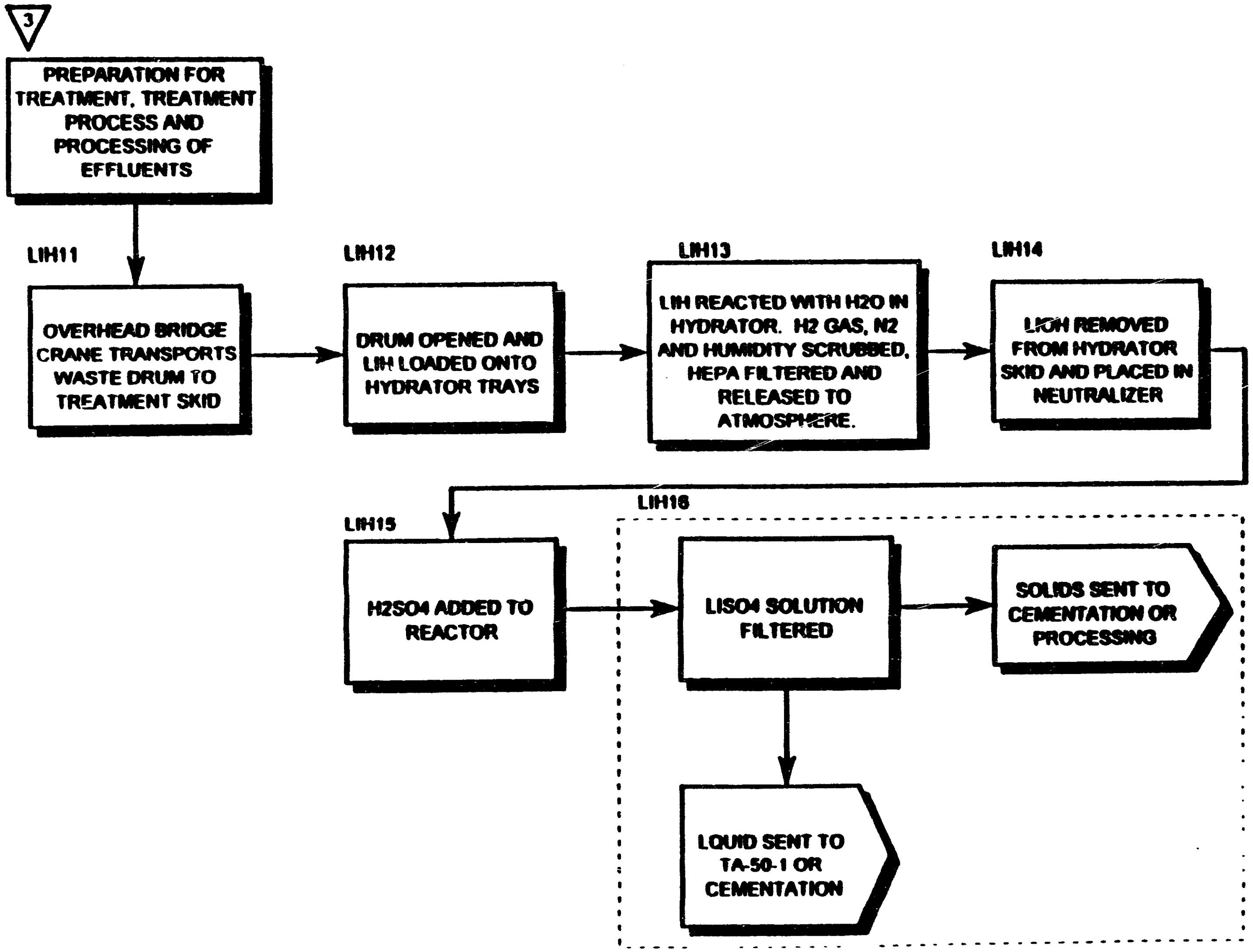

Fig. A-4. Flow diagram for water reactive waste treatment process (cont).

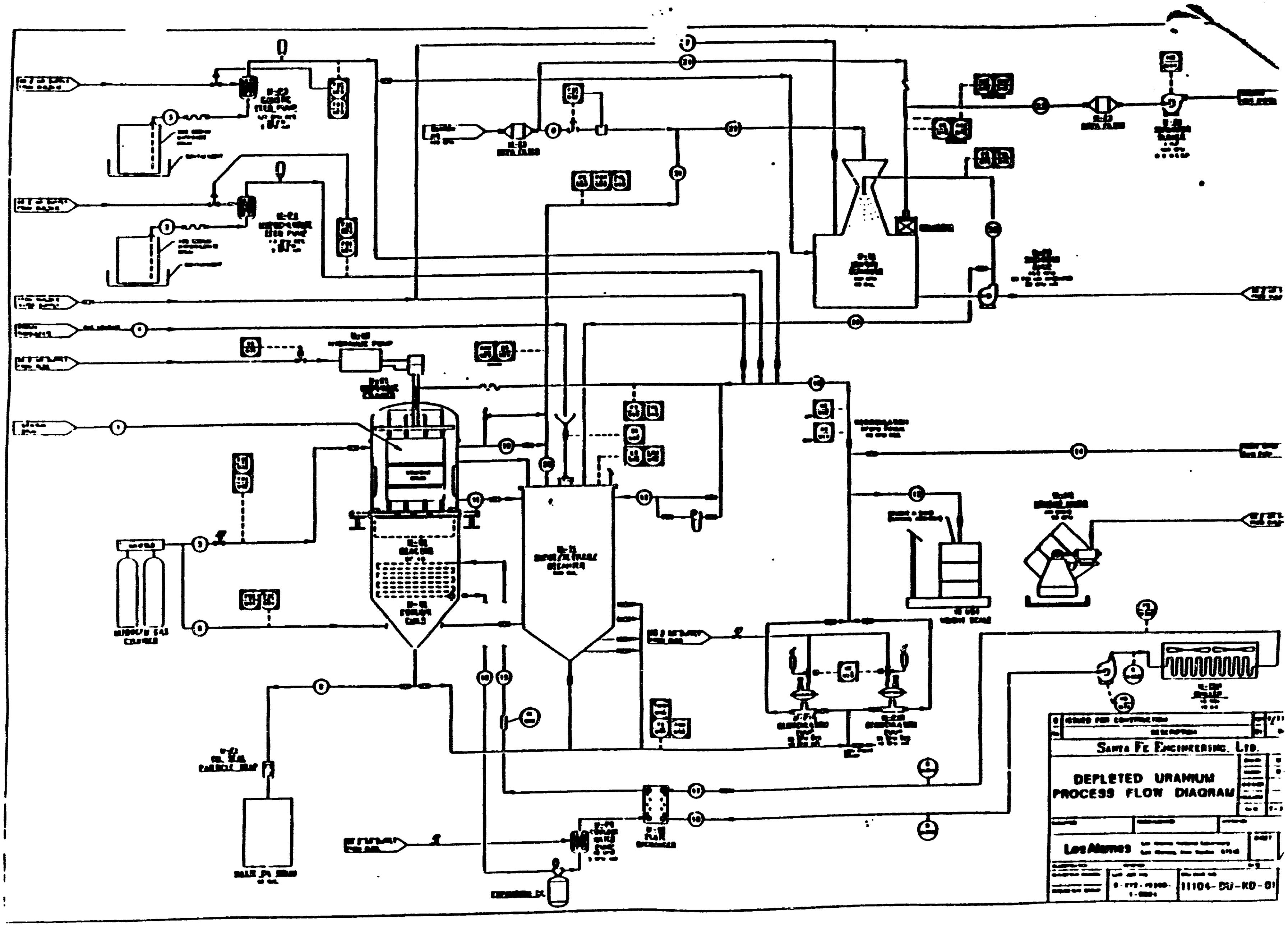

Fig. A-5. Depleted uranium process flow diagram.

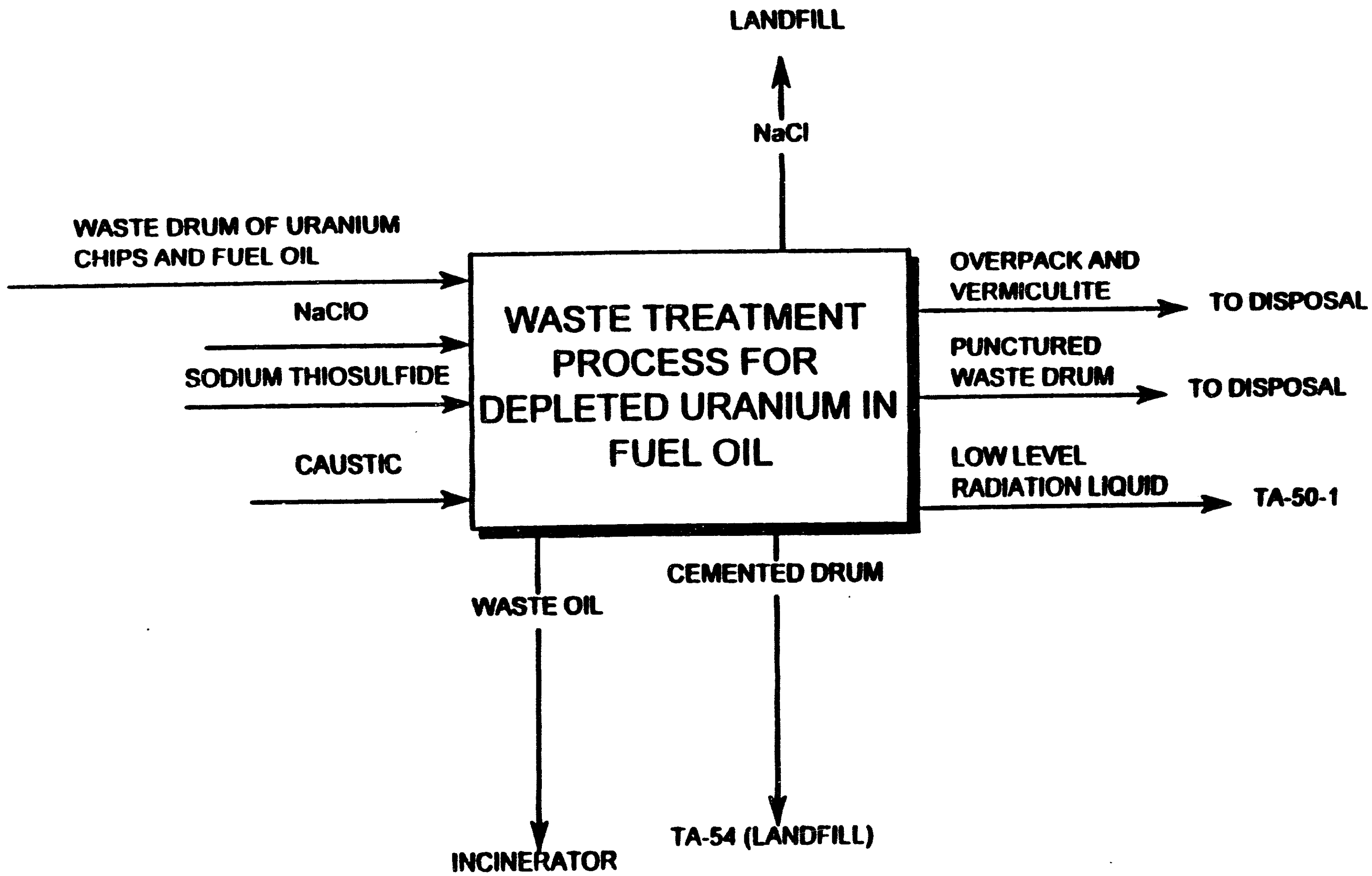

Fig. A-6. Feed/waste streams for the depleted uranium waste treatment process.

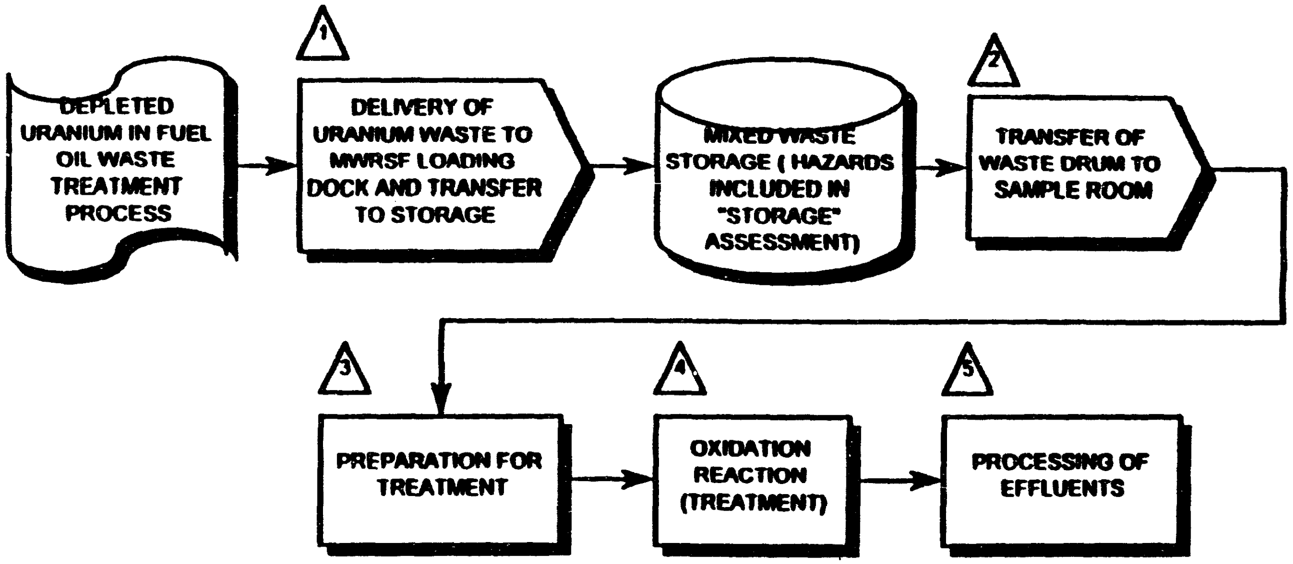

Fig. A-7. Flow diagram for depleted uranium waste treatment process.

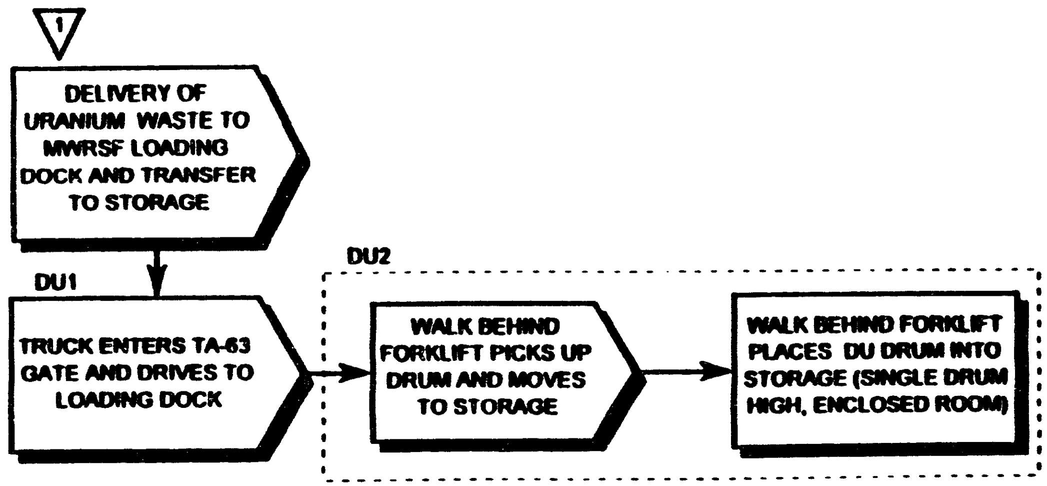

Fig. A-7. Flow diagram for depleted uranium waste treatment process (cont).

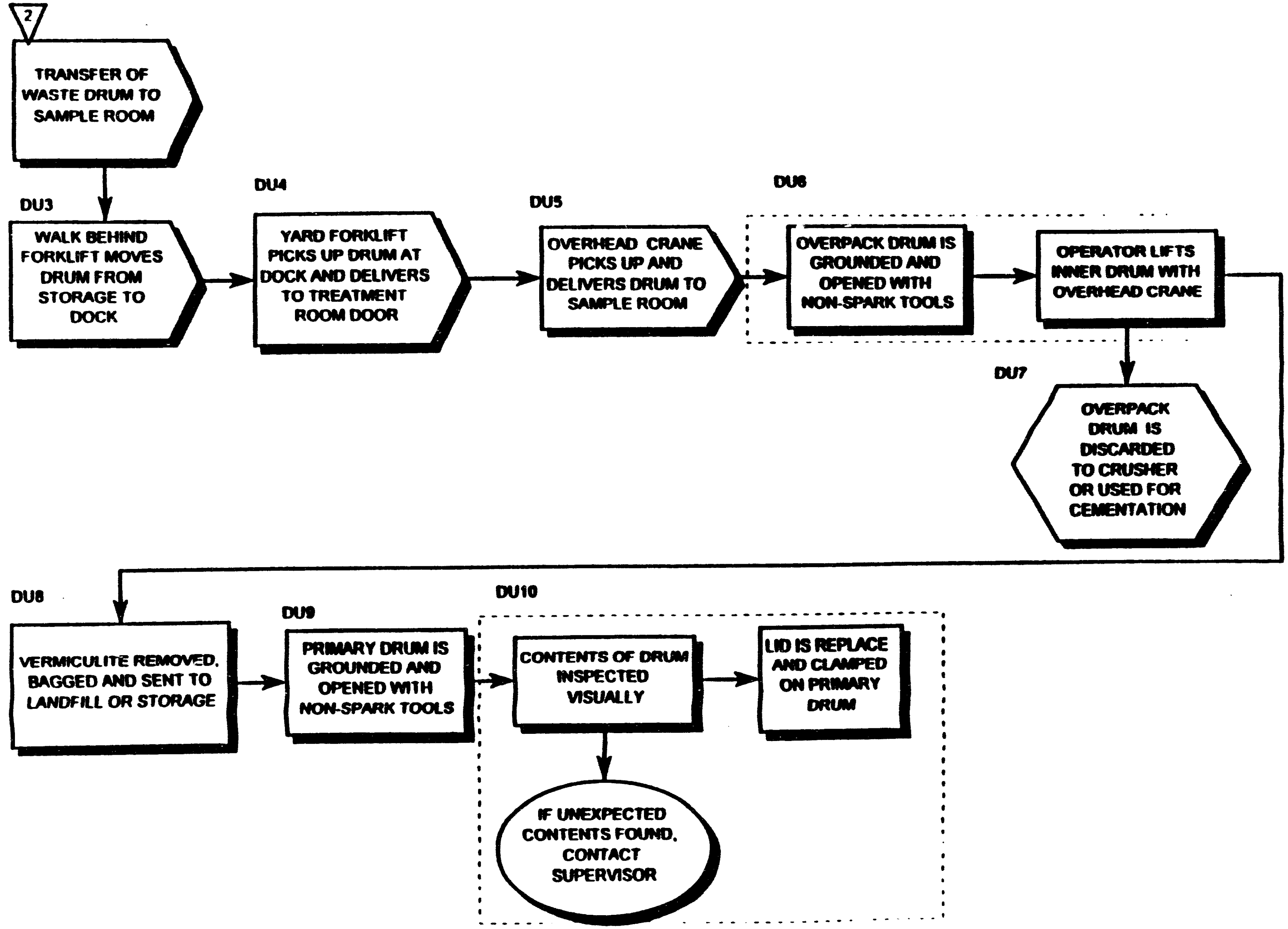

Fig. A-7. Flow diagram for depleted uranium waste treatment process (cont).

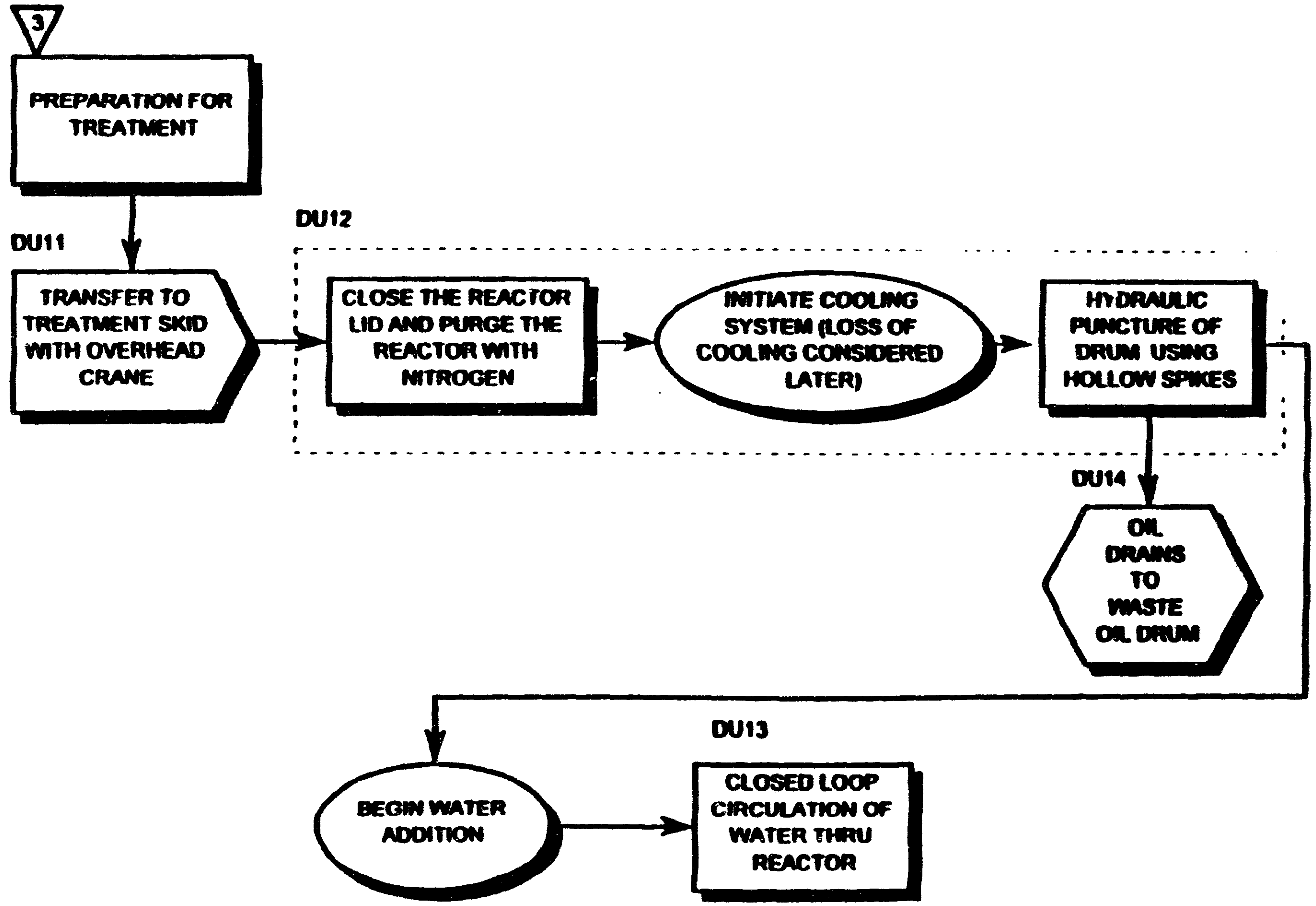

Fig. A-7. Flow diagram for depleted uranium waste treatment process (cont).

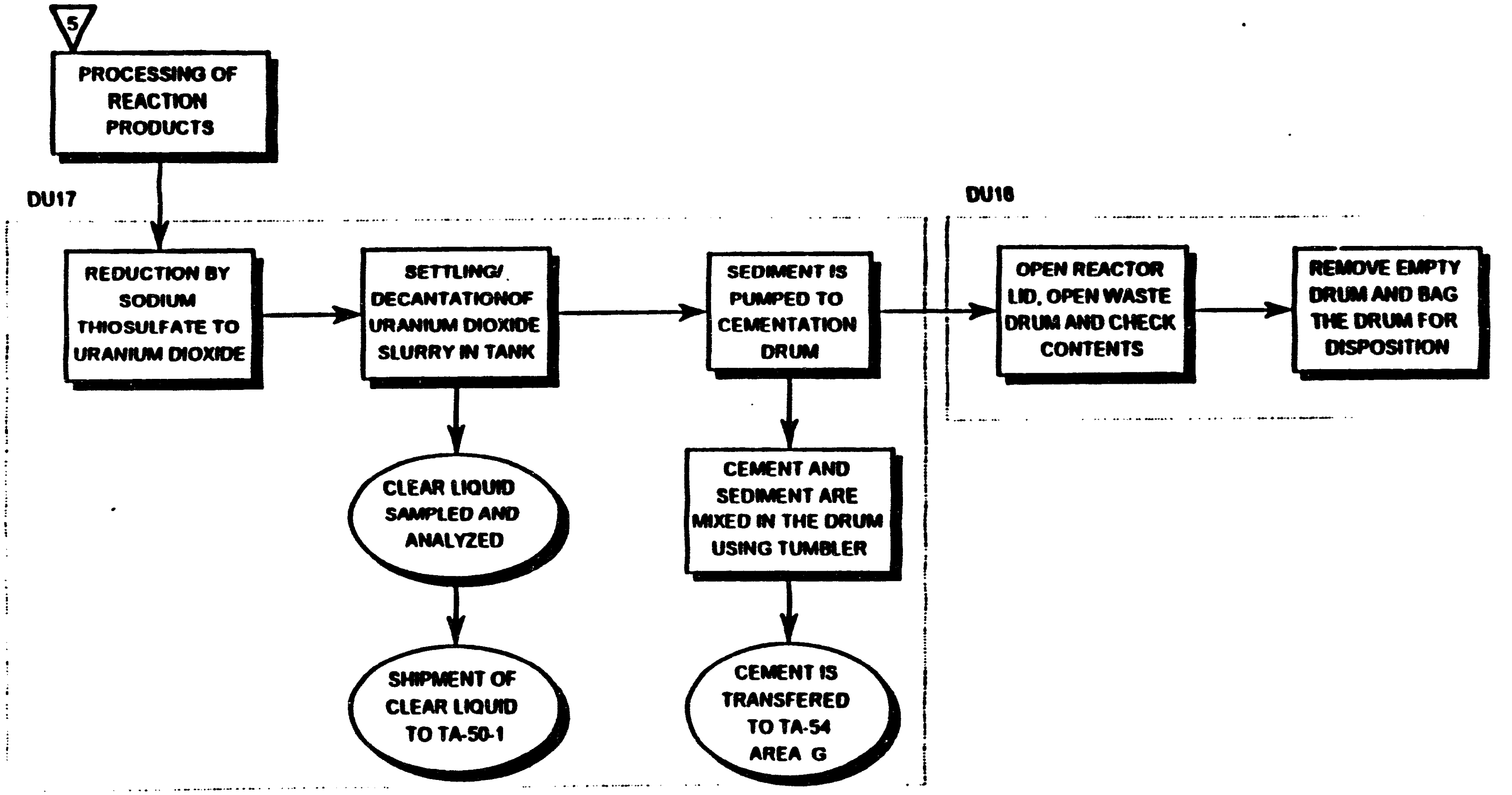

Fig. A-7. Flow diagram for depleted uranium waste treatment process (cont).

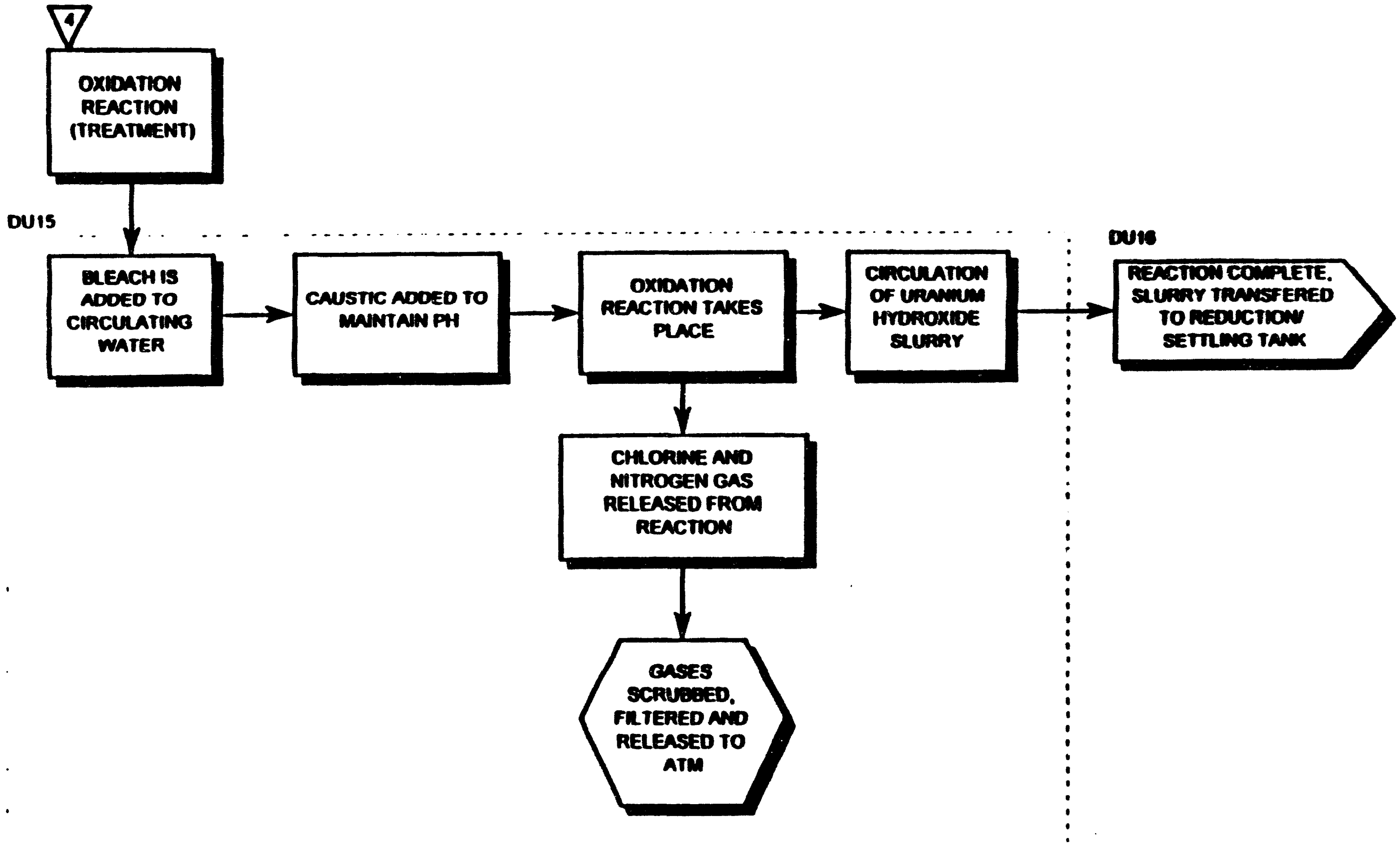

Fig. A-7. Flow diagram for depleted uranium waste treatment process (cont).

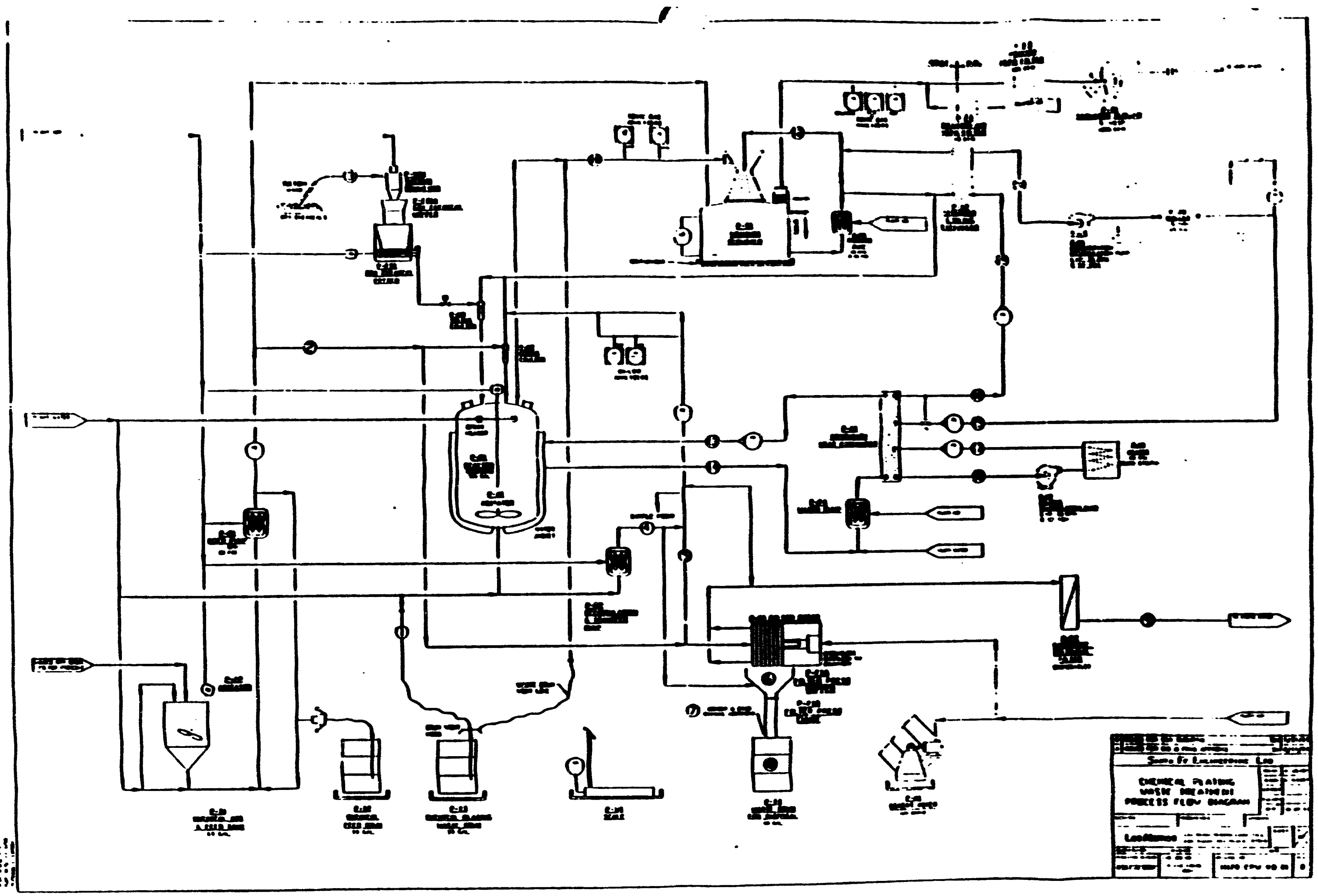

Fig. A-8. Chemical plating waste treatment process flow diagram.

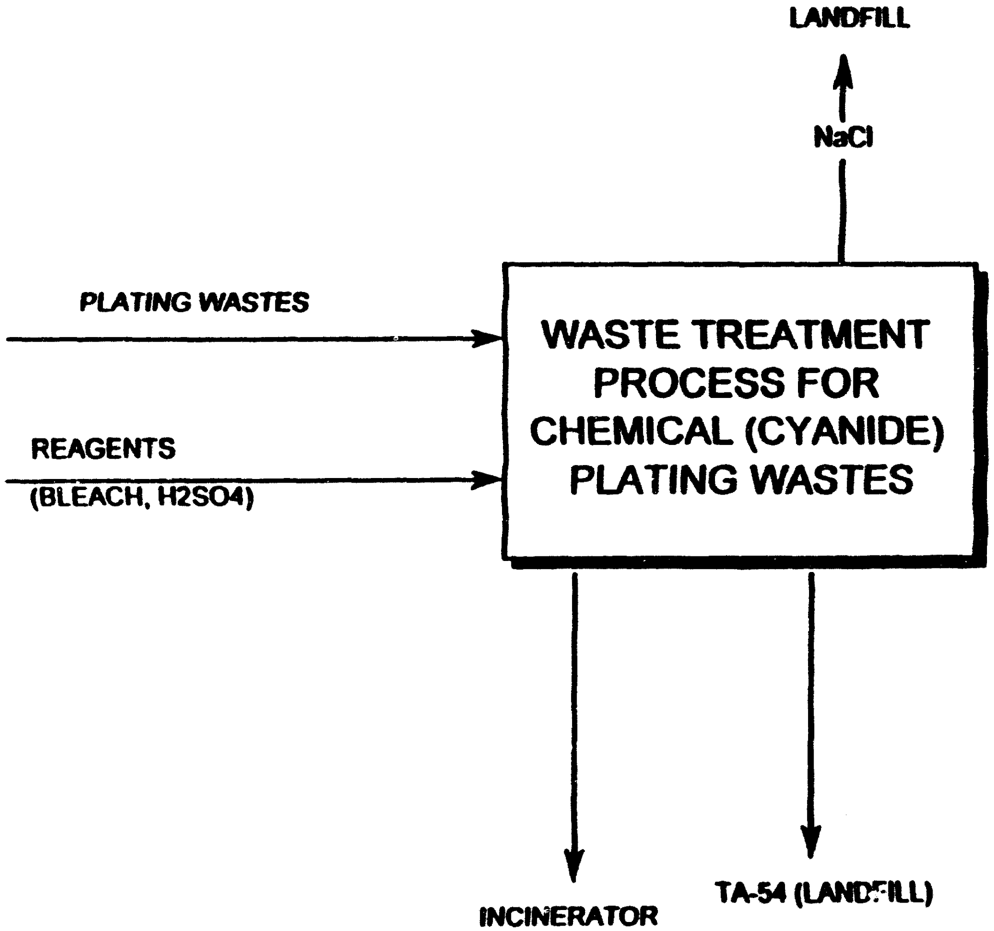

Fig. A-9. Feed/waste streams for the chemical plating wastes treatment process.

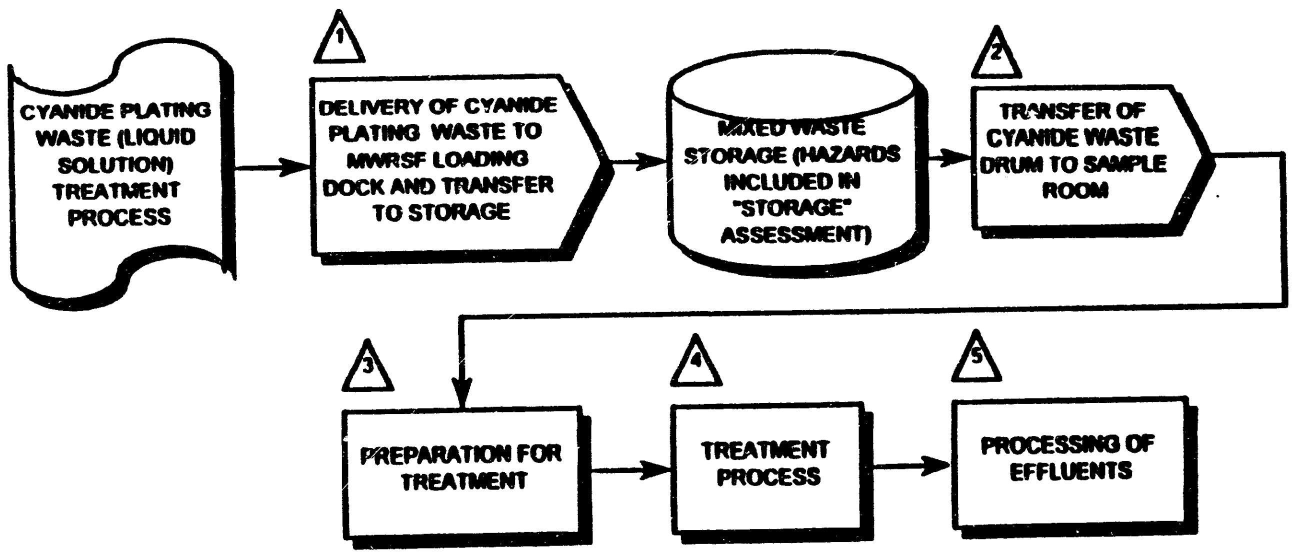

Fig. A-10. Flow diagram for chemical plating waste treatment process.

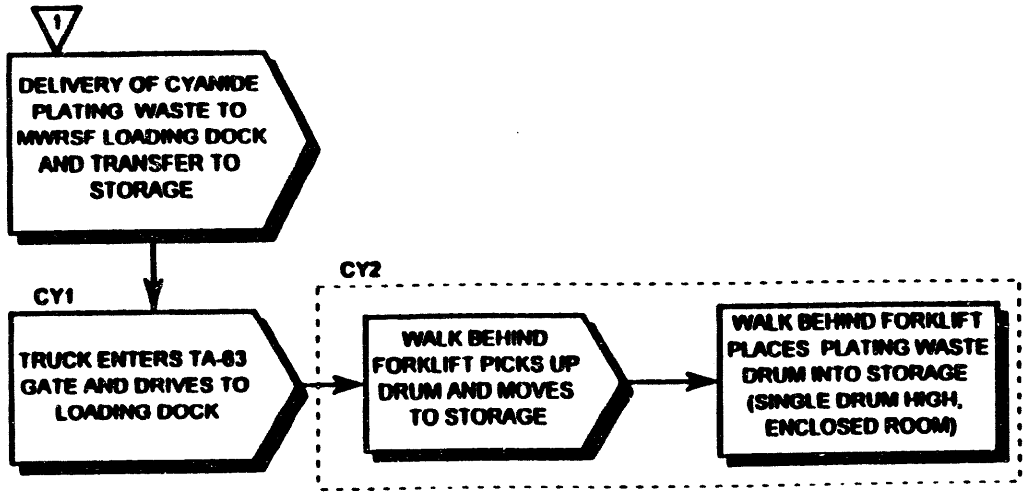

Fig. A-10. Flow diagram for chemical plating waste treatment process (cont).

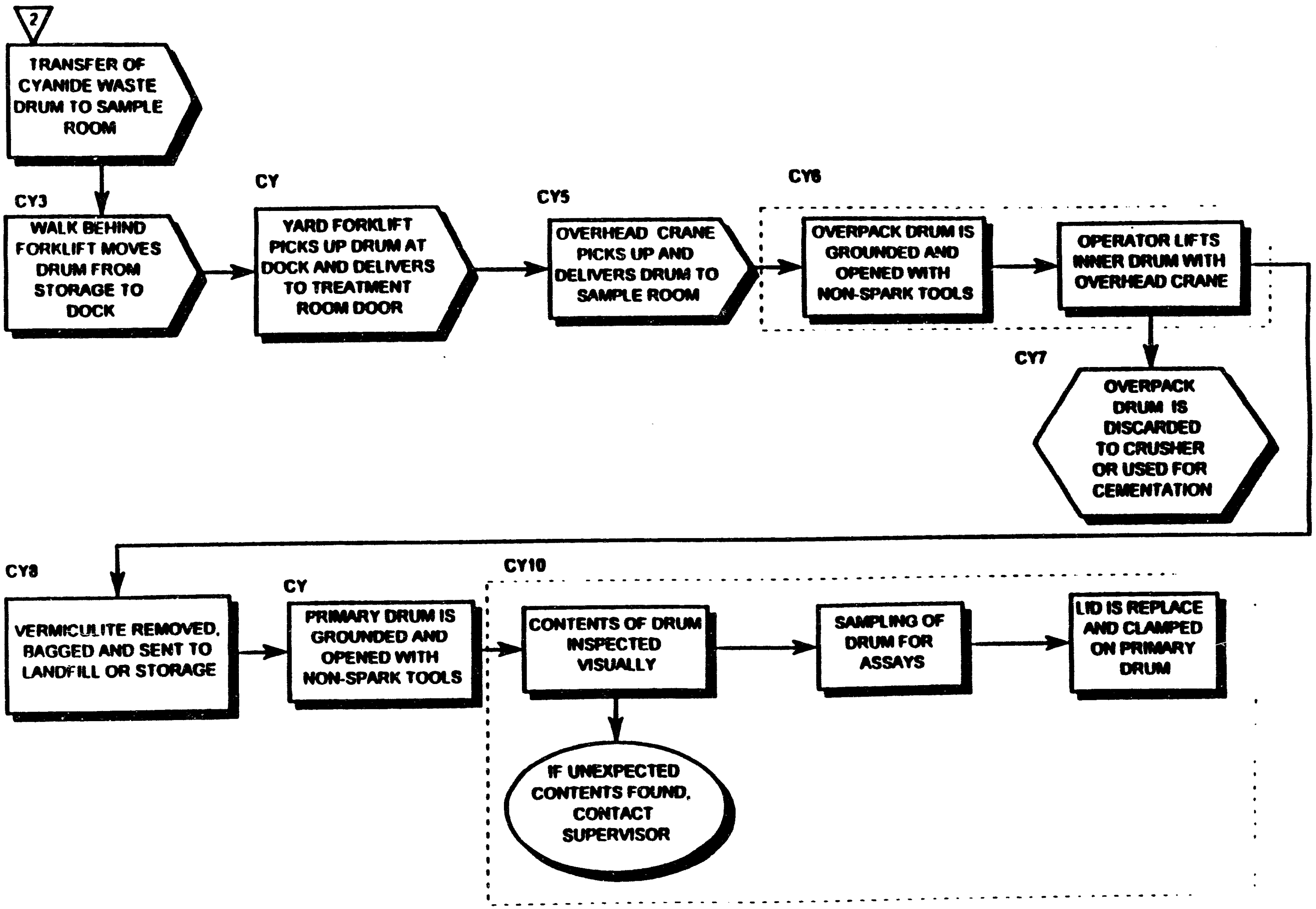

Fig. A-10. Flow diagram for chemical plating waste treatment process (cont).

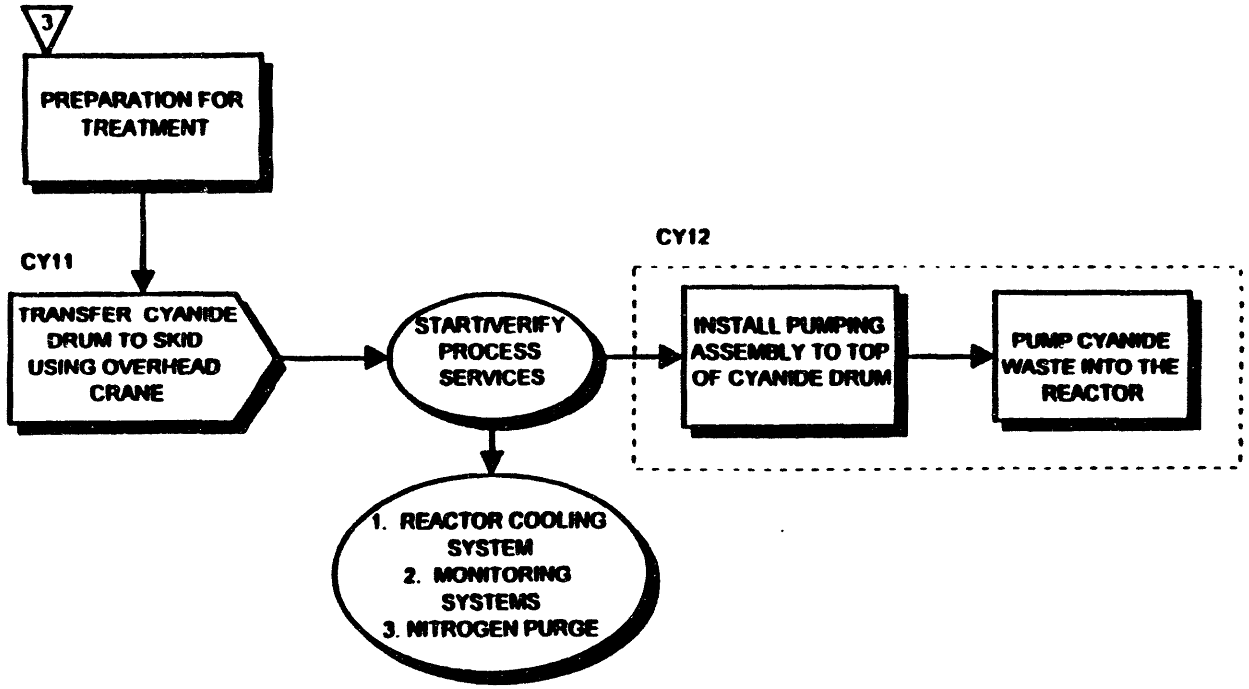

Fig. A-10. Flow diagram for chemical plating waste treatment process (cont).

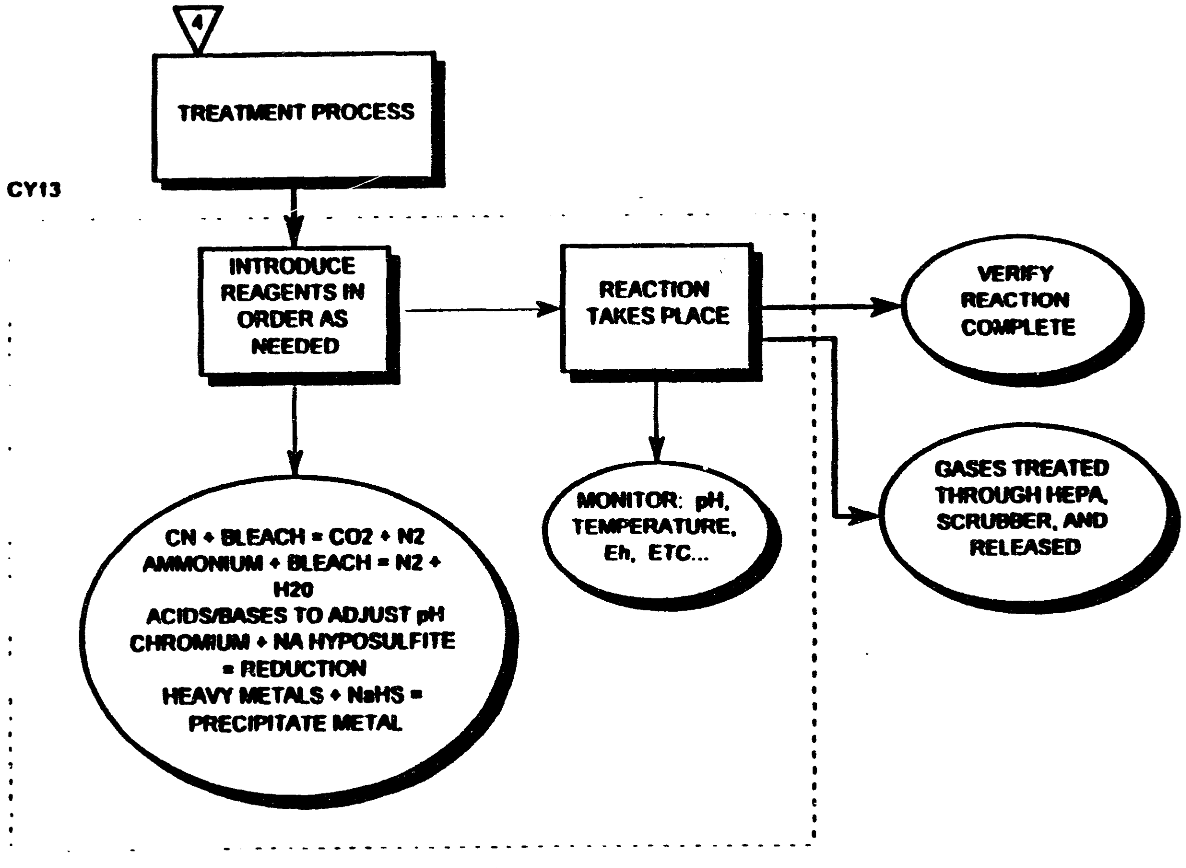

Fig. A-10. Flow diagram for chemical plating waste treatment process (cont).

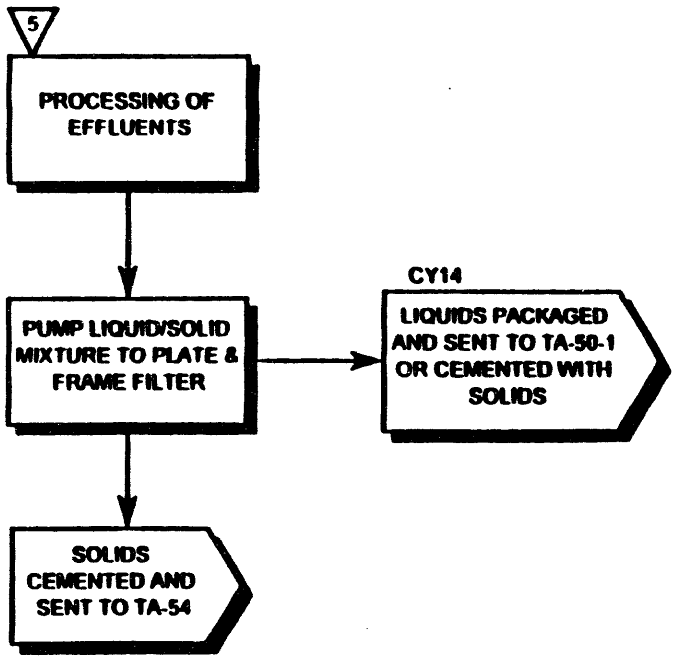

Fig. A-10. Flow diagram for chemical plating waste treatment process (cont).

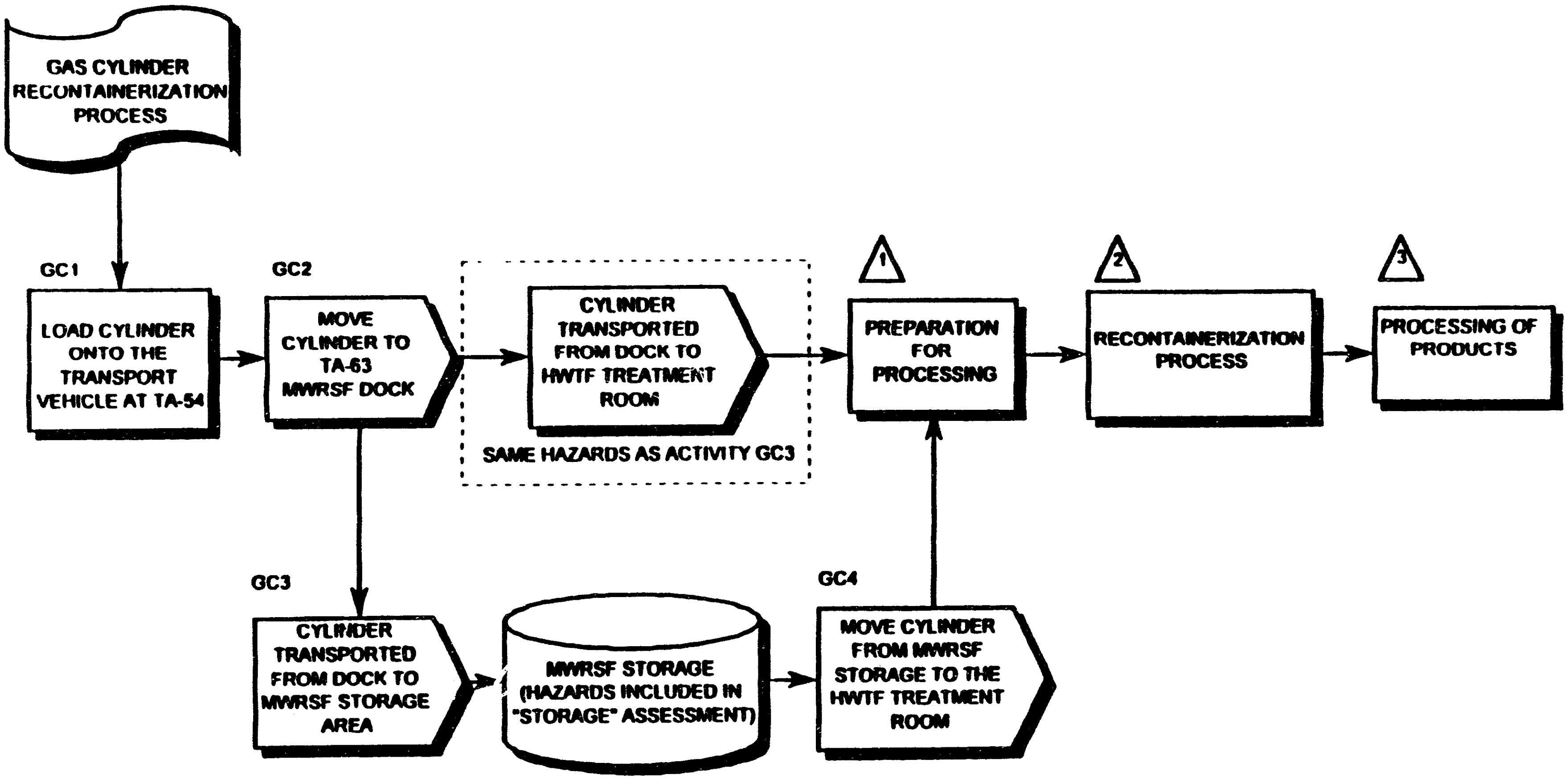

Fig. A-11. Gas cylinder recontainerization process.

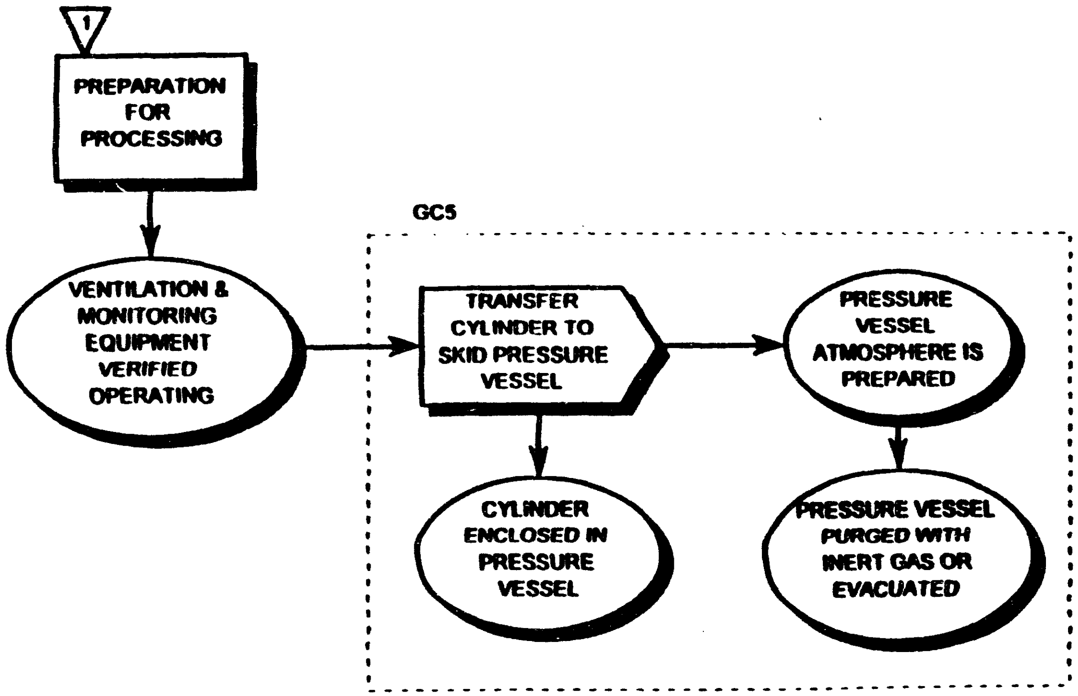

Fig. A-11. Gas cylinder recontainerization process (cont).

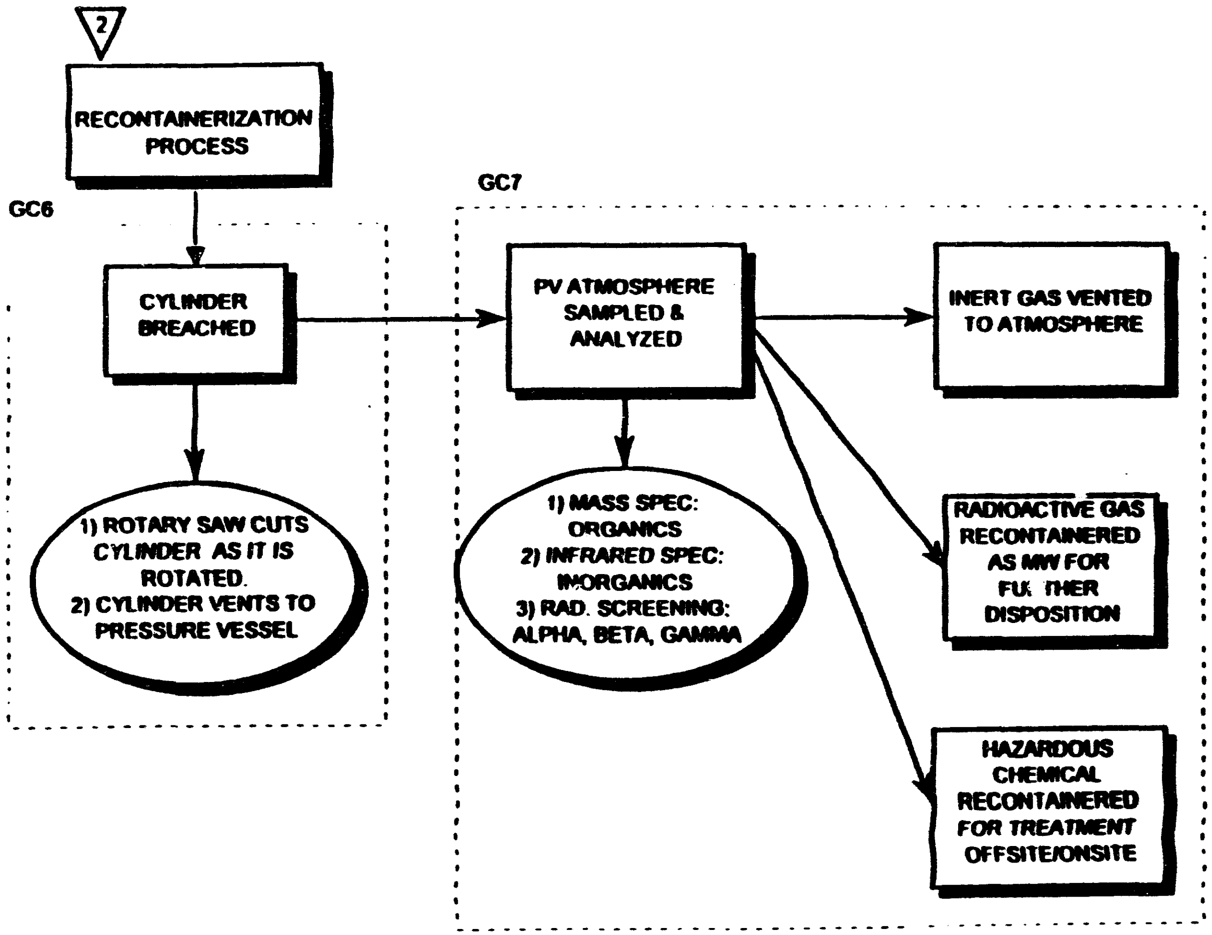

Fig. A-11. Gas cylinder recontainerization process (cont).

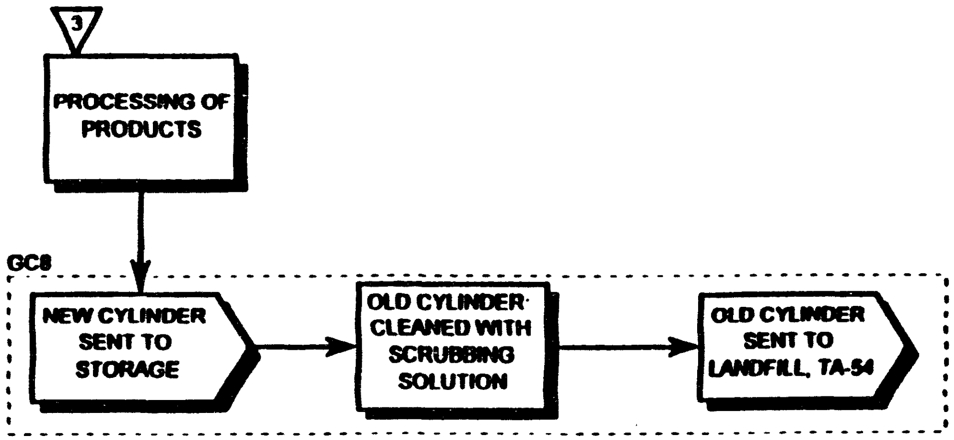

Fig. A-11. Gas cylinder recontainerization process (cont).

APPENDIX B
MIXED WASTE RECEIVING AND STORAGE FACILITY

DESIGN DESCRIPTION

The Design Criteria Report* provides the most complete description of the facility design currently available. Only a brief description of the facility and process is provided here.

Introduction. The proposed Los Alamos Mixed Waste Receiving and Storage Facility (MWRSF), located in TA-63, will receive and store mixed waste generated on-site at Los Alamos National Laboratory.

Facility Description. A new facility, called the Mixed Waste Receiving and Storage Facility (MWRSF), is proposed to house mixed wastes generated by the Laboratory. Figure B-1 shows the site plan as envisioned in the preconceptual design report. The MWRSF will be fully independent and will include necessary areas such as airlocks, waste storage room, change room facilities, mechanical/electrical rooms, and the loading dock area.

The MWRSF is an enclosed building (see Fig. B-1) containing the following room classifications: Flammables, Oxidizers, Caustics, Acids, Unregulated (non-RCRA), Compressed Gases, Cyanides and Sulfides, Reactives (metals and hydrides), and PCBs. The last three rooms are completely enclosed; the others are open on one side. The bulking room is used to rebulk solids and liquids. The ventilation system has HEPA filtration, and the stack will have radiation monitoring.

EPA Classification Methodology. The mixed wastes expected to be received by the MWRSF are listed in the following tables and are classified according to EPA classifications for Potentially Incompatible Waste. The EPA classification is used to avoid mixing hazardous waste with other waste or material at a hazardous waste facility that could result in effects that are harmful to human health and the environment. These effects could be (1) heat or pressure; (2) fire or explosion; (3) violent reaction; (4) toxic dusts, mists, or fumes; or (5) flammable fumes or gases.

Table B-1 contains examples of potentially incompatible wastes, waste components, and materials, along with the harmful consequences that result from mixing materials in one group with materials from another group. The list is intended to be a guide for operators of treatment, storage, and disposal facilities and to indicate the need for special precautions when managing these potentially incompatible waste materials or components.

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*"Design Criteria Report for Mixed Waste Receiving and Storage Facility," LANL Facilities Engineering Division, February 10, 1993.

Table B-2 lists the hazardous wastes, according to EPA classification, that potentially could be treated at the MWRSF.

DESIGN CHANGES DURING PHA

The PHA was performed for the basic facility design as described in the Pre-conceptual Conceptual Design Report. However, a number of changes were made to the facility process, layout, and/or structural design during the course of the PHA. Some of these were made as a result of the PHA analysis (e.g., concerns over the large number of human interactions with potentially hazardous waste materials) or during CST-7 attempts to improve the process for efficiency, economy, or risk reduction.

The design changes known as of this report are as follows.

1. **Replace Motorized Forklift with Walk-Behind Forklift.** To reduce the risk of puncturing a waste container during transportation, a motorized fork-lift will not be used to transport mixed waste from the loading dock to the storage area. The motorized forklift has been replaced with a small, walk-behind forklift (flat with wheels). Compared with the larger, motorized forklift, this small forklift has less potential for accidents because it will be moved manually (pushed) from one location to another. There is better control, less momentum, and less or no motive force.

2. **Change Classification Procedure.** The mixed waste will be classified according to the EPA classification system for potentially incompatible waste. The classification at the previous storage site was based on DOT a classification and did not take into consideration the compatibilities of mixed waste. The EPA classification aided in PHA team's recommen-dations for the final locations of the various waste.

3. **Relocation of Incompatible Waste.** The final recommended locations for the mixed waste rooms in the MWRSF (see Fig. B-2) were determined using the EPA classifications (Table B-1) and by analyzing the properties of the various classified wastes. It was decided to enclose the rooms containing reactives, cyanides, and PCBs.

4. **Loading Dock Procedures.** The original design called for a crane hoist to be used when loading the waste from trucks to the loading dock. To reduce the risk of a crane accident, the decision was made to use an elevator plat-form with the walk-behind dolly to reduce the number of handling operations.

RESULTS OF PHA

The results of the PHA on the MWRSF are in the form of Hazard Analysis Reports and are contained in Tables B-3 and B-4. Table B-3 lists the hazards identified by their activity number; within each activity, the hazards are listed in order of severity by risk ranking. Table B-4 lists the hazards according to their risk rank; the most severe hazards have the lowest risk rank and are listed first.

TABLE B-1
EXAMPLES OF INCOMPATIBLE WASTES

Group 1-A
Acetylene sludge
Alkaline caustic liquids
Alkaline cleaner
Alkaline corrosive liquids
Alkaline corrosive battery fluid
Caustic wastewater
Lime sludge and other corrosive alkalies
Lime wastewater
Lime and water
Spent caustic

Group 1-B
Acid sludge
Acid and water
Battery acid
Chemical cleaners
Electrolyte, acid
Etching acid liquid or solvent
Pickling liquor and other corrosive acids
Spent acid
Spent mixed acid
Spent sulfuric acid
Potential consequences: Heat generation; violent reaction

Group 2-A
Aluminum
Beryllium
Calcium
Lithium
Magnesium
Potassium
Sodium
Zinc powder
Other reactive metals and metal hydrides

Group 2-B
Any waste in Group 1-A or 1-B
Potential consequences: Fire or explosion; generation of hydrogen gas.

Group 3-A
Alcohols
Water

Group 3-B
Any concentrated waste in Group 1-A or 1-B
Calcium
Lithium
Metal hydrides
Potassium
SO_2Cl_2, $SOCl_2$, PCl_3, CH_3SiCl_3
Other water-reactive wastes
Potential consequences: Fire, explosion, or heat generation; generation of flammable or toxic gases.

Group 4-A
Alcohols
Aldehydes
Halogenated hydrocarbons
Nitrated hydrocarbons
Unsaturated hydrocarbons
Other reactive organic compounds and solvents

Group 4-B
Concentrated Group 1-A or 1-B wastes
Group 2-A wastes
Potential consequences: Fire, explosion, or violent reaction

Group 5-A
Spent cyanide and sulfide solutions

Group 5-B
Group 1-B wastes
Potential consequences: Generation of toxic hydrogen cyanide or hydrogen sulfide gas.

Group 6-A
Chlorates
Chlorine
Chlorites
Chromic acid
Hypochlorites
Nitrates
Nitric acid, fuming
Perchlorates
Permanganates
Peroxides
Other strong oxidizers

Group 6-B
Acetic acid and other organic acids
Concentrated mineral acids
Group 2-A wastes
Group 4-A wastes
Other flammable and combustible flammable wastes
Potential consequences: Fire, explosion, or violent reaction.

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TABLE B-2
LIST OF MIXED WASTE FOR POTENTIAL STORAGE

Reference Number	Name of chemical (formula) LL SOLID	Stored	Treatment	MSDS	Incompatibilities: Light Heat	Incompatibilities: H2O Moist	Incompatibilities: Acids	Incompatibilities: Bases	Incompatibilities: Oxidizers	Incompatibilities: Reducers	Incompatibilities: Others	Health Hazard: CERCLA	Health Hazard: NFPA	Health Hazard: Threshold Value or LD	Flammability: Flash Point	Flammability: CERCLA	Flammability: NFPA	Reactivity: CERCLA	Reactivity: NFPA	Persistance	Hazardous Combustion or Decomposition Products	Unusual fire and Explosion Hazards	Additional Information	HWTF Storage Class	Quantity FT3
94	chromium	Area G	TBD								See # 9		4				3		2					1A	4100
36	selenium	Area L	HWTF	1			Y		Y				4	TLV 0.2 mg/m3			3		0		nature of decomposition products not known	emits toxic fumes under fire conditions.		1A	16
9	chromium	Area G	HWTF	2		Y						3	4	OSHA 0.5 mg/m3		3	3	0	0	3	none	most soluble chromic or chromous salts are not combustible	chromyl chloride causes ignition of ammonia, ethyl alchohol, turpentine, and other combustible materials	1A	15
33	chromium	Area L	HWTF	2		Y						3	4	OSHA 0.5 mg/m3		3	3	0	0	3	none	most soluble chromic or chromous salts are not combustible	chromyl chloride causes ignition of ammonia, ethyl alchohol, turpentine, and other combustible materials	1A	15
37	silver	Area L	HWTF	1	Y		Y	Y			oxygen	3	4	OSHA 0.01 mg/m3		3	3	0	0	3	nature of decomposition products not known	emits toxic fumes under fire conditions, this material, like most in powder form,is capable of creating a dust explosion		1A	19
6	arsenic	Area G	HWTF	3	Y				Y		air	3	2	OSHA .2mg/M3 TLV .01 mg/M3		0	0	0	0	3		a moderate fire hazard exists if material is in form of dust and is exposed to heat, a slight explosion hazard also exists if dust is exposed to flame		1A	7
10	lead	Area G	HWTF	5					Y		hydrogen peroxide and active metals	3	4	OSHA 0.05 mg/m3 ACGIH TLV 0.15 mg/m3		0	0	0	0	3		none	lead and its compounds has tentatively been found to be a class B-2 carcinogen, the use of lead pipes or lead sheet in any private potable water system	1A	5767

Reference Number	Name of chemical (formula) LL SOLID	Stored	Treatment	MSDS	Incompatibilities: Light Heat	H2O Moist	Acids	Bases	Oxidizers	Reducers	Others	Health Hazard: CERCLA	NFPA	Threshold Value or LD	Flammability: Flash Point	CERCLA	NFPA	Reactivity: CERCLA	NFPA	Persistance	Hazardous Combustion or Decomposition Products	Unusual fire and Explosion Hazards	Additional Information	HWTF Storage Class	Quantity FT3
11	mercury	Area G	HWTF	6	Y				Y		acetylene, aluminum, amines, ammonia, born diodosphide, bromine, 3-bromopropyne, calcium, chlorine, chlorine dioxide, copper(and alloys), ethyleneoxide, lithium, sodium, sodium carbide, sulfuric acid, tetracarbonylnickel, ****** see additional information	3	3	29 mg/m3		0	0	0	0	3	thermal decomposition products may include highly toxic vapors of mercury and mercury oxides	negotiable fire hazard when exposed to heat or flame	**** methvl azide, methylsiline, nitric acid, oxalic acid, oxidants, peroxyformic acid, potassium, rubidium, silver perchlorate, silver perchlorate	1A	75
30	arsenic	Area L	HWTF	1	Y		Y		Y		halogens, air sensitive	3	2	TLV 0.2 mg/m3		0	0	0	0	0	arsenic oxides	emits toxic fumes under fire conditions	non-combustible but produces fumes at high temperature, hydrogen gas can react with inorganic arsenic to form the highly toxic gas arsine	1A	23
34	lead	Area L	HWTF	5					Y		hydrogen peroxide, active metals	3	4	OSHA 0.05 mg/m3 ACGIH TLV 0.15 mg/m3		0	0	0	0	3		none	lead and its compounds has tentatively been found to be a class B-2 carcinogen, the use of lead pipes or lead sheet in any private potable water system	1A	5767
35	mercury	Area L	HWTF	6	Y				Y		acetylene, aluminum, amines, ammonia, born diodosphide, bromine, 3-bromopropyne, calcium, chlorine, chlorine dioxide, copper(and alloys), ethyleneoxide,lithium, sodium, sodium carbide, sulfuric acid, and tetracarbonylnickel	3	3	29 mg/m3		0	0	0	0	3	thermal decomposition products may include highly toxic vapors of mercury and mercury oxides.	negotiable fire hazard when exposed to heat or flame		1A	75

Reference Number	Name of chemical (formula) LL SOLID	Stored	Treatment	MSDS	Incompatibilities: Light Heat	H2O Moist	Acids	Bases	Oxidizers	Reducers	Others	Health Hazard: CERCLA	NFPA	Threshold Value or LD	Flammability: Flash Point	CERCLA	NFPA	Reactivity: CERCLA	NFPA	Persistance	Hazardous Combustion or Decomposition Products	Unusual fire and Explosion Hazards	Additional Information	HWTF Storage Class	Quantity FT3
78	thallium chloride	Area L	TBD	1	Y				Y		may discolor on exposure to light	3	3	TLV-TWA 0.1 mg/m3		0	0	0	0	3	nature of decomposition not known	emits toxic fumes under fire conditions	reacts vigorously with fluorine and reacts violently with potassium	1A	Trace
79	thioacetamide	Area L	CAI	1			Y	Y	Y			3	3			0	0	0	0	0	carbon monoxide, carbon dioxide, nitrogen oxides, sulfur oxides, hydrogen sulfide gas	emits toxic fumes under fire conditions		1A	11.2
80	thiourea	Area L	CAI	1			Y		Y			3	2	LD 147 mg/Kg		0	0	0	0	0	carbon monoxide, carbon dioxide, nitrogen oxides, sulfur oxides	emits toxic fumes under fire conditions		1A	Trace
8	cadmium	Area G	HWTF	4			Y	Y			alkalis		2	OSHA 0.1 mg/m3; TLV .05 mg/m3			0		0			heating of metal beyond boiling point results in evolution of cadmium vapor, which immediately reacts with air to form cadmium oxide fume (highly toxic)		1A	118
32	cadmium	Area L	HWTF	4			Y				alkalis		2	OSHA 0.1 mg/m3; TLV .05 mg/m3			0		0			heating of metal beyond boiling point results in evolution of cadmium vapor, which immediately reacts with air to form cadmium oxide fume (highly toxic)		1A	118
50	vanadium oxide	Area L	HWTF	1							air	4	4	TLV 0.05 mg/m3		0	0	0	0	3	nature of decomposition products not known	emits toxic fumes under fire conditions	slowly oxidized by heat and air to vanadium oxide	1A	0.04

Reference Number	Name of chemical (formula) LL SOLID	Stored	Treatment	MSDS	Incompatiblities							Health Hazard			Flammability			Reactivity			Hazardous Combustion or Decomposition Products	Unusual fire and Explosion Hazards	Additional Information	HWTF Storage Class	Quantity FT3
					Light Heat	H2O Moist	Acids	Bases	Oxidizers	Reducers	Others	CERCLA	NFPA	Threshold Value or LD	Flash Point	CERCLA	NFPA	CERCLA	NFPA	Persistance					
67	lead acetate	Area L	TBD	1			Y	Y			may decompose on exposure to air, absorbs CO2 from air	3	4	LD 714 mg/Kg		0	0	0	0	3	carbon monoxide, carbon dioxide, lead and lead oxides	emits toxic fumes under fire conditins	have been reported to cross the placenta and to induce embryo- and feto- mortality, they also have teratogenic effect in some animals species, excessive exposure can affect blood, nervous and digestive system	1A	0.02
74	selenium dioxide	Area L	TBD	1		Y	Y				organic materials and ammonia	3	3	TLV-TWA 0.2 mg/M3		0	0	0	0	3	nature of decomposition not known	emits toxic fumes under fire conditions		1A	0.02
91	mercury		HWTF		Y			Y			See # 11	3	3			0	0	0	0	3				1A	
95	lead	Area G	TBD								See # 10	3	4			0	0	0	0	3				1A	72400
96	lead	Area G	TBD								See # 10	3	4			0	0	0	0	3				1A	536
44	arsenic oxide	Area L	HWTF	1	Y	Y	Y		Y		halogens			29 mg/kg							arsenic oxides	emits toxic fumes under fire conditions		1A	0.25
49	thallium oxide	Area L	HWTF	1					Y					TLV 0.1 mg/m3							nature of decomposition products not known	emits toxic fumes under fire conditions		1A	Trace
28	hydroxide salts solutions	Area L	HWTF																					1A	42
68	mercury	Area L	TBD								See # 8													1A	0.23
21	nitric acid; hydro sulfuric acid; sulfuric acid; HF, HP3O4; acetic acid	Area L	HWTF	10	Y	Y		Y	Y		See # 22, 23, 24, 25, 26, 27	3	4			3	3	1	0	3				1B	180
26	hydrofluoric acid		offsite	2	Y	Y		Y	Y		alkali metals, acetic anhydride, 2-aminoethanol, ammonium hydrohide, arsenic trioxide, bismuthic acid, calcium oxide, chlorosulfuric acid, cyanogen, cyanides, diphosphorus pentoxide, ethylene diamine, ethyleneimine, fluorine, ***** see additional info.	3	4	OSHA TWA 3ppm		0	0	1	0	0		emits toxic fumes	do not store in glass, can cause severe burns which can be not immediately painful - - - - *****glass, concrete, leather, mercury oxide, methanesulfonic acid, nitric acid, oleum, organics, phosphorus oxide, plastics, potassium permanganate, light	1B	

Reference Number	Name of chemical (formula) LL SOLID	Stored	Treatment	MSDS	Incompatibilities: Light Heat	H2O Moist	Acids	Bases	Oxidizers	Reducers	Others	Health Hazard: CERCLA	NFPA	Threshold Value or LD	Flammability: Flash Point	CERCLA	NFPA	Reactivity: CERCLA	NFPA	Persistance	Hazardous Combustion or Decomposition Products	Unusual fire and Explosion Hazards	Additional Information	HWTF Storage Class	Quantity FT3
90	hydrogen fluoride	Area L	HWTF	1	Y			Y			do not store in glass, avoid contact with metals, alkali metals, and light sensitive	3	4	LC 50 ppm / 30m		0	0	1	0	0	hydrogen fluoride	emits toxic fumes under fire conditions, container explosion may occur under fire conditions	contact with glass, concrete and other silicon-bearing materials yield silicon tetrafluoride gas, contact with cyanides and sulfides produce highly toxic gases of hydrogen cyanide and hydrogen sulfide	1B	0.02
23	phosphoric acid		offsite					Y			chlorides +SS steel, ferrous metals and alloys, granite, metals, nitromethane, plastics, rubber, coatings, porcelain, sodium tetrahyborate	3	3	OSWA, TWA 1mg/m3		0	0	1	0	0	emits toxic fumes of phosphoric oxides	may ignite combustibles		1B	
27	acetic acid	Area L	HWTF	1	Y	Y		Y				2	2	OSHA 25 mg/m3	104F	1	1	0	0	0	toxic fumes of carbon monoxide & carbon dioxide			1B	
24	hydrosulfuric acid	Area L	HWTF	1																	toxic fumes, irritating fumes	hazardous polymerization		1B	
25	sulfuric acid	Area L	HWTF	1		Y		Y			halides, metals			OSHA 1 mg/m3							sulfur oxides	emits toxic fumes under fire conditions	incompatible with carbides, chlorates, fulminates, nitrates, picrates, cyanides, alkali halides, zinc lodide, permanganates, hydrogen peroxide, azides, perchlorates, nitromethane, phosphorous, nitrites	1B	
2	lithium (hydride), potassium & sodium	Area G	HWTF			Y	Y		Y			4	3			3	4	2	2	0				2A	399
3	lithium hydride		offsite	1		Y	Y		Y		alcohols		3	OSHA TWA 0.025 mg/m3			4		2		liberates hydrogen	in powder form can cause dust explosion	corrosive, inhalation may be fatal	2A	
7	barium	Area G	HWTF	2		Y	Y				organics, combustibles	3	4	OSHA 0.5 mg/m3		3	3	2	2		toxic gases and vapors			2A	208
31	barium	Area L	HWTF	2		Y	Y				organics	3	4	OSHA 0.5 mg/m3		3	3	2	2		toxic gases and vapors			2A	208
93	barium	Area G	TBD								See # 7	3	4			3	3	2	2					2A	531

Reference Number	Name of chemical (formula) LL SOLID	Stored	Treatment	MSDS	Incompatibilities							Health Hazard			Flammability			Reactivity			Hazardous Combustion or Decomposition Products	Unusual fire and Explosion Hazards	Additional Information	HWTF Storage Class	Quantity FT3
					Light Heat	H2O Moist	Acids	Bases	Oxidizers	Reducers	Others	CERCLA	NFPA	Threshold Value or LD	Flash Point	CERCLA	NFPA	CERCLA	NFPA	Persistance					
4	sodium	Area G	TBD	1		Y	Y		Y		ammonia nitrate salts, sodium chormate		3	IPR 40 mg/Kg			1		2		nature of decomposition products not known	material readily reacts with water generating flammable and/or explosive hydrogen gas, reducing agent	dispersions of sodium in volatile solvents become pyrophoric when the solvent evaporates	2A	3900
92	sodium	Area G	TBD	1		Y	Y		Y				3				1		2		nature of decomposition products not known	material readily reacts with water generating flammable and/or explosive hydrogen gas, reducing agent	dispersions of sodium in volatile solvents become pyrophoric when the solvent evaporates	2A	3900
5	potassium			2			Y		Y			4	3	no data		3	1	2	2	0	thermal decomposition mat release toxic and/or hazardous gases	dangerous fire hazard when exposed to heat or flame, finly divided material may ignite on exposure to air		2A	
61	ethyl ether	Area L	CAI	1	Y				Y				2	LD 260 mg/Kg			4		1		carbon monoxide, carbon dioxide	extremely flammable, vapor travels to cause flash back, container explosion may occur under fire conditions	tends to form explosive peroxides especially when anhydrous inhibited with 0.0001% BHT	4A	4

Reference Number	Name of chemical (formula) LL SOLID	Stored	Treatment	MSDS	Incompatibilities							Health Hazard			Flammability			Reactivity			Hazardous Combustion or Decomposition Products	Unusual fire and Explosion Hazards	Additional Information	HWTF Storage Class	Quantity FT3
					Light Heat	H2O Moist	Acids	Bases	Oxidizers	Reducers	Others	CERCLA	NFPA	Threshold Value or LD	Flash Point	CERCLA	NFPA	CERCLA	NFPA	Persistance					
63	formaldehyde		offsite	2			Y	Y	Y		ammonia, anhydrides, aniline +perchloric acid, bisulfides, copper and alloys, copper salts, iodine, iron compounds, isocyanates, *hydrochloric acid*, H2O2, NO2, nitromethane, oxides, peroxyformic acid, phenol, potassium permanganate, silver salts	3	2	OSHA TWA 0.75ppm	185F	3	4	0	0	0	carbon oxides		corrosive, sensitizer, carcinogen, highly toxic	4A	
54	chloromethane	Area L	CAI	1		Y			Y		galvanized iron, may decompose on exposure to moist air and water		2	TLV-TWA 50 ppm			4		0		carbon monoxide, carbon dioxide, phosgene gas, hydrogen chloride gas	may form explosives with air, extremely flammable, emits toxic fumes	methly chloride is rapidly asborbed throught the lungs, symptoms include: dizziness, headache, vomiting, tremors, convulsions, emtreme nervousness, and death	4A	0.02
58	1,2-dichloroethane	Area L	CAI	1					Y		aluminum		2	LD 286 mg/Kg			3		2		carbon monoxide, carbon dioxide, phosgene gas, hydrogen chloride gas	flammable liquid, vapor travels to cause flashback, emits toxic fumes *under fire conditions*		4A	0.45
66	hydrazine	Area L	TBD	1					Y		oxygen, copper, zinc, and organic materials		3	TLV-TWA 0.01 ppm			3		2		nitrogen oxides	catches fire if contact with air, explode when heated, reducing agent, emits toxic fumes	vapor in air is flammable at 4 7 to 100%, handle under nitrogen, some metals and alloy including monel, bronze, brass, gold, cadmium and stainless steel with more than 0.5% molybdenium cause decompostion of hydrazine	4A	0.06

Reference Number	Name of chemical (formula) LL SOLID	Stored	Treatment	MSDS	Incompatibilities: Light Heat	Incompatibilities: H2O Moist	Incompatibilities: Acids	Incompatibilities: Bases	Incompatibilities: Oxidizers	Incompatibilities: Reducers	Incompatibilities: Others	Health Hazard: CERCLA	Health Hazard: NFPA	Health Hazard: Threshold Value or LD	Flammability: Flash Point	Flammability: CERCLA	Flammability: NFPA	Reactivity: CERCLA	Reactivity: NFPA	Reactivity: Persistance	Hazardous Combustion or Decomposition Products	Unusual fire and Explosion Hazards	Additional Information	HWTF Storage Class	Quantity FT3
12	1,1,1, trichloroethane; trichloroehtylene; methylene chloride; chlorinated flourocarbons; toluene	Area G	TBD		Y			Y	Y		See # 59, 81, 83, 85	3	2			3	3	0	1	1				4A	9529
98	chromium, 1,1,1; trichloroethane; trichloroethylene; methylene chloride; toluene	Area G	TBD		Y	Y		Y	Y		See # 9, 59, 81, 83, 85	3	4			3	3	0	1	3				4A	6500
77	tetrahydrofuran	Area L	CAI	1			Y	Y	Y		oxygen		2	TLV-TWA 200 ppm			3		1		carbon monoxide, carbon dioxide	extremely flammable, vapor travels to cause flash back, container explosion may occur under fire conditions	on exposure to air, tetrehydrofuran forms peroxides which can explode upon contact with strong base or metal hydrides when he peroxide concentration is greater than 0.5%	4A	0.04
99	1,1,1 trichloroethane; trichloroethylene; methylene chloride; toluene; f-solv/dioxin	Area G	TBD	2					Y		See # 59, 81, 83, 85	3	2			3	3	0	1	1				4A	38500
60	ethyl acetate	Area L	CAI	1	Y	Y	Y	Y	Y				1				3		0		carbon monoxide, carbon dioxide	flammable liquid, vapor travels to cause flashback, forms explosive mixtures in air	slowly decomposed by moisture and reacts explosively with lithium aluminum hydride	4A	0.07

Reference Number	Name of chemical (formula) LL SOLID	Stored	Treatment	MSDS	Incompatibilities: Light Heat	Incompatibilities: H2O Moist	Incompatibilities: Acids	Incompatibilities: Bases	Incompatibilities: Oxidizers	Incompatibilities: Reducers	Incompatibilities: Others	Health Hazard: CERCLA	Health Hazard: NFPA	Health Hazard: Threshold Value or LD	Flammability: Flash Point	Flammability: CERCLA	Flammability: NFPA	Reactivity: CERCLA	Reactivity: NFPA	Persistance	Hazardous Combustion or Decomposition Products	Unusual fire and Explosion Hazards	Additional Information	HWTF Storage Class	Quantity FT3
43	pyridine waste		offsite	2	Y		Y		Y		beta propiolactone, brominetrifluoride +carbon tetrachloride, chlorosulfonic acid, chromic trioxide, dinitrogen tetraoxide, fluorine, formamide + iodine+sulfur trioxide, maleic anhydride, nitric acid, oleum	3	2	OSHA TWA 5ppm	68F	3	3	0	0	1	emits toxic fumes of nitrogen and carbon oxides		avoid heat and ignition sourses ********perchloric acid, perchromates, plastics, silver perchlorate, sulfuric acid, trifluoromethyl, hypofluorite, heat	4A	
15	methanol	Area G	CAI	7	Y				Y		chromic anhydride, iodine, ethyl alchohol, mercuric oxide, lead perchlorate, perchloric acid, sodium or potassium hydroxide and chloroform	3	1	OSHA 200 ppm		3	3	0	0		carbon monoxide, carbon dioxide, formaldehyde, and other toxic gases may be formed in a fire	reacts violently to oxidizers		4A	
14	acetone	Area G	CAI	7					Y				1	OSHA 1000 ppm, TLV 750 ppm			3		0		carbon monoxide, carbon dioxide, organic acid	extremely flammable		4A	72
16	xylene	Area G	CAI	8					Y		nitric acid, plastics, rubber, coatings, sulfric acid		2	200 ppm			3		0		carbon dioxide and/or carbon monoxide	a SCBA should be worn by fire fighting personnel		4A	
42	benzene		offsite	1		Y			Y				3	OSHA TWA 1ppm			3		0		CO, CO2	extremely flammable	carcinogen, blood effects, bone marrow effects	4A	
51	acetone	Area L	CAI	7					Y				1	OSHA 1000 ppm,TLV 750 ppm			3		0		carbon monoxide, carbon dioxide, organic acid	extremely flammable		4A	72

Reference Number	Name of chemical (formula) LL SOLID	Stored	Treatment	MSDS	Incompatibilities: Light Heat	H2O Moist	Acids	Bases	Oxidizers	Reducers	Others	Health Hazard: CERCLA	NFPA	Threshold Value or LD	Flammability: Flash Point	CERCLA	NFPA	Reactivity: CERCLA	NFPA	Persistance	Hazardous Combustion or Decomposition Products	Unusual fire and Explosion Hazards	Additional Information	HWTF Storage Class	Quantity FT3
81	toluene	Area L	CAI	2					Y		iron, ferric chloride, *uranium hexafluoride*, tetranitromethane, plastics, nitrogen tetroxide, *nitric adic*, bromine trifluoride, silver perchlorate, sulfur dichloride, sulfuric acid, dinitrogen tetrafluoride	3	2	LD 50 mg/Kg	40 F	3	3	0	0	1	thermal decomposition may release acrid smoke and irritating fumes	dangerous fire hazard when exposed to heat or flame	stimulants such as epinephrine may induce ventricular fibrillation, alcohol may enhance the toxic effects, the metabolism of ohter solvents may be inhibited resulting in a potentiation of toxic effects of those chemicals	4A	0.15
70	methyl ethyl ketone peroxide	Area L	CAI	1	Y		Y	Y		Y	heavy metals		1	TLV-CL 0.2 ppm			3		0		carbon monoxide, carbon dioxide	organic peroxide, may explode when heated, contact with other material may cause fire	contains 8.6%-9.0% active oxygen	4A	0.04
40	acetone; *methanol*; xylene	Area L	CAI, HWTF		Y			Y			See # 14, 15, 16	3	2			3	3	0	0					4A	570
69	methanol	Area L	CAI								See # 15		1				3		0					4A	4.5
86	xylene	Area L	CAI								See # 16		2				3		0					4A	6.7
52	aniline	Area L	CAI	1			Y	Y	Y		*iron and iron salts*, aluminum, zinc		3	LD 150 mg/Kg			2		0		carbon monoxide, carbon dioxide, nitrogen oxides	emits toxic fumes under fire conditions		4A	0.03
55	creasol	Area L	CAI	2			Y	Y	Y		aluminum, brass alloys, chlorosulfonic acid, copper, nitric acid, oleum		3	LD 114 mg/Kg	178 F		2		0		thermal decomposition products may include toxic and hazardous fumes of formaldehyde and oxides of carbon	moderate fire hazard when exposed to heat or flame	may burn but does not ignite readily, containers may explode in heat of fire	4A	0.02
72	phenol	Area L	CAI	1			Y	Y	Y		may discolor on exposure to light		3	LD 140 mg/Kg			2		0		carbon monoxide, carbon dioxide	emits toxic fumes under fire conditions		4A	0.18
64	formic acid	Area L	CAI	1		Y		Y	Y		*finely powdered metals*		3	TLV-TWA 50 ppm			2		0		carbon monoxide, carbon dioxide	*emits toxic fumes* under fire conditions	reacts violently with furfuryl *alcohol, hydorgen peroxide*, hydrated thallium nitrate, permanganates, sulfuric acid	4A	1 9
56	cyclohexanone	Area L	CAI	1					Y	Y	plastics		1	OSHA TWA 50 ppm	116 F		2		0		carbon monoxide, carbon dioxide			4A	7.5

Reference Number	Name of chemical (formula) LL SOLID	Stored	Treatment	MSDS	Incompatibilities: Light Heat	H2O Moist	Acids	Bases	Oxidizers	Reducers	Others	Health Hazard: CERCLA	NFPA	Threshold Value or LD	Flammability: Flash Point	CERCLA	NFPA	Reactivity: CERCLA	NFPA	Persistance	Hazardous Combustion or Decomposition Products	Unusual fire and Explosion Hazards	Additional Information	HWTF Storage Class	Quantity FT3
71	napthalene	Area L	CAI	1					Y				2	LD 29 mg/Kg			2		0		carbon monoxide, carbon dioxide	capable of creating a dust explosion		4A	Trace
13	1,1,1 trichloroethane; trichloroethylene	Area G	CAI, HWTF		Y			Y	Y		See # 83, 85		3				1		1					4A	771
83	1,1,1 trichloroethane	Area L	CAI	1	Y			Y	Y		reacts violently with sodium, potassium, magnesium, aluminum, zinc		3	TLV-TWA 10 ppm			1		1		carbon monoxide, carbon dioxide, phosgene gas, hydrogen chloride gas	emits toxic fumes under fire conditions		4A	57.4
97	1,1,1 trichlorethane; trichloroethylene; methylene chloride; ~~chlorinated~~ fluorocarbons	Area G	CAI						Y		See # 59, 83, 85	3	3			1	1	0	1	1				4A	9758
84	1,1,2, trichloroethane	Area L	CAI	1	Y			Y	Y	Y	aluminum, magnesium	3	3	LD 7 gm/Kg		1	1	0	0	3	carbon monoxide, carbon dioxide, phosgene gas, hydrogen chloride gas	emits toxic fumes under fire conditions		4A	0.43
73	phthalic anhydride	Area L	CAI	1		Y	Y	Y	Y	Y			2	TLV-TWA 1 ppm			1		0		carbon monoxide, carbon dioxide	dust explosion and emits toxic fumes under fire conditions	reacts vigorously with nitric acid and nitrating mixtures to produce potentially explosive products, react when heated with sodium nitrate or copper	4A	0.04
59	methylene chloride	Area L	CAI	1					Y		alkali metals, aluminum, caustics, copper, iron, lithium, dinitrogen pentoxide, dinitrogen tetroxide, nickel, nitric acid, oxygen, plastics, potassium, sodium, sodium-potassium alloy, zinc, titanium, stainless steel	3	2	LD 357 mg/Kg		1	1	0	0	1	thermal decomposition products may include toxic and hazardous phosgene gas, toxic and corrosive fumes of chlorides, and oxides of carbon	slight fire hazard when exposed to heat or flame		4A	0.4

Reference Number	Name of chemical (formula) LL SOLID	Stored	Treatment	MSDS	Incompatibilities: Light Heat	H2O Moist	Acids	Bases	Oxidizers	Reducers	Others	Health Hazard: CERCLA	NFPA	Threshold Value or LD	Flammability: Flash Point	CERCLA	NFPA	Reactivity: CERCLA	NFPA	Persisance	Hazardous Combustion or Decomposition Products	Unusual fire and Explosion Hazards	Additional Information	HWTF Storage Class	Quantity FT3
38	1,1,1, trichloroethane; trichlorothylene; meathylene chloride; chlorinated flourocarbons	Area L	CAI, HWTF		Y		Y	Y			See # 59, 83, 85	3	3			1	1	0	1	1				4A	313
39	1,1,1, trichloroethane, trichlorothylene	Area L	CAI, HWTF		Y		Y	Y			See # 83, 85		3				1		1					4A	450
85	trichloroethlyene	Area L	CAI										2				1		0					4A	21.9
88	bromoethane	Area L	CAI	CTX							chemically active metals, sodium, potassium, calcium, powdered aluminum, zinc, magnesium		2				1		0		runoff to sewer may create fire or explosion hazard	flammable / combustible material, may be ignited by heat, sparks or flames, vapor may travel to a source of ignition and flash back	may be poisonous if unhaled or absorbed through skin	4A	0.2
65	hexachloroethane	Area L	CAI	2			Y	Y	Y		alkalies, aluminum, iron, plastics, rubber, zinc	3	4			0	0	0	0	3	thermal decomposition realeases highly toxic fumes of phosgene, chlorine, ethylenes, and choloethylenes	negligible fire hazard when exposed to heat or flame	may burn but does not ignite readily, prevent dispersion of dust in air, do not allow spilled material to contaminate water sources	4A	0.02
53	chloroform	Area L	CAI	1	Y			Y			aluminum, light		2	LD 546 mg/Kg			0		0		carbon monoxide, carbon dioxide, phosgene gas, hydrogen chloride gas	emits toxic fumes under fire conditions		4A	0.02
82	bromoform	Area L	TBD	1	Y			Y			alkali metals, aluminum, acetone	3	1	LD 143 mg/Kg		0	0	0	0	2	carbon monoxide, carbon dioxide, hydrogen bromide gas	emits toxic fumes under fire conditions	incompatible with aluminum, magnesium, and their alloys	4A	0.04
75	tetra-chloroethylene	Area L	CAI	1				Y					2	TLV-TWA 50 ppm			0		0		carbon monoxide, carbon dioxide, phosgene gas, hydrogen chloride gas	emits toxic fumes under fire conditions		4A	0.01

Reference Number	Name of chemical (formula) LL SOLID	Stored	Treatment	MSDS	Incompatibilities: Light Heat	Incompatibilities: H2O Moist	Incompatibilities: Acids	Incompatibilities: Bases	Incompatibilities: Oxidizers	Incompatibilities: Reducers	Incompatibilities: Others	Health Hazard: CERCLA	Health Hazard: NFPA	Health Hazard: Threshold Value or LD	Flammability: Flash Point	Flammability: CERCLA	Flammability: NFPA	Reactivity: CERCLA	Reactivity: NFPA	Reactivity: Persistance	Hazardous Combustion or Decomposition Products	Unusual fire and Explosion Hazards	Additional Information	HWTF Storage Class	Quantity FT3
41	benzene; pyridine; toluene	Area L	CAI, HWTF		Y	Y	Y		Y		See # 42, 43, 81													4A	381
62	trichloro-fluoromethane	Area L	TBD	1	Y				Y		sodium, potassium, magnesium, aluminum, zinc, away from heat and sunlight			TLV-CL 1000 ppm							carbon monoxide, carbon dioxide, phosgene gas, hydrogen fluoride, hydrogen chloride gas	emits toxic fumes under fire conditions	incompatible with: copper, bronze, silver, beryllium, alkali and alkaline earth materials	4A	1.9
76	tetra-chloromethane	Area L	CAI	1					Y		alkali metals, finely powdered metals			LD 93 mg/Kg							phosgene gas, carbon monoxide, carbon dioxide	emits toxic fumes under fire conditions	reacts violently with dimethyl formamide (DMF) above 65 C	4A	0.43
89	dichloro-difluoromethane	Area L	CAI	1	Y						potassium, sodium, aluminum, magnesium, zinc			TLV-TWA 1000 ppm							carbon monoxide, carbon dioxide, phosgene gas, hydrogen fluoride, hydrogen chloride gas	emits toxic fumes under fire conditions	incompatible with aluminum, magnesium, and alloys of more than 2% magnesium, zinc, beryllium, alkali or alkaline earth metals, silver and copper bearing alloys can act as catalysts at high temps	4A	4
19	ignitable chemical reagents scintillation vials	Area L	CAI, HWTF																					4A	2800, 2750, 40
47	potassium cyanide	Area L	HWTF	1		Y	Y		Y		absorbs CO2 from air		3	2.8 mg/kg			0		0		hydrogen cyanide, carbon monoxide, carbon dioxide, nitrogen oxides	emits toxic fumes under fire conditions		5A	0.06
48	sodium cyanide	Area L	HWTF	1		Y	Y		Y		carbon dioxide		3	2.8 mg/kg			0		0		hydrogen cyanide, carbon monoxide, carbon dioxide, nitrogen oxides	emits toxic fumes under fire conditions		5A	0.04
45	copper cyanide	Area L	HWTF	1			Y		Y		magnesium			OSHA & TLV 5 mg/m3							carbon monoxide, carbon dioxide, nitrogen oxides, hydrogen cyanide	emits toxic fumes under fire conditions		5A	0.6
87	cyanogen bromide	Area L	TBD	1	Y	Y			Y				4	LC 92 ppm / 10m			4		2		hydrogen bromide gas, hydrogen cyanide	emits toxic fumes under fire conditions, may explode when heated	can polymerize violently on prolonged storage at ambient temperature	5A	1.3
29	cyanide and sulfide solutions	Area L	HWTF																					5A	72

Reference Number	Name of chemical (formula) LL SOLID	Stored	Treatment	MSDS	Incompatibilities							Health Hazard			Flammability			Reactivity			Hazardous Combustion or Decomposition Products	Unusual fire and Explosion Hazards	Additional Information	HWTF Storage Class	Quantity FT3
					Light Heat	H2O Moist	Acids	Bases	Oxidizers	Reducers	Others	CERCLA	NFPA	Threshold Value or LD	Flash Point	CERCLA	NFPA	CERCLA	NFPA	Persistance					
1	nitrates & nitrate compounds	Area G	HWTF	1,2		Y	Y			Y	strong acids, strong reducers, finely powdered metals, cyanides, thiocyanates, isothiocyanates, hypophosphines, combustibles, sulfur	3	1	ACGIH TWA 2mg/m3		0	0	0	0	1	nitrogen oxides, aluminum oxides	contact with other materials may cause fire	a mixture of aluminum powder water , metal nitrate may explode due to self accelerating reaction, mixture of metal nitrates and alkyl esters may explode, mixture of metal nitrates with phosphorus may explode, mixture of metal nitrates and organic explode	6A	597
22	nitric acid	Area L	HWTF	10							metallic powders, carbides, sulfides, turpentine, cyanides	3	3	OSHA 5mg/m3, TLV 5 mg/m3		3	3	0	0	3	oxides of nitrogen	nitric acid will not burn but may cause combustibles in contact with it to burn		6A	
17	hydrogen	Area L	CAI	9	Y				Y		alkaline metal calcium carbonate+magnesium, chlorine dioxide, copper(II) oxide, dichlorine oxide, difluorodiazene, dinitrogen oxide, dinitrogen tetraoxide, dioxane+nickel, fluorine perchlorate, halogens, interhalogens **** see additional information	0	0			3	4	0	0	0	none hazardous	dangerous explosion hazard when exposed to heat or flame	***** isopropyl alcohol, nitroanisole + nickel, nitrogen (liquid), nitrogen oxide, nitrogen trifluoride, nitrosyl chloride, nitryl fluride, ozone, palladium II, palladium trifluoride,1-pentol, poly ethane, 1-1-1 tris nitromethane, 1-1-1 tris ethane	7A	5
46	phosgene	Area I	TBD	1		Y					amines, ammonia, alcohols, sodium, potassium		4	OSHA 0.4 mg/m3			0		0		carbon dioxide, carbon monoxide, hydrogen chloride gas	contents under pressure;container explosion may occur under fire conditions;emits toxic fumes under fire conditions		7A	30
18	ignitable gases	Area L	CAI																					7A	711
20	corrosive gases	Area L	HWTF																					7A	9

Reference Number	Name of chemical (formula) LL SOLID	Stored	Treatment	MSDS	Incompatibilities							Health Hazard			Flammability			Reactivity			Hazardous Combustion or Decomposition Products	Unusual fire and Explosion Hazards	Additional Information	HWTF Storage Class	Quantity FT3
					Light Heat	H2O Moist	Acids	Bases	Oxidizers	Reducers	Others	CERCLA	NFPA	Threshold Value or LD	Flash Point	CERCLA	NFPA	CERCLA	NFPA	Persistance					
57	dichlorodifluoro-methane	Area L	TBD	CTX							chemically active metals, sodium, potassium, calcium, powdered aluminum, zinc, magnesium			TLV 10 ppm --- 40 mg/m3								some of these materials may burn, but none of them ignites readily, cylinder may explode in heat of fire	vapors may cause dizziness or suffocation, contact with liquid may cause frostbite, fire may produce irritating or poisonous gases.	7A	0.35

TABLE B-3
HAZMAN RESULTS SORTED BY ACTIVITY FOR MWRSF

PRELIMINARY HAZARD/RISK ANALYSIS RECORD BY ACTIVITY FOR MIXED WASTE STORAGE

ACTIVITY NUMBER: MW1A

ACTIVITY NAME: MWRSF CAUSTICS (GROUP 1A)

ACTIVITY DESCRIPTION: STORAGE OF CAUSTICS IN MWRSF (GROUP 1A)

R--F--C	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
3 III B	SODIUM AZIDE EXPLODES DUE TO SEVERE SHOCK, HEAT OR FRICTION.	EXPLOSION AND RELEASE OF TOXIC GAS (NOX). (D;D;B;C)	FIRE PROTECTION AND SCRUBBER SYSTEM.	DO NOT ACCEPT/ALLOW SODIUM AZIDE IN THE MWSRF.
3 III B	EXTERNAL FIRE	RELEASE OF MODERATELY TOXIC GASES. WORKER INJURY. (D;C;B;C)	FIRE PROTECTION AND SCRUBBER SYSTEM.	NONE
3 IV B	OVERHEAD CRANE ACCIDENT CAUSING SIMULTANEOUS SPILL OF CAUSTC MATERIAL AND INCOMPATIBLE MATERIAL(E.G., H2SO4(1B), TETRAHYDRO FURAN(4A), NITRIC ACID(6A), METAL CYANIDE(5A),LITHIUM HYDRIDE(2A)) DUE TO MISLABELING.	POTENTIAL FIRE, EXPLOSION, HYDROGEN GAS PRODUCTION AND HEAVY METAL FUME GENERATION. WORKER INJURY/EXPOSURE. (D;D;B;C)	FIRE SUPPRESSION AND SCRUBBER SYSTEM.	NONE
4 II D	SPILL OF A SINGLE CAUSTIC WASTE DRUM.	MINOR WORKER EXPOSURE. (D;D;D;D)	NONE	NONE

PRELIMINARY HAZARD/RISK ANALYSIS RECORD BY ACTIVITY FOR MIXED WASTE STORAGE

ACTIVITY NUMBER: MW1B

ACTIVITY NAME: MWRSF ACIDS (GROUP 1B)

ACTIVITY DESCRIPTION: STORAGE OF ACIDS IN MWRSF (GROUP 1B)

R--F--C	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
3 III B	SPILL OF A SINGLE ACID WASTE DRUM DUE TO CORROSION OR CRANE ACCIDENTS.	TOXIC GAS RELEASE (E.G., HF). WORKER EXPOSURE AND INJURY DUE TO CONTACT WITH GAS/LIQUIDS. (D;D;B;D)	(1) SCRUBBER SYSTEM. (2) THE SUMP CAPACITY IS TEN PERCENT OF THE INVENTORY IN THE ROOM, EQUIVALENT TO THREE SPRINKLER HEADS DISCHARGING FOR 30 MINUTES.	(1) VERIFY CONSTRUCTION MATERIAL OF STORAGE CONTAINER AND THE SUMP SYSTEM, (2) FREQUENT INSPECTIONS, (3) INSTALL GAS DETECTORS, (4) DO NOT PERFORM ANY UNNECESSARY ACTIVITIES WHILE THE SCRUBBER IS DOWN, (5) REVIEW/CONSIDER STORING HF IN GAS CYLINDER AREA (GROUP 7A).
3 III B	SPILL OF A SINGLE ACID WASTE DRUM DUE TO CORROSION OR CRANE ACCIDENTS. SRCUBBER NOT OPERATIONAL, BUT BLOWER IS WORKING.	TOXIC GAS RELEASE (E.G., HF OR HCL). WORKER EXPOSURE AND INJURY. (C;C;B;D)	THE SUMP CAPACITY IS TEN PERCENT OF THE INVENTORY IN THE ROOM, EQUIVALENT TO THREE SPRINKLER HEADS DISCHARGING FOR 30 MINUTES.	(1) VERIFY CONSTRUCTION MATERIAL OF STORAGE CONTAINER AND THE SUMP SYSTEM, (2) FREQUENT INSPECTIONS, (3) INSTALL GAS DETECTORS, (4) DO NOT PERFORM ANY UNNECESSARY ACTIVITIES WHILE THE SCRUBBER IS DOWN.
3 III B	EXTERNAL FIRE	RELEASE OF MODERATELY TOXIC GASES. WORKER INJURY. (D;C;B;C)	FIRE PROTECTION AND SCRUBBER SYSTEM.	NONE
3 III C	SPILL OF A SINGLE ACID WASTE DRUM DUE TO CORROSION OR CRANE ACCIDENTS.	RELEASE OF ACID FUMES (E.G., HCL). WORKER EXPOSURE AND INJURY DUE TO CONTACT WITH GAS/LIQUIDS. (D;D;C;D)	(1) SCRUBBER SYSTEM. (2) THE SUMP CAPACITY IS TEN PERCENT OF THE INVENTORY IN THE ROOM, EQUIVALENT TO THREE SPRINKLER HEADS DISCHARGING FOR 30 MINUTES.	(1) VERIFY CONSTRUCTION MATERIAL OF STORAGE CONTAINER AND THE SUMP SYSTEM, (2) FREQUENT INSPECTIONS, (3) INSTALL GAS DETECTORS, (4) DO NOT PERFORM ANY UNNECESSARY ACTIVITIES WHILE THE SCRUBBER IS DOWN.

PRELIMINARY HAZARD/RISK ANALYSIS RECORD BY ACTIVITY FOR MIXED WASTE STORAGE

ACTIVITY NUMBER: MW1B

ACTIVITY NAME: MWRSF ACIDS (GROUP 1B)

ACTIVITY DESCRIPTION: STORAGE OF ACIDS IN MWRSF (GROUP 1B)

R--F--C	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
3 IV B	OVERHEAD CRANE ACCIDENT CAUSING SIMULTANEOUS SPILL OF ACID MATERIAL AND INCOMPATIBLE MATERIAL (E.G., NAOH(1A), PYRIDINE(4A), HYDROGEN PEROXIDE(6A), METAL CYANIDE(5A), LITHIUM HYDRIDE(2A)) DUE TO MISLABELING.	POTENTIAL FIRE, EXPLOSION, HYDROGEN GAS PRODUCTION AND TOXIC GAS GENERATION. SEVERE WORKER INJURY/EXPOSURE. (D;D;B;C)	FIRE SUPPRESSION AND SCRUBBER SYSTEM.	NONE

PRELIMINARY HAZARD/RISK ANALYSIS RECORD BY ACTIVITY FOR MIXED WASTE STORAGE

ACTIVITY NUMBER: MW2A

ACTIVITY NAME: MWRSF REACTIVES (GROUP 2A)

ACTIVITY DESCRIPTION: STORAGE OF REACTIVES IN AN ENCLOSED AREA (GROUP 2A)

R--F--C	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
3 II C	WALK BEHIND FORKLIFT ACCIDENT OR OTHER EVENT CAUSES SPILL OF WATER REACTIVE WASTE.	WORKER EXPOSURE, CONTAMINATION OF STORAGE AREA. (D;D;C;D)	(1) DRY CHEMICAL FIRE SUPPRESSION SYSTEM, (2) SCRUBBER SYSTEM, (3) THE SUMP CAPACITY IS TEN PERCENT OF THE INVENTORY IN THE ROOM, EQUIVALENT TO THREE SPRINKLER HEADS DISCHARGING FOR 30 MINUTES.	NONE
3 III B	WALK BEHIND FORKLIFT ACCIDENT OR OTHER EVENT CAUSES SPILL OF WATER REACTIVE WASTE INTO THE SUMP WITH WATER PRESENT IN THE SUMP.	HYDROGEN EVOLUTION, POTENTIAL FIRE/EXPLOSION IN SUMP. POSSIBLE RELEASE OF TOXIC METAL FUMES. LOW LEVEL RADIOACTIVE CONTAMINATION THROUGHOUT THE FACILITY. (D;D;B;C)	(1) DRY CHEMICAL FIRE SUPPRESSION SYSTEM, (2) SCRUBBER SYSTEM, (3) THE SUMP CAPACITY IS TEN PERCENT OF THE INVENTORY IN THE ROOM, EQUIVALENT TO THREE SPRINKLER HEADS DISCHARGING FOR 30 MINUTES, (4) SUMP SHOULD BE MAINTAINED FREE OF WATER, (5) RESTRICT USE OF WATER IN THIS STORAGE AREA.	(1) INSTALL HYDROGEN ANALYZER AND ALARM.
3 III B	ACCIDENT CAUSES SIMULTANEOUS SPILL OF WATER REACTIVE WASTE AND INCOMPATIBLE WASTE DUE TO MISLABELING. (E.G., REACTIVE WASTE MIXED WITH, SULFURIC ACID(1B), NAOH(1A), PERCHLORIC ACID(6A) OR TRICHLORA ETHYLENE(4A))	PRODUCTION OF HYDROGEN GAS, POTENTIAL FIRE AND/OR EXPLOSION AND PRODUCTION OF TOXIC FUMES. SEVERE WORKER INJURY, AND LOW LEVEL RADIOACTIVE CONTAMINATION THROUGHOUT THE FACILITY. (D;D;B;C)	FIRE PROTECTION SYSTEM, SCRUBBER SYSTEM.	NONE
3 III C	WALK BEHIND FORKLIFT ACCIDENT OR OTHER EVENT CAUSES SPILL OF DEPLETED URANIUM WASTE.	BURNING OF THE DEPLETED URANIUM DUE TO PROLONGED EXPOSURE TO AIR, RELEASE OF TOXIC FUMES AND RADIOACTIVITY.	DRY CHEMICAL FIRE SUPPRESSION SYSTEM, SCRUBBER SYSTEM.	NONE

PRELIMINARY HAZARD/RISK ANALYSIS RECORD BY ACTIVITY FOR MIXED WASTE STORAGE

ACTIVITY NUMBER: MW2A

ACTIVITY NAME: MWRSF REACTIVES (GROUP 2A)

ACTIVITY DESCRIPTION: STORAGE OF REACTIVES IN AN ENCLOSED AREA (GROUP 2A)

R--F--C	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
		WORKER EXPOSURE AND LOW LEVEL RADIOACTIVE CONTAMINATION THROUGHOUT THE FACILITY. (D;D;C;C)		
3 IV B	WATER INTRUSION INTO THE STORAGE DRUM DUE TO HUMAN ERROR.	RUPTURE OF DRUM DUE TO HYDROGEN EVOLUTION, POTENTIAL FIRE/EXPLOSION. POSSIBLE RELEASE OF TOXIC METAL FUMES. (D;D;B;C)	DRY CHEMICAL FIRE SUPPRESSION SYSTEM, SCRUBBER SYSTEM.	NONE

PRELIMINARY HAZARD/RISK ANALYSIS RECORD BY ACTIVITY FOR MIXED WASTE STORAGE

ACTIVITY NUMBER: MW4A

ACTIVITY NAME: MWRSF FLAMMABLES (GROUP 4A)

ACTIVITY DESCRIPTION: STORAGE OF FLAMMABLES IN AN ENCLOSED AREA

R--F--C	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
2 III A	SPILL OF LOW FLASH POINT CHEMICALS (ACETHALHEHYE(-38F), FURAN (-32F), ANHYDROUS ETHYLE (-49F)) DUE TO FORKLIFT ACCIDENT, CRANE ACCIDENT OR CORROSION. FIRE SUPPRESSION SYSTEM INADEQUATE.	IGNITION OF FLAMMABLE VAPORS LEADS TO A MAJOR FIRE AND EXPLOSION (E.G., NITROMETHANE) IN THE STORAGE AREA. RELEASE OF MULTIPLE TOXIC GASES (E.G., PHOSGENE) TO ATMOSPHERE. (B;B;A;A)	GROUNDING OF ELECTRICAL EQUIPMENT AND DRUMS DURING TRANSPORTATION. NONSPARK TOOLS ARE USED.	(1) TREAT HIGHLY FLAMMABLE MATERIALS ON AN PRIORITY BASIS, DO NOT ALLOW ACCUMULATIONS OF LARGE INVENTORIES, (2) CONSIDER SPECIALLY DESIGNED STORAGE CONFIGURATION FOR THE MOST HAZARDOUS (LOW FLASH POINT) FLAMMABLE WASTES, (3) INSTALL GAS DETECTOR AND ALARM, (4) CONSIDER ADDING A FLARE TO THE SCRUBBER SYSTEM, (5) CONSIDER INERT FIRE SUPPRESSION SYSTEM, (E.G., INERT THE ROOM WITH N2 WHEN THE GAS ANALYZERS ALARM).
2 III A	OVERHEAD CRANE DROPS DRUM CAUSING DUAL SPILL OF INCOMPATIBLE MATERIALS DUE TO MISLABELING OF WASTE DRUM. (E.G., FLAMMABLE WASTE MIXED WITH; (1) NAOH(1A), (2) H2SO4(1B), (3) LITHIUM HYDRIDE(2A), (4) NITRIC ACID(6A), (5) CHLOROBENZENE.)	RELEASE OF TOXIC GASES AND POTENTIAL FIRE WITH GENERATION OF PHOSGENE AND WORKER FATALITY. (C;C;A;C)	(1) CARBON ABSORBTION BED IN THE HEPA FILTER, (2) FIRE SUPPRESSION SYSTEM.	(1) DEVELOP PROCEDURES TO PREVENT OR MINIMIZE CRANE MOVEMENTS OVER STORED WASTES, (2) VERIFY DRUM CONTENTS AND LABELING AT WASTE GENERATORS SITE, (3) DEVELOP LAB WIDE PROCEDURE (LAB ES&H MANUAL) FOR WASTE IDENTIFICATION AND LABELING OF WASTE CONTAINERS.
2 III A	OVERHEAD CRANE DROPS DRUM CAUSING DUAL SPILL OF INCOMPATIBLE FLAMMABLE MATERIALS ROUTINELY STORED IN THE SAME AREA. (E.G., NITROMETHANE WITH ACETONE)	RELEASE OF TOXIC GASES (E.G., PHOSGENE) AND POTENTIAL FIRE. WORKER INJURY. (C;C;A;C)	CARBON ABSORBTION BED IN THE HEPA FILTER.	(1) DEVELOP PROCEDURES TO PREVENT OR MINIMIZE CRANE MOVEMENTS OVER STORED WASTES, (2) STORE INCOMPATIBLE FLAMMABLE MATERIALS IN SEPARATE LOCATIONS WITHIN THE

PRELIMINARY HAZARD/RISK ANALYSIS RECORD BY ACTIVITY FOR MIXED WASTE STORAGE

ACTIVITY NUMBER: NW6A

ACTIVITY NAME: NWRSF FLAMMABLES (GROUP 6A)

ACTIVITY DESCRIPTION: STORAGE OF FLAMMABLES IN AN ENCLOSED AREA

R--F--C	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
				FLAMMABLE STORAGE AREA.
3 II C	SPILL OF LOW FLASH POINT CHEMICALS (ACETHALHENYE(-38F), FURAN (-32F), ANHYDROUS ETHYL (-49F)) DUE TO FORKLIFT ACCIDENT, CRANE ACCIDENT OR CORROSION.	WORKER EXPOSED TO TOXIC FUMES. (D;D;C;D)	CARBON ABSORBTION BED IN HEPA FILTER, FIRE SUPPRESSION SYSTEM.	INSTALL GAS ANALYZER WITH ALARM.
3 II C	SPILL OF LOW FLASH POINT CHEMICALS (ACETHALHENYE(-38F), FURAN (-32F), ANHYDROUS ETHYL (-49F)) DUE TO FORKLIFT ACCIDENT, CRANE ACCIDENT OR CORROSION. FIRE SUPPRESSION SYSTEM OPERATIONAL.	IGNITION OF FLAMMABLE VAPORS LEADS TO CONTAINED FIRE IN THE STORAGE AREA. (D;D;C;D)	(1) FIRE SUPPRESSION SYSTEM, (2) CARBON ABSORBTION BED IN HEPA FILTER, AND SCRUBBING SYSTEM.	(1) TREAT HIGHLY FLAMMABLE MATERIALS ON AN PRIORITY BASIS, DO NOT ALLOW ACCUMULATIONS OF LARGE INVENTORIES, (2) CONSIDER SPECIALLY DESIGNED STORAGE CONFIGURATION FOR THE MOST HAZARDOUS (LOW FLASH POINT) FLAMMABLE WASTES, (3) INSTALL GAS DETECTOR AND ALARM, (4) CONSIDER ADDING A FLARE TO THE SCRUBBER SYSTEM, (5) CONSIDER INERT FIRE SUPPRESSION SYSTEM, (E.G., INERT THE ROOM WITH N2 WHEN THE GAS ANALYZERS ALARM).

PRELIMINARY HAZARD/RISK ANALYSIS RECORD BY ACTIVITY FOR MIXED WASTE STORAGE

ACTIVITY NUMBER: MW5A

ACTIVITY NAME: MWRSF CYANIDES AND SULFIDES (GROUP 5A)

ACTIVITY DESCRIPTION: STORAGE OF CYANIDES AND SULFIDES IN THE MWRSF

R--F--C	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
2 III A	FORKLIFT ACCIDENT CAUSES SIMULTANEOUS SPILL OF CYANIDE AND OTHER NONCOMPATIBLE WASTE (E.G., H2SO4(1B), OR PERCHLORIC ACID(6A)) DUE TO MISLABELING.	RELEASE OF TOXIC GASES (E.G., HCN AND CYANOGEN) AND POSSIBLE EXPLOSION AND FIRE. SEVERE WORKER INJURY, AND LOW LEVEL RADIOACTIVE CONTAMINATION IN THE FACILITY. (D;D;A;C)	(1) USE OF SMALL "WALK BEHIND" FORKLIFTS, (2) DRUMS ARE STORED ONLY ONE LEVEL HIGH, (3) SCRUBBER SYSTEM, (4) FIRE SUPPRESSION SYSTEM.	(1) PROVIDE HCN ANALYZER AND ALARM, (2) VERIFY DRUM CONTENTS AND LABELING AT WASTE GENERATORS SITE, (3) DEVELOP LAB WIDE PROCEDURE (LAB ES&H MANUAL) FOR WASTE IDENTIFICATION AND LABELING OF WASTE CONTAINERS.
3 III B	EXTERNAL FIRE CAUSES CYANIDE COMPOUNDS (CYANOGEN BROMIDE) TO DECOMPOSE.	THERMAL DECOMPOSITION OF CYANIDE LEADING TO TOXIC GAS RELEASE (E.G., HCN AND CYANOGEN), LOW LEVEL RADIOACTIVE CONTAMINATION IN FACILITY. (D;D;B;C)	FIRE SUPPRESSION (AT FIRE INITIATION LOCATION) AND SCRUBBING SYSTEM.	PROVIDE HCN ANALYZER AND ALARM.
3 III B	MERCURY OXYCYANIDE DETONATES DUE TO HEATING, FROM SHOCK OR FRICTION (E.G., FORKLIFT ACCIDENT).	SMALL EXPLOSION LEADING TO TOXIC GAS RELEASE. SEVERE WORKER INJURY DUE TO TOXIC GAS EXPOSURE. (D;D;B;C)	SCRUBBING SYSTEM.	DEVELOP AND ENFORCE POLICY NOT TO STORE EXPLOSIVE AND SHOCK SENSITIVE MATERIALS AT TA-63.
3 IV A	FORKLIFT ACCIDENT CAUSES SIMULTANEOUS SPILL OF CYANIDE AND OTHER NONCOMPATIBLE WASTE (E.G., H2SO4(1B), OR PERCHLORIC ACID(6A)) DUE TO MISLABELING, AND FAILURE OF THE SCRUBBER SYSTEM WITH THE VENT BLOWER WORKING.	RELEASE OF TOXIC GASES (E.G., HCN AND CYANOGEN) AND POSSIBLE EXPLOSION AND FIRE. SEVERE WORKER INJURY, AND LOW LEVEL RADIOACTIVE CONTAMINATION IN THE FACILITY. (C;B;A;C)	(1) USE OF SMALL "WALK BEHIND" FORKLIFTS, (2) DRUMS ARE STORED ONLY ONE LEVEL HIGH.	(1) PROVIDE HCN ANALYZER AND ALARM, (2) DO NOT PERFORM ANY UNNECESSARY ACTIVITIES IF THE SCRUBBER IS NONOPERATIONAL, (4) ADD ALARMS TO MONITOR SCRUBBER OPERATION.
4 II D	SPILL OF CYANIDE DUE TO WALK BEHIND FORKLIFT ACCIDENT OR CORROSION.	CONTAMINATION OF THE STORAGE AREA, MINOR WORKER EXPOSURE. NO TOXIC GAS RELEASED DUE TO LOW VOLATILITY. (D;D;D;D)	NONE	NONE

PRELIMINARY HAZARD/RISK ANALYSIS RECORD BY ACTIVITY FOR MIXED WASTE STORAGE

ACTIVITY NUMBER: MW6A

ACTIVITY NAME: MWSF OXIDIZERS (GROUP 6A)

ACTIVITY DESCRIPTION: STORAGE OF OXIDIZERS IN MWSF

R--F--C	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
2 II B	AMMONIUM PERCHLORATE OR METHYL ETHYL KETONE PEROXIDE (DRIED OVER TIME) SUBJECTED TO SHOCK, FRICTION OR SUNLIGHT(MEKP).	EXPLOSION OR FIRE IN MWSF, RELEASE OF TOXIC GASES, WORKER INJURY. (D;D;B;C)	(1) AMMONIUM PERCHLORATE IS ONLY ACCEPTED IN AN OXIDE (LIQUID) FORM, (2) FIRE SUPPRESSION AND SCRUBBER SYSTEM.	(1) DEVELOP AND ENFORCE STRICT ACCEPTANCE CRITERIA FOR SENSITIVE OXIDIZERS (E.G., DILUTED FORM, FREQUENT INSPECTION, WETTED MATERIAL), (2) CONSIDER STORAGE OF HIGHLY SENSITIVE OXIDIZERS IN A SEPARATE BUILDING IN A REMOTE LOCATION.
2 III A	OVERHEAD CRANE DROPS DRUM CAUSING DUAL SPILL OF INCOMPATIBLE MATERIALS DUE TO MISLABELING OF WASTE DRUM. (E.G., OXIDIZER WASTE MIXED WITH; (1) NAOH(1A), (2) ACETIC ACID(1B), (3) SODIUM(2A), (4) ORGANICS(4A) SUCH AS CHLORO BENZENE, (5) GOLD CYANIDE(5A))	RELEASE OF HIGHLY TOXIC GASES, POTENTIAL EXPLOSION AND POTENTIAL FIRE. VERY HIGH FIRE POTENTIAL WITH GENERATION OF PHOSGEN WITH SPILLS INVOLVING CHLORO BENZENE. POTENTIAL WORKER FATALITY. (C;B;A;C)	(1) CARBON ABSORBTION BED IN THE HEPA FILTER, (2) FIRE SUPPRESSION AND SCRUBBER SYSTEM.	(1) DEVELOP PROCEDURES TO PREVENT OR MINIMIZE CRANE MOVEMENT OVER STORED WASTES, (2) VERIFY DRUM CONTENTS AND LABELING AT WASTE GENERATORS SITE, (3) DEVELOP LAB WIDE PROCEDURE (LAB ES&H MANUAL) FOR WASTE IDENTIFICATION AND LABELING OF WASTE CONTAINERS.
4 II D	SPILL OF OXIDIZERS DUE TO WALK BEHIND FORKLIFT OR OVERHEAD CRANE ACCIDENTS.	LOW LEVEL TOXIC SPILL. WORKER EXPOSURE. (D;D;D;D)	HEPA FILTER AND SCRUBBING SYSTEM.	NONE

PRELIMINARY HAZARD/RISK ANALYSIS RECORD BY ACTIVITY FOR MIXED WASTE STORAGE

ACTIVITY NUMBER: MW7A

ACTIVITY NAME: MWRSF GASES (GROUP 7A)

ACTIVITY DESCRIPTION: GASES STORED IN MWRSF (GROUP 7A)

R--F--C	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
1 II A	MAJOR BREACH OF LEGACY CYLINDER OF DOUBTFUL INTEGRITY DURING STORAGE.	RELEASE OF HIGHLY TOXIC GASES (PHOSPHINE, PHOSGEN, ARSINE, AND OTHERS). WORKER FATALITY, POTENTIAL COLOCATED WORKER AND PUBLIC EXPOSURE. (C;B;A;D)	HEPA AND SCRUBBING SYSTEM.	(1) DO NOT STORE LEGACY CYLINDERS IN THE MWSRF, (2) PROCESS LEGACY CYLINDERS WITHOUT INTERMEDIATE STORAGE, (3) PROVIDE SECONDARY CONTAINMENT WHEN TRANSPORTING LEGACY CYLINDERS.
2 III A	BREACH OF CYLINDER (NON-LEGACY) DUE TO ACCIDENTAL CAUSES (E.G., CYLINDER DROPPED AND REGULATOR LINE BREAKS) WHICH RESULT IN MAJOR CYLINDER DAMAGE.	RELEASE OF HIGHLY TOXIC GASES (PHOSPHINE, PHOSGEN, ARSINE, AND OTHERS). WORKER FATALITY, POTENTIAL COLOCATED WORKER AND PUBLIC EXPOSURE. (C;C;A;D)	HEPA AND SCRUBBING SYSTEM.	(1) TRANSPORT AND STORE CYLINDERS SECURELY, (2) CONSIDER INSTALLATION OF A FLARE AND/OR A SPECIAL SCRUBBER FOR THIS FACILITY, (3) INSTALL GAS DETECTORS AND ALARMS, (4) CONSIDER SECONDARY CONTAINMENT FOR MOST HAZARDOUS CYLINDERS, (5) GAS CYLINDERS TO BE PROCESSED WITH HIGH PRIORITY, (6) WORK IN THIS AREA TO BE PERFORMED WITH PROTECTION (I.E., WEAR SCBA, OPERATE UNDER THE BUDDY SYSTEM), (7) PROTECTIVE CAP FOR CYLINDER REGULATORS SHOULD BE IN PLACE AT ALL TIMES., (8) STORE GAS CYLINDERS IN AN ENCLOSED AREA.
2 III A	EXTERNAL FIRE (INITIATED WITHIN THE MWRSF BUILDING).	PRESSURIZATION AND RUPTURE OF GAS CYLINDERS. HIGHLY TOXIC GAS RELEASE AND POTENTIAL CYLINDER MISSILE GENERATION. (A;A;A;A)	(1) FIRE PROTECTION SYSTEM, (2) HEPA AND SCRUBBING SYSTEM, (3) FUSIBLE PRESSURE RELIEF.	STORE GAS CYLINDERS IN AN ENCLOSED AREA WITH FIRE DOOR AND FIRE WALL.

PRELIMINARY HAZARD/RISK ANALYSIS RECORD BY ACTIVITY FOR MIXED WASTE STORAGE

ACTIVITY NUMBER: MW7A

ACTIVITY NAME: MWRSF GASES (GROUP 7A)

ACTIVITY DESCRIPTION: GASES STORED IN MWRSF (GROUP 7A)

R--F--C	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
3 III B	BREACH OF CYLINDER (NON-LEGACY) DUE TO ACCIDENTAL CAUSES (E.G., CYLINDER DROPPED AND REGULATOR LINE BREAKS).	RELEASE OF MODERATELY TOXIC GASES (H2S, NO2, AND OTHERS). WORKER EXPOSURE. (C;C;B;D)	HEPA AND SCRUBBING SYSTEM.	(1) TRANSPORT AND STORE CYLINDERS SECURELY, (2) CONSIDER INSTALLATION OF A FLARE AND/OR A SPECIAL SCRUBBER FOR THIS FACILITY, (3) INSTALL GAS DETECTORS AND ALARMS, (4) CONSIDER SECONDARY CONTAINMENT FOR MOST HAZARDOUS CYLINDERS, (5) GAS CYLINDERS TO BE PROCESSED WITH HIGH PRIORITY, (6) WORK IN THIS AREA TO BE PERFORMED WITH PROTECTION (I.E., WEAR SCBA, OPERATE UNDER THE BUDDY SYSTEM), (7) PROTECTIVE CAP FOR CYLINDER REGULATORS SHOULD BE IN PLACE AT ALL TIMES., (8) STORE GAS CYLINDERS IN AN ENCLOSED AREA.
3 III B	EXTERNAL FIRE (INITIATED WITHIN THE MWRSF BUILDING).	PRESSURIZATION AND RUPTURE OF GAS CYLINDERS. MODERATELY TOXIC GAS RELEASE AND POTENTIAL CYLINDER MISSILE GENERATION. (C;C;B;C)	(1) FIRE PROTECTION SYSTEM, (2) HEPA AND SCRUBBING SYSTEM, (3) FUSIBLE PRESSURE RELIEF.	STORE GAS CYLINDERS IN AN ENCLOSED AREA.
3 IV B	SIMULTANEOUS RUPTURE OF TWO INCOMPATIBLE (E.G., FLORINE AND H2S) GAS CYLINDERS (DUE TO MISHANDLING, FORKLIFT ACCIDENT, ETC...)	FIRE IN STORAGE AREA OR VENT SYSTEM DUE TO MIXING OF INCOMPATIBLE GASES. TOXIC GAS RELEASE. SEVERE WORKER INJURY. (C;C;B;C)	(1) FIRE PROTECTION AND (2) HEPA AND SCRUBBING SYSTEM.	NONE

PRELIMINARY HAZARD/RISK ANALYSIS RECORD BY ACTIVITY FOR MIXED WASTE STORAGE

ACTIVITY NUMBER: MW8

ACTIVITY NAME: MWRSF PCB (GROUP 8)

ACTIVITY DESCRIPTION: STORAGE OF PCB WASTES IN AN ENCLOSED AREA (GROUP 8)

R--F--C	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
3 III C	MISLABELED DRUM RESULTS IN PCB DRUM BEING STORED NEAR FLAMMABLE WASTE. ACCIDENTAL BREACH OF THE CONTAINERS LEADS TO FIRE AND BURNIG OF PCB WASTE.	BURNING OF PCB WASTE FILTER THROUGH THE BUILDING SCRUBBER SYSTEM. (C;C;C;C)	FIRE PROTECTION AND SCRUBBER SYSTEMS.	NONE
3 IV A	LARGE EXTERNAL FIRE WITH BREACH OF BUILDING OR THE SCRUBBER SYSTEM.	POTENTIAL SPILL AND BURNING OF PCB WASTE, DISPERSION OF PCB WASTE TO THE ENVIRONMENT. (B;B;B;A)	(1) FIRE PROTECTION SYSTEM, (2) HEPA/SCRUBBER WITH CARBONBED.	CONSIDER STORING PCB WASTE AWAY FROM FLAMMABLES.
3 IV A	SPILL OF PCB WASTE DRUM DUE TO FORKLIFT ACCIDENT, RELEASE TO THE SUMP.	POTENTIAL RELEASE TO THE ENVIRONMENT THROUGH THE SUMP SYSTEM. ENVIRONMENTAL CONTAMINATION. (D;D;D;A)	(1) INSTALL PROCEDURES TO DETECT SUMP LEVELS, (2) TEST SUMP CONTENTS BEFORE DISCHARGE, (3) SUMP SYSTEM.	NONE
4 II D	SPILL OF PCB WASTE DRUM DUE TO FORKLIFT ACCIDENT.	CONTAMINATION OF THE STORAGE AREA. (D;D;D;D)	SUMP SYSTEM.	NONE

PRELIMINARY HAZARD/RISK ANALYSIS RECORD BY ACTIVITY FOR MIXED WASTE STORAGE

ACTIVITY NUMBER: MW9

ACTIVITY NAME: MWRSF NONREGULATED WASTES (GROUP 9)

ACTIVITY DESCRIPTION: STORAGE OF NONREGULATED WASTES IN MWRSF STORAGE AREA (GROUP 9)

R--F--C	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
3 II C	SPILL OF AMMONIUM BIFLORIDE DUE TO OVERHEAD CRANE OR FORKLIFT ACCIDENT.	POTENTIAL WORKER EXPOSURE. (D;D;C;D)	NONE	CONSIDER RELOCATION OF AMMONIUM BIFLORIDE TO ONE OF THE REGULATED AREAS, SUCH AS CAUSTIC(1A).
3 III B	ACCIDENTAL SPILL OF INCOMPATIBLE WASTES ROUTINELY STORED IN NONREGULATED AREA (E.G., MISLABLED, TEMPORARY STORAGE, OR DO NOT BELONG IN OTHER DEFINED REGULATED AREAS)	FIRE AND RELEASE OF TOXIC GASES. (C;C;B;C)	FIRE PROTECTION AND SCRUBBER SYSTEMS.	(1) CONSIDER ELIMINATING THIS AREA, (2) CLASSIFY AND STORE ALL NONREGULATED WASTES IN COMPATIBLE REGULATED AREAS, (3) ENCLOSE THE NONREGULATED AREA.

PRELIMINARY HAZARD/RISK ANALYSIS RECORD BY ACTIVITY FOR MIXED WASTE STORAGE

ACTIVITY NUMBER: MWBK

ACTIVITY NAME: MWRSF BULKING ROOM

ACTIVITY DESCRIPTION: SAMPLING AND REPACKAGING OF MIXED WASTE

R--F--C	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
2 I C	INADEQUATE GUIDELINES OR PROCEDURES FOR MIXING AND REBULKING WASTES.	VIOLENT REACTION, RELEASE OF TOXIC GAS WITH WORKER EXPOSURE AND FACILITY CONTAMINATION. (D;D;C;D)	(1) FUME HOOD AND FIRE SUPPRESSION SYSTEM, (2) FULL PROTECTIVE GEAR, E.G. SUITS, FACE SHIELDS).	(1) GUIDELINES (PROCEDURES) FOR MIXING AND BULKING SHOULD BE DEVELOPED AND REVIEWED, (2) WORKER SHOULD WEAR RESPIRATOR UNTIL DETERMINATION OF POSSIBLE REACTIONS.
2 II B	INADEQUATE GUIDELINES OR PROCEDURES FOR MIXING AND REBULKING WASTES LEADS TO VIOLENT REACTION, AND FUME HOOD FAILURE.	VIOLENT REACTION, RELEASE OF TOXIC GAS WITH WORKER EXPOSURE AND FACILITY CONTAMINATION. (D;D;B;C)	(1) FIRE SUPPRESSION SYSTEM, (2) FULL PROTECTIVE GEAR, E.G. SUITS, FACE SHIELDS).	(1) GUIDELINES (PROCEDURES) FOR MIXING AND BULKING SHOULD BE DEVELOPED AND REVIEWED, (2) WORKER SHOULD WEAR REPIRATOR UNTIL THE POSSIBILITY OF VIOLENT REACTIONS IS PASSED..
3 II C	HUMAN ERROR DURING BULKING OPERATION LEADS TO WASTE SPILL.	WORKER EXPOSURE TO TOXIC CHEMICALS AND TOXIC FUMES. (D;D;C;D)	(1) WASTE IS OPENED AND REPACKAGED UNDER FUME HOOD, (2) USE OF NONSPARKING TOOLS, (3) PROTECTIVE GEAR, E.G. SUIT, FACE SHIELD.	NONE
3 III B	OPERATOR OPENS MISLABELED WASTE CONTAINER.	POTENTIAL WORKER EXPOSURE TO HIGHLY TOXIC CHEMICALS AND TOXIC FUMES, POTENTIAL FIRE. (D;D;B;C)	(1) WASTE IS OPENED AND REPACKAGED UNDER FUME HOOD, (2) USE OF NONSPARKING TOOLS, (3) PROTECTIVE GEAR, E.G. SUIT, FACE SHIELD.	WORKER SHOULD WEAR PROTECTIVE EQUIPMENT.
3 III B	INCOMPATIBLE WASTE ARE MIXED DURING REPACKAGING PROCESS DUE TO MISLABELING OR OPERATOR ERROR.	VIOLENT REACTION, RELEASE OF TOXIC GAS WITH WORKER EXPOSURE AND FACILITY CONTAMINATION. (D;D;B;C)	(1) FUME HOOD AND FIRE SUPPRESSION SYSTEM, (2) FULL PROTECTIVE GEAR, E.G. SUITS, FACE SHIELDS).	WORKER SHOULD WEAR PROTECTIVE EQUIPMENT.

PRELIMINARY HAZARD/RISK ANALYSIS RECORD BY ACTIVITY FOR MIXED WASTE STORAGE

ACTIVITY NUMBER: MWG

ACTIVITY NAME: MWRSF GLOBAL (INTERNAL AND EXTERNAL) EVENTS

ACTIVITY DESCRIPTION: MWRSF GLOBAL (INTERNAL AND EXTERNAL) EVENTS

R--F--C	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
2 II B	ACCIDENTS DURING TRANSPORTATION OF WASTE WITHIN THE MWRSF (FORKLIFTS, CRANES, OR MANUAL).	SPILL OF FLAMMABLES, REACTIVES, OR INCOMPATIBLE WASTES LEADING TO TOXIC GAS RELEASE/ FIRE. WORKER INJURY. (D;C;B;C)	NONE	(1) MAINTAIN PHYSICAL SEPARATION OF INCOMPATIBLE WASTES DURING TRANSPORTATION (E.G., DO NOT TRANSPORT DRUM OVER INCOMPATIBLE WASTES WITH THE CRANE), (2) LIMIT SIMULTANEOUS OPERATION OF MULTIPLE FORKLIFTS.
2 III A	MEDIUM INTENSITY SEISMIC EVENT WITH HORIZONTAL ACCELERATION OF 0.17 G.	MIXING OF INCOMPATIBLE WASTES STORED IN ADJACENT AREAS. VIOLENT REACTIONS, POTENTIAL FIRE, AND RELEASE OF TOXIC FUMES (E.G., PHOSGENE OR HCN). POTENTIAL LOSS OF SCRUBBER. NOTE: SHOCK SENSITIVE MATERIAL NOT CONSIDERED IN THIS SCENARIO. (C;C;A;C)	NONE	(1) REVIEW SEISMIC DESIGN CRITERIA, (2) ENSURE THAT INCOMPATIBLE WASTES ARE NOT STORED IN ADJACENT AREAS. SEE POTENTIAL MWRSF FLOORPLAN DEVELOPED BY PHA TEAM, (3) MINIMIZE STORAGE TIME OF MOST FLAMMABLE/ TOXIC MATERIALS.
2 III A	ACCIDENT DURING TRANSPORTATION OF THE MOST TOXIC WASTE DRUMS (E.G., TOXIC GAS CYLINDERS OR INCOMPATIBLE WASTES) FROM MWRSF TO CAI OR OTHER FACILITIES.	SPILL LEADING TO THE UNMITIGATED RELEASE OF TOXIC GASES. PUBLIC EXPOSURE. (A;A;A;A)	NONE	(1) CONSIDER ROAD CLOSURE WHILE TRANSPORTING THE MOST HAZARDOUS MATERIALS BETWEEN LAB AREAS, (2) REVIEW PROCEDURES FOR SECURING WASTE DRUMS DURING TRANSPORTATION, (3) DO NOT TRANSPORT INCOMPATIBLE WASTE DRUMS TOGETHER.
3 I D	LIGHTNING STRIKES STORAGE BUILDING.	NOT A HAZARD. (D;D;D;D)	MWSRF EQUIPED WITH LIGHTNING RODS.	NONE
3 I D	HIGH WINDS	NO HAZARD. (D;D;D;D)	ENCLOSED STORAGE STRUCTURE.	NONE

PRELIMINARY HAZARD/RISK ANALYSIS RECORD BY ACTIVITY FOR MIXED WASTE STORAGE

ACTIVITY NUMBER: MWG

ACTIVITY NAME: MWRSF GLOBAL (INTERNAL AND EXTERNAL) EVENTS

ACTIVITY DESCRIPTION: MWRSF GLOBAL (INTERNAL AND EXTERNAL) EVENTS

R--F--C	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
3 III B	INADVERTENT OPERATION OF THE FIRE SPRINKLERS OR RUPTURE OF WATER PIPING DUE TO CORROSION, IN THE BULKING ROOM DURING BULKING OPERATION.	WATER MIXING WITH WATER REACTIVES OR ACIDS COULD CAUSE WORKER INJURY. (D;D;B;D)	NONE	(1) DO NOT LEAVE OPEN WASTE CONTAINERS IN BULKING ROOM, (2) CONSIDER USE OF DRY CHEMICAL FIRE SUPPRESSION SYSTEM IN THE BULKING ROOM.
3 III C	INADVERTENT OPERATION OF THE FIRE SPRINKLERS OR RUPTURE OF WATER PIPING DUE TO CORROSION.	IF FLOOD SOURCE NOT MITIGATED, COULD CAUSE WATER INTRUSION INTO REACTIVE WASTE AREA, GENERATION OF HYDROGEN GAS AND RADIOACTIVE CONTAMINATION IN THE FACILITY. (D;D;D;C)	(1) DRY CHEMICAL FIRE SUPPRESSION SYSTEM IN WATER REACTIVE(GROUP 2A) STORAGE AREA, (2) PERIODIC WALKDOWNS OF THE FACILITY ARE PERFORMED, (3) OPERATION OF SPRINKLERS WILL INITIATE A 911 ALARM.	(1) INSTALL SUMP HIGH LEVEL ALARMS, (2) DESIGN STORAGE AREA TO PREVENT INTRUSION OF WATER TO THE WATER REACTIVE WASTE AREA.
3 IV A	LOW INTENSITY SEISMIC EVENT WITH HORIZONTAL ACCELERATION OF 0.1 G.	EXPLOSION OF SHOCK SENSITIVE MATERIALS (E.G., NITRO METHANE, SODIUM AZIDE). STRUCTURAL DAMAGE TO BUILDING, FIRE AND RELEASE OF TOXIC GASES. (A;A;A;A)	NONE	(1) DEVELOP AND ENFORCE POLICY NOT TO STORE EXPLOSIVE OR SHOCK SENSITIVE MATERIAL IN THIS BUILDING, (2) PROCESS SHOCK SENSITIVE MATERIALS IMMEDIATELY.
3 IV A	HIGH INTENSITY SEISMIC EVENT WITH HORIZONTAL ACCELERATION OF 0.3 G OR GREATER.	STRUCTURAL COLLAPSE OF BUILDING, BREACH OF MULTIPLE DRUMS, MAJOR FIRE, RELEASE OF TOXIC GAS TO ENVIRONMENT AND RADIOACTIVE CONTAMINATION. (A;A;A;A)	NONE	(1) REVIEW SEISMIC DESIGN CRITERIA, (2) MINIMIZE STORAGE TIME OF MOST FLAMMABLE/ TOXIC MATERIALS.
3 IV A	EXTERNAL FIRE	FIRE PENETRATES THE MWRSF, MAJOR FIRE RELEASES TOXIC GAS TO THE ENVIRONMENT AND RADIOACTIVE CONTAMINATION.	(1) AREA SURROUNDING THE MWRSF IS CLEARED OF COMBUSTIBLE MATERIAL, (2) BUILDING IS DESIGNED TO RETARD FIRE.	NONE

PRELIMINARY HAZARD/RISK ANALYSIS RECORD BY ACTIVITY FOR MIXED WASTE STORAGE

ACTIVITY NUMBER: MWG

ACTIVITY NAME: MWRSF GLOBAL (INTERNAL AND EXTERNAL) EVENTS

ACTIVITY DESCRIPTION: MWRSF GLOBAL (INTERNAL AND EXTERNAL) EVENTS

R--F--C	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
		(A;A;A;A)		

TABLE B-4
HAZMAN RESULTS SORTED BY RISK RANK FOR MWRSF

HAZARD ANALYSIS REPORT BY RISK

R---F---C	ACT/FAC	ACTIVITY NAME	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
1 II A	MW7A/MWRSF	MWRSF GASES (GROUP 7A)	MAJOR BREACH OF LEGACY CYLINDER OF DOUBTFUL INTEGRITY DURING STORAGE.	RELEASE OF HIGHLY TOXIC GASES (PHOSPHINE, PHOSGEN, ARSINE, AND OTHERS). WORKER FATALITY, POTENTIAL COLOCATED WORKER AND PUBLIC EXPOSURE. (C;B;A;D)	HEPA AND SCRUBBING SYSTEM.	(1) DO NOT STORE LEGACY CYLINDERS IN THE MWSRF, (2) PROCESS LEGACY CYLINDERS WITHOUT INTERMEDIATE STORAGE, (3) PROVIDE SECONDARY CONTAINMENT WHEN TRANSPORTING LEGACY CYLINDERS.
2 I C	MWBK/MWRSF	MWRSF BULKING ROOM	INADEQUATE GUIDELINES OR PROCEDURES FOR MIXING AND REBULKING WASTES.	VIOLENT REACTION, RELEASE OF TOXIC GAS WITH WORKER EXPOSURE AND FACILITY CONTAMINATION. (D;D;C;D)	(1) FUME HOOD AND FIRE SUPPRESSION SYSTEM, (2) FULL PROTECTIVE GEAR, E.G. SUITS, FACE SHIELDS).	(1) GUIDELINES (PROCEDURES) FOR MIXING AND BULKING SHOULD BE DEVELOPED AND REVIEWED, (2) WORKER SHOULD WEAR RESPIRATOR UNTIL DETERMINATION OF POSSIBLE REACTIONS.
2 II B	MW6A/MWRSF	MWRSF OXIDIZERS (GROUP 6A)	AMMONIUM PERCHLORATE OR METHYL ETHYL KETONE PEROXIDE (DRIED OVER TIME) SUBJECTED TO SHOCK, FRICTION OR SUNLIGHT(MEKP).	EXPLOSION OR FIRE IN MWRSF, RELEASE OF TOXIC GASES, WORKER INJURY. (D;D;B;C)	(1) AMMONIUM PERCHLORATE IS ONLY ACCEPTED IN AN OXIDE (LIQUID) FORM, (2) FIRE SUPPRESSION AND SCRUBBER SYSTEM.	(1) DEVELOP AND ENFORCE STRICT ACCEPTANCE CRITERIA FOR SENSITIVE OXIDIZERS (E.G., DILUTED FORM, FREQUENT INSPECTION, WETTED MATERIAL), (2) CONSIDER STORAGE OF HIGHLY SENSITIVE OXIDIZERS IN A SEPARATE BUILDING IN A REMOTE LOCATION.
2 II B	MWBK/MWRSF	MWRSF BULKING ROOM	INADEQUATE GUIDELINES OR PROCEDURES FOR MIXING AND REBULKING WASTES LEADS TO VIOLENT REACTION, AND FUME HOOD FAILURE.	VIOLENT REACTION, RELEASE OF TOXIC GAS WITH WORKER EXPOSURE AND FACILITY CONTAMINATION. (D;D;B;C)	(1) FIRE SUPPRESSION SYSTEM, (2) FULL PROTECTIVE GEAR, E.G. SUITS, FACE SHIELDS).	(1) GUIDELINES (PROCEDURES) FOR MIXING AND BULKING SHOULD BE DEVELOPED AND REVIEWED, (2) WORKER SHOULD WEAR REPIRATOR UNTIL THE POSSIBILITY OF VIOLENT REACTIONS IS PASSED..
2 II B	MWG/MWRSF	MWRSF GLOBAL (INTERNAL AND EXTERNAL) EVENTS	ACCIDENTS DURING TRANSPORTATION OF WASTE WITHIN THE MWRSF (FORKLIFTS, CRANES, OR MANUAL).	SPILL OF FLAMMABLES, REACTIVES, OR INCOMPATIBLE WASTES LEADING TO TOXIC GAS RELEASE/ FIRE. WORKER INJURY. (D;C;B;C)	NONE	(1) MAINTAIN PHYSICAL SEPARATION OF INCOMPATIBLE WASTES DURING TRANSPORTATION (E.G., DO NOT TRANSPORT DRUM OVER INCOMPATIBLE WASTES WITH THE CRANE), (2) LIMIT SIMULTANEOUS OPERATION OF MULTIPLE FORKLIFTS.
2 III A	MW4A/MWRSF	MWRSF FLAMMABLES (GROUP 4A)	SPILL OF LOW FLASH POINT CHEMICALS (ACETHALHENYE(-38F), FURAN (-32F), ANHYDROUS ETHYLE (-49F)) DUE TO FORKLIFT ACCIDENT, CRANE	IGNITION OF FLAMMABLE VAPORS LEADS TO A MAJOR FIRE AND EXPLOSION (E.G., NITROMETHANE) IN THE STORAGE AREA. RELEASE OF MULTIPLE TOXIC GASES	GROUNDING OF ELECTRICAL EQUIPMENT AND DRUMS DURING TRANSPORTATION. NONSPARK TOOLS ARE USED.	(1) TREAT HIGHLY FLAMMABLE MATERIALS ON AN PRIORITY BASIS, DO NOT ALLOW ACCUMULATIONS OF LARGE INVENTORIES, (2) CONSIDER SPECIALLY

HAZARD ANALYSIS REPORT BY RISK

R---F---C	ACT/FAC	ACTIVITY NAME	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
			ACCIDENT OR CORROSION. FIRE SUPPRESSION SYSTEM INADEQUATE.	(E.G., PHOSGENE) TO ATMOSPHERE. (B;B;A;A)		DESIGNED STORAGE CONFIGURATION FOR THE MOST HAZARDOUS (LOW FLASH POINT) FLAMMABLE WASTES, (3) INSTALL GAS DETECTOR AND ALARM, (4) CONSIDER ADDING A FLARE TO THE SCRUBBER SYSTEM, (5) CONSIDER INERT FIRE SUPPRESSION SYSTEM, (E.G., INERT THE ROOM WITH N2 WHEN THE GAS ANALYZERS ALARM).
2 III A	MW4A/MWRSF	MWRSF FLAMMABLES (GROUP 4A)	OVERHEAD CRANE DROPS DRUM CAUSING DUAL SPILL OF INCOMPATIBLE MATERIALS DUE TO MISLABELING OF WASTE DRUM. (E.G., FLAMMABLE WASTE MIXED WITH; (1) NAOH(1A), (2) H2SO4(1B), (3) LITHIUM HYDRIDE(2A), (4) NITRIC ACID(6A), (5) CHLOROBENZENE.)	RELEASE OF TOXIC GASES AND POTENTIAL FIRE WITH GENERATION OF PHOSGENE AND WORKER FATALITY. (C;C;A;C)	(1) CARBON ABSORBTION BED IN THE HEPA FILTER, (2) FIRE SUPPRESSION SYSTEM.	(1) DEVELOP PROCEDURES TO PREVENT OR MINIMIZE CRANE MOVEMENTS OVER STORED WASTES, (2) VERIFY DRUM CONTENTS AND LABELING AT WASTE GENERATORS SITE, (3) DEVELOP LAB WIDE PROCEDURE (LAB ES&H MANUAL) FOR WASTE IDENTIFICATION AND LABELING OF WASTE CONTAINERS.
2 III A	MW4A/MWRSF	MWRSF FLAMMABLES (GROUP 4A)	OVERHEAD CRANE DROPS DRUM CAUSING DUAL SPILL OF INCOMPATIBLE FLAMMABLE MATERIALS ROUTINELY STORED IN THE SAME AREA. (E.G., NITROMETHANE WITH ACETONE)	RELEASE OF TOXIC GASES (E.G., PHOSGENE) AND POTENTIAL FIRE. WORKER INJURY. (C;C;A;C)	CARBON ABSORBTION BED IN THE HEPA FILTER.	(1) DEVELOP PROCEDURES TO PREVENT OR MINIMIZE CRANE MOVEMENTS OVER STORED WASTES, (2) STORE INCOMPATIBLE FLAMMABLE MATERIALS IN SEPARATE LOCATIONS WITHIN THE FLAMMABLE STORAGE AREA.
2 III A	MW5A/MWRSF	MWRSF CYANIDES AND SULFIDES (GROUP 5A)	FORKLIFT ACCIDENT CAUSES SIMULTANEOUS SPILL OF CYANIDE AND OTHER NONCOMPATIBLE WASTE (E.G., H2SO4(1B), OR PERCHLORIC ACID(6A)) DUE TO MISLABELING.	RELEASE OF TOXIC GASES (E.G., HCN AND CYANOGEN) AND POSSIBLE EXPLOSIION AND FIRE. SEVERE WORKER INJURY, AND LOW LEVEL RADIOACTIVE CONTAMINATION IN THE FACILITY. (D;D;A;C)	(1) USE OF SMALL "WALK BEHIND" FORKLIFTS, (2) DRUMS ARE STORED ONLY ONE LEVEL HIGH, (3) SCRUBBER SYSTEM, (4) FIRE SUPPRESSION SYSTEM.	(1) PROVIDE HCN ANALYZER AND ALARM, (2) VERIFY DRUM CONTENTS AND LABELING AT WASTE GENERATORS SITE, (3) DEVELOP LAB WIDE PROCEDURE (LAB ES&H MANUAL) FOR WASTE IDENTIFICATION AND LABELING OF WASTE CONTAINERS.
2 III A	MW6A/MWRSF	MWRSF OXIDIZERS (GROUP 6A)	OVERHEAD CRANE DROPS DRUM CAUSING DUAL SPILL OF INCOMPATIBLE MATERIALS DUE TO MISLABELING OF WASTE DRUM. (E.G., OXIDIZER WASTE MIXED WITH; (1) NAOH(1A), (2) ACETIC ACID(1B), (3) SODIUM(2A), (4)	RELEASE OF HIGHLY TOXIC GASES, POTENTIAL EXPLOSION AND POTENTIAL FIRE. VERY HIGH FIRE POTENTIAL WITH GENERATION OF PHOSGEN WITH SPILLS INVOLVING CHLORO BENZENE. POTENTIAL WORKER FATALITY. (C;B;A;C)	(1) CARBON ABSORBTION BED IN THE HEPA FILTER, (2) FIRE SUPPRESSION AND SCRUBBER SYSTEM.	(1) DEVELOP PROCEDURES TO PREVENT OR MINIMIZE CRANE MOVEMENT OVER STORED WASTES, (2) VERIFY DRUM CONTENTS AND LABELING AT WASTE GENERATORS SITE, (3) DEVELOP LAB WIDE PROCEDURE (LAB ES&H MANUAL) FOR WASTE

HAZARD ANALYSIS REPORT BY RISK

R---F---C	ACT/FAC	ACTIVITY NAME	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
			ORGANICS(4A) SUCH AS CHLORO BENZENE, (5) GOLD CYANIDE(5A))			IDENTIFICATION AND LABELING OF WASTE CONTAINERS.
2 III A	MW7A/MWRSF	MWRSF GASES (GROUP 7A)	BREACH OF CYLINDER (NON-LEGACY) DUE TO ACCIDENTAL CAUSES (E.G., CYLINDER DROPPED AND REGULATOR LINE BREAKS) WHICH RESULT IN MAJOR CYLINDER DAMAGE.	RELEASE OF HIGHLY TOXIC GASES (PHOSPHINE, PHOSGEN, ARSINE, AND OTHERS). WORKER FATALITY, POTENTIAL COLOCATED WORKER AND PUBLIC EXPOSURE. (C;C;A;D)	HEPA AND SCRUBBING SYSTEM.	(1) TRANSPORT AND STORE CYLINDERS SECURELY, (2) CONSIDER INSTALLATION OF A FLARE AND/OR A SPECIAL SCRUBBER FOR THIS FACILITY, (3) INSTALL GAS DETECTORS AND ALARMS, (4) CONSIDER SECONDARY CONTAINMENT FOR MOST HAZARDOUS CYLINDERS, (5) GAS CYLINDERS TO BE PROCESSED WITH HIGH PRIORITY, (6) WORK IN THIS AREA TO BE PERFORMED WITH PROTECTION (I.E., WEAR SCBA, OPERATE UNDER THE BUDDY SYSTEM), (7) PROTECTIVE CAP FOR CYLINDER REGULATORS SHOULD BE IN PLACE AT ALL TIMES., (8) STORE GAS CYLINDERS IN AN ENCLOSED AREA.
2 III A	MW7A/MWRSF	MWRSF GASES (GROUP 7A)	EXTERNAL FIRE (INITIATED WITHIN THE MWRSF BUILDING).	PRESSURIZATION AND RUPTURE OF GAS CYLINDERS. HIGHLY TOXIC GAS RELEASE AND POTENTIAL CYLINDER MISSILE GENERATION. (A;A;A;A)	(1) FIRE PROTECTION SYSTEM, (2) HEPA AND SCRUBBING SYSTEM, (3) FUSIBLE PRESSURE RELIEF.	STORE GAS CYLINDERS IN AN ENCLOSED AREA WITH FIRE DOOR AND FIRE WALL.
2 III A	MWG/MWRSF	MWRSF GLOBAL (INTERNAL AND EXTERNAL) EVENTS	MEDIUM INTENSITY SEISMIC EVENT WITH HORIZONTAL ACCELERATION OF 0.17 G.	MIXING OF INCOMPATIBLE WASTES STORED IN ADJACENT AREAS. VIOLENT REACTIONS, POTENTIAL FIRE, AND RELEASE OF TOXIC FUMES (E.G., PHOSGENE OR HCN). POTENTIAL LOSS OF SCRUBBER. NOTE: SHOCK SENSITIVE MATERIAL NOT CONSIDERED IN THIS SCENARIO. (C;C;A;C)	NONE	(1) REVIEW SEISMIC DESIGN CRITERIA, (2) ENSURE THAT INCOMPATIBLE WASTES ARE NOT STORED IN ADJACENT AREAS. SEE POTENTIAL MWRSF FLOORPLAN DEVELOPED BY PHA TEAM, (3) MINIMIZE STORAGE TIME OF MOST FLAMMABLE/ TOXIC MATERIALS.
2 III A	MWG/MWRSF	MWRSF GLOBAL (INTERNAL AND EXTERNAL) EVENTS	ACCIDENT DURING TRANSPORTATION OF THE MOST TOXIC WASTE DRUMS (E.G., TOXIC GAS CYLINDERS OR INCOMPATIBLE WASTES) FROM MWRSF TO CAI OR OTHER FACILITIES.	SPILL LEADING TO THE UNMITIGATED RELEASE OF TOXIC GASES. PUBLIC EXPOSURE. (A;A;A;A)	NONE	(1) CONSIDER ROAD CLOSURE WHILE TRANSPORTING THE MOST HAZARDOUS MATERIALS BETWEEN LAB AREAS, (2) REVIEW PROCEDURES FOR SECURING WASTE DRUMS DURING TRANSPORTATION, (3) DO NOT TRANSPORT INCOMPATIBLE WASTE DRUMS TOGETHER.

HAZARD ANALYSIS REPORT BY RISK

R---F---C	ACT/FAC	ACTIVITY NAME	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
3 I D	MWG/MWRSF	MWRSF GLOBAL (INTERNAL AND EXTERNAL) EVENTS	LIGHTNING STRIKES STORAGE BUILDING.	NOT A HAZARD. (D;D;D;D)	MWSRF EQUIPED WITH LIGHTNING RODS.	NONE
3 I D	MWG/MWRSF	MWRSF GLOBAL (INTERNAL AND EXTERNAL) EVENTS	HIGH WINDS	NO HAZARD. (D;D;D;D)	ENCLOSED STORAGE STRUCTURE.	NONE
3 II C	MW4A/MWRSF	MWRSF FLAMMABLES (GROUP 4A)	SPILL OF LOW FLASH POINT CHEMICALS (ACETHALHEHYE(-38F), FURAN (-32F), ANHYDROUS ETHYL (-49F)) DUE TO FORKLIFT ACCIDENT, CRANE ACCIDENT OR CORROSION.	WORKER EXPOSED TO TOXIC FUMES. (D;D;C;D)	CARBON ABSORBTION BED IN HEPA FILTER, FIRE SUPPRESSION SYSTEM.	INSTALL GAS ANALYZER WITH ALARM.
3 II C	MW4A/MWRSF	MWRSF FLAMMABLES (GROUP 4A)	SPILL OF LOW FLASH POINT CHEMICALS (ACETHALHEHYE(-38F), FURAN (-32F), ANHYDROUS ETHYL (-49F)) DUE TO FORKLIFT ACCIDENT, CRANE ACCIDENT OR CORROSION. FIRE SUPPRESSION SYSTEM OPERATIONAL.	IGNITION OF FLAMMABLE VAPORS LEADS TO CONTAINED FIRE IN THE STORAGE AREA. (D;D;C;D)	(1) FIRE SUPPRESSION SYSTEM, (2) CARBON ABSORBTION BED IN HEPA FILTER, AND SCRUBBING SYSTEM.	(1) TREAT HIGHLY FLAMMABLE MATERIALS ON AN PRIORITY BASIS, DO NOT ALLOW ACCUMULATIONS OF LARGE INVENTORIES, (2) CONSIDER SPECIALLY DESIGNED STORAGE CONFIGURATION FOR THE MOST HAZARDOUS (LOW FLASH POINT) FLAMMABLE WASTES, (3) INSTALL GAS DETECTOR AND ALARM, (4) CONSIDER ADDING A FLARE TO THE SCRUBBER SYSTEM, (5) CONSIDER INERT FIRE SUPPRESSION SYSTEM, (E.G., INERT THE ROOM WITH N2 WHEN THE GAS ANALYZERS ALARM).
3 II C	MW2A/MWRSF	MWRSF REACTIVES (GROUP 2A)	WALK BEHIND FORKLIFT ACCIDENT OR OTHER EVENT CAUSES SPILL OF WATER REACTIVE WASTE.	WORKER EXPOSURE, CONTAMINATION OF STORAGE AREA. (D;D;C;D)	(1) DRY CHEMICAL FIRE SUPPRESSION SYSTEM, (2) SCRUBBER SYSTEM, (3) THE SUMP CAPACITY IS TEN PERCENT OF THE INVENTORY IN THE ROOM, EQUIVALENT TO THREE SPRINKLER HEADS DISCHARGING FOR 30 MINUTES.	NONE
3 II C	MW9/MWRSF	MWRSF NONREGULATED WASTES (GROUP 9)	SPILL OF AMMONIUM BIFLORIDE DUE TO OVERHEAD CRANE OR FORKLIFT ACCIDENT.	POTENTIAL WORKER EXPOSURE. (D;D;C;D)	NONE	CONSIDER RELOCATION OF AMMONIUM BIFLORIDE TO ONE OF THE REGULATED AREAS, SUCH AS CAUSTIC(1A).
3 II C	MWBK/MWRSF	MWRSF BULKING ROOM	HUMAN ERROR DURING BULKING OPERATION LEADS TO WASTE SPILL.	WORKER EXPOSURE TO TOXIC CHEMICALS AND TOXIC FUMES. (D;D;C;D)	(1) WASTE IS OPENED AND REPACKAGED UNDER FUME HOOD, (2) USE OF NONSPARKING TOOLS, (3) PROTECTIVE GEAR, E.G. SUIT, FACE SHIELD.	NONE

HAZARD ANALYSIS REPORT BY RISK

R---F---C	ACT/FAC	ACTIVITY NAME	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
3 III B	MW5A/MWRSF	MWRSF CYANIDES AND SULFIDES (GROUP 5A)	EXTERNAL FIRE CAUSES CYANIDE COMPOUNDS (CYANOGEN BROMIDE) TO DECOMPOSE.	THERMAL DECOMPOSITION OF CYANIDE LEADING TO TOXIC GAS RELEASE (E.G., HCN AND CYANOGEN), LOW LEVEL RADIOACTIVE CONTAMINATION IN FACILITY. (D;D;B;C)	FIRE SUPPRESSION (AT FIRE INITIATION LOCATION) AND SCRUBBING SYSTEM.	PROVIDE HCN ANALYZER AND ALARM.
3 III B	MW5A/MWRSF	MWRSF CYANIDES AND SULFIDES (GROUP 5A)	MERCURY OXYCYANIDE DETONATES DUE TO HEATING, FROM SHOCK OR FRICTION (E.G., FORKLIFT ACCIDENT).	SMALL EXPLOSION LEADING TO TOXIC GAS RELEASE. SEVERE WORKER INJURY DUE TO TOXIC GAS EXPOSURE. (D;D;B;C)	SCRUBBING SYSTEM.	DEVELOP AND ENFORCE POLICY NOT TO STORE EXPLOSIVE AND SHOCK SENSITIVE MATERIALS AT TA-63.
3 III B	MW2A/MWRSF	MWRSF REACTIVES (GROUP 2A)	WALK BEHIND FORKLIFT ACCIDENT OR OTHER EVENT CAUSES SPILL OF WATER REACTIVE WASTE INTO THE SUMP WITH WATER PRESENT IN THE SUMP.	HYDROGEN EVOLUTION, POTENTIAL FIRE/EXPLOSION IN SUMP. POSSIBLE RELEASE OF TOXIC METAL FUMES. LOW LEVEL RADIOACTIVE CONTAMINATION THROUGHOUT THE FACILITY. (D;D;B;C)	(1) DRY CHEMICAL FIRE SUPPRESSION SYSTEM, (2) SCRUBBER SYSTEM, (3) THE SUMP CAPACITY IS TEN PERCENT OF THE INVENTORY IN THE ROOM, EQUIVALENT TO THREE SPRINKLER HEADS DISCHARGING FOR 30 MINUTES, (4) SUMP SHOULD BE MAINTAINED FREE OF WATER, (5) RESTRICT USE OF WATER IN THIS STORAGE AREA.	(1) INSTALL HYDROGEN ANALYZER AND ALARM.
3 III B	MW2A/MWRSF	MWRSF REACTIVES (GROUP 2A)	ACCIDENT CAUSES SIMULTANEOUS SPILL OF WATER REACTIVE WASTE AND INCOMPATIBLE WASTE DUE TO MISLABELING. (E.G., REACTIVE WASTE MIXED WITH, SULFURIC ACID(1B), NAOH(1A), PERCHLORIC ACID(6A) OR TRICHLORA ETHYLENE(4A))	PRODUCTION OF HYDROGEN GAS, POTENTIAL FIRE AND/OR EXPLOSION AND PRODUCTION OF TOXIC FUMES. SEVERE WORKER INJURY, AND LOW LEVEL RADIOACTIVE CONTAMINATION THROUGHOUT THE FACILITY. (D;D;B;C)	FIRE PROTECTION SYSTEM, SCRUBBER SYSTEM.	NONE
3 III B	MW7A/MWRSF	MWRSF GASES (GROUP 7A)	BREACH OF CYLINDER (NON-LEGACY) DUE TO ACCIDENTAL CAUSES (E.G., CYLINDER DROPPED AND REGULATOR LINE BREAKS).	RELEASE OF MODERATELY TOXIC GASES (H2S, NO2, AND OTHERS). WORKER EXPOSURE. (C;C;B;D)	HEPA AND SCRUBBING SYSTEM.	(1) TRANSPORT AND STORE CYLINDERS SECURELY, (2) CONSIDER INSTALLATION OF A FLARE AND/OR A SPECIAL SCRUBBER FOR THIS FACILITY, (3) INSTALL GAS DETECTORS AND ALARMS, (4) CONSIDER SECONDARY CONTAINMENT FOR MOST HAZARDOUS CYLINDERS, (5) GAS CYLINDERS TO BE PROCESSED WITH HIGH PRIORITY, (6) WORK IN THIS AREA TO BE PERFORMED WITH PROTECTION (I.E., WEAR SCBA, OPERATE UNDER THE BUDDY SYSTEM), (7) PROTECTIVE CAP FOR CYLINDER REGULATORS

HAZARD ANALYSIS REPORT BY RISK

R---F---C	ACT/FAC	ACTIVITY NAME	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
						SHOULD BE IN PLACE AT ALL TIMES., (8) STORE GAS CYLINDERS IN AN ENCLOSED AREA.
3 III B	MW7A/MWRSF	MWRSF GASES (GROUP 7A)	EXTERNAL FIRE (INITIATED WITHIN THE MWRSF BUILDING).	PRESSURIZATION AND RUPTURE OF GAS CYLINDERS. MODERATELY TOXIC GAS RELEASE AND POTENTIAL CYLINDER MISSILE GENERATION. (C;C;B;C)	(1) FIRE PROTECTION SYSTEM, (2) HEPA AND SCRUBBING SYSTEM, (3) FUSIBLE PRESSURE RELIEF.	STORE GAS CYLINDERS IN AN ENCLOSED AREA.
3 III B	MW1A/MWRSF	MWRSF CAUSTICS (GROUP 1A)	SODIUM AZIDE EXPLODES DUE TO SEVERE SHOCK, HEAT OR FRICTION.	EXPLOSION AND RELEASE OF TOXIC GAS (NOX). (D;D;B;C)	FIRE PROTECTION AND SCRUBBER SYSTEM.	DO NOT ACCEPT/ALLOW SODIUM AZIDE IN THE MWSRF.
3 III B	MW1A/MWRSF	MWRSF CAUSTICS (GROUP 1A)	EXTERNAL FIRE	RELEASE OF MODERATELY TOXIC GASES. WORKER INJURY. (D;C;B;C)	FIRE PROTECTION AND SCRUBBER SYSTEM.	NONE
3 III B	MW1B/MWRSF	MWRSF ACIDS (GROUP 1B)	SPILL OF A SINGLE ACID WASTE DRUM DUE TO CORROSION OR CRANE ACCIDENTS.	TOXIC GAS RELEASE (E.G., HF). WORKER EXPOSURE AND INJURY DUE TO CONTACT WITH GAS/LIQUIDS. (D;D;B;D)	(1) SCRUBBER SYSTEM. (2) THE SUMP CAPACITY IS TEN PERCENT OF THE INVENTORY IN THE ROOM, EQUIVALENT TO THREE SPRINKLER HEADS DISCHARGING FOR 30 MINUTES.	(1) VERIFY CONSTRUCTION MATERIAL OF STORAGE CONTAINER AND THE SUMP SYSTEM, (2) FREQUENT INSPECTIONS, (3) INSTALL GAS DETECTORS, (4) DO NOT PERFORM ANY UNNECESSARY ACTIVITIES WHILE THE SCRUBBER IS DOWN, (5) REVIEW/CONSIDER STORING HF IN GAS CYLINDER AREA (GROUP 7A).
3 III B	MW1B/MWRSF	MWRSF ACIDS (GROUP 1B)	SPILL OF A SINGLE ACID WASTE DRUM DUE TO CORROSION OR CRANE ACCIDENTS. SRCUBBER NOT OPERATIONAL, BUT BLOWER IS WORKING.	TOXIC GAS RELEASE (E.G., HF OR HCL). WORKER EXPOSURE AND INJURY. (C;C;B;D)	THE SUMP CAPACITY IS TEN PERCENT OF THE INVENTORY IN THE ROOM, EQUIVALENT TO THREE SPRINKLER HEADS DISCHARGING FOR 30 MINUTES.	(1) VERIFY CONSTRUCTION MATERIAL OF STORAGE CONTAINER AND THE SUMP SYSTEM, (2) FREQUENT INSPECTIONS, (3) INSTALL GAS DETECTORS, (4) DO NOT PERFORM ANY UNNECESSARY ACTIVITIES WHILE THE SCRUBBER IS DOWN.
3 III B	MW1B/MWRSF	MWRSF ACIDS (GROUP 1B)	EXTERNAL FIRE	RELEASE OF MODERATELY TOXIC GASES. WORKER INJURY. (D;C;B;C)	FIRE PROTECTION AND SCRUBBER SYSTEM.	NONE
3 III B	MW9/MWRSF	MWRSF NONREGULATED WASTES (GROUP 9)	ACCIDENTAL SPILL OF INCOMPATIBLE WASTES ROUTINELY STORED IN NONREGULATED AREA (E.G., MISLABLED, TEMPORARY STORAGE, OR DO NOT BELONG IN OTHER DEFINED REGULATED AREAS)	FIRE AND RELEASE OF TOXIC GASES. (C;C;B;C)	FIRE PROTECTION AND SCRUBBER SYSTEMS.	(1) CONSIDER ELIMINATING THIS AREA, (2) CLASSIFY AND STORE ALL NONREGULATED WASTES IN COMPATIBLE REGULATED AREAS, (3) ENCLOSE THE NONREGULATED AREA.
3 III B	MWBK/MWRSF	MWRSF BULKING ROOM	OPERATOR OPENS MISLABELED	POTENTIAL WORKER EXPOSURE	(1) WASTE IS OPENED AND	WORKER SHOULD WEAR

HAZARD ANALYSIS REPORT BY RISK

R---F---C	ACT/FAC	ACTIVITY NAME	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
			WASTE CONTAINER.	TO HIGHLY TOXIC CHEMICALS AND TOXIC FUMES, POTENTIAL FIRE. (D;D;B;C)	REPACKAGED UNDER FUME HOOD, (2) USE OF NONSPARKING TOOLS, (3) PROTECTIVE GEAR, E.G. SUIT, FACE SHIELD.	PROTECTIVE EQUIPMENT.
3 III B	MWBK/MWRSF	MWRSF BULKING ROOM	INCOMPATIBLE WASTE ARE MIXED DURING REPACKAGING PROCESS DUE TO MISLABELING OR OPERATOR ERROR.	VIOLENT REACTION, RELEASE OF TOXIC GAS WITH WORKER EXPOSURE AND FACILITY CONTAMINATION. (D;D;B;C)	(1) FUME HOOD AND FIRE SUPPRESSION SYSTEM, (2) FULL PROTECTIVE GEAR, E.G. SUITS, FACE SHIELDS).	WORKER SHOULD WEAR PROTECTIVE EQUIPMENT.
3 III B	MWG/MWRSF	MWRSF GLOBAL (INTERNAL AND EXTERNAL) EVENTS	INADVERTENT OPERATION OF THE FIRE SPRINKLERS OR RUPTURE OF WATER PIPING DUE TO CORROSION, IN THE BULKING ROOM DURING BULKING OPERATION.	WATER MIXING WITH WATER REACTIVES OR ACIDS COULD CAUSE WORKER INJURY. (D;D;B;D)	NONE	(1) DO NOT LEAVE OPEN WASTE CONTAINERS IN BULKING ROOM, (2) CONSIDER USE OF DRY CHEMICAL FIRE SUPPRESSION SYSTEM IN THE BULKING ROOM.
3 III C	MW2A/MWRSF	MWRSF REACTIVES (GROUP 2A)	WALK BEHIND FORKLIFT ACCIDENT OR OTHER EVENT CAUSES SPILL OF DEPLETED URANIUM WASTE.	BURNING OF THE DEPLETED URANIUM DUE TO PROLONGED EXPOSURE TO AIR, RELEASE OF TOXIC FUMES AND RADIOACTIVITY. WORKER EXPOSURE AND LOW LEVEL RADIOACTIVE CONTAMINATION THROUGHOUT THE FACILITY. (D;D;C;C)	DRY CHEMICAL FIRE SUPPRESSION SYSTEM, SCRUBBER SYSTEM.	NONE
3 III C	MW1B/MWRSF	MWRSF ACIDS (GROUP 1B)	SPILL OF A SINGLE ACID WASTE DRUM DUE TO CORROSION OR CRANE ACCIDENTS.	RELEASE OF ACID FUMES (E.G., HCL). WORKER EXPOSURE AND INJURY DUE TO CONTACT WITH GAS/LIQUIDS. (D;D;C;D)	(1) SCRUBBER SYSTEM. (2) THE SUMP CAPACITY IS TEN PERCENT OF THE INVENTORY IN THE ROOM, EQUIVALENT TO THREE SPRINKLER HEADS DISCHARGING FOR 30 MINUTES.	(1) VERIFY CONSTRUCTION MATERIAL OF STORAGE CONTAINER AND THE SUMP SYSTEM, (2) FREQUENT INSPECTIONS, (3) INSTALL GAS DETECTORS, (4) DO NOT PERFORM ANY UNNECESSARY ACTIVITIES WHILE THE SCRUBBER IS DOWN.
3 III C	MW8/MWRSF	MWRSF PCB (GROUP 8)	MISLABELED DRUM RESULTS IN PCB DRUM BEING STORED NEAR FLAMMABLE WASTE. ACCIDENTAL BREACH OF THE CONTAINERS LEADS TO FIRE AND BURNIG OF PCB WASTE.	BURNING OF PCB WASTE FILTER THROUGH THE BUILDING SCRUBBER SYSTEM. (C;C;C;C)	FIRE PROTECTION AND SCRUBBER SYSTEMS.	NONE
3 III C	MWG/MWRSF	MWRSF GLOBAL (INTERNAL AND EXTERNAL) EVENTS	INADVERTENT OPERATION OF THE FIRE SPRINKLERS OR RUPTURE OF WATER PIPING DUE TO CORROSION.	IF FLOOD SOURCE NOT MITIGATED, COULD CAUSE WATER INTRUSION INTO REACTIVE WASTE AREA, GENERATION OF HYDROGEN GAS AND RADIOACTIVE CONTAMINATION IN THE FACILITY. (D;D;D;C)	(1) DRY CHEMICAL FIRE SUPPRESSION SYSTEM IN WATER REACTIVE(GROUP 2A) STORAGE AREA, (2) PERIODIC WALKDOWNS OF THE FACILITY ARE PERFORMED, (3) OPERATION OF SPRINKLERS WILL INITIATE A 911 ALARM.	(1) INSTALL SUMP HIGH LEVEL ALARMS, (2) DESIGN STORAGE AREA TO PREVENT INTRUSION OF WATER TO THE WATER REACTIVE WASTE AREA.

HAZARD ANALYSIS REPORT BY RISK

R---F---C	ACT/FAC	ACTIVITY NAME	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
3 IV A	MW5A/MWRSF	MWRSF CYANIDES AND SULFIDES (GROUP 5A)	FORKLIFT ACCIDENT CAUSES SIMULTANEOUS SPILL OF CYANIDE AND OTHER NONCOMPATIBLE WASTE (E.G., H2SO4(1B), OR PERCHLORIC ACID(6A)) DUE TO MISLABELING, AND FAILURE OF THE SCRUBBER SYSTEM WITH THE VENT BLOWER WORKING.	RELEASE OF TOXIC GASES (E.G., HCN AND CYANOGEN) AND POSSIBLE EXPLOSION AND FIRE. SEVERE WORKER INJURY, AND LOW LEVEL RADIOACTIVE CONTAMINATION IN THE FACILITY. (C;B;A;C)	(1) USE OF SMALL "WALK BEHIND" FORKLIFTS, (2) DRUMS ARE STORED ONLY ONE LEVEL HIGH.	(1) PROVIDE HCN ANALYZER AND ALARM, (2) DO NOT PERFORM ANY UNNECESSARY ACTIVITIES IF THE SCRUBBER IS NONOPERATIONAL, (4) ADD ALARMS TO MONITOR SCRUBBER OPERATION.
3 IV A	MW8/MWRSF	MWRSF PCB (GROUP 8)	LARGE EXTERNAL FIRE WITH BREACH OF BUILDING OR THE SCRUBBER SYSTEM.	POTENTIAL SPILL AND BURNING OF PCB WASTE. DISPERSION OF PCB WASTE TO THE ENVIRONMENT. (B;B;B;A)	(1) FIRE PROTECTION SYSTEM, (2) HEPA/SCRUBBER WITH CARBONBED.	CONSIDER STORING PCB WASTE AWAY FROM FLAMMABLES.
3 IV A	MW8/MWRSF	MWRSF PCB (GROUP 8)	SPILL OF PCB WASTE DRUM DUE TO FORKLIFT ACCIDENT, RELEASE TO THE SUMP.	POTENTIAL RELEASE TO THE ENVIRONMENT THROUGH THE SUMP SYSTEM. ENVIRONMENTAL CONTAMINATION. (D;D;D;A)	(1) INSTALL PROCEDURES TO DETECT SUMP LEVELS, (2) TEST SUMP CONTENTS BEFORE DISCHARGE, (3) SUMP SYSTEM.	NONE
3 IV A	MWG/MWRSF	MWRSF GLOBAL (INTERNAL AND EXTERNAL) EVENTS	LOW INTENSITY SEISMIC EVENT WITH HORIZONTAL ACCELERATION OF 0.1 G.	EXPLOSION OF SHOCK SENSITIVE MATERIALS (E.G., NITRO METHANE, SODIUM AZIDE). STRUCTURAL DAMAGE TO BUILDING, FIRE AND RELEASE OF TOXIC GASES. (A;A;A;A)	NONE	(1) DEVELOP AND ENFORCE POLICY NOT TO STORE EXPLOSIVE OR SHOCK SENSITIVE MATERIAL IN THIS BUILDING, (2) PROCESS SHOCK SENSITIVE MATERIALS IMMEDIATELY.
3 IV A	MWG/MWRSF	MWRSF GLOBAL (INTERNAL AND EXTERNAL) EVENTS	HIGH INTENSITY SEISMIC EVENT WITH HORIZONTAL ACCELERATION OF 0.3 G OR GREATER.	STRUCTURAL COLLAPSE OF BUILDING, BREACH OF MULTIPLE DRUMS, MAJOR FIRE, RELEASE OF TOXIC GAS TO ENVIRONMENT AND RADIOACTIVE CONTAMINATION. (A;A;A;A)	NONE	(1) REVIEW SEISMIC DESIGN CRITERIA, (2) MINIMIZE STORAGE TIME OF MOST FLAMMABLE/ TOXIC MATERIALS.
3 IV A	MWG/MWRSF	MWRSF GLOBAL (INTERNAL AND EXTERNAL) EVENTS	EXTERNAL FIRE	FIRE PENETRATES THE MWRSF, MAJOR FIRE RELEASES TOXIC GAS TO THE ENVIRONMENT AND RADIOACTIVE CONTAMINATION. (A;A;A;A)	(1) AREA SURROUNDING THE MWRSF IS CLEARED OF COMBUSTIBLE MATERIAL, (2) BUILDING IS DESIGNED TO RETARD FIRE.	NONE
3 IV B	MW2A/MWRSF	MWRSF REACTIVES (GROUP 2A)	WATER INTRUSION INTO THE STORAGE DRUM DUE TO HUMAN ERROR.	RUPTURE OF DRUM DUE TO HYDROGEN EVOLUTION, POTENTIAL FIRE/EXPLOSION. POSSIBLE RELEASE OF TOXIC METAL FUMES. (D;D;B;C)	DRY CHEMICAL FIRE SUPPRESSION SYSTEM, SCRUBBER SYSTEM.	NONE
3 IV B	MW7A/MWRSF	MWRSF GASES (GROUP 7A)	SIMULTANEOUS RUPTURE OF TWO INCOMPATIBLE (E.G., FLORINE AND H2S) GAS CYLINDERS (DUE TO MISHANDLING, FORKLIFT	FIRE IN STORAGE AREA OR VENT SYSTEM DUE TO MIXING OF INCOMPATIBLE GASES. TOXIC GAS RELEASE. SEVERE WORKER INJURY. (C;C;B;C)	(1) FIRE PROTECTION AND (2) HEPA AND SCRUBBING SYSTEM.	NONE

HAZARD ANALYSIS REPORT BY RISK

R---F---C	ACT/FAC	ACTIVITY NAME	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
			ACCIDENT, ETC...)			
3 IV B	MW1A/MWRSF	MWRSF CAUSTICS (GROUP 1A)	OVERHEAD CRANE ACCIDENT CAUSING SIMULTANEOUS SPILL OF CAUSTIC MATERIAL AND INCOMPATIBLE MATERIAL(E.G., H2SO4(1B), TETRAHYDRO FURAN(4A), NITRIC ACID(6A), METAL CYANIDE(5A),LITHIUM HYDRIDE(2A)) DUE TO MISLABELING.	POTENTIAL FIRE, EXPLOSION, HYDROGEN GAS PRODUCTION AND HEAVY METAL FUME GENERATION. WORKER INJURY/EXPOSURE. (D;D;B;C)	FIRE SUPPRESSION AND SCRUBBER SYSTEM.	NONE
3 IV B	MW1B/MWRSF	MWRSF ACIDS (GROUP 1B)	OVERHEAD CRANE ACCIDENT CAUSING SIMULTANEOUS SPILL OF ACID MATERIAL AND INCOMPATIBLE MATERIAL (E.G., NAOH(1A), PYRIDINE(4A), HYDROGEN PEROXIDE(6A), METAL CYANIDE(5A), LITHIUM HYDRIDE(2A)) DUE TO MISLABELING.	POTENTIAL FIRE, EXPLOSION, HYDROGEN GAS PRODUCTION AND TOXIC GAS GENERATION. SEVERE WORKER INJURY/EXPOSURE. (D;D;B;C)	FIRE SUPPRESSION AND SCRUBBER SYSTEM.	NONE
4 II D	MW5A/MWRSF	MWRSF CYANIDES AND SULFIDES (GROUP 5A)	SPILL OF CYANIDE DUE TO WALK BEHIND FORKLIFT ACCIDENT OR CORROSION.	CONTAMINATION OF THE STORAGE AREA, MINOR WORKER EXPOSURE. NO TOXIC GAS RELEASED DUE TO LOW VOLATILITY. (D;D;D;D)	NONE	NONE
4 II D	MW6A/MWRSF	MWRSF OXIDIZERS (GROUP 6A)	SPILL OF OXIDIZERS DUE TO WALK BEHIND FORKLIFT OR OVERHEAD CRANE ACCIDENTS.	LOW LEVEL TOXIC SPILL. WORKER EXPOSURE. (D;D;D;D)	HEPA FILTER AND SCRUBBING SYSTEM.	NONE
4 II D	MW1A/MWRSF	MWRSF CAUSTICS (GROUP 1A)	SPILL OF A SINGLE CAUSTIC WASTE DRUM.	MINOR WORKER EXPOSURE. (D;D;D;D)	NONE	NONE
4 II D	MW8/MWRSF	MWRSF PCB (GROUP 8)	SPILL OF PCB WASTE DRUM DUE TO FORKLIFT ACCIDENT.	CONTAMINATION OF THE STORAGE AREA. (D;D;D;D)	SUMP SYSTEM.	NONE

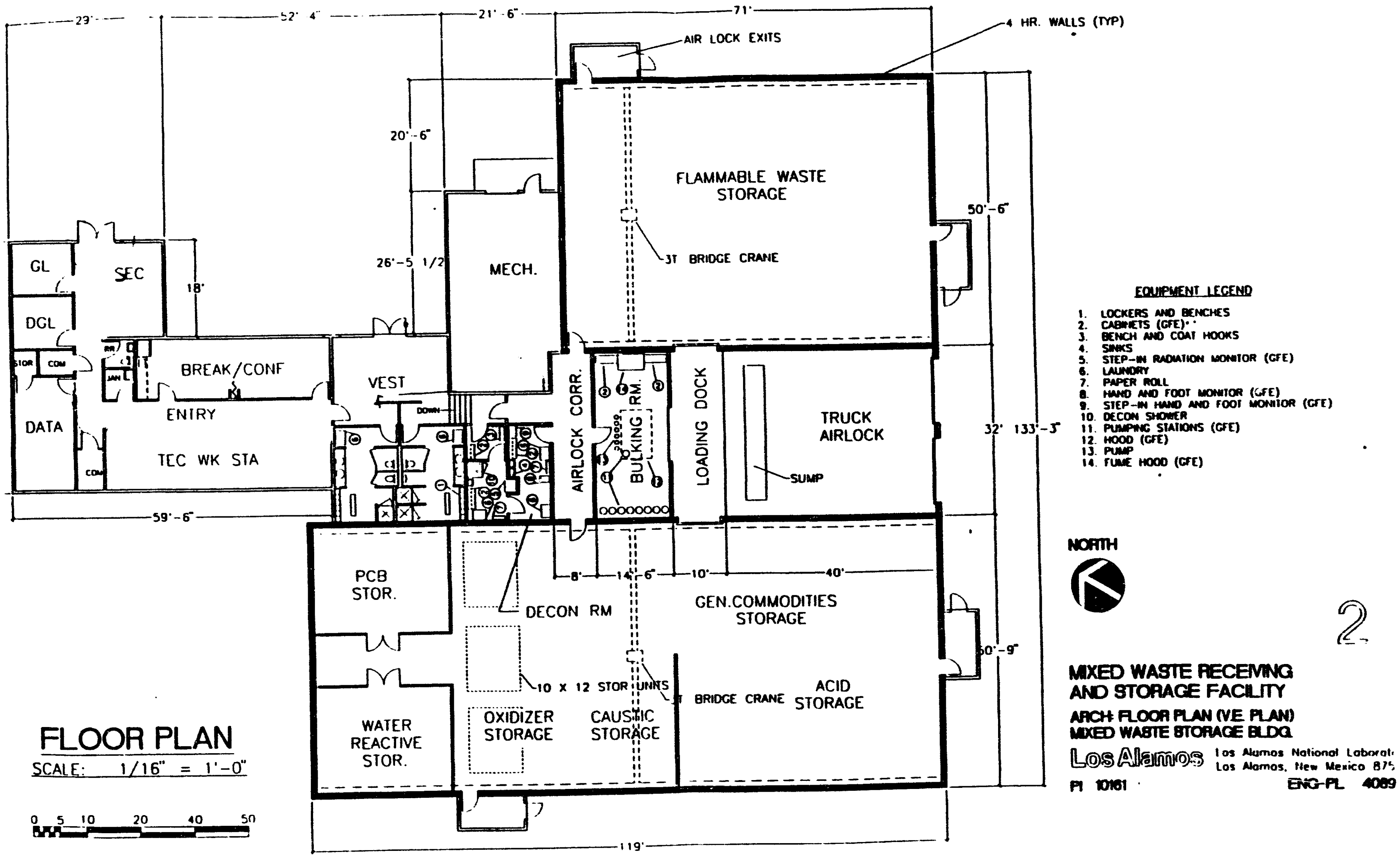

Fig. B-1. Floor plan of MWRSF.

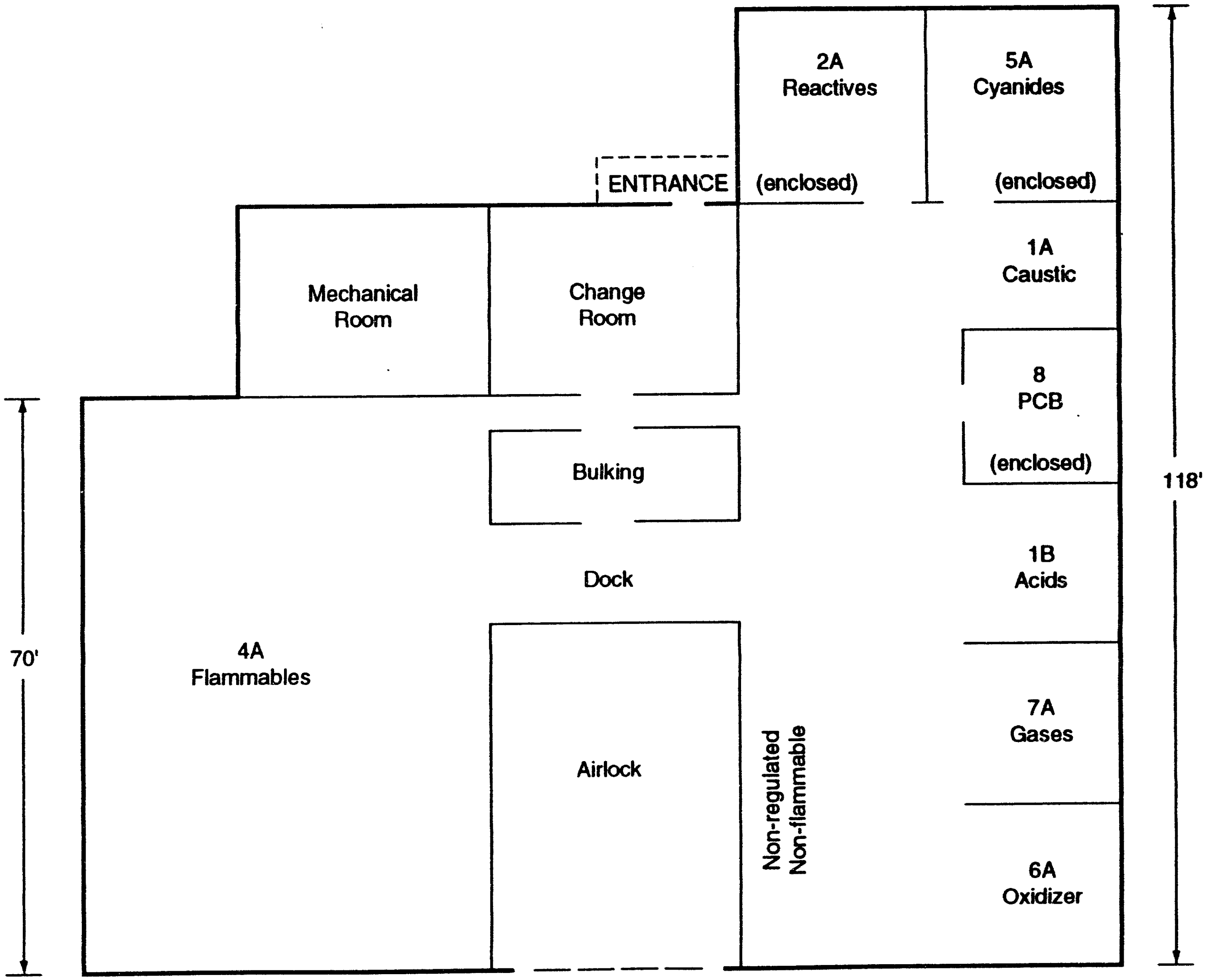

Fig. B-2. Proposed MWRSF layout.

APPENDIX C
HWTF DRUM STORAGE BUILDING

FACILITY

Design Description

The Hazardous Waste Treatment Facility (HWTF) to be located at TA-63 will include an independent drum storage building (DSB). The proposed DSB will receive and store hazardous waste generated on-site at Los Alamos. The facility will store waste from the existing storage facility at TA-54 and also receive future waste from Laboratory waste generators. This appendix provides a brief description of the storage facility. (Note: The PHA team has not seen a preconceptual design report or any other reference material for this DSB).

The currently planned DSB is an open structure consisting of a concrete base with a roof. For this hazards assessment, it was assumed that the construction of the new DSB would be similar to that of the existing facility located in TA-54. The DSB will be divided into nine segregated storage areas. Each of the nine areas will correspond to one of the following waste classifications: Caustics, Acids, Reactives, Flammables, Cyanides and Sulfides, Oxidizers, Gases, PCBs, and nonregulated wastes. The storage areas will be separated by 4-ft-high divider walls, and each storage area will have a sump system designed to hold at least 10% of the volume of the materials in storage. The new facility will include an active fire suppression system, but because it will be open to the atmosphere, there will be no active ventilation or particulate filtration systems.

EPA Classification Methodology

The hazardous wastes expected to be received by the DSB are listed in the tables and are classified according to the EPA classifications for potentially incompatible waste. The EPA classification is used to avoid mixing hazardous waste with other waste or material at a hazardous waste facility that could result in effects that are harmful to human health and the environment. These effects could be (1) heat or pressure; (2) fire or explosion; (3) violent reaction; (4) toxic dusts, mists, or fumes; or (5) flammable fumes or gases.

Table C-1 lists examples of potentially incompatible wastes, waste components, and materials, along with the harmful consequences that result from mixing materials in one group with materials from another group. This list is intended to be a guide for operators of treatment, storage, and disposal facilities and to indicate the need for special precautions when managing these potentially incompatible waste materials or components. Table C-2 lists the hazardous wastes, sorted according to EPA classification, that potentially could be stored at the DSB.

Design Changes during the PHA

The PHA was performed based on the assumptions stated above with regard to the facility design. Specifically, the new DSB at TA-63 would be similar in design to the existing facility at TA-54. During the course of the PHA, a number of changes were made to the baseline structural design and operational procedures. Some of these were made as a result of the PHA analysis (e.g., concerns over the large number of human interactions with potentially hazardous waste materials or potential mixing of incompatible wastes) or during CST-7 attempts to improve the process for efficiency, economy, or risk reduction. The design changes implemented during the course of performing the PHA are listed below.

- **Replace Motorized Forklift with Walk-Behind Forklift**

  To reduce the risk of puncturing a waste container during transportation, a motorized forklift will not be used to transport the waste from the loading dock to the storage area. The motorized forklift has been replaced with a smal, walk-behind forklift (flat with wheels). Compared with the larger, motorized forklift, the small forklift has less potential for accidents because it will be moved (pushed) manually from one location to another. There is better control, less momentum, and less or no motive force.

- **Change Classification Procedure**

  The mixed waste will be by classified by EPA categories for potentially incompatible waste (see Table C-1). The classification at the existing TA-54 storage site is based on a DOT system used and does not take into account the compatibilities of mixed waste.

PHA RESULTS

The results of the PHA for the HWTFS are presented in Tables C-3 and C-4. Each of the nine storage areas within the HWSF was treated as a separate activity. The PHA team analyzed each activity, documenting any potentially risk-significant scenario involving the corresponding storage area. Table C-3 presents the resulting scenarios sorted by activity. One additional activity, namely, "HWG," was defined to include all scenarios initiated by external or internal events that could have a global or facility-wide effect, such as seismic events.

Scenarios are ranked by risk (the most risk significant scenarios to the least) in Table C-4. The most significant risk ranking is "1," and the least significant rank is "4."

TABLE C-1
EXAMPLE OF POTENTIAL INCOMPATIBLE WASTE

Group 1-A
Acetylene sludge
Alkaline caustic liquids
Alkaline cleaner
Alkaline corrosive liquids
Alkaline corrosive battery fluid
Caustic wastewater
Lime sludge and other corrosive alkalies
Lime wastewater
Lime and water
Spent caustic

Group 1-B
Acid sludge
Acid and water
Battery acid
Chemical cleaners
Electrolyte, acid
Etching acid liquid or solvent
Pickling liquor and other corrosive acids
Spent acid
Spent mixed acid
Spent sulfuric acid
Potential consequences: Heat generation; violent reaction

Group 2-A
Aluminum
Beryllium
Calcium
Lithium
Magnesium
Potassium
Sodium
Zinc powder
Other reactive metals and metal hydrides

Group 2-B
Any waste in Group 1-A or 1-B
Potential consequences: Fire or explosion; generation of hydrogen gas.

Group 3-A
Alcohols
Water

Group 3-B
Any concentrated waste in Group 1-A or 1-B
Calcium
Lithium
Metal hydrides
Potassium
SO_2Cl_2, $SOCl_2$, PCl_3, CH_3SiCl_3
Other water-reactive wastes
Potential consequences: Fire, explosion, or heat generation; generation of flammable or toxic gases.

Group 4-A
Alcohols
Aldehydes
Halogenated hydrocarbons
Nitrated hydrocarbons
Unsaturated hydrocarbons
Other reactive organic compounds and solvents

Group 4-B
Concentrated Group 1-A or 1-B wastes
Group 2-A wastes
Potential consequences: Fire, explosion, or violent reaction

Group 5-A
Spent cyanide and sulfide solutions

Group 5-B
Group 1-B wastes
Potential consequences: Generation of toxic hydrogen cyanide or hydrogen sulfide gas.

Group 6-A
Chlorates
Chlorine
Chlorites
Chromic acid
Hypochlorites
Nitrates
Nitric acid, fuming
Perchlorates
Permanganates
Peroxides
Other strong oxidizers

Group 6-B
Acetic acid and other organic acids
Concentrated mineral acids
Group 2-A wastes
Group 4-A wastes
Other flammable and combustible flammable wastes
Potential consequences: Fire, explosion, or violent reaction.

TABLE C-2
LIST OF HAZARDOUS WASTE FOR POTENTIAL STORAGE

Reference Number	Name of chemical (formula)	Incompatibilities: Light Heat	H2O Moist	Acids	Bases	Oxides	Reduce	Other	Health Hazard: CERCLA	NFPA	Threshold Value or LD	Flammability: Flash Point	CERCLA	NFPA	Reactivity: CERCLA	NFPA	Hazardous Combustion or Decomposition Products	Fire Hazards Information	Additional Information	HWTF Storage Class
311	sodium azide			Y					3	4	OSHA TWA 0.1ppm		1	1	3	3	Thermal decomposition products may include toxic oxides of Nitrogen		Highly toxic	1A
12	sodium hydroxide		Y	Y					3	3	OSHA TWA 2mg/m3		0	0	1	1	Emits toxic fumes of Sodium Oxides	May ignite combustibles	Corrosive	1A
288	arsenic pentoxide			Y		Y			3	3	OSWA TWA 10ug/m3		0	0	0	0	Emits toxic fumes of Arsenic , Sodium Oxide and Arsine gas	Non-flammable	Highly toxic	1A
290	arsenic trioxide	Y	Y	Y		Y			3	3	MAN LD 29mg/kg		0	0	0	0	Emits toxic fumes of Arsenic Oxides under fire		Carcinogen, highly toxic, mutagen	1A
92	arsenic metal			Y		Y			3	2	OSHA TWA 10 mg/m3		0	0	0	0	Emits toxic fumes of Arsine gas and arsenic		Carcinogen, poison	1A
71	sulfuric acid		Y		Y				3	3	OSHA TWA 1 MG/M3		0	0	2	2	Emits toxic fumes of Sulfur Oxides	May ignite combustibles	Corrosive	1B
59	hydrofluoric acid	Y	Y		Y	Y		Mercury Oxide, Methanesulfonic Acid, Nitric Acid, Oleum, Organics, Phosphorus Oxide, Plastics, Potassium Permanganate, light	3	4	OSHA TWA 3ppm		0	0	1	0	Emits toxic fumes	May burn but doesnt not ignite readily	Do not store in glass. Can cause severe burns which can be not immediately painful	1B
58	hydrochloric acid		Y		Y	Y				3	UNR-MAN LD 81mg/kg			0		0	HCL	Emits toxic fumes		1B

Reference Number	Name of chemical (formula)	Incompatibilities: Light Heat	H2O Moist	Acids	Bases	Oxides	Reduce	Other	Health Hazard: CERCLA	NFPA	Threshold Value or LD	Flammability: Flash Point	CERCLA	NFPA	Reactivity: CERCLA	NFPA	Hazardous Combustion or Decomposition Products	Fire Hazards information	Additional Information	HWTF Storage Class
201	carbon tetrachloride				Y	Y				3	LD 93 mg/kg			0		0	Phosphene gas, CO, CO2			1B
287	arsenic acid								3	3	10ug/kg		0	0	0	0	include arsine gas	Non-flammable	Highly toxic	1B
219	1,1,2,2-tetrachloroethylyene wastes				Y					2	RAT LD 2629mg/kg	250F		0		0	Emits toxic fumes: Phosgene gas, HCL, CO, CO2		Carcinogen, mutagen, extremely stable and resists hydrolysis	1B
243	trichlorotrifluorethane	Y			Y						OSHA TWA 1000ppm						Emits toxic fumes: CO, CO2, HCL (gas), Phosgene, HF gas		Non-flammable, carcinogen	1B
83	lithium hydride		Y	Y		Y				3	OSHA TWA 0.025mg/m3			4		2			Corrosive, inhalation may be fatal	2A
108	Barium		Y	Y		Y			3	4	OSHA TWA 0.5mg/m3		3	3	2	2		Enits toxic fumes of Barium Oxides	Carcinogen	2A

Reference Number	Name of chemical (formula)	Incompatibilities						Other	Health Hazard			Flammability			Reactivity		Hazardous Combustion or Decomposition Products	Fire Hazards Information	Additional Information	HWTF Storage Class
		Light Heat	H2O Moist	Acids	Bases	Oxides	Reduce		CERCLA	NFPA	Threshold Value or LD	Flash Point	CERCLA	NFPA	CERCLA	NFPA				
85	magnesium		Y	Y		Y		Carbonates, Chloroformamidinium, Nitrate, Dinitrogen Tetraoxide, Ethylene Oxide, Fluorocarbon Polymers, Gold Cyanide, Halocarbons, Halogens or interhalogens, HJ, H2O2, Mn, Metal Cyanides, Metal Haloganates, Metal Oxides, Metal Oxosalts, Methanol	3	0	no		3	1	3	3	Emits corrosive fumes	Flammable solid		2A
89	sodium		Y	Y		Y				3	IPR 40mg/kg			1		2		Flammable solid		2A
78	Calcium		Y	Y		Y			U	1	no		3	1	2	2	Emits toxic fumes	Flammable solid		2A

Reference Number	Name of chemical (formula)	Incompatibilities							Health Hazard			Flammability			Reactivity		Hazardous Combustion or Decomposition Products	Fire Hazards Information	Additional Information	HWTF Storage Class
		Light Heat	H2O Moist	Acids	Bases	Oxides	Reduce	Other	CERCLA	NFPA	Threshold Value or LD	Flash Point	CERCLA	NFPA	CERCLA	NFPA				
84	Lithium in oil			Y		Y		Cobbalt alloys, Diazomethane, Diborane, Ethylene, Ferrous Sulfide, . Halocarbons, Halogens, Hydrogen, Iodine, Iodoform, Iron Alloys, Maleic Anhydride, Manganese Alloys, Mercury, metal Oxides, Methyl Dichloride, Methyl Diiodide, Molybdenium Trioxide	2	1	no data		3	1	1	1	Lithium Hydride and Hydrogen gas	May ignite itselv exposed to air or moisture . May reignite after fire is extinguished	Water Hydrolyzes material liberating acidic gas in contact with metal can generate Hydrgen	2A
74	picric acid	Y			Y	Y	Y		3	3	OSHA TWA 0.1mg/m3		4	4	4	4	CO, CO2, NOx	May explode when heated	Nitromethane can detonate if sensitized by amines amd high temperature. It can detonate by adiabatic decompression. Dry Alkali or Amine Salts of Nitromethane era shock sensitive and Sodium Salt burts into flame upon contact with water	4A

Reference Number	Name of chemical (formula)	Incompatibilities							Health Hazard			Flammability			Reactivity		Hazardous Combustion or Decomposition Products	Fire Hazards Information	Additional Information	HWTF Storage Class
		Light Heat	H2O Moist	Acids	Bases	Oxides	Reduce	Other	CERCLA	NFPA	Threshold Value or LD	Flash Point	CERCLA	NFPA	CERCLA	NFPA				
31	nitromethane	Y		Y	Y	Y	Y			1	OSHA TWA 100ppm	95F		3		3	CO, CO2, NOx	Very dangerous fire hazard when exposed to heat, oxidizers or flame	May be fatal when inhaled	4A
301	methyl isocyanate	Y	Y	Y	Y	Y				2	OSHA TWA 0.02ppm	20F		3		3	CO, CO2,, NOx, HCN	Very dangerous fire hazard when exposed to heat, flame or oxidizers		4A
323	acethalhehyde	Y		Y	Y		Y	Metals, Oxygen, Phenols, Phosphorus Cyanate, Plastic Rubber, Coatings, Silver Nitrate, Sodium Hydroxide, Sulfuric Acid, Air, light, heat	3	2	OSHA TWA 150 ppm	(-38)F	3	4	2	2	Emits toxic fumes of Carbon Oxide		Carcinogen,corrosive, toxic by inhalation	4A
327	acrylonitrile	Y		Y	Y	Y				4	ACGH TWA 2ppm	32F		3		2	CO, CO2, NOx, HCN	Flash back, emits toxic fumes		4A
11	Acetonitrile		Y	Y	Y	Y	Y			4		42F		3		2	CO,CO2, Nitogen Oxides, Hydrogen Cyanide	Dangerous fire hazard when exposed to heat flame or oxidizers	toxic, corrosive, narcotic	4A

Reference Number	Name of chemical (formula)	Incompatibilities: Light Heat	H2O Moist	Acids	Bases	Oxides	Reduce	Other	Health Hazard: CERCLA	NFPA	Threshold Value or LD	Flammability: Flash Point	CERCLA	NFPA	Reactivity: CERCLA	NFPA	Hazardous Combustion or Decomposition Products	Fire Hazards Information	Additional Information	HWTF Storage Class
367	hydrazine					Y		metal catalyst, metal oxides, Nickel, Nickel Perchlorate, Nitric Acid, Nitrous Oxide, Organics, Pt, K, Potassium Dichromate, Rubber, Silver Chloride, Na, Tetryl, Ti compounds,Zinc Amide		3	osha twa 0.1mg/m3	100F		3		2	CO, NOx			4A
365	furan			Y		Y			3	1	no data	(-32)F	3	4	1	1	Carbon Oxides	Very dangerous when exposed to heat, flame or Oxidants		4A

Reference Number	Name of chemical (formula)	Incompatibilities							Health Hazard			Flammability			Reactivity		Hazardous Combustion or Decomposition Products	Fire Hazards Information	Additional Information	HWTF Storage Class
		Light Heat	H2O Moist	Acids	Bases	Oxides	Reduce	Other	CERCLA	NFPA	Threshold Value or LD	Flash Point	CERCLA	NFPA	CERCLA	NFPA				
77	anhydrous ethyl ether					Y		Nitrosyl Perchlorate, Nitryl Hypofluoride, Nitril Perchlorate, Oxygen Ozone, Peat Soils, Perchloric Acid, Permanganic Acid, Peroxodisulfuric Acid, Potassium Peroxide, Silver Perchlorate, Sodium Peroxide, Sulfonyl Chloride, Thiotrithiazyl Perchlorate	2	2	OSHA TWA 400ppm	(-49)F	3	4	1	1	Emits Carbon oxides under fire condition	very dangerous fire and explosion hazard when exposed to heat or flame.	Corrosive, sensitizer, carcinogen, highly toxic	4A
363	formaldehyde			Y	Y	Y			3	2	OSHA TWA 0.75ppm	185F	3	4	0	0	Carbon Oxides	Combustible liquid hhen exposed to heat or flame. The gas is more dangerous fire hazard than vapors.	Hydrochloric Acid forms highly toxic Bis (Chloromethyl) Ether	4A
332	Benzyl Chloride	Y	Y			Y			3	3	OSHA TWA 1ppm	153F	2	2	1	1	Toxic fumes may include Phosgene, Oxides of Chloride and Carbon	Flammable when exposed to heat or flame	Irritant, attacts central nervous system	4A
396	Toluene diisocyanate			Y	Y	Y				3	OSHA TWA 0.005mg/m	260F		1		1	HCN, CO, CO2, NOx	Combustible when exposed to heat or flame	Moderately toxic by digestion	4A

Reference Number	Name of chemical (formula)	Incompatibilities: Light Heat	Incompatibilities: H2O Moist	Incompatibilities: Acids	Incompatibilities: Bases	Incompatibilities: Oxides	Incompatibilities: Reduce	Other	Health Hazard: CERCLA	Health Hazard: NFPA	Health Hazard: Threshold Value or LD	Flammability: Flash Point	Flammability: CERCLA	Flammability: NFPA	Reactivity: CERCLA	Reactivity: NFPA	Hazardous Combustion or Decomposition Products	Fire Hazards Information	Additional Information	HWTF Storage Class
9	2 Pentene		Y			Y			0	0	No data	(-4F)	3	4	0	0	CO, CO2	Fire hazard when exposed to heat or flame		4A
204	chlorobenzene analytical solutions					Y			2	2	OSHA TWA 75 ppm	82F	3	3	0	0	Emits toxic fumec of phosgene, Chlorides, Carbon Oxides	Dangerous fire hazard when exposed to heat or flame	Carcinogen	4A
209	1,2-dichloroethane					Y				2	LD 286 mg/kg	56F		3		0	Phosphene gas, CO, CO2, HCL gas	Fire hazard, flash back	Carcinogen,	4A
46	2,4 dichlorophenoxyacetic acid					Y			3	4	OSHA, TWA, 10mg/m3		1	1	0	0	Emits toxic fumes of Phosgene, Chlorides, Carbon Oxides	Dangerous fire hazard when exposed to heat or flame	Carcinogen, Irritant, neurological hazard	4A
351	dichloromethane	Y				Y				2	LD 357 mg/kg	no data		1		0	CO, CO2, HCL gas, Phosgene	Emits toxic fumes under fire condition	Irritant	4A
389	1,1,2,2 tetrachloroethane				Y				3	3	no data	more 235F	1	1	0	0	HCL(gas), Oxides of Carbon, Phosgene, Chloroacetylene	Moderate fire hazard	Carcinogen Highly toxic	4A
214	pentachlorophenol					Y			3		OSHA TWA 0.5mg/m3	190 F	0	0	0	0	Emits toxic fumes: Chlorine, Chlorinated Phenols		Corrosive, toxic,Poison, may be fatal when inhaled, flammable	4A
169	mercury oxycyanide			Y					3	3	OSHA TWA 0.05mg/m3	0		0	3	3	Termal decomposition products may include toxic and hazardous fumes of Mercury, Cyanides, NOx	In contact with acids releases flammable poisonous gas	Corrosive carcinogen,	5A

Reference Number	Name of chemical (formula)	Incompatibilities: Light Heat	Incompatibilities: H2O Moist	Incompatibilities: Acids	Incompatibilities: Bases	Incompatibilities: Oxides	Incompatibilities: Reduce	Other	Health Hazard: CERCLA	Health Hazard: NFPA	Health Hazard: Threshold Value or LD	Flammability: Flash Point	Flammability: CERCLA	Flammability: NFPA	Reactivity: CERCLA	Reactivity: NFPA	Hazardous Combustion or Decomposition Products	Fire Hazards Information	Additional Information	HWTF Storage Class
405	cyanogen bromide			Y		Y			3	3	no data	0		0	2	2	Bromides, HCN, Oxides of Nitrogen and Carbon	May burn but not ignite readily	Poison	5A
283	Gold cyanide stripper		Y	Y	Y	Y			4	4	OSHA TWA 5mg/m3			0	0	0	Thermal decomposition may yield very toxic fumes: HCN, Cyanogen, Carbon Oxides, Nitrogen Oxides		Poison	5A
76	ammonium perchlorate	Y		Y			Y			2	RAT LD 4200mg/kg			0		4	Ammonia	Easily ignited by friction		6A
375	methyl ethyl ketone peroxide	Y					Y			2	LD 500mg/kg	125.6F		2		3	Emits toxic fumes under fire, contact with other materials may cause a fire			6A
65	perchloric acid		Y	Y	Y		Y			3	RAT LD 1100 mg/kg			0		3	HCL		68 - 72% cold Perchloric Acid Acid behaves as a strong but non-oxidizing acid. It becomes strong oxidant and powerful dehydrator at elevated temperatures. It may be fairly readily dehydrated to the Anhydrous Acid, strong concentrated acids	6A

Reference Number	Name of chemical (formula)	Incompatibilities: Light Heat	Incompatibilities: H2O Moist	Incompatibilities: Acids	Incompatibilities: Bases	Incompatibilities: Oxides	Incompatibilities: Reduce	Other	Health Hazard: CERCLA	Health Hazard: NFPA	Health Hazard: Threshold Value or LD	Flammability: Flash Point	Flammability: CERCLA	Flammability: NFPA	Reactivity: CERCLA	Reactivity: NFPA	Hazardous Combustion or Decomposition Products	Fire Hazards Information	Additional Information	HWTF Storage Class
26	Hydrogen pyroxide						Y	Lithium Tetrahydroaluminate, Metals and alloys, Metal Oxides, Metal Salts, Nitric Acid + Thiourea, Nitric Acid, Nitrogenous Bases, Organics, Phenylselenoketones, Phosphorus, Phoshorus Oxide, K, Na, Tetrahydrothiopene, Sulfuric Acid, Tin (II) Chloride,	3	2	OSHA TWA 1ppm		0	0	3	3		Thermal decomposition realises flammable Oxygen and heat. Reaction becomes self-sustaining. Decomposition isaccelerated by agitation, Contact with rough surfaces, Alkalis, Finely divided metals,	Corrosive, highly toxic	6A
51	calcium hypochlorite			Y			Y			2	RAT LD 850mg/kg			0		2	HCL(gas)			6A
64	nitric acid		Y	Y	Y	Y	Y		3	3	OSHA TWA 2ppm		0	0	0	0	NOx		Contact with other materials may cause fire. Container may explode under fire condition.	6A
14	Ammonium Persulfate		Y				Y			0				3		0	Nitrogen Oxides, Sulfur Oxides	Contact with other materials may cause fire		6A
13	Aluminum Nitrate		Y	Y			Y		3	1	ACGIH TWA 2mg/m3		0	0	0	1	Nitrogen Oxides, Aluminum Oxides			6A

Reference Number	Name of chemical (formula)	Incompatibilities: Light Heat	H2O Moist	Acids	Bases	Oxides	Reduce	Other	Health Hazard: CERCLA	NFPA	Threshold Value or LD	Flammability: Flash Point	CERCLA	NFPA	Reactivity: CERCLA	NFPA	Hazardous Combustion or Decomposition Products	Fire Hazards Information	Additional Information	HWTF Storage Class
299	cyanogen	Y	Y	Y		Y			3	4	OSHA TWA 20 mg/m3		3	4	2	2	Under heat decomposes to HCN, NOx and Carbon Oxides	Very dangerous fire hazard when exposed to heat, flames or oxidizers	Irritant,highly toxic, aphyxiant	7A
308	phosphine					Y				3	OHSA PEL 400microgram/m3			4		1	POx	Very dangerous fire hazard by spontaneous chemical reaction	poison, highly toxic	7A
370	hydrogen sulfide							Chromic Anhydride, Copper, Copper Chromate, Copper Oxide, Dibismuth Dichromium Nonaoxide, Dichlorine Oxide, Fluorine, Heptasilver Nitrate Octaoxide, Iron Oxide, Lead (II) Hypochlorite, Lead (IV) Oxide, Manganese Dioxide, Mercury (I) Bromate, Metals,	3	3	OSHA TWA 10ppm		3	4	0	0	Sulfur Oxides		Inc:Metal Oxides, Nitric Acid, Nitrogen Trichloride, Nitrogen Trifluoride, Nitrogen Triiodide, Oxygen, Oxygen Difluoride, Perchloryl Fluoride, Phenyl Diazonium Chloride, Potassium Hydroxide, rust, Silver Bromate, Silver Fulminate, Silver Oxides, Soda Lime	7A

Reference Number	Name of chemical (formula)	Incompatibilities							Health Hazard			Flammability			Reactivity		Hazardous Combustion or Decomposition Products	Fire Hazards Information	Additional Information	HWTF Storage Class
		Light Heat	H2O Moist	Acids	Bases	Oxides	Reduce	Other	CERCLA	NFPA	Threshold Value or LD	Flash Point	CERCLA	NFPA	CERCLA	NFPA				
94	arsine gas cylinders	Y	Y			Y			3	4	OSHA TWA 0.05mg/m3		3	3	0	0		Flammable when exposed to flame	Poison, Carcinogen	7A
325	carbon disulfide	Y				Y			3	2	OSHA TWA 4ppm	(-22F)	3	3	0	0	Sulfur Oxides, Carbon Oxides	Dangerous fire hazard when exposed to heat, flame, spark, friction or oxidizers	Chronic exposure may cause neurologic effects	7A
304	nitrogen oxide						Y	Nitrogen Trichloride, K, Potassium Sulfide, Rubidium Carbide, Phosphorus Hydride Nitride, Sodium Monoxide, Sulfur, Trichloroethane, , Trichloroethylene, Uranium, Uranium Dicarbide, Vinyl Chloride	4	4	OSHA TWA 1ppm		0	0	3	3	None reported other than possible unburned vapors		Mixture with fuel may explode, container may explode in heat of fire, poison, may be fatal when inhaled.	7A
	Phosgene			Y		Y			3	3	0.1ppm		0	0	1	1		non-flammable		7A

Reference Number	Name of chemical (formula)	Incompatibilities							Health Hazard			Flammability			Reactivity		Hazardous Combustion or Decomposition Products	Fire Hazards Information	Additional Information	HWTF Storage Class
		Light Heat	H2O Moist	Acids	Bases	Oxides	Reduce	Other	CERCLA	NFPA	Threshold Value or LD	Flash Point	CERCLA	NFPA	CERCLA	NFPA				
300	fluorine	Y	Y					Fluorocarboxylic Acid, Graphite, Chloroform, Iodoform,Perfluorocy clobutane, silver cyanide, Nitric Acid, Sulfur Dioxide, Cacbon Monoxide, Sodium Acetate, Sodium Bromate, Cyanoguadinine, Perchloric Acid, Potassium Chlorate, Potassium Hydroxide, Acetonitril		4	OSHA TWA 0.1ppm			0		3	Heated produces highly toxic fumes		Ignition or violent reaction on contact with: Acetylene, ceramic materials, covalent halides (Chromyl Chlorides, PCl5, BoCl3, SiCl4), metal Acetylides, metal hydrides, poison gas, corrosive, powerful oxidizer	7A

TABLE C-3
HAZMAN RESULTS SORTED BY ACTIVITY FOR DSB

PRELIMINARY HAZARD/RISK ANALYSIS RECORD BY ACTIVITY FOR HAZARDOUS WASTE STORAGE

ACTIVITY NUMBER: HW1A

ACTIVITY NAME: HW CAUSTICS (GROUP 1A)

ACTIVITY DESCRIPTION: STORAGE OF CAUSTICS IN OPEN AREA (GROUP 1A)

R--F--C	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
3 III B	SODIUM AZIDE EXPLODES DUE TO SEVERE SHOCK, HEAT OR FRICTION.	EXPLOSION AND RELEASE OF TOXIC GAS (NOX). (C;C;B;C)	FIRE PROTECTION SYSTEM.	DEVELOP AND ENFORCE STRICT POLICY NOT TO STORE EXPLOSIVES OR SHOCK SENSITIVE MATERIALS IN THIS BUILDING.
3 III B	FORKLIFT ACCIDENT OR FREEZING CAUSING SIMULTANEOUS SPILL OF CAUSTC MATERIAL AND INCOMPATIBLE MATERIAL(E.G., H2SO4(1B), NITROBENZENE(4A), PERCHLORIC ACID(6A), METAL CYANIDE(5A),LITHIUM HYDRIDE(2A)) DUE TO MISLABELING.	POTENTIAL FIRE, EXPLOSION, HYDROGEN GAS PRODUCTION AND HEAVY METAL FUME GENERATION. WORKER INJURY/EXPOSURE. (C;C;B;C)	FIRE SUPPRESSION SYSTEM.	ENCLOSE THE HWTF STORAGE BUILDING TO PREVENT FREEZING.
3 III B	EXTERNAL FIRE	RELEASE OF MODERATELY TOXIC GASES. WORKER INJURY. (C;C;B;C)	FIRE PROTECTION SYSTEM.	NONE
4 II D	SPILL OF A SINGLE CAUSTIC WASTE DRUM CAUSED BY HUMAN ERROR, FORKLIFT ACCIDENT OR FREEZING.	MINOR WORKER EXPOSURE. (D;D;D;D)	NONE	NONE

PRELIMINARY HAZARD/RISK ANALYSIS RECORD BY ACTIVITY FOR HAZARDOUS WASTE STORAGE

ACTIVITY NUMBER: HW1B

ACTIVITY NAME: HW ACIDS (GROUP 1B)

ACTIVITY DESCRIPTION: STORAGE OF ACIDS IN OPEN STORAGE AREA (GROUP 1B)

R--F--C	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
2 III B	FORKLIFT ACCIDENT OR FREEZING CAUSING SIMULTANEOUS SPILL OF ACID MATERIAL AND INCOMPATIBLE MATERIAL (E.G., NAOH(1A), NITROBENZENE(4A), HYDROGEN PEROXIDE(6A), METAL CYANIDE(5A), LITHIUM HYDRIDE(2A)) DUE TO MISLABELING.	POTENTIAL FIRE, EXPLOSION, HYDROGEN GAS PRODUCTION AND TOXIC GAS GENERATION (E.G., HCN). WORKER INJURY/EXPOSURE. (B;B;B;C)	FIRE SUPPRESSION SYSTEM.	(1) VERIFY DRUM CONTENTS AND LABELING AT WASTE GENERATORS SITE, (2) DEVELOP LAB WIDE PROCEDURE (LAB ES&H MANUAL) FOR WASTE IDENTIFICATION AND LABELING OF WASTE CONTAINERS, (3) STORE WASTE IN ENCLOSED BUILDING TO PREVENT FREEZING.
3 III B	SPILL OF A SINGLE ACID WASTE DRUM DUE TO CORROSION, FREEZING OR CRANE ACCIDENTS.	TOXIC GAS RELEASE (E.G., HF OR HCL). WORKER EXPOSURE AND INJURY. (C;C;B;D)	NONE	(1) VERIFY CONSTRUCTION MATERIAL OF STORAGE CONTAINER AND THE SUMP SYSTEM, (2) FREQUENT INSPECTIONS, (3) ENCLOSE THE HWTF STORAGE BUILDING.
3 III B	EXTERNAL FIRE INIYTIATED WITHIN THE BUILDING.	RELEASE OF MODERATELY TOXIC GASES (E.G.,HF). WORKER INJURY. (C;C;B;C)	FIRE PROTECTION SYSTEM.	STORE WASTE IN ENCLOSED BUILDING TO PROVIDE SCRUBBING OF RELEASE AND MINIMIZE PUBLIC AND COLOCATED WORKER EXPOSURE.

PRELIMINARY HAZARD/RISK ANALYSIS RECORD BY ACTIVITY FOR HAZARDOUS WASTE STORAGE

ACTIVITY NUMBER: HW2A

ACTIVITY NAME: HW REACTIVES (GROUP 2A)

ACTIVITY DESCRIPTION: STORAGE OF REACTIVES IN AN OPEN STORAGE AREA (GROUP 2A)

R--F--C	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
2 II B	FORKLIFT ACCIDENT OR FREEZING OF WASTE CAUSES SPILL OF WATER REACTIVE WASTE WITH WATER PRESENT IN THE AREA.	HYDROGEN EVOLUTION, POTENTIAL FIRE/EXPLOSION. POSSIBLE RELEASE OF TOXIC METAL FUMES. SEVERE WORKER INJURY. (C;B;B;C)	NONE	(1) RESTRICT USE OF WATER IN THE REACTIVES STORAGE AREA, (2) ENCLOSE THE BUILDING FOR WATER CONTROL AND FIRE SUPPRESSION EFFICIENCY, (3) INSTALL HVAC AND SCRUBBER..
2 III B	ACCIDENT DUE TO HUMAN ERROR CAUSES SIMULTANEOUS SPILL OF WATER REACTIVE WASTE AND INCOMPATIBLE WASTE DUE TO MISLABELING. (E.G., REACTIVE WASTE MIXED WITH, SULFURIC ACID(1B), NAOH(1A), PERCHLORIC ACID(6A) OR TRICHLORA ETHYLENE(4A))	PRODUCTION OF HYDROGEN GAS, POTENTIAL FIRE AND/OR EXPLOSION AND PRODUCTION OF TOXIC FUMES (E.G., HCN). SEVERE WORKER INJURY. (B;B;B;D)	NONE	(1) VERIFY DRUM CONTENTS AND LABELING AT WASTE GENERATORS SITE, (2) DEVELOP LAB WIDE PROCEDURE (LAB ES&H MANUAL) FOR WASTE IDENTIFICATION AND LABELING OF WASTE CONTAINERS.
3 III B	WATER INTRUSION INTO THE STORAGE DRUM (THROUGH EXISTING BREACH IN DRUM) DUE TO HUMAN ERROR OR RUPTURE OF WATER LINE IN THIS AREA.	RUPTURE OF DRUM DUE TO HYDROGEN EVOLUTION, POTENTIAL FIRE/EXPLOSION. POSSIBLE RELEASE OF TOXIC METAL FUMES. (C;C;B;D)	NONE	(1) RESTRICT USE OF WATER IN THE REACTIVES STORAGE AREA, (2) ENCLOSE THE BUILDING FOR WATER CONTROL AND FIRE SUPPRESSION EFFICIENCY.

PRELIMINARY HAZARD/RISK ANALYSIS RECORD BY ACTIVITY FOR HAZARDOUS WASTE STORAGE

ACTIVITY NUMBER: HW4A

ACTIVITY NAME: HW FLAMMABLE STORAGE (GROUP 4A)

ACTIVITY DESCRIPTION: STORAGE OF FLAMMABLES IN AN OPEN STORAGE FACILITY

R--F--C	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
2 III A	PICRIC ACID DROPPED OR JARRED.	DETONATION, MAJOR FIRE IN HWTF STORAGE AREA, MULTIPLE TOXIC GASES (E.G., PHOSGENE, HCN, ETC...) RELEASED DIRECTLY TO ENVIRONMENT, WORKER FATALITY, PUBLIC EXPOSURE. (A;A;A;A)	NONE	DEVELOP AND ENFORCE POLICY NOT TO STORE EXPLOSIVES OR SHOCK SENSITIVE MATERIALS IN THIS BUILDING.
2 III A	SPILL OF LOW FLASH POINT CHEMICALS (ACETHALHENYE(-38F), FURAN (-32F), ANHYDROUS ETHYL ETHER(-49F)) DUE TO FORKLIFT ACCIDENT, OR CORROSION. FIRE SUPPRESSION SYSTEM INADEQUATE.	IGNITION OF FLAMMABLE VAPORS LEADS TO A MAJOR FIRE AND EXPLOSION (E.G., NITROMETHANE) IN THE STORAGE AREA. RELEASE OF MULTIPLE TOXIC GASES (E.G., PHOSGENE) TO ATMOSPHERE. (B;B;A;A)	FIRE SUPPRESSION SYSTEM.	(1) TREAT HIGHLY FLAMMABLE MATERIALS ON AN PRIORITY BASIS, DO NOT ALLOW ACCUMULATIONS OF LARGE INVENTORIES, (2) CONSIDER SPECIALLY DESIGNED STORAGE CONFIGURATION FOR THE MOST HAZARDOUS (LOW FLASH POINT) FLAMMABLE WASTES, (3) CONSIDER ENCLOSING THE BUILDING TO INCREASE THE EFFICIENCY OF THE FIRE SUPPRESSION SYSTEM AND INSTALL GAS DETECTOR AND ALARM.
2 III A	FORKLIFT ACCIDENT CAUSING DUAL SPILL OF INCOMPATIBLE FLAMMABLE MATERIALS ROUTINELY STORED IN THE SAME AREA. (E.G., NITROMETHANE WITH ACETONE)	RELEASE OF TOXIC GASES (E.G., PHOSGENE) AND POTENTIAL FIRE. POTENTIAL WORKER FATALITY. (B;B;A;B)	NONE	(1) CONSIDER ENCLOSING THE BUILDING TO REDUCE TOXIC GAS EXPOSURE TO THE PUBLIC AND COLOCATED WORKER, (2) STORE INCOMPATIBLE FLAMMABLE MATERIALS IN SEPARATE LOCATIONS WITHIN THE FLAMMABLE STORAGE AREA, (3) INSTALL SCRUBBING SYSTEM.
2 III A	FORKLIFT ACCIDENT CAUSING DUAL SPILL	RELEASE OF TOXIC GASES AND POTENTIAL	NONE	(1) CONSIDER ENCLOSING THE

PRELIMINARY HAZARD/RISK ANALYSIS RECORD BY ACTIVITY FOR HAZARDOUS WASTE STORAGE

ACTIVITY NUMBER: HW4A

ACTIVITY NAME: HW FLAMMABLE STORAGE (GROUP 4A)

ACTIVITY DESCRIPTION: STORAGE OF FLAMMABLES IN AN OPEN STORAGE FACILITY

R--F--C	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
	OF INCOMPATIBLE MATERIALS DUE TO MISLABELING OF WASTE DRUM. (E.G., FLAMMABLE WASTE MIXED WITH; (1) NAOH(1A), (2) H2SO4(1B), (3) LITHIUM HYDRIDE(2A), (4) NITRIC ACID(6A), (5) CHLOROBENZENE.)	FIRE AND GENERATION OF TOXIC GASES (E.G., PHOSGENE). POTENTIAL WORKER AND COLOCATED WORKER FATALITY. (B;B;A;B)		BUILDING TO REDUCE TOXIC GAS EXPOSURE TO THE PUBLIC AND COLOCATED WORKER, (2) INSTALL SCRUBBING SYSTEM, (3) VERIFY DRUM CONTENTS AND LABELING AT WASTE GENERATORS SITE, (4) DEVELOP LAB WIDE PROCEDURE (LAB ES&H MANUAL) FOR WASTE IDENTIFICATION AND LABELING OF WASTE CONTAINERS.
3 II C	FREEZING TEMPERATURES CAUSES RUPTURE OF DRUM AND SPILL OF FLAMMABLE MATERIALS.	WORKER EXPOSED TO TOXIC FUMES. (D;D;C;D)	NONE	NONE
3 II C	SPILL OF LOW FLASH POINT CHEMICALS (ACETHALHENYE(-38F), FURAN (-32F), ANHYDROUS ETHYL ETHER (-49F)) DUE TO FORKLIFT ACCIDENT OR CORROSION. FIRE SUPPRESSION SYSTEM OPERATIONAL.	IGNITION OF FLAMMABLE VAPORS LEADS TO CONTAINED FIRE IN THE STORAGE AREA. (D;D;C;D)	FIRE SUPPRESSION SYSTEM.	NONE
3 II C	SPILL OF LOW FLASH POINT CHEMICALS (ACETHALHENYE(-38F), FURAN (-32F), ANHYDROUS ETHYL ETHER (-49F)) DUE TO FORKLIFT ACCIDENT OR CORROSION.	WORKER EXPOSED TO CHEMICAL FUMES. (D;D;C;D)	NONE	NONE

PRELIMINARY HAZARD/RISK ANALYSIS RECORD BY ACTIVITY FOR HAZARDOUS WASTE STORAGE

ACTIVITY NUMBER: HW5A

ACTIVITY NAME: HWTF CYANIDES AND SULFIDES STORAGE

ACTIVITY DESCRIPTION: STORAGE OF CYANIDES AND SULFIDES IN THE HWTF STORAGE BUILDING

R--F--C	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
2 II B	MISLABELED CYANIDE DRUM IS PLACED IN THE OPEN STORAGE AREA. FREEZES CAUSING SIMULTANEOUS SPILL OF CYANIDES AND NONCOMPATIBLE WASTE, SUCH AS ACIDS.	RELEASE OF TOXIC GASES (E.G., HCN AND CYANOGEN) AND POSSIBLE EXPLOSION AND FIRE. SEVERE WORKER INJURY. (C;B;B;C)	NONE	(1) CONSIDER ENCLOSING THE HWTF STORAGE BUILDING AND PROVIDING HVAC, (2) INSTALL A SCRUBBER SYSTEM, (3) PROVIDE HCN ANALYZER AND ALARM.
2 III B	ACCIDENT CAUSES SIMULTANEOUS SPILL OF CYANIDE AND OTHER NONCOMPATIBLE WASTE (E.G., H_2SO_4(1B), OR PERCHLORIC ACID(6A)) DUE TO MISLABELING.	RELEASE OF TOXIC GASES (E.G., HCN AND CYANOGEN) AND POSSIBLE EXPLOSION AND FIRE. SEVERE WORKER INJURY. (B;B;B;C)	SEPARATE STORAGE BUILDING FOR HAZARDOUS CYANIDE WASTE.	(1) CONSIDER ENCLOSING THE HWTF STORAGE BUILDING AND PROVIDING HVAC, (2) INSTALL A SCRUBBER SYSTEM, (3) PROVIDE HCN ANALYZER AND ALARM, (4) VERIFY DRUM CONTENTS AND LABELING AT WASTE GENERATORS SITE, (5) DEVELOP LAB WIDE PROCEDURE (LAB ES&H MANUAL) FOR WASTE IDENTIFICATION AND LABELING OF WASTE CONTAINERS.
2 III B	MERCURY OXYCYANIDE DETONATES DUE TO HEATING, FROM SHOCK OR FRICTION (E.G., FORKLIFT ACCIDENT).	SMALL EXPLOSION LEADING TO TOXIC GAS (E.G., MERCURY FUMES, CYANIDE AND NOX) RELEASE. SEVERE WORKER INJURY DUE TO TOXIC GAS EXPOSURE. (B;B;B;C)	NONE	DEVELOP AND ENFORCE POLICY NOT TO STORE EXPLOSIVES OR SHOCK SENSITIVE MATERIALS IN THIS BUILDING.
3 III B	EXTERNAL FIRE CAUSES CYANIDE COMPOUNDS (E.G., CYANOGEN BROMIDE) TO DECOMPOSE.	THERMAL DECOMPOSITION OF CYANIDE LEADING TO TOXIC GAS RELEASE (E.G., HCN AND CYANOGEN). (D;D;B;C)	NONE	PROVIDE HCN ANALYZER AND ALARM.
4 II D	SPILL OF CYANIDE DUE TO YARD FORKLIFT ACCIDENT OR CORROSION.	CONTAMINATION OF THE STORAGE AREA, MINOR WORKER EXPOSURE. NO TOXIC GAS RELEASED TO LOW VOLATILITY. (D;D;D;D)	NONE	NONE

PRELIMINARY HAZARD/RISK ANALYSIS RECORD BY ACTIVITY FOR HAZARDOUS WASTE STORAGE

ACTIVITY NUMBER: HW5A

ACTIVITY NAME: HWTF CYANIDES AND SULFIDES STORAGE

ACTIVITY DESCRIPTION: STORAGE OF CYANIDES AND SULFIDES IN THE HWTF STORAGE BUILDING

R--F--C	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS

PRELIMINARY HAZARD/RISK ANALYSIS RECORD BY ACTIVITY FOR HAZARDOUS WASTE STORAGE

ACTIVITY NUMBER: HW6A

ACTIVITY NAME: HW OXIDIZERS (GROUP 6A)

ACTIVITY DESCRIPTION: STORAGE OF OXIDIZERS IN OPEN STORAGE AREA

R--F--C	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
2 II B	AMMONIUM PERCHLORATE OR METHYL ETHYL KETONE PEROXIDE (MEKP), DRIED OVER TIME, SUBJECTED TO SHOCK, FRICTION OR SUNLIGHT.	EXPLOSION OR FIRE IN STORAGE AREA, RELEASE OF TOXIC GASES, WORKER INJURY. (C;C;B;D)	(1) AMMONIUM PERCHLORATE IS ONLY ACCEPTED IN AN OXIDE (LIQUID) FORM, (2) FIRE SUPPRESSION SYSTEM.	(1) DEVELOP AND ENFORCE STRICT ACCEPTANCE CRITERIA FOR SENSITIVE OXIDIZERS (E.G., DILUTED FORM, FREQUENT INSPECTION, WETTED MATERIAL), (2) CONSIDER STORAGE OF HIGHLY SENSITIVE OXIDIZERS IN A SEPARATE BUILDING IN A REMOTE LOCATION.
2 III A	FORKLIFT ACCIDENT OR FREEZING CAUSING DUAL SPILL OF INCOMPATIBLE MATERIALS DUE TO MISLABELING OF WASTE DRUM. (E.G., OXIDIZER WASTE MIXED WITH; (1) NAOH(1A), (2) ACETIC ACID(1B), (3) SODIUM(2A), (4) ORGANICS SUCH AS CHLORO BENZENE(4A), (5) GOLD CYANIDE(5A))	RELEASE OF TOXIC GASES, POTENTIAL EXPLOSION AND POTENTIAL FIRE. FIRE INVOLVING CHLORA BENZENE COULD GENERATE PHOSGENE GAS. POTENTIAL WORKER FATALITY. (B;A;A;B)	FIRE SUPPRESSION SYSTEM.	(1) VERIFY DRUM CONTENTS AND LABELING AT WASTE GENERATORS SITE, (2) DEVELOP LAB WIDE PROCEDURE (LAB ES&H MANUAL) FOR WASTE IDENTIFICATION AND LABELING OF WASTE CONTAINERS, (3) ENCLOSE THE HWTF STORAGE BUILDING AND INSTALL SCRUBBER SYSTEM.
4 II D	SPILL OF OXIDIZERS DUE TO FREEZING, YARD FORKLIFT OR OVERHEAD CRANE ACCIDENTS.	LOW LEVEL TOXIC SPILL. WORKER EXPOSURE. (D;D;D;D)	NONE	NONE

PRELIMINARY HAZARD/RISK ANALYSIS RECORD BY ACTIVITY FOR HAZARDOUS WASTE STORAGE

ACTIVITY NUMBER: HW7A

ACTIVITY NAME: HW GASES (GROUP 7A)

ACTIVITY DESCRIPTION: GASES STORED IN OPEN STORAGE AREA (GROUP 7A)

R--F--C	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
1 II A	BREACH OF LEGACY CYLINDER OF DOUBTFUL INTEGRITY DURING STORAGE.	RELEASE OF HIGHLY TOXIC GASES (PHOSPHINE, PHOSGEN, ARSINE, AND OTHERS). WORKER FATALITY, POTENTIAL COLOCATED WORKER AND PUBLIC EXPOSURE. (A;A;A;D)	NONE	(1) DO NOT STORE LEGACY CYLINDERS IN HWTF AREA, (2) PROCESS LEGACY CYLINDERS WITHOUT INTERMEDIATE STORAGE, (3) PROVIDE SECONDARY CONTAINMENT FOR THE CYLINDERS, (4) CONSIDER ENCLOSING THE HWTF STORAGE AND PROVIDING HVAC AND SCRUBBER.
2 III A	BREACH OF CYLINDER (NON-LEGACY) DUE TO ACCIDENTAL CAUSES (E.G., CYLINDER DROPPED AND REGULATOR LINE BREAKS).	RELEASE OF HIGHLY TOXIC GASES (PHOSPHINE, PHOSGEN, ARSINE, AND OTHERS). WORKER FATALITY, POTENTIAL COLOCATED WORKER AND PUBLIC EXPOSURE. (A;A;A;D)	NONE	(1) TRANSPORT AND STORE CYLINDERS SECURELY, (2) CONSIDER SECONDARY CONTAINMENT FOR MOST HAZARDOUS CYLINDERS, (3) GAS CYLINDERS TO BE PROCESSED WITH HIGH PRIORITY, (4) WORK IN THIS AREA TO BE PERFORMED WITH PROTECTION (I.E., WEAR SCBA, OPERATE UNDER THE BUDDY SYSTEM), (5) PROTECTIVE CAP FOR CYLINDER REGULATORS SHOULD BE IN PLACE AT ALL TIMES, (6) CONSIDER STORING GAS CYLINDERS IN ENCLOSED ROOM IN AN INCLOSED BUILDING.
2 III A	EXTERNAL FIRE (INITIATED WITHIN THE BUILDING).	PRESSURIZATION AND RUPTURE OF GAS CYLINDERS. HIGHLY TOXIC GAS RELEASE AND POTENTIAL CYLINDER MISSILE GENERATION. (A;A;A;A)	FIRE PROTECTION SYSTEM, FUSIBLE PRESSURE RELIEF.	(1) INITIATE FIRE SUPPRESSION SPRINKLERS GIVEN FIRE IN ADJACENT AREAS, (2) ENCLOSE THE HW STORAGE AREA AND STORE GAS CYLINDERS IN AN ENCLOSED AREA.
3 III B	BREACH OF CYLINDER	RELEASE OF	NONE	(1) TRANSPORT AND

PRELIMINARY HAZARD/RISK ANALYSIS RECORD BY ACTIVITY FOR HAZARDOUS WASTE STORAGE

ACTIVITY NUMBER: HW7A

ACTIVITY NAME: HW GASES (GROUP 7A)

ACTIVITY DESCRIPTION: GASES STORED IN OPEN STORAGE AREA (GROUP 7A)

R--F--C	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
	(NON-LEGACY) DUE TO ACCIDENTAL CAUSES (E.G., CYLINDER DROPPED AND REGULATOR LINE BREAKS).	MODERATELY TOXIC GASES (H2S, NO2, AND OTHERS). WORKER EXPOSURE. (C;C;B;D)		STORE CYLINDERS SECURELY, (2) CONSIDER SECONDARY CONTAINMENT FOR MOST HAZARDOUS CYLINDERS, (3) GAS CYLINDERS TO BE PROCESSED WITH HIGH PRIORITY, (4) WORK IN THIS AREA TO BE PERFORMED WITH PROTECTION (I.E., WEAR SCBA, OPERATE UNDER THE BUDDY SYSTEM), (5) PROTECTIVE CAP FOR CYLINDER REGULATORS SHOULD BE IN PLACE AT ALL TIMES, (6) CONSIDER STORING GAS CYLINDERS IN ENCLOSED ROOM IN AN INCLOSED BUILDING.
3 III B	EXTERNAL FIRE.	PRESSURIZATION AND RUPTURE OF GAS CYLINDERS. MODERATELY TOXIC GAS RELEASE AND POTENTIAL CYLINDER MISSILE GENERATION. (C;C;B;C)	FIRE PROTECTION SYSTEM, FUSIBLE PRESSURE RELIEF.	(1) INITIATE FIRE SUPPRESSION SPRINKLERS GIVEN FIRE IN ADJACENT AREAS, (2)STORE GAS CYLINDERS IN AN ENCLOSED AREA.

PRELIMINARY HAZARD/RISK ANALYSIS RECORD BY ACTIVITY FOR HAZARDOUS WASTE STORAGE

ACTIVITY NUMBER: HW8

ACTIVITY NAME: HW PCB (GROUP 8)

ACTIVITY DESCRIPTION: STORAGE OF PCB WASTES IN AN OPEN AREA (GROUP 8)

R--F--C	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
2 III B	MISLABELED DRUM RESULTS IN PCB DRUM BEING STORED NEAR FLAMMABLE WASTE. ACCIDENTAL BREACH OF THE CONTAINERS LEADS TO FIRE AND BURNING OF PCB WASTE.	BURNING OF PCB WASTE. DISPERSION OF PCB WASTE TO THE ENVIRONMENT. (B;B;B;B).	FIRE PROTECTION SYSTEM.	(1) VERIFY DRUM CONTENTS AND LABELING AT WASTE GENERATORS SITE, (2) DEVELOP LAB WIDE PROCEDURE (LAB ES&H MANUAL) FOR WASTE IDENTIFICATION AND LABELING OF WASTE CONTAINERS.
2 III B	SPILL OF PCB WASTE DRUM DUE TO FORKLIFT ACCIDENT, RELEASE TO THE SUMP.	POTENTIAL RELEASE TO THE ENVIRONMENT THROUGH THE SUMP SYSTEM. ONSITE CONTAMINATION. (D;D;D;B)	SUMP SYSTEM.	(1) INSTALL PROCEDURES TO DETECT SUMP LEVELS, (2) TEST SUMP CONTENTS BEFORE DISCHARGE.
3 IV A	LARGE EXTERNAL FIRE.	POTENTIAL SPILL AND BURNING OF PCB WASTE. DISPERSION OF PCB WASTE TO THE ENVIRONMENT. (B;B;B;A)	FIRE PROTECTION SYSTEM.	CONSIDER STORING PCB WASTE AWAY FROM FLAMMABLES.
4 II D	SPILL OF PCB WASTE DRUM DUE TO FORKLIFT ACCIDENT.	CONTAMINATION OF THE STORAGE AREA. (D;D;D;D)	SUMP SYSTEM.	NONE

PRELIMINARY HAZARD/RISK ANALYSIS RECORD BY ACTIVITY FOR HAZARDOUS WASTE STORAGE

ACTIVITY NUMBER: HW9

ACTIVITY NAME: HW NONREGULATED WASTES (GROUP 9)

ACTIVITY DESCRIPTION: STORAGE OF NONREGULATED WASTES IN AN OPEN STORAGE AREA (GROUP 9)

R--F--C	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
2 III A	SPILL (DUE TO FREEZING OR FORKLIFT ACCIDENT) OF INCOMPATIBLE WASTES ROUTINELY STORED IN NONREGULATED AREA (E.G., MISLABLED, TEMPORARY STORAGE, OR DO NOT BELONG IN OTHER DEFINED REGULATED AREAS)	FIRE AND RELEASE OF TOXIC GASES (E.G., HF). (B;B;A;B)	FIRE PROTECTION SYSTEM.	(1) CONSIDER ELIMINATING THIS AREA, (2) CLASSIFY AND STORE ALL NONREGULATED WASTES IN COMPATIBLE REGULATED AREAS, (3) ENCLOSE THE HAZARDOUS WASTE STORAGE BUILDING.
3 II C	SPILL OF AMMONIUM BIFLORIDE DUE TO FORKLIFT ACCIDENT OR FREEZING.	POTENTIAL WORKER EXPOSURE. (D;C;C;D)	NONE	CONSIDER RELOCATION OF AMMONIUM BIFLORIDE TO ONE OF THE REGULATED AREAS, SUCH AS CAUSTIC(1A).

PRELIMINARY HAZARD/RISK ANALYSIS RECORD BY ACTIVITY FOR HAZARDOUS WASTE STORAGE

ACTIVITY NUMBER: HWG

ACTIVITY NAME: HW GLOBAL (INTERNAL AND EXTERNAL) EVENTS

ACTIVITY DESCRIPTION: HW GLOBAL (INTERNAL AND EXTERNAL) EVENTS

R--F--C	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
1 II A	LOW INTENSITY SEISMIC EVENT WITH HORIZONTAL ACCELERATION OF 0.1 G.	EXPLOSION OF SHOCK SENSITIVE MATERIALS (E.G., PICRIC ACID, NITRO METHANE, SODIUM AZIDE). STRUCTURAL DAMAGE TO BUILDING, FIRE AND RELEASE OF TOXIC GASES. (A;A;A;A)	NONE	(1) DEVELOP AND ENFORCE STRICT POLICY NOT TO STORE EXPLOSIVES OR SHOCK SENSITIVE MATERIALS IN THE BUILDING, (2) CONSIDER STORAGE OF SHOCK SENSITIVE IN A SEPARATE BUILDING IN A REMOTE LOCATION.
2 I C	HIGH WINDS	WASTE DRUMS TIP OVER CAUSING SPILL AND RELEASE OF TOXIC GASES. (C;C;C;C)	NONE	ENCLOSE THE HW STORAGE BUILDING.
2 II B	CRACKS IN STORAGE CONTAINERS PROPAGATED BY RAIN OR SNOW (BLOWN ONTO DRUMS) FREEZES OVER.	RUPTURE OF WASTE CONTAINER, SPILL WITH RELEASE OF TOXIC GASES. (C;C;B;C)	NONE	ENCLOSE THE HW STORAGE BUILDING.
2 II B	ACCIDENTS DURING TRANSPORTATION OF WASTE WITHIN THE HW STORAGE AREA (FORKLIFTS OR MANUAL).	SPILL OF FLAMMABLES, REACTIVES, OR INCOMPATIBLE WASTES LEADING TO TOXIC GAS RELEASE/ FIRE. WORKER INJURY. (C;B;B;B)	NONE	(1) ENCLOSE THE HW STORAGE AREA, (2) MAINTAIN PHYSICAL SEPARATION OF INCOMPATIBLE WASTES DURING TRANSPORTATION, (3) LIMIT SIMULTANEOUS OPERATION OF MULTIPLE FORKLIFTS.
2 III A	MEDIUM INTENSITY SEISMIC EVENT WITH HORIZONTAL ACCELERATION OF 0.17 G.	MIXING OF INCOMPATIBLE WASTES STORED IN ADJACENT AREAS. VIOLENT REACTIONS, POTENTIAL FIRE, AND RELEASE OF TOXIC FUMES (E.G., PHOSGENE, HCN). NOTE: SHOCK SENSITIVE MATERIAL NOT CONSIDERED IN THIS SCENARIO. (B;B;A;B)	NONE	(1) REVIEW SEISMIC DESIGN CRITERIA, (2) ENSURE THAT INCOMPATIBLE WASTES ARE NOT STORED IN ADJACENT AREAS. SEE POTENTIAL HWRSF FLOORPLAN DEVELOPED BY PHA TEAM, (3) MINIMIZE STORAGE TIME OF MOST FLAMMABLE/ TOXIC MATERIALS, (4) ENCLOSE THE HW STORAGE AREA.
2 III A	ACCIDENT DURING	SPILL LEADING TO THE	NONE	(1) CONSIDER ROAD

PRELIMINARY HAZARD/RISK ANALYSIS RECORD BY ACTIVITY FOR HAZARDOUS WASTE STORAGE

ACTIVITY NUMBER: HWG

ACTIVITY NAME: HW GLOBAL (INTERNAL AND EXTERNAL) EVENTS

ACTIVITY DESCRIPTION: HW GLOBAL (INTERNAL AND EXTERNAL) EVENTS

R--F--C	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
	TRANSPORTATION OF WASTE (TOXIC GAS CYLINDERS OR INCOMPATIBLE WASTE DRUMS) FROM HW STORAGE TO CAI OR OTHER FACILITY.	UNMITIGATED RELEASE OF TOXIC GASES. PUBLIC EXPOSURE. (A;A;A;A)		CLOSURE WHILE TRANSPORTING THE MOST HAZARDOUS MATERIALS BETWEEN LAB AREAS, (2) REVIEW PROCEDURES FOR SECURING WASTE DRUMS DURING TRANSPORTATION, (3) DO NOT TRANSPORT INCOMPATIBLE WASTE DRUMS TOGETHER.
3 I D	LIGHTNING STRIKES STORAGE BUILDING.	NOT A HAZARD. (D;D;D;D)	EQUIPPED WITH LIGHTNING RODS.	NONE
3 II C	INADVERTENT OPERATION OF THE FIRE SPRINKLERS OR RUPTURE OF WATER PIPING DUE TO CORROSION OR FREEZING (INCLUDING WATER FROM EXTERNAL SOURCES).	WATER INTRUSION INTO REACTIVE WASTE STORAGE DRUMS, GENERATION OF HYDROGEN GAS. (D;D;D;C)	NONE	(1) INSTALL SUMP HIGH LEVEL ALARMS, (2) PERIODIC WALKDOWN OF THE FACILITY.
3 IV A	HIGH INTENSITY SEISMIC EVENT WITH HORIZONTAL ACCELERATION OF 0.3 G OR GREATER.	STRUCTURAL COLLAPSE OF BUILDING, BREACH OF MULTIPLE DRUMS, MAJOR FIRE, RELEASE OF TOXIC GAS TO ENVIRONMENT. (A;A;A;A)	NONE	(1) REVIEW SEISMIC DESIGN CRITERIA, (2) MINIMIZE STORAGE TIME OF MOST FLAMMABLE/ TOXIC MATERIALS.
3 IV A	EXTERNAL FIRE	FIRE PENETRATES THE HWRSF, MAJOR FIRE RELEASES TOXIC GAS TO THE ENVIRONMENT. (A;A;A;A)	(1) AREA SURROUNDING THE HWRSF IS CLEARED OF COMBUSTIBLE MATERIAL, (2) BUILDING IS DESIGNED TO RETARD FIRE.	NONE

TABLE C-4
HAZMAN RESULTS SORTED BY RISK RANK FOR DSB

HAZARD ANALYSIS REPORT BY RISK

R---F---C	ACT/FAC	ACTIVITY NAME	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
1 II A	HW7A /HWSF	HW GASES (GROUP 7A)	BREACH OF LEGACY CYLINDER OF DOUBTFUL INTEGRITY DURING STORAGE.	RELEASE OF HIGHLY TOXIC GASES (PHOSPHINE, PHOSGEN, ARSINE, AND OTHERS). WORKER FATALITY, POTENTIAL COLOCATED WORKER AND PUBLIC EXPOSURE. (A;A;A;D)	NONE	(1) DO NOT STORE LEGACY CYLINDERS IN HWTF AREA, (2) PROCESS LEGACY CYLINDERS WITHOUT INTERMEDIATE STORAGE, (3) PROVIDE SECONDARY CONTAINMENT FOR THE CYLINDERS, (4) CONSIDER ENCLOSING THE HWTF STORAGE AND PROVIDING HVAC AND SCRUBBER.
1 II A	HWG /HWSF	HW GLOBAL (INTERNAL AND EXTERNAL) EVENTS	LOW INTENSITY SEISMIC EVENT WITH HORIZONTAL ACCELERATION OF 0.1 G.	EXPLOSION OF SHOCK SENSITIVE MATERIALS (E.G., PICRIC ACID, NITRO METHANE, SODIUM AZIDE). STRUCTURAL DAMAGE TO BUILDING, FIRE AND RELEASE OF TOXIC GASES. (A;A;A;A)	NONE	(1) DEVELOP AND ENFORCE STRICT POLICY NOT TO STORE EXPLOSIVES OR SHOCK SENSITIVE MATERIALS IN THE BUILDING, (2) CONSIDER STORAGE OF SHOCK SENSITIVE IN A SEPARATE BUILDING IN A REMOTE LOCATION.
2 I C	HWG /HWSF	HW GLOBAL (INTERNAL AND EXTERNAL) EVENTS	HIGH WINDS	WASTE DRUMS TIP OVER CAUSING SPILL AND RELEASE OF TOXIC GASES. (C;C;C;C)	NONE	ENCLOSE THE HW STORAGE BUILDING.
2 II B	HW5A /HWSF	HWTF CYANIDES AND SULFIDES STORAGE	MISLABELED CYANIDE DRUM IS PLACED IN THE OPEN STORAGE AREA. FREEZES CAUSING SIMULTANEOUS SPILL OF CYANIDES AND NONCOMPATIBLE WASTE, SUCH AS ACIDS.	RELEASE OF TOXIC GASES (E.G., HCN AND CYANOGEN) AND POSSIBLE EXPLOSION AND FIRE. SEVERE WORKER INJURY. (C;B;B;C)	NONE	(1) CONSIDER ENCLOSING THE HWTF STORAGE BUILDING AND PROVIDING HVAC, (2) INSTALL A SCRUBBER SYSTEM, (3) PROVIDE HCN ANALYZER AND ALARM.
2 II B	HW2A /HWSF	HW REACTIVES (GROUP 2A)	FORKLIFT ACCIDENT OR FREEZING OF WASTE CAUSES SPILL OF WATER REACTIVE WASTE WITH WATER PRESENT IN THE AREA.	HYDROGEN EVOLUTION, POTENTIAL FIRE/EXPLOSION. POSSIBLE RELEASE OF TOXIC METAL FUMES. SEVERE WORKER INJURY. (C;B;B;C)	NONE	(1) RESTRICT USE OF WATER IN THE REACTIVES STORAGE AREA, (2) ENCLOSE THE BUILDING FOR WATER CONTROL AND FIRE SUPPRESSION EFFICIENCY, (3) INSTALL HVAC AND SCRUBBER..
2 II B	HW6A /HWSF	HW OXIDIZERS (GROUP 6A)	AMMONIUM PERCHLORATE OR METHYL ETHYL KETONE PEROXIDE (MEKP), DRIED OVER TIME, SUBJECTED TO SHOCK, FRICTION OR SUNLIGHT.	EXPLOSION OR FIRE IN STORAGE AREA, RELEASE OF TOXIC GASES, WORKER INJURY. (C;C;B;D)	(1) AMMONIUM PERCHLORATE IS ONLY ACCEPTED IN AN OXIDE (LIQUID) FORM, (2) FIRE SUPPRESSION SYSTEM.	(1) DEVELOP AND ENFORCE STRICT ACCEPTANCE CRITERIA FOR SENSITIVE OXIDIZERS (E.G., DILUTED FORM, FREQUENT INSPECTION, WETTED MATERIAL), (2) CONSIDER STORAGE OF HIGHLY SENSITIVE OXIDIZERS IN A SEPARATE BUILDING IN A REMOTE LOCATION.
2 II B	HWG /HWSF	HW GLOBAL (INTERNAL AND EXTERNAL) EVENTS	CRACKS IN STORAGE CONTAINERS PROPAGATED BY	RUPTURE OF WASTE CONTAINER, SPILL WITH	NONE	ENCLOSE THE HW STORAGE BUILDING.

HAZARD ANALYSIS REPORT BY RISK

R---F---C	ACT/FAC	ACTIVITY NAME	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
			RAIN OR SNOW (BLOWN ONTO DRUMS) FREEZES OVER.	RELEASE OF TOXIC GASES. (C;C;B;C)		
2 II B	HWG /HWSF	HW GLOBAL (INTERNAL AND EXTERNAL) EVENTS	ACCIDENTS DURING TRANSPORTATION OF WASTE WITHIN THE HW STORAGE AREA (FORKLIFTS OR MANUAL).	SPILL OF FLAMMABLES, REACTIVES, OR INCOMPATIBLE WASTES LEADING TO TOXIC GAS RELEASE/ FIRE. WORKER INJURY. (C;B;B;B)	NONE	(1) ENCLOSE THE HW STORAGE AREA, (2) MAINTAIN PHYSICAL SEPARATION OF INCOMPATIBLE WASTES DURING TRANSPORTATION, (3) LIMIT SIMULTANEOUS OPERATION OF MULTIPLE FORKLIFTS.
2 III A	HW4A /HWSF	HW FLAMMABLE STORAGE (GROUP 4A)	PICRIC ACID DROPPED OR JARRED.	DETONATION, MAJOR FIRE IN HWTF STORAGE AREA, MULTIPLE TOXIC GASES (E.G., PHOSGENE, HCN, ETC...) RELEASED DIRECTLY TO ENVIRONMENT, WORKER FATALITY, PUBLIC EXPOSURE. (A;A;A;A)	NONE	DEVELOP AND ENFORCE POLICY NOT TO STORE EXPLOSIVES OR SHOCK SENSITIVE MATERIALS IN THIS BUILDING.
2 III A	HW4A /HWSF	HW FLAMMABLE STORAGE (GROUP 4A)	SPILL OF LOW FLASH POINT CHEMICALS (ACETHALHENYE(-38F), FURAN (-32F), ANHYDROUS ETHYL ETHER(-49F)) DUE TO FORKLIFT ACCIDENT, OR CORROSION. FIRE SUPPRESSION SYSTEM INADEQUATE.	IGNITION OF FLAMMABLE VAPORS LEADS TO A MAJOR FIRE AND EXPLOSION (E.G., NITROMETHANE) IN THE STORAGE AREA. RELEASE OF MULTIPLE TOXIC GASES (E.G., PHOSGENE) TO ATMOSPHERE. (B;B;A;A)	FIRE SUPPRESSION SYSTEM.	(1) TREAT HIGHLY FLAMMABLE MATERIALS ON AN PRIORITY BASIS, DO NOT ALLOW ACCUMULATIONS OF LARGE INVENTORIES, (2) CONSIDER SPECIALLY DESIGNED STORAGE CONFIGURATION FOR THE MOST HAZARDOUS (LOW FLASH POINT) FLAMMABLE WASTES, (3) CONSIDER ENCLOSING THE BUILDING TO INCREASE THE EFFICIENCY OF THE FIRE SUPPRESSION SYSTEM AND INSTALL GAS DETECTOR AND ALARM.
2 III A	HW4A /HWSF	HW FLAMMABLE STORAGE (GROUP 4A)	FORKLIFT ACCIDENT CAUSING DUAL SPILL OF INCOMPATIBLE FLAMMABLE MATERIALS ROUTINELY STORED IN THE SAME AREA. (E.G., NITROMETHANE WITH ACETONE)	RELEASE OF TOXIC GASES (E.G., PHOSGENE) AND POTENTIAL FIRE. POTENTIAL WORKER FATALITY. (B;B;A;B)	NONE	(1) CONSIDER ENCLOSING THE BUILDING TO REDUCE TOXIC GAS EXPOSURE TO THE PUBLIC AND COLOCATED WORKER, (2) STORE INCOMPATIBLE FLAMMABLE MATERIALS IN SEPARATE LOCATIONS WITHIN THE FLAMMABLE STORAGE AREA, (3) INSTALL SCRUBBING SYSTEM.
2 III A	HW4A /HWSF	HW FLAMMABLE STORAGE (GROUP 4A)	FORKLIFT ACCIDENT CAUSING DUAL SPILL OF INCOMPATIBLE MATERIALS DUE TO MISLABELING OF WASTE DRUM. (E.G., FLAMMABLE WASTE MIXED	RELEASE OF TOXIC GASES AND POTENTIAL FIRE AND GENERATION OF TOXIC GASES (E.G., PHOSGENE). POTENTIAL WORKER AND COLOCATED WORKER	NONE	(1) CONSIDER ENCLOSING THE BUILDING TO REDUCE TOXIC GAS EXPOSURE TO THE PUBLIC AND COLOCATED WORKER, (2) INSTALL SCRUBBING SYSTEM, (3)

HAZARD ANALYSIS REPORT BY RISK

R---F---C	ACT/FAC	ACTIVITY NAME	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
			WITH; (1) NAOH(1A), (2) H_2SO_4(1B), (3) LITHIUM HYDRIDE(2A), (4) NITRIC ACID(6A), (5) CHLOROBENZENE.)	FATALITY. (B;B;A;B)		VERIFY DRUM CONTENTS AND LABELING AT WASTE GENERATORS SITE, (4) DEVELOP LAB WIDE PROCEDURE (LAB ES&H MANUAL) FOR WASTE IDENTIFICATION AND LABELING OF WASTE CONTAINERS.
2 III A	HW6A /HWSF	HW OXIDIZERS (GROUP 6A)	FORKLIFT ACCIDENT OR FREEZING CAUSING DUAL SPILL OF INCOMPATIBLE MATERIALS DUE TO MISLABELING OF WASTE DRUM. (E.G., OXIDIZER WASTE MIXED WITH; (1) NAOH(1A), (2) ACETIC ACID(1B), (3) SODIUM(2A), (4) ORGANICS SUCH AS CHLORO BENZENE(4A), (5) GOLD CYANIDE(5A))	RELEASE OF TOXIC GASES, POTENTIAL EXPLOSION AND POTENTIAL FIRE. FIRE INVOLVING CHLORA BENZENE COULD GENERATE PHOSGENE GAS. POTENTIAL WORKER FATALITY. (B;A;A;B)	FIRE SUPPRESSION SYSTEM.	(1) VERIFY DRUM CONTENTS AND LABELING AT WASTE GENERATORS SITE, (2) DEVELOP LAB WIDE PROCEDURE (LAB ES&H MANUAL) FOR WASTE IDENTIFICATION AND LABELING OF WASTE CONTAINERS, (3) ENCLOSE THE HWTF STORAGE BUILDING AND INSTALL SCRUBBER SYSTEM.
2 III A	HW7A /HWSF	HW GASES (GROUP 7A)	BREACH OF CYLINDER (NON-LEGACY) DUE TO ACCIDENTAL CAUSES (E.G., CYLINDER DROPPED AND REGULATOR LINE BREAKS).	RELEASE OF HIGHLY TOXIC GASES (PHOSPHINE, PHOSGEN, ARSINE, AND OTHERS). WORKER FATALITY, POTENTIAL COLOCATED WORKER AND PUBLIC EXPOSURE. (A;A;A;D)	NONE	(1) TRANSPORT AND STORE CYLINDERS SECURELY, (2) CONSIDER SECONDARY CONTAINMENT FOR MOST HAZARDOUS CYLINDERS, (3) GAS CYLINDERS TO BE PROCESSED WITH HIGH PRIORITY, (4) WORK IN THIS AREA TO BE PERFORMED WITH PROTECTION (I.E., WEAR SCBA, OPERATE UNDER THE BUDDY SYSTEM), (5) PROTECTIVE CAP FOR CYLINDER REGULATORS SHOULD BE IN PLACE AT ALL TIMES, (6) CONSIDER STORING GAS CYLINDERS IN ENCLOSED ROOM IN AN INCLOSED BUILDING.
2 III A	HW7A /HWSF	HW GASES (GROUP 7A)	EXTERNAL FIRE (INITIATED WITHIN THE BUILDING).	PRESSURIZATION AND RUPTURE OF GAS CYLINDERS. HIGHLY TOXIC GAS RELEASE AND POTENTIAL CYLINDER MISSILE GENERATION. (A;A;A;A)	FIRE PROTECTION SYSTEM, FUSIBLE PRESSURE RELIEF.	(1) INITIATE FIRE SUPPRESSION SPRINKLERS GIVEN FIRE IN ADJACENT AREAS, (2) ENCLOSE THE HW STORAGE AREA AND STORE GAS CYLINDERS IN AN ENCLOSED AREA.
2 III A	HW9 /HWSF	HW NONREGULATED WASTES (GROUP 9)	SPILL (DUE TO FREEZING OR FORKLIFT ACCIDENT) OF INCOMPATIBLE WASTES ROUTINELY STORED IN NONREGULATED AREA (E.G., MISLABLED, TEMPORARY	FIRE AND RELEASE OF TOXIC GASES (E.G., HF). (B;B;A;B)	FIRE PROTECTION SYSTEM.	(1) CONSIDER ELIMINATING THIS AREA, (2) CLASSIFY AND STORE ALL NONREGULATED WASTES IN COMPATIBLE REGULATED AREAS, (3) ENCLOSE THE

HAZARD ANALYSIS REPORT BY RISK

R---F---C	ACT/FAC	ACTIVITY NAME	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
			STORAGE, OR DO NOT BELONG IN OTHER DEFINED REGULATED AREAS)			HAZARDOUS WASTE STORAGE BUILDING.
2 III A	HWG /HWSF	HW GLOBAL (INTERNAL AND EXTERNAL) EVENTS	MEDIUM INTENSITY SEISMIC EVENT WITH HORIZONTAL ACCELERATION OF 0.17 G.	MIXING OF INCOMPATIBLE WASTES STORED IN ADJACENT AREAS. VIOLENT REACTIONS, POTENTIAL FIRE, AND RELEASE OF TOXIC FUMES (E.G., PHOSGENE, HCN). NOTE: SHOCK SENSITIVE MATERIAL NOT CONSIDERED IN THIS SCENARIO. (B;B;A;B)	NONE	(1) REVIEW SEISMIC DESIGN CRITERIA, (2) ENSURE THAT INCOMPATIBLE WASTES ARE NOT STORED IN ADJACENT AREAS. SEE POTENTIAL HWRSF FLOORPLAN DEVELOPED BY PHA TEAM, (3) MINIMIZE STORAGE TIME OF MOST FLAMMABLE/ TOXIC MATERIALS, (4) ENCLOSE THE HW STORAGE AREA.
2 III A	HWG /HWSF	HW GLOBAL (INTERNAL AND EXTERNAL) EVENTS	ACCIDENT DURING TRANSPORTATION OF WASTE (TOXIC GAS CYLINDERS OR INCOMPATIBLE WASTE DRUMS) FROM HW STORAGE TO CAI OR OTHER FACILITY.	SPILL LEADING TO THE UNMITIGATED RELEASE OF TOXIC GASES. PUBLIC EXPOSURE. (A;A;A;A)	NONE	(1) CONSIDER ROAD CLOSURE WHILE TRANSPORTING THE MOST HAZARDOUS MATERIALS BETWEEN LAB AREAS, (2) REVIEW PROCEDURES FOR SECURING WASTE DRUMS DURING TRANSPORTATION, (3) DO NOT TRANSPORT INCOMPATIBLE WASTE DRUMS TOGETHER.
2 III B	HW5A /HWSF	HWTF CYANIDES AND SULFIDES STORAGE	ACCIDENT CAUSES SIMULTANEOUS SPILL OF CYANIDE AND OTHER NONCOMPATIBLE WASTE (E.G., H2SO4(1B), OR PERCHLORIC ACID(6A)) DUE TO MISLABELING.	RELEASE OF TOXIC GASES (E.G., HCN AND CYANOGEN) AND POSSIBLE EXPLOSION AND FIRE. SEVERE WORKER INJURY. (B;B;B;C)	SEPARATE STORAGE BUILDING FOR HAZARDOUS CYANIDE WASTE.	(1) CONSIDER ENCLOSING THE HWTF STORAGE BUILDING AND PROVIDING HVAC, (2) INSTALL A SCRUBBER SYSTEM, (3) PROVIDE HCN ANALYZER AND ALARM, (4) VERIFY DRUM CONTENTS AND LABELING AT WASTE GENERATORS SITE, (5) DEVELOP LAB WIDE PROCEDURE (LAB ES&H MANUAL) FOR WASTE IDENTIFICATION AND LABELING OF WASTE CONTAINERS.
2 III B	HW5A /HWSF	HWTF CYANIDES AND SULFIDES STORAGE	MERCURY OXYCYANIDE DETONATES DUE TO HEATING, FROM SHOCK OR FRICTION (E.G., FORKLIFT ACCIDENT).	SMALL EXPLOSION LEADING TO TOXIC GAS (E.G., MERCURY FUMES, CYANIDE AND NOX) RELEASE. SEVERE WORKER INJURY DUE TO TOXIC GAS EXPOSURE. (B;B;B;C)	NONE	DEVELOP AND ENFORCE POLICY NOT TO STORE EXPLOSIVES OR SHOCK SENSITIVE MATERIALS IN THIS BUILDING.
2 III B	HW2A /HWSF	HW REACTIVES (GROUP 2A)	ACCIDENT DUE TO HUMAN ERROR CAUSES SIMULTANEOUS SPILL OF WATER REACTIVE WASTE AND INCOMPATIBLE WASTE DUE TO MISLABELING. (E.G., REACTIVE WASTE	PRODUCTION OF HYDROGEN GAS, POTENTIAL FIRE AND/OR EXPLOSION AND PRODUCTION OF TOXIC FUMES (E.G., HCN). SEVERE WORKER INJURY. (B;B;B;D)	NONE	(1) VERIFY DRUM CONTENTS AND LABELING AT WASTE GENERATORS SITE, (2) DEVELOP LAB WIDE PROCEDURE (LAB ES&H MANUAL) FOR WASTE

HAZARD ANALYSIS REPORT BY RISK

R---F---C	ACT/FAC	ACTIVITY NAME	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
			MIXED WITH, SULFURIC ACID(1B), NAOH(1A), PERCHLORIC ACID(6A) OR TRICHLORA ETHYLENE(4A))			IDENTIFICATION AND LABELING OF WASTE CONTAINERS.
2 III B	HW1B /HWSF	HW ACIDS (GROUP 1B)	FORKLIFT ACCIDENT OR FREEZING CAUSING SIMULTANEOUS SPILL OF ACID MATERIAL AND INCOMPATIBLE MATERIAL (E.G., NAOH(1A), NITROBENZENE(4A), HYDROGEN PEROXIDE(6A), METAL CYANIDE(5A), LITHIUM HYDRIDE(2A)) DUE TO MISLABELING.	POTENTIAL FIRE, EXPLOSION, HYDROGEN GAS PRODUCTION AND TOXIC GAS GENERATION (E.G., HCN). WORKER INJURY/EXPOSURE. (B;B;B;C)	FIRE SUPPRESSION SYSTEM.	(1) VERIFY DRUM CONTENTS AND LABELING AT WASTE GENERATORS SITE, (2) DEVELOP LAB WIDE PROCEDURE (LAB ES&H MANUAL) FOR WASTE IDENTIFICATION AND LABELING OF WASTE CONTAINERS, (3) STORE WASTE IN ENCLOSED BUILDING TO PREVENT FREEZING.
2 III B	HW8 /HWSF	HW PCB (GROUP 8)	MISLABELED DRUM RESULTS IN PCB DRUM BEING STORED NEAR FLAMMABLE WASTE. ACCIDENTAL BREACH OF THE CONTAINERS LEADS TO FIRE AND BURNING OF PCB WASTE.	BURNING OF PCB WASTE. DISPERSION OF PCB WASTE TO THE ENVIRONMENT. (B;B;B;B).	FIRE PROTECTION SYSTEM.	(1) VERIFY DRUM CONTENTS AND LABELING AT WASTE GENERATORS SITE, (2) DEVELOP LAB WIDE PROCEDURE (LAB ES&H MANUAL) FOR WASTE IDENTIFICATION AND LABELING OF WASTE CONTAINERS.
2 III B	HW8 /HWSF	HW PCB (GROUP 8)	SPILL OF PCB WASTE DRUM DUE TO FORKLIFT ACCIDENT, RELEASE TO THE SUMP.	POTENTIAL RELEASE TO THE ENVIRONMENT THROUGH THE SUMP SYSTEM. ONSITE CONTAMINATION. (D;D;D;B)	SUMP SYSTEM.	(1) INSTALL PROCEDURES TO DETECT SUMP LEVELS, (2) TEST SUMP CONTENTS BEFORE DISCHARGE.
3 I D	HWG /HWSF	HW GLOBAL (INTERNAL AND EXTERNAL) EVENTS	LIGHTNING STRIKES STORAGE BUILDING.	NOT A HAZARD. (D;D;D;D)	EQUIPPED WITH LIGHTNING RODS.	NONE
3 II C	HW4A /HWSF	HW FLAMMABLE STORAGE (GROUP 4A)	FREEZING TEMPERATURES CAUSES RUPTURE OF DRUM AND SPILL OF FLAMMABLE MATERIALS.	WORKER EXPOSED TO TOXIC FUMES. (D;D;C;D)	NONE	NONE
3 II C	HW4A /HWSF	HW FLAMMABLE STORAGE (GROUP 4A)	SPILL OF LOW FLASH POINT CHEMICALS (ACETHALHENYE(-38F), FURAN (-32F), ANHYDROUS ETHYL ETHER (-49F)) DUE TO FORKLIFT ACCIDENT OR CORROSION. FIRE SUPPRESSION SYSTEM OPERATIONAL.	IGNITION OF FLAMMABLE VAPORS LEADS TO CONTAINED FIRE IN THE STORAGE AREA. (D;D;C;D)	FIRE SUPPRESSION SYSTEM.	NONE
3 II C	HW4A /HWSF	HW FLAMMABLE STORAGE (GROUP 4A)	SPILL OF LOW FLASH POINT CHEMICALS (ACETHALHENYE(-38F), FURAN (-32F), ANHYDROUS ETHYL ETHER (-49F)) DUE TO FORKLIFT ACCIDENT OR	WORKER EXPOSED TO CHEMICAL FUMES. (D;D;C;D)	NONE	NONE

HAZARD ANALYSIS REPORT BY RISK

R---F---C	ACT/FAC	ACTIVITY NAME	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
			CORROSION.			
3 II C	HW9 /HWSF	HW NONREGULATED WASTES (GROUP 9)	SPILL OF AMMONIUM BIFLORIDE DUE TO FORKLIFT ACCIDENT OR FREEZING.	POTENTIAL WORKER EXPOSURE. (D;C;C;D)	NONE	CONSIDER RELOCATION OF AMMONIUM BIFLORIDE TO ONE OF THE REGULATED AREAS, SUCH AS CAUSTIC(1A).
3 II C	HWG /HWSF	HW GLOBAL (INTERNAL AND EXTERNAL) EVENTS	INADVERTENT OPERATION OF THE FIRE SPRINKLERS OR RUPTURE OF WATER PIPING DUE TO CORROSION OR FREEZING (INCLUDING WATER FROM EXTERNAL SOURCES).	WATER INTRUSION INTO REACTIVE WASTE STORAGE DRUMS, GENERATION OF HYDROGEN GAS. (D;D;D;C)	NONE	(1) INSTALL SUMP HIGH LEVEL ALARMS, (2) PERIODIC WALKDOWN OF THE FACILITY.
3 III B	HW5A /HWSF	HWTF CYANIDES AND SULFIDES STORAGE	EXTERNAL FIRE CAUSES CYANIDE COMPOUNDS (E.G., CYANOGEN BROMIDE) TO DECOMPOSE.	THERMAL DECOMPOSITION OF CYANIDE LEADING TO TOXIC GAS RELEASE (E.G., HCN AND CYANOGEN). (D;D;B;C)	NONE	PROVIDE HCN ANALYZER AND ALARM.
3 III B	HW2A /HWSF	HW REACTIVES (GROUP 2A)	WATER INTRUSION INTO THE STORAGE DRUM (THROUGH EXISTING BREACH IN DRUM) DUE TO HUMAN ERROR OR RUPTURE OF WATER LINE IN THIS AREA.	RUPTURE OF DRUM DUE TO HYDROGEN EVOLUTION, POTENTIAL FIRE/EXPLOSION. POSSIBLE RELEASE OF TOXIC METAL FUMES. (C;C;B;D)	NONE	(1) RESTRICT USE OF WATER IN THE REACTIVES STORAGE AREA, (2) ENCLOSE THE BUILDING FOR WATER CONTROL AND FIRE SUPPRESSION EFFICIENCY.
3 III B	HW7A /HWSF	HW GASES (GROUP 7A)	BREACH OF CYLINDER (NON-LEGACY) DUE TO ACCIDENTAL CAUSES (E.G., CYLINDER DROPPED AND REGULATOR LINE BREAKS).	RELEASE OF MODERATELY TOXIC GASES (H2S, NO2, AND OTHERS). WORKER EXPOSURE. (C;C;B;D)	NONE	(1) TRANSPORT AND STORE CYLINDERS SECURELY, (2) CONSIDER SECONDARY CONTAINMENT FOR MOST HAZARDOUS CYLINDERS, (3) GAS CYLINDERS TO BE PROCESSED WITH HIGH PRIORITY, (4) WORK IN THIS AREA TO BE PERFORMED WITH PROTECTION (I.E., WEAR SCBA, OPERATE UNDER THE BUDDY SYSTEM), (5) PROTECTIVE CAP FOR CYLINDER REGULATORS SHOULD BE IN PLACE AT ALL TIMES, (6) CONSIDER STORING GAS CYLINDERS IN ENCLOSED ROOM IN AN INCLOSED BUILDING.
3 III B	HW7A /HWSF	HW GASES (GROUP 7A)	EXTERNAL FIRE.	PRESSURIZATION AND RUPTURE OF GAS CYLINDERS. MODERATELY TOXIC GAS RELEASE AND POTENTIAL CYLINDER MISSILE GENERATION. (C;C;B;C)	FIRE PROTECTION SYSTEM, FUSIBLE PRESSURE RELIEF.	(1) INITIATE FIRE SUPPRESSION SPRINKLERS GIVEN FIRE IN ADJACENT AREAS, (2)STORE GAS CYLINDERS IN AN ENCLOSED AREA.
3 III B	HW1A /HWSF	HW CAUSTICS (GROUP 1A)	SODIUM AZIDE EXPLODES DUE TO SEVERE SHOCK, HEAT OR FRICTION.	EXPLOSION AND RELEASE OF TOXIC GAS (NOX). (C;C;B;C)	FIRE PROTECTION SYSTEM.	DEVELOP AND ENFORCE STRICT POLICY NOT TO STORE EXPLOSIVES OR SHOCK SENSITIVE MATERIALS IN

HAZARD ANALYSIS REPORT BY RISK

R---F---C	ACT/FAC	ACTIVITY NAME	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
						THIS BUILDING.
3 III B	HW1A /HWSF	HW CAUSTICS (GROUP 1A)	FORKLIFT ACCIDENT OR FREEZING CAUSING SIMULTANEOUS SPILL OF CAUSTIC MATERIAL AND INCOMPATIBLE MATERIAL(E.G., H2SO4(1B), NITROBENZENE(4A), PERCHLORIC ACID(6A), METAL CYANIDE(5A), LITHIUM HYDRIDE(2A)) DUE TO MISLABELING.	POTENTIAL FIRE, EXPLOSION, HYDROGEN GAS PRODUCTION AND HEAVY METAL FUME GENERATION. WORKER INJURY/EXPOSURE. (C;C;B;C)	FIRE SUPPRESSION SYSTEM.	ENCLOSE THE HWTF STORAGE BUILDING TO PREVENT FREEZING.
3 III B	HW1A /HWSF	HW CAUSTICS (GROUP 1A)	EXTERNAL FIRE	RELEASE OF MODERATELY TOXIC GASES. WORKER INJURY. (C;C;B;C)	FIRE PROTECTION SYSTEM.	NONE
3 III B	HW1B /HWSF	HW ACIDS (GROUP 1B)	SPILL OF A SINGLE ACID WASTE DRUM DUE TO CORROSION, FREEZING OR CRANE ACCIDENTS.	TOXIC GAS RELEASE (E.G., HF OR HCL). WORKER EXPOSURE AND INJURY. (C;C;B;D)	NONE	(1) VERIFY CONSTRUCTION MATERIAL OF STORAGE CONTAINER AND THE SUMP SYSTEM, (2) FREQUENT INSPECTIONS, (3) ENCLOSE THE HWTF STORAGE BUILDING.
3 III B	HW1B /HWSF	HW ACIDS (GROUP 1B)	EXTERNAL FIRE INIYTIATED WITHIN THE BUILDING.	RELEASE OF MODERATELY TOXIC GASES (E.G.,HF). WORKER INJURY. (C;C;B;C)	FIRE PROTECTION SYSTEM.	STORE WASTE IN ENCLOSED BUILDING TO PROVIDE SCRUBBING OF RELEASE AND MINIMIZE PUBLIC AND COLOCATED WORKER EXPOSURE.
3 IV A	HW8 /HWSF	HW PCB (GROUP 8)	LARGE EXTERNAL FIRE.	POTENTIAL SPILL AND BURNING OF PCB WASTE. DISPERSION OF PCB WASTE TO THE ENVIRONMENT. (B;B;B;A)	FIRE PROTECTION SYSTEM.	CONSIDER STORING PCB WASTE AWAY FROM FLAMMABLES.
3 IV A	HWG /HWSF	HW GLOBAL (INTERNAL AND EXTERNAL) EVENTS	HIGH INTENSITY SEISMIC EVENT WITH HORIZONTAL ACCELERATION OF 0.3 G OR GREATER.	STRUCTURAL COLLAPSE OF BUILDING, BREACH OF MULTIPLE DRUMS, MAJOR FIRE, RELEASE OF TOXIC GAS TO ENVIRONMENT. (A;A;A;A)	NONE	(1) REVIEW SEISMIC DESIGN CRITERIA, (2) MINIMIZE STORAGE TIME OF MOST FLAMMABLE/ TOXIC MATERIALS.
3 IV A	HWG /HWSF	HW GLOBAL (INTERNAL AND EXTERNAL) EVENTS	EXTERNAL FIRE	FIRE PENETRATES THE HWRSF, MAJOR FIRE RELEASES TOXIC GAS TO THE ENVIRONMENT. (A;A;A;A)	(1) AREA SURROUNDING THE HWRSF IS CLEARED OF COMBUSTIBLE MATERIAL, (2) BUILDING IS DESIGNED TO RETARD FIRE.	NONE
4 II D	HW5A /HWSF	HWTF CYANIDES AND SULFIDES STORAGE	SPILL OF CYANIDE DUE TO YARD FORKLIFT ACCIDENT OR CORROSION.	CONTAMINATION OF THE STORAGE AREA, MINOR WORKER EXPOSURE. NO TOXIC GAS RELEASED TO LOW VOLATILITY. (D;D;D;D)	NONE	NONE

HAZARD ANALYSIS REPORT BY RISK

R---F---C	ACT/FAC	ACTIVITY NAME	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
4 II D	HW6A /HWSF	HW OXIDIZERS (GROUP 6A)	SPILL OF OXIDIZERS DUE TO FREEZING, YARD FORKLIFT OR OVERHEAD CRANE ACCIDENTS.	LOW LEVEL TOXIC SPILL. WORKER EXPOSURE. (D;D;D;D)	NONE	NONE
4 II D	HW1A /HWSF	HW CAUSTICS (GROUP 1A)	SPILL OF A SINGLE CAUSTIC WASTE DRUM CAUSED BY HUMAN ERROR, FORKLIFT ACCIDENT OR FREEZING.	MINOR WORKER EXPOSURE. (D;D;D;D)	NONE	NONE
4 II D	HW8 /HWSF	HW PCB (GROUP 8)	SPILL OF PCB WASTE DRUM DUE TO FORKLIFT ACCIDENT.	CONTAMINATION OF THE STORAGE AREA. (D;D;D;D)	SUMP SYSTEM.	NONE

APPENDIX D

CST-7 PRELIMINARY HAZARDS ANALYSIS OVERALL RESULTS

Table D-1 presents the all the scenarios generated as part of the CST-7 PHA. This includes scenarios for the HWTF and the four process skids analyzed, the MWRSF, and the DSB. The scenarios are ranked by risk, with the most risk significant scenarios listed first.

TABLE D-1
COMPILED HAZMAN RESULTS SORTED BY RISK RANK FOR CST-7

HAZARD ANALYSIS REPORT BY RISK

R---F---C	ACT/FAC	ACTIVITY NAME	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
1 II A	HW7A / HW*	HWRSF GASES (GROUP 7A)	MAJOR BREACH OF LEGACY CYLINDER OF DOUBTFUL INTEGRITY DURING STORAGE.	RELEASE OF HIGHLY TOXIC GASES (PHOSPHINE, PHOSGEN, ARSINE, AND OTHERS). WORKER FATALITY, POTENTIAL COLOCATED WORKER AND PUBLIC EXPOSURE. (C;B;A;D)	HEPA AND SCRUBBING SYSTEM.	(1) DO NOT STORE LEGACY CYLINDERS IN THE HWSRF, (2) PROCESS LEGACY CYLINDERS WITHOUT INTERMEDIATE STORAGE, (3) PROVIDE SECONDARY CONTAINMENT WHEN TRANSPORTING LEGACY CYLINDERS.
1 II A	HW7A / HW*	HW GASES (GROUP 7A)	BREACH OF LEGACY CYLINDER OF DOUBTFUL INTEGRITY DURING STORAGE.	RELEASE OF HIGHLY TOXIC GASES (PHOSPHINE, PHOSGEN, ARSINE, AND OTHERS). WORKER FATALITY, POTENTIAL COLOCATED WORKER AND PUBLIC EXPOSURE. (A;A;A;D)	NONE	(1) DO NOT STORE LEGACY CYLINDERS IN HWTF AREA, (2) PROCESS LEGACY CYLINDERS WITHOUT INTERMEDIATE STORAGE, (3) PROVIDE SECONDARY CONTAINMENT FOR THE CYLINDERS, (4) CONSIDER ENCLOSING THE HWTF STORAGE AND PROVIDING HVAC AND SCRUBBER.
1 II A	CY12 / HWTF	INSTALL PUMPING ASSEMBLY TO THE TOP OF THE CYANIDE WASTE DRUM	CYANIDE PLATING WASTE PUMPED TO WRONG LOCATION AND MIXED WITH NONCOMPATIBLE MATERIAL (I.E., WASTE DRUM, WASTE WATER SYSTEM, CHEMICAL MIX AND FEED TANK, CHEMICAL FEED DRUM OR THE DRY CHEMICAL FEEDER.) PLATING WASTE PROCESS.	HCN, H2S, NH3 OR OTHER TOXIC GAS PRODUCED AND RELEASED IN THE TREATMENT ROOM. WORKER EXPOSURE AND INJURY. (D;D;A;D)	NONE	(1) INSTALL CHECK VALVES ON OUTLET LINES OF THE CHEMICAL MIX FEED TANK, CHEMICAL FEED DRUM AND CHEMICAL PLATING WASTE DRUM (2) FOLLOW VALVE ALIGNMENT CHECKLIST PROCEDURE (3) VALVES SHOULD HAVE POSITION INDICATORS (4) OPERATORS SHOULD BE EQUIPED WITH PROTECTIVE CLOTHING AND RESPIRATOR (5) HAVE TWO OPERATORS CHECK VALVE POSITIONING (6) INSTALL INTERLOCK WHICH ALLOWS OPENING OF ONE VALVE AT A TIME
1 II A	HWG / HW*	HW GLOBAL (INTERNAL AND EXTERNAL) EVENTS	LOW INTENSITY SEISMIC EVENT WITH HORIZONTAL ACCELERATION OF 0.1 G.	EXPLOSION OF SHOCK SENSITIVE MATERIALS (E.G., PICRIC ACID, NITRO METHANE, SODIUM AZIDE). STRUCTURAL DAMAGE TO BUILDING, FIRE AND RELEASE OF TOXIC GASES. (A;A;A;A)	NONE	(1) DEVELOP AND ENFORCE STRICT POLICY NOT TO STORE EXPLOSIVES OR SHOCK SENSITIVE MATERIALS IN THE BUILDING, (2) CONSIDER STORAGE OF SHOCK SENSITIVE IN A SEPARATE BUILDING IN A REMOTE LOCATION.
2 I C	HWBK / HW*	HWRSF BULKING ROOM	INADEQUATE GUIDELINES OR PROCEDURES FOR MIXING AND REBULKING WASTES.	VIOLENT REACTION, RELEASE OF TOXIC GAS WITH WORKER EXPOSURE AND FACILITY CONTAMINATION. (D;D;C;D)	(1) FUME HOOD AND FIRE SUPPRESSION SYSTEM, (2) FULL PROTECTIVE GEAR, E.G. SUITS, FACE SHIELDS).	(1) GUIDELINES (PROCEDURES) FOR MIXING AND BULKING SHOULD BE DEVELOPED AND REVIEWED, (2) WORKER SHOULD WEAR RESPIRATOR UNTIL

HAZARD ANALYSIS REPORT BY RISK

R---F---C	ACT/FAC	ACTIVITY NAME	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
						DETERMINATION OF POSSIBLE REACTIONS.
2 I C	HWG / HW*	HW GLOBAL (INTERNAL AND EXTERNAL) EVENTS	HIGH WINDS	WASTE DRUMS TIP OVER CAUSING SPILL AND RELEASE OF TOXIC GASES. (C;C;C;C)	NONE	ENCLOSE THE HW STORAGE BUILDING.
2 I C	GC6 / HWTF	CYLINDER BREACHED	SAW JAMS OR OTHER MECHANICAL FAILURES DURING CUTTING AND GAS IS RELEASED INTO PRESSURE VESSEL, WORKER OPENS VESSEL AFTER PURGING TO INSPECT.	RELEASE OF RESIDUAL TOXIC GAS, MINOR WORKER EXPOSURE. (D;D;C;D)	ONLINE GAS DETECTORS.	(1) VERIFY ATMOSPHERE PRIOR TO OPENING VESSEL. (2) WEAR PROTECTIVE GEAR (SCBA) WHEN OPENING VESSEL.
2 II B	HW5A / HW*	HWTF CYANIDES AND SULFIDES STORAGE	MISLABELED CYANIDE DRUM IS PLACED IN THE OPEN STORAGE AREA. FREEZES CAUSING SIMULTANEOUS SPILL OF CYANIDES AND NONCOMPATIBLE WASTE, SUCH AS ACIDS.	RELEASE OF TOXIC GASES (E.G., HCN AND CYANOGEN) AND POSSIBLE EXPLOSION AND FIRE. SEVERE WORKER INJURY. (C;B;B;C)	NONE	(1) CONSIDER ENCLOSING THE HWTF STORAGE BUILDING AND PROVIDING HVAC, (2) INSTALL A SCRUBBER SYSTEM, (3) PROVIDE HCN ANALYZER AND ALARM.
2 II B	HW2A / HW*	HW REACTIVES (GROUP 2A)	FORKLIFT ACCIDENT OR FREEZING OF WASTE CAUSES SPILL OF WATER REACTIVE WASTE WITH WATER PRESENT IN THE AREA.	HYDROGEN EVOLUTION, POTENTIAL FIRE/EXPLOSION. POSSIBLE RELEASE OF TOXIC METAL FUMES. SEVERE WORKER INJURY. (C;B;B;C)	NONE	(1) RESTRICT USE OF WATER IN THE REACTIVES STORAGE AREA, (2) ENCLOSE THE BUILDING FOR WATER CONTROL AND FIRE SUPPRESSION EFFICIENCY, (3) INSTALL HVAC AND SCRUBBER..
2 II B	HW6A / HW*	HWRSF OXIDIZERS (GROUP 6A)	AMMONIUM PERCHLORATE OR METHYL ETHYL KETONE PEROXIDE (DRIED OVER TIME) SUBJECTED TO SHOCK, FRICTION OR SUNLIGHT(MEKP).	EXPLOSION OR FIRE IN HWRSF, RELEASE OF TOXIC GASES, WORKER INJURY. (D;D;B;C)	(1) AMMONIUM PERCHLORATE IS ONLY ACCEPTED IN AN OXIDE (LIQUID) FORM, (2) FIRE SUPPRESSION AND SCRUBBER SYSTEM.	(1) DEVELOP AND ENFORCE STRICT ACCEPTANCE CRITERIA FOR SENSITIVE OXIDIZERS (E.G., DILUTED FORM, FREQUENT INSPECTION, WETTED MATERIAL), (2) CONSIDER STORAGE OF HIGHLY SENSITIVE OXIDIZERS IN A SEPARATE BUILDING IN A REMOTE LOCATION.
2 II B	HW6A / HW*	HW OXIDIZERS (GROUP 6A)	AMMONIUM PERCHLORATE OR METHYL ETHYL KETONE PEROXIDE (MEKP), DRIED OVER TIME, SUBJECTED TO SHOCK, FRICTION OR SUNLIGHT.	EXPLOSION OR FIRE IN STORAGE AREA, RELEASE OF TOXIC GASES, WORKER INJURY. (C;C;B;D)	(1) AMMONIUM PERCHLORATE IS ONLY ACCEPTED IN AN OXIDE (LIQUID) FORM, (2) FIRE SUPPRESSION SYSTEM.	(1) DEVELOP AND ENFORCE STRICT ACCEPTANCE CRITERIA FOR SENSITIVE OXIDIZERS (E.G., DILUTED FORM, FREQUENT INSPECTION, WETTED MATERIAL), (2) CONSIDER STORAGE OF HIGHLY SENSITIVE OXIDIZERS IN A SEPARATE BUILDING IN A REMOTE LOCATION.
2 II B	HWBK / HW*	HWRSF BULKING ROOM	INADEQUATE GUIDELINES OR	VIOLENT REACTION, RELEASE	(1) FIRE SUPPRESSION	(1) GUIDELINES

HAZARD ANALYSIS REPORT BY RISK

R---F---C	ACT/FAC	ACTIVITY NAME	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
			PROCEDURES FOR MIXING AND REBULKING WASTES LEADS TO VIOLENT REACTION, AND FUME HOOD FAILURE.	OF TOXIC GAS WITH WORKER EXPOSURE AND FACILITY CONTAMINATION. (D;D;B;C)	SYSTEM, (2) FULL PROTECTIVE GEAR, E.G. SUITS, FACE SHIELDS).	(PROCEDURES) FOR MIXING AND BULKING SHOULD BE DEVELOPED AND REVIEWED. (2) WORKER SHOULD WEAR REPIRATOR UNTIL THE POSSIBILITY OF VIOLENT REACTIONS IS PASSED..
2 11 B	MWG / MW*	MWRSF GLOBAL (INTERNAL AND EXTERNAL) EVENTS	ACCIDENTS DURING TRANSPORTATION OF WASTE WITHIN THE MWRSF (FORKLIFTS, CRANES, OR MANUAL).	SPILL OF FLAMMABLES, REACTIVES, OR INCOMPATIBLE WASTES LEADING TO TOXIC GAS RELEASE/ FIRE. WORKER INJURY. (D;C;B;C)	NONE	(1) MAINTAIN PHYSICAL SEPARATION OF INCOMPATIBLE WASTES DURING TRANSPORTATION (E.G., DO NOT TRANSPORT DRUM OVER INCOMPATIBLE WASTES WITH THE CRANE), (2) LIMIT SIMULTANEOUS OPERATION OF MULTIPLE FORKLIFTS.
2 11 B	MWG / MW*	MW GLOBAL (INTERNAL AND EXTERNAL) EVENTS	CRACKS IN STORAGE CONTAINERS PROPAGATED BY RAIN OR SNOW (BLOWN ONTO DRUMS) FREEZES OVER.	RUPTURE OF WASTE CONTAINER, SPILL WITH RELEASE OF TOXIC GASES. (C;C;B;C)	NONE	ENCLOSE THE MW STORAGE BUILDING.
2 11 B	MWG / MW*	MW GLOBAL (INTERNAL AND EXTERNAL) EVENTS	ACCIDENTS DURING TRANSPORTATION OF WASTE WITHIN THE MW STORAGE AREA (FORKLIFTS OR MANUAL).	SPILL OF FLAMMABLES, REACTIVES, OR INCOMPATIBLE WASTES LEADING TO TOXIC GAS RELEASE/ FIRE. WORKER INJURY. (C;B;B;B)	NONE	(1) ENCLOSE THE MW STORAGE AREA, (2) MAINTAIN PHYSICAL SEPARATION OF INCOMPATIBLE WASTES DURING TRANSPORTATION, (3) LIMIT SIMULTANEOUS OPERATION OF MULTIPLE FORKLIFTS.
2 11 B	GC6 / MWTF	CYLINDER BREACHED	SAW JAMS OR OTHER MECHANICAL FAILURES DURING CUTTING, WORKER OPENS VESSEL TO INSPECT, CAUSING UNEXPECTED RELEASE.	RELEASE OF TOXIC GAS, WORKER EXPOSURE AND SERIOUS INJURY. (D;D;B;D)	ONLINE GAS DETECTORS.	(1) VERIFY ATMOSPHERE PRIOR TO OPENING VESSEL. (2) WEAR PROTECTIVE GEAR (SCBA) WHEN OPENING VESSEL.
2 11 B	GC6 / MWTF	CYLINDER BREACHED	TREATMENT SKID (VALVES FOR CONTAINMENT VESSEL) MISALIGNED BEFORE OR AFTER CYLINDER BREACH.	RELEASE OF MODERATELY TOXIC GASES (E.G., NO2, H2S, ETC...) TO ATMOSPHERE AND/OR BUILDING. WORKER EXPOSURE. (C;C;B;D)	HEPA AND SCRUBBING SYSTEM.	(1) INDEPENDENT VERIFICATION OF SYSTEM ALIGNMENT BEFORE CUTTING. (2) USE PROCEDURE WITH CHECKLIST, (3) PROVIDE VALVE POSITION INDICATION.
2 11 B	LIH14 / MWTF	LITHIUM OXIDE REMOVED FROM THE HUMIDIFIER AND PLACED IN THE REACTOR	INCOMPLETE REACTION OF THE LITHIUM HYDRIDE IN THE HUMIDIFIER	POTENTIAL FOR LITHIUM HYDRIDE FIRE AND WORKER EXPOSURE TO LIH/DEPLETED URANIUM WHILE DISPOSING OF PARTIALLY REACTED WASTE. (D;D;B;D)	NONE	USE DIVERSE METHODS FOR VERIFICATION THAT THE REACTION IS COMPLETE. CONTINUE WEARING PROTECTIVE CLOTHING/BREATHING APPARATUS WHILE PROCESSING REACTION

HAZARD ANALYSIS REPORT BY RISK

R---F---C	ACT/FAC	ACTIVITY NAME	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
						PRODUCTS.
2 III A	HW4A / HW*	HWRSF FLAMMABLES (GROUP 4A)	SPILL OF LOW FLASH POINT CHEMICALS (ACETHALHENYE(-38F), FURAN (-32F), ANHYDROUS ETHYLE (-49F)) DUE TO FORKLIFT ACCIDENT, CRANE ACCIDENT OR CORROSION. FIRE SUPPRESSION SYSTEM INADEQUATE.	IGNITION OF FLAMMABLE VAPORS LEADS TO A MAJOR FIRE AND EXPLOSION (E.G., NITROMETHANE) IN THE STORAGE AREA. RELEASE OF MULTIPLE TOXIC GASES (E.G., PHOSGENE) TO ATMOSPHERE. (B;B;A;A)	GROUNDING OF ELECTRICAL EQUIPMENT AND DRUMS DURING TRANSPORTATION. NONSPARK TOOLS ARE USED.	(1) TREAT HIGHLY FLAMMABLE MATERIALS ON AN PRIORITY BASIS, DO NOT ALLOW ACCUMULATIONS OF LARGE INVENTORIES, (2) CONSIDER SPECIALLY DESIGNED STORAGE CONFIGURATION FOR THE MOST HAZARDOUS (LOW FLASH POINT) FLAMMABLE WASTES, (3) INSTALL GAS DETECTOR AND ALARM, (4) CONSIDER ADDING A FLARE TO THE SCRUBBER SYSTEM, (5) CONSIDER INERT FIRE SUPPRESSION SYSTEM, (E.G., INERT THE ROOM WITH N2 WHEN THE GAS ANALYZERS ALARM).
2 III A	HW4A / HW*	HWRSF FLAMMABLES (GROUP 4A)	OVERHEAD CRANE DROPS DRUM CAUSING DUAL SPILL OF INCOMPATIBLE MATERIALS DUE TO MISLABELING OF WASTE DRUM. (E.G., FLAMMABLE WASTE MIXED WITH; (1) NAOH(1A), (2) H2SO4(1B), (3) LITHIUM HYDRIDE(2A), (4) NITRIC ACID(6A), (5) CHLOROBENZENE.)	RELEASE OF TOXIC GASES AND POTENTIAL FIRE WITH GENERATION OF PHOSGENE AND WORKER FATALITY. (C;C;A;C)	(1) CARBON ABSORBTION BED IN THE HEPA FILTER, (2) FIRE SUPPRESSION SYSTEM.	(1) DEVELOP PROCEDURES TO PREVENT OR MINIMIZE CRANE MOVEMENTS OVER STORED WASTES, (2) VERIFY DRUM CONTENTS AND LABELING AT WASTE GENERATORS SITE, (3) DEVELOP LAB WIDE PROCEDURE (LAB ES&H MANUAL) FOR WASTE IDENTIFICATION AND LABELING OF WASTE CONTAINERS.
2 III A	HW4A / HW*	HWRSF FLAMMABLES (GROUP 4A)	OVERHEAD CRANE DROPS DRUM CAUSING DUAL SPILL OF INCOMPATIBLE FLAMMABLE MATERIALS ROUTINELY STORED IN THE SAME AREA. (E.G., NITROMETHANE WITH ACETONE)	RELEASE OF TOXIC GASES (E.G., PHOSGENE) AND POTENTIAL FIRE. WORKER INJURY. (C;C;A;C)	CARBON ABSORBTION BED IN THE HEPA FILTER.	(1) DEVELOP PROCEDURES TO PREVENT OR MINIMIZE CRANE MOVEMENTS OVER STORED WASTES, (2) STORE INCOMPATIBLE FLAMMABLE MATERIALS IN SEPARATE LOCATIONS WITHIN THE FLAMMABLE STORAGE AREA.
2 III A	HW4A / HW*	HW FLAMMABLE STORAGE (GROUP 4A)	PICRIC ACID DROPPED OR JARRED.	DETONATION, MAJOR FIRE IN HWTF STORAGE AREA, MULTIPLE TOXIC GASES (E.G., PHOSGENE, HCN, ETC...) RELEASED DIRECTLY TO ENVIRONMENT, WORKER FATALITY, PUBLIC EXPOSURE. (A;A;A;A)	NONE	DEVELOP AND ENFORCE POLICY NOT TO STORE EXPLOSIVES OR SHOCK SENSITIVE MATERIALS IN THIS BUILDING.
2 III A	HW4A / HW*	HW FLAMMABLE STORAGE (GROUP 4A)	SPILL OF LOW FLASH POINT CHEMICALS (ACETHALHENYE(-39F), FURAN (-32F), ANHYDROUS	IGNITION OF FLAMMABLE VAPORS LEADS TO A MAJOR FIRE AND EXPLOSION (E.G., NITROMETHANE) IN THE	FIRE SUPPRESSION SYSTEM.	(1) TREAT HIGHLY FLAMMABLE MATERIALS ON AN PRIORITY BASIS, DO NOT ALLOW ACCUMULATIONS OF

HAZARD ANALYSIS REPORT BY RISK

R---F---C	ACT/FAC	ACTIVITY NAME	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
			ETHYL ETHER(-49F)) DUE TO FORKLIFT ACCIDENT, OR CORROSION. FIRE SUPPRESSION SYSTEM INADEQUATE.	STORAGE AREA. RELEASE OF MULTIPLE TOXIC GASES (E.G., PHOSGENE) TO ATMOSPHERE. (B;B;A;A)		LARGE INVENTORIES, (2) CONSIDER SPECIALLY DESIGNED STORAGE CONFIGURATION FOR THE MOST HAZARDOUS (LOW FLASH POINT) FLAMMABLE WASTES, (3) CONSIDER ENCLOSING THE BUILDING TO INCREASE THE EFFICIENCY OF THE FIRE SUPPRESSION SYSTEM AND INSTALL GAS DETECTOR AND ALARM.
2 III A	HW4A / HW*	HW FLAMMABLE STORAGE (GROUP 4A)	FORKLIFT ACCIDENT CAUSING DUAL SPILL OF INCOMPATIBLE FLAMMABLE MATERIALS ROUTINELY STORED IN THE SAME AREA. (E.G., NITROMETHANE WITH ACETONE)	RELEASE OF TOXIC GASES (E.G., PHOSGENE) AND POTENTIAL FIRE. POTENTIAL WORKER FATALITY. (B;B;A;B)	NONE	(1) CONSIDER ENCLOSING THE BUILDING TO REDUCE TOXIC GAS EXPOSURE TO THE PUBLIC AND COLOCATED WORKER, (2) STORE INCOMPATIBLE FLAMMABLE MATERIALS IN SEPARATE LOCATIONS WITHIN THE FLAMMABLE STORAGE AREA, (3) INSTALL SCRUBBING SYSTEM.
2 III A	HW4A / HW*	HW FLAMMABLE STORAGE (GROUP 4A)	FORKLIFT ACCIDENT CAUSING DUAL SPILL OF INCOMPATIBLE MATERIALS DUE TO MISLABELING OF WASTE DRUM. (E.G., FLAMMABLE WASTE MIXED WITH; (1) NAOH(1A), (2) H2SO4(1B), (3) LITHIUM HYDRIDE(2A), (4) NITRIC ACID(6A), (5) CHLOROBENZENE.)	RELEASE OF TOXIC GASES AND POTENTIAL FIRE AND GENERATION OF TOXIC GASES (E.G., PHOSGENE). POTENTIAL WORKER AND COLOCATED WORKER FATALITY. (B;B;A;B)	NONE	(1) CONSIDER ENCLOSING THE BUILDING TO REDUCE TOXIC GAS EXPOSURE TO THE PUBLIC AND COLOCATED WORKER, (2) INSTALL SCRUBBING SYSTEM, (3) VERIFY DRUM CONTENTS AND LABELING AT WASTE GENERATORS SITE, (4) DEVELOP LAB WIDE PROCEDURE (LAB ES&H MANUAL) FOR WASTE IDENTIFICATION AND LABELING OF WASTE CONTAINERS.
2 III A	HW5A / HW*	HWRSF CYANIDES AND SULFIDES (GROUP 5A)	FORKLIFT ACCIDENT CAUSES SIMULTANEOUS SPILL OF CYANIDE AND OTHER NONCOMPATIBLE WASTE (E.G., H2SO4(1B), OR PERCHLORIC ACID(6A)) DUE TO MISLABELING.	RELEASE OF TOXIC GASES (E.G., HCN AND CYANOGEN) AND POSSIBLE EXPLOSION AND FIRE. SEVERE WORKER INJURY, AND LOW LEVEL RADIOACTIVE CONTAMINATION IN THE FACILITY. (D;D;A;C)	(1) USE OF SMALL "WALK BEHIND" FORKLIFTS, (2) DRUMS ARE STORED ONLY ONE LEVEL HIGH, (3) SCRUBBER SYSTEM, (4) FIRE SUPPRESSION SYSTEM.	(1) PROVIDE HCN ANALYZER AND ALARM, (2) VERIFY DRUM CONTENTS AND LABELING AT WASTE GENERATORS SITE, (3) DEVELOP LAB WIDE PROCEDURE (LAB ES&H MANUAL) FOR WASTE IDENTIFICATION AND LABELING OF WASTE CONTAINERS.
2 III A	HW6A / HW*	HWRSF OXIDIZERS (GROUP 6A)	OVERHEAD CRANE DROPS DRUM CAUSING DUAL SPILL OF INCOMPATIBLE MATERIALS DUE TO MISLABELING OF	RELEASE OF HIGHLY TOXIC GASES, POTENTIAL EXPLOSION AND POTENTIAL FIRE. VERY HIGH FIRE	(1) CARBON ABSORBTION BED IN THE HEPA FILTER, (2) FIRE SUPPRESSION AND SCRUBBER SYSTEM.	(1) DEVELOP PROCEDURES TO PREVENT OR MINIMIZE CRANE MOVEMENT OVER STORED WASTES, (2) VERIFY DRUM

HAZARD ANALYSIS REPORT BY RISK

R---F---C	ACT/FAC	ACTIVITY NAME	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
			WASTE DRUM. (E.G., OXIDIZER WASTE MIXED WITH; (1) NAOH(1A), (2) ACETIC ACID(1B), (3) SODIUM(2A), (4) ORGANICS(4A) SUCH AS CHLORO BENZENE, (5) GOLD CYANIDE(5A))	POTENTIAL WITH GENERATION OF PHOSGEN WITH SPILLS INVOLVING CHLORO BENZENE. POTENTIAL WORKER FATALITY. (C;B;A;C)		CONTENTS AND LABELING AT WASTE GENERATORS SITE, (3) DEVELOP LAB WIDE PROCEDURE (LAB ES&H MANUAL) FOR WASTE IDENTIFICATION AND LABELING OF WASTE CONTAINERS.
2 III A	HW6A / HW*	HW OXIDIZERS (GROUP 6A)	FORKLIFT ACCIDENT OR FREEZING CAUSING DUAL SPILL OF INCOMPATIBLE MATERIALS DUE TO MISLABELING OF WASTE DRUM. (E.G., OXIDIZER WASTE MIXED WITH; (1) NAOH(1A), (2) ACETIC ACID(1B), (3) SODIUM(2A), (4) ORGANICS SUCH AS CHLORO BENZENE(4A), (5) GOLD CYANIDE(5A))	RELEASE OF TOXIC GASES, POTENTIAL EXPLOSION AND POTENTIAL FIRE. FIRE INVOLVING CHLORA BENZENE COULD GENERATE PHOSGENE GAS. POTENTIAL WORKER FATALITY. (B;A;A;B)	FIRE SUPPRESSION SYSTEM.	(1) VERIFY DRUM CONTENTS AND LABELING AT WASTE GENERATORS SITE, (2) DEVELOP LAB WIDE PROCEDURE (LAB ES&H MANUAL) FOR WASTE IDENTIFICATION AND LABELING OF WASTE CONTAINERS, (3) ENCLOSE THE HWTF STORAGE BUILDING AND INSTALL SCRUBBER SYSTEM.
2 III A	HW7A / HW*	HWRSF GASES (GROUP 7A)	BREACH OF CYLINDER (NON-LEGACY) DUE TO ACCIDENTAL CAUSES (E.G., CYLINDER DROPPED AND REGULATOR LINE BREAKS) WHICH RESULT IN MAJOR CYLINDER DAMAGE.	RELEASE OF HIGHLY TOXIC GASES (PHOSPHINE, PHOSGEN, ARSINE, AND OTHERS). WORKER FATALITY, POTENTIAL COLOCATED WORKER AND PUBLIC EXPOSURE. (C;C;A;B)	HEPA AND SCRUBBING SYSTEM.	(1) TRANSPORT AND STORE CYLINDERS SECURELY, (2) CONSIDER INSTALLATION OF A FLARE AND/OR A SPECIAL SCRUBBER FOR THIS FACILITY, (3) INSTALL GAS DETECTORS AND ALARMS, (4) CONSIDER SECONDARY CONTAINMENT FOR MOST HAZARDOUS CYLINDERS, (5) GAS CYLINDERS TO BE PROCESSED WITH HIGH PRIORITY, (6) WORK IN THIS AREA TO BE PERFORMED WITH PROTECTION (I.E., WEAR SCBA, OPERATE UNDER THE BUDDY SYSTEM), (7) PROTECTIVE CAP FOR CYLINDER REGULATORS SHOULD BE IN PLACE AT ALL TIMES., (8) STORE GAS CYLINDERS IN AN ENCLOSED AREA.
2 III A	HW7A / HW*	HWRSF GASES (GROUP 7A)	EXTERNAL FIRE (INITIATED WITHIN THE HWRSF BUILDING).	PRESSURIZATION AND RUPTURE OF GAS CYLINDERS. HIGHLY TOXIC GAS RELEASE AND POTENTIAL CYLINDER MISSILE GENERATION. (A;A;A;A)	(1) FIRE PROTECTION SYSTEM, (2) HEPA AND SCRUBBING SYSTEM, (3) FUSIBLE PRESSURE RELIEF.	STORE GAS CYLINDERS IN AN ENCLOSED AREA WITH FIRE DOOR AND FIRE WALL.
2 III A	HW7A / HW*	HW GASES (GROUP 7A)	BREACH OF CYLINDER (NON-LEGACY) DUE TO ACCIDENTAL CAUSES (E.G., CYLINDER DROPPED AND	RELEASE OF HIGHLY TOXIC GASES (PHOSPHINE, PHOSGEN, ARSINE, AND OTHERS). WORKER	NONE	(1) TRANSPORT AND STORE CYLINDERS SECURELY, (2) CONSIDER SECONDARY CONTAINMENT FOR MOST

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HAZARD ANALYSIS REPORT BY RISK

R---F---C	ACT/FAC	ACTIVITY NAME	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
			REGULATOR LINE BREAKS).	FATALITY, POTENTIAL COLOCATED WORKER AND PUBLIC EXPOSURE. (A;A;A;D)		HAZARDOUS CYLINDERS, (3) GAS CYLINDERS TO BE PROCESSED WITH HIGH PRIORITY, (4) WORK IN THIS AREA TO BE PERFORMED WITH PROTECTION (I.E., WEAR SCBA, OPERATE UNDER THE BUDDY SYSTEM), (5) PROTECTIVE CAP FOR CYLINDER REGULATORS SHOULD BE IN PLACE AT ALL TIMES, (6) CONSIDER STORING GAS CYLINDERS IN ENCLOSED ROOM IN AN INCLOSED BUILDING.
2 III A	HW7A / HW*	HW GASES (GROUP 7A)	EXTERNAL FIRE (INITIATED WITHIN THE BUILDING).	PRESSURIZATION AND RUPTURE OF GAS CYLINDERS. HIGHLY TOXIC GAS RELEASE AND POTENTIAL CYLINDER MISSILE GENERATION. (A;A;A;A)	FIRE PROTECTION SYSTEM, FUSIBLE PRESSURE RELIEF.	(1) INITIATE FIRE SUPPRESSION SPRINKLERS GIVEN FIRE IN ADJACENT AREAS, (2) ENCLOSE THE HW STORAGE AREA AND STORE GAS CYLINDERS IN AN ENCLOSED AREA.
2 III A	HW9 / HW*	HW NONREGULATED WASTES (GROUP 9)	SPILL (DUE TO FREEZING OR FORKLIFT ACCIDENT) OF INCOMPATIBLE WASTES ROUTINELY STORED IN NONREGULATED AREA (E.G., MISLABLED, TEMPORARY STORAGE, OR DO NOT BELONG IN OTHER DEFINED REGULATED AREAS)	FIRE AND RELEASE OF TOXIC GASES (E.G., HF). (B;B;A;B)	FIRE PROTECTION SYSTEM.	(1) CONSIDER ELIMINATING THIS AREA, (2) CLASSIFY AND STORE ALL NONREGULATED WASTES IN COMPATIBLE REGULATED AREAS, (3) ENCLOSE THE HAZARDOUS WASTE STORAGE BUILDING.
2 III A	HWG / HW*	HWRSF GLOBAL (INTERNAL AND EXTERNAL) EVENTS	MEDIUM INTENSITY SEISMIC EVENT WITH HORIZONTAL ACCELERATION OF 0.17 G.	MIXING OF INCOMPATIBLE WASTES STORED IN ADJACENT AREAS. VIOLENT REACTIONS, POTENTIAL FIRE, AND RELEASE OF TOXIC FUMES (E.G., PHOSGENE OR HCN). POTENTIAL LOSS OF SCRUBBER. NOTE: SHOCK SENSITIVE MATERIAL NOT CONSIDERED IN THIS SCENARIO. (C;C;A;C)	NONE	(1) REVIEW SEISMIC DESIGN CRITERIA, (2) ENSURE THAT INCOMPATIBLE WASTES ARE NOT STORED IN ADJACENT AREAS. SEE POTENTIAL HWRSF FLOORPLAN DEVELOPED BY PHA TEAM, (3) MINIMIZE STORAGE TIME OF MOST FLAMMABLE/ TOXIC MATERIALS.
2 III A	HWG / HW*	HWRSF GLOBAL (INTERNAL AND EXTERNAL) EVENTS	ACCIDENT DURING TRANSPORTATION OF THE MOST TOXIC WASTE DRUMS (E.G., TOXIC GAS CYLINDERS OR INCOMPATIBLE WASTES) FROM HWRSF TO CAI OR OTHER FACILITIES.	SPILL LEADING TO THE UNMITIGATED RELEASE OF TOXIC GASES. PUBLIC EXPOSURE. (A;A;A;A)	NONE	(1) CONSIDER ROAD CLOSURE WHILE TRANSPORTING THE MOST HAZARDOUS MATERIALS BETWEEN LAB AREAS, (2) REVIEW PROCEDURES FOR SECURING WASTE DRUMS DURING TRANSPORTATION, (3) DO NOT TRANSPORT INCOMPATIBLE WASTE DRUMS TOGETHER.

HAZARD ANALYSIS REPORT BY RISK

R---F---C	ACT/FAC	ACTIVITY NAME	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
2 III A	HWG / HW*	HW GLOBAL (INTERNAL AND EXTERNAL) EVENTS	MEDIUM INTENSITY SEISMIC EVENT WITH HORIZONTAL ACCELERATION OF 0.17 G.	MIXING OF INCOMPATIBLE WASTES STORED IN ADJACENT AREAS. VIOLENT REACTIONS, POTENTIAL FIRE, AND RELEASE OF TOXIC FUMES (E.G., PHOSGENE, HCN). NOTE: SHOCK SENSITIVE MATERIAL NOT CONSIDERED IN THIS SCENARIO. (B;B;A;B)	NONE	(1) REVIEW SEISMIC DESIGN CRITERIA, (2) ENSURE THAT INCOMPATIBLE WASTES ARE NOT STORED IN ADJACENT AREAS. SEE POTENTIAL MWRSF FLOORPLAN DEVELOPED BY PHA TEAM, (3) MINIMIZE STORAGE TIME OF MOST FLAMMABLE/ TOXIC MATERIALS, (4) ENCLOSE THE HW STORAGE AREA.
2 III A	HWG / HW*	HW GLOBAL (INTERNAL AND EXTERNAL) EVENTS	ACCIDENT DURING TRANSPORTATION OF WASTE (TOXIC GAS CYLINDERS OR INCOMPATIBLE WASTE DRUMS) FROM HW STORAGE TO CAI OR OTHER FACILITY.	SPILL LEADING TO THE UNMITIGATED RELEASE OF TOXIC GASES. PUBLIC EXPOSURE. (A;A;A;A)	NONE	(1) CONSIDER ROAD CLOSURE WHILE TRANSPORTING THE MOST HAZARDOUS MATERIALS BETWEEN LAB AREAS, (2) REVIEW PROCEDURES FOR SECURING WASTE DRUMS DURING TRANSPORTATION, (3) DO NOT TRANSPORT INCOMPATIBLE WASTE DRUMS TOGETHER.
2 III A	GC1 / MWRSF	LOAD CYLINDER FROM TA-54 ONTO TRANSPORT VEHICLE AND MOVE TO TA-63	HANDLING ACCIDENT WHILE REMOVING CYLINDER FROM STORAGE, (E.G., CYLINDER FALLS BREAKING VALVE OR CONNECTIONS OR RUPTURE OF A CORRODED CYLINDER).	RELEASE OF TOXIC GAS FROM A SINGLE CYLINDER (E.G., CYANOGEN, ARSENIC PENTAFLORIDE, HF, PHOSGENE). POSSIBLE WORKER FATALITY. (C;D;A;D)	NONE	(1) CONSIDER SECONDARY CONTAINMENT FOR KNOWN HIGHLY TOXIC GAS CYLINDERS AND ALL UNKNOWN GAS CYLINDERS, (2) VALVE COVERS SHOULD BE IN PLACE ON ALL CYLINDERS, (3) TRAIN WORKERS TO EVACUATE IN UPWIND DIRECTION, AND LOCATE GAS MASKS IN UPWIND DIRECTION, (4) INSTALL A WIND SOCK FOR CONTINUOUS WIND DIRECTION INDICATION, (5) CONSIDER PROTECTIVE CLOTHING FOR MIXED WASTE GAS RELEASE.
2 III A	GC2 / MWRSF	TRANSPORT OF GAS CYLINDER TO TA-63 MWRSF	TRUCK ACCIDENT ON PUBLIC ROAD BETWEEN TA-54 AND TA-63 WITH BREACH OF GAS CYLINDER(S).	POTENTIAL RELEASE OF TOXIC GASES WITH PUBLIC AND WORKER EXPOSURE. (A;C;A;D)	NONE	ADMINISTRATIVE CONTROLS; (1) PROVIDE ESCORT FOR THE TRANSPORT VEHICLE AND CONSIDER ROAD CLOSURE DURING TRANSPORT, (2) DRIVER TRAINING, (3) RESTRICT NIGHT OR POOR WEATHER DELIVERIES, (4) CONSIDER SECONDARY CONTAINMENT FOR CYLINDERS OF QUESTIONABLE INTEGRITY, UNKNOWN CONTENTS, OR THOSE CONTAINING MOST HIGHLY TOXIC MATERIALS.
2 III A	GC6 / MWTF	CYLINDER BREACHED	TREATMENT SKID (VALVES	RELEASE OF HIGHLY TOXIC	HEPA AND SCRUBBING	(1) INDEPENDENT

HAZARD ANALYSIS REPORT BY RISK

R---F-- C	ACT/FAC	ACTIVITY NAME	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
			FOR CONTAINMENT VESSEL) MISALIGNED BEFORE OR AFTER CYLINDER BREACH.	GASES (PHOSPINE, PHOSGEN, ARSINE, AND OTHERS) TO ATMOSPHERE AND/OR BUILDING. WORKER FATALITY, POTENTIAL COLOCATED WORKER AND PUBLIC EXPOSURE. (C;B;A;D)	SYSTEM.	VERIFICATION OF SYSTEM ALIGNMENT BEFORE CUTTING. (2) USE PROCEDURE WITH CHECKLIST, (3) PROVIDE VALVE POSITION INDICATION.
2 III A	GC6 / HWTF	CYLINDER BREACHED	INADVERTANT CUTTING OF CYLINDER PRIOR TO SEALING VESSEL.	RELEASE OF TOXIC GAS INTO ROOM, WORKER EXPOSURE AND POSSIBLE FATALITY. (D;D;A;D)	NONE	(1) INSTALL INTERLOCKS TO PREVENT SAW OPERATION BEFORE SEALING AND INERTING PRESSURE VESSEL. (2) VERIFY DOOR CLOSURE PRIOR TO STARTING SAW.
2 III A	GC6 / HWTF	CYLINDER BREACHED	PRESSURE VESSEL INCORRECTLY SEALED (SUCH AS DOOR SEAL) OR SEAL FAILS CAUSING LEAKAGE.	MINOR LEAK OF HIGHLY TOXIC GAS (PHOSPHINE, PHOSGEN, ARSINE) FROM LEAKY SEALS, POTENTIAL WORKER FATALITY. (D;D;A;D)	NONE	(1) PERFORM CHECK OF PRESSURE VESSEL SEAL BEFORE CUTTING OPERATION. (2) MINIMIZE TIME BETWEEN CUTTING AND DISPOSAL OR RECONTAINERIZATION. (3) LOCATE CONTROL PANEL AWAY FROM SKID.
2 III A	CY1 / MWRSF	TRUCK ENTERS FACILITY AND DRIVES TO DOCK (PLATING WASTES).	TRUCK ACCIDENT WITH BREACH OF MULTIPLE WASTE CONTAINERS LEADING TO MIXING OF INCOMPATIBLE WASTES. DUE TO (1) NORMAL TRANSPORT OF INCOMPATIBLES, (2) MISLABELED DRUMS.	POSSIBLE PRODUCTION OF HCN. WORKER(S) EXPOSED TO HCN GAS WITH POSSIBLE FATALITIES, AND INJURY TO COLOCATED WORKERS. MINOR ONSITE CONTAMINATION. (B;B;A;C)	NONE	ADMINISTRATIVE CONTROLS; (1) ANNOUNCEMENT OF DELIVERY, (2) DRIVER TRAINING, (3) RESTRICT OTHER TRAFFIC DURING DELIVERY. CONSIDER REVIEW OF TRANSPORTATION PROCEDURES, E.G., (1) RESTRICT THE TRANSPORTATION OF INCOMPATIBLE WASTES IN SINGLE TRUCK, (2) CONSIDER TRANSPORT OF ONE DRUM AT A TIME.
2 III B	DU4 / HWTF	YARD FORKLIFT DELIVERS DEPLETED URANIUM WASTE DRUM TO TREATMENT ROOM DOOR	FORKLIFT ACCIDENT DURING TRANSPORT BETWEEN BUILDINGS.	SPILL OF DRUM CONTENTS WITH FIRE AND CRASH INFLICTED INJURY TO DRIVER. DRIVER EXPOSED TO FIRE, FUMES AND DEPLETED URANIUM. CONTAMINATION OF FACILITY (TA) WITH MINOR OFFSITE CONTAMINATION. (C;C;B;B)	NONE	MOVE ONLY ONE PALLET OR DRUM AT A TIME, RESTRICT OTHER VEHICLE DURING TRANSPORT.
2 III B	DU1 / MWRSF	TRUCK ENTERS AND DRIVES TO DOCK	TRUCK ACCIDENT WITH FIRE AND BREACH OF DEPLETED URANIUM WASTE CONTAINER.	RADIOACTIVE RELEASE TO ATMOSPHERE DUE TO BURNING OF DEPLETED URANIUM. TRUCK DRIVER INCAPACITATED DUE TO ACCIDENT, IS EXPOSED TO FUMES AND DEPLETED	NONE	ADMINISTRATIVE CONTROLS SUCH AS (1) ANNOUNCEMENT OF DELIVERY, (2) DRIVER TRAINING, (3) RESTRICT OTHER TRAFFIC DURING DELIVERY.

HAZARD ANALYSIS REPORT BY RISK

R---F---C	ACT/FAC	ACTIVITY NAME	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
				URANIUM. CONTAMINATION OF FACILITY (TA) AND MINOR OFFSITE CONTAMINATION. (C;C;B;B).		
2 III B	HW5A / HW*	HWTF CYANIDES AND SULFIDES STORAGE	ACCIDENT CAUSES SIMULTANEOUS SPILL OF CYANIDE AND OTHER NONCOMPATIBLE WASTE (E.G., H2SO4(1B), OR PERCHLORIC ACID(6A)) DUE TO MISLABELING.	RELEASE OF TOXIC GASES (E.G., HCN AND CYANOGEN) AND POSSIBLE EXPLOSION AND FIRE. SEVERE WORKER INJURY. (B;B;B;C)	SEPARATE STORAGE BUILDING FOR HAZARDOUS CYANIDE WASTE.	(1) CONSIDER ENCLOSING THE HWTF STORAGE BUILDING AND PROVIDING HVAC, (2) INSTALL A SCRUBBER SYSTEM, (3) PROVIDE HCN ANALYZER AND ALARM, (4) VERIFY DRUM CONTENTS AND LABELING AT WASTE GENERATORS SITE, (5) DEVELOP LAB WIDE PROCEDURE (LAB ES&H MANUAL) FOR WASTE IDENTIFICATION AND LABELING OF WASTE CONTAINERS.
2 III B	HW5A / HW*	HWTF CYANIDES AND SULFIDES STORAGE	MERCURY OXYCYANIDE DETONATES DUE TO HEATING, FROM SHOCK OR FRICTION (E.G., FORKLIFT ACCIDENT).	SMALL EXPLOSION LEADING TO TOXIC GAS (E.G., MERCURY FUMES, CYANIDE AND NOX) RELEASE. SEVERE WORKER INJURY DUE TO TOXIC GAS EXPOSURE. (B;B;B;C)	NONE	DEVELOP AND ENFORCE POLICY NOT TO STORE EXPLOSIVES OR SHOCK SENSITIVE MATERIALS IN THIS BUILDING.
2 III B	HW2A / HW*	HW REACTIVES (GROUP 2A)	ACCIDENT DUE TO HUMAN ERROR CAUSES SIMULTANEOUS SPILL OF WATER REACTIVE WASTE AND INCOMPATIBLE WASTE DUE TO MISLABELING. (E.G., REACTIVE WASTE MIXED WITH, SULFURIC ACID(1B), NAOH(1A), PERCHLORIC ACID(6A) OR TRICHLORA ETHYLENE(4A))	PRODUCTION OF HYDROGEN GAS, POTENTIAL FIRE AND/OR EXPLOSION AND PRODUCTION OF TOXIC FUMES (E.G., HCN). SEVERE WORKER INJURY. (B;B;B;D)	NONE	(1) VERIFY DRUM CONTENTS AND LABELING AT WASTE GENERATORS SITE, (2) DEVELOP LAB WIDE PROCEDURE (LAB ES&H MANUAL) FOR WASTE IDENTIFICATION AND LABELING OF WASTE CONTAINERS.
2 III B	HW1B / HW*	HW ACIDS (GROUP 1B)	FORKLIFT ACCIDENT OR FREEZING CAUSING SIMULTANEOUS SPILL OF ACID MATERIAL AND INCOMPATIBLE MATERIAL (E.G., NAOH(1A), NITROBENZENE(4A), HYDROGEN PEROXIDE(6A), METAL CYANIDE(5A), LITHIUM HYDRIDE(2A)) DUE TO MISLABELING.	POTENTIAL FIRE, EXPLOSION, HYDROGEN GAS PRODUCTION AND TOXIC GAS GENERATION (E.G., HCN). WORKER INJURY/EXPOSURE. (B;B;B;C)	FIRE SUPPRESSION SYSTEM.	(1) VERIFY DRUM CONTENTS AND LABELING AT WASTE GENERATORS SITE, (2) DEVELOP LAB WIDE PROCEDURE (LAB ES&H MANUAL) FOR WASTE IDENTIFICATION AND LABELING OF WASTE CONTAINERS, (3) STORE WASTE IN ENCLOSED BUILDING TO PREVENT FREEZING.
2 III B	HW8 / HW*	HW PCB (GROUP 8)	MISLABELED DRUM RESULTS IN PCB DRUM BEING STORED NEAR FLAMMABLE WASTE. ACCIDENTAL BREACH OF THE	BURNING OF PCB WASTE. DISPERSION OF PCB WASTE TO THE ENVIRONMENT. (B;B;B;B).	FIRE PROTECTION SYSTEM.	(1) VERIFY DRUM CONTENTS AND LABELING AT WASTE GENERATORS SITE, (2) DEVELOP LAB WIDE

HAZARD ANALYSIS REPORT BY RISK

R---F---C	ACT/FAC	ACTIVITY NAME	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
			CONTAINERS LEADS TO FIRE AND BURNING OF PCB WASTE.			PROCEDURE (LAB ES&H MANUAL) FOR WASTE IDENTIFICATION AND LABELING OF WASTE CONTAINERS.
2 III B	HW8 / HW*	HW PCB (GROUP 8)	SPILL OF PCB WASTE DRUM DUE TO FORKLIFT ACCIDENT, RELEASE TO THE SUMP.	POTENTIAL RELEASE TO THE ENVIRONMENT THROUGH THE SUMP SYSTEM. ONSITE CONTAMINATION. (D;D;D;B)	SUMP SYSTEM.	(1) INSTALL PROCEDURES TO DETECT SUMP LEVELS, (2) TEST SUMP CONTENTS BEFORE DISCHARGE.
2 III B	GC7 / HWTF	SAMPLE, ANALYZE, AND DISPOSE PRESSURE VESSEL CONTENTS	MISROUTING OF TOXIC GAS (E.G., GAS SENT TO ATMOSPHERE) DUE TO HUMAN ERROR, SCRUBBER FAILED OR INEFFECTIVE.	TOXIC GASES INADVERTENTLY VENTED TO ATMOSPHERE, EXPOSURE TO PUBLIC, COLOCATED WORKERS AND WORKERS OUTSIDE THE BUILDING. (B;B;B;D)	NONE	(1) PROVIDE SAMPLING PROCEDURES WITH INDEPENDENT VERIFICATION, (2) VERIFY SYSTEM LINE-UP PRIOR TO ROUTING PRESSURE VESSEL CONTENTS.
2 III B	GC8 / HWTF	SCRUBBING AND DISPOSING OF CYLINDERS	RADIOACTIVE CONTAINER MISLABELED AS HAZARDOUS AND SENT OFF-SITE FOR TREATMENT.	VIOLATION OF REGULATIONS, LOCALIZED MINOR OFFSITE CONTAMINATION. (D;D;D;B)	ONLINE SAMPLING.	INDEPENDENTLY VERIFY CORRECT LABELING.
3 I D	DU8 / HWTF	VERMICULITE REMOVED AND BAGGED	LEAK FROM THE INNER DRUM (DEPLETED URANIUM IN OIL) TO THE VERMICULITE.	POTENTIAL MINOR CONTAMINATION PROBLEMS. LEAK CONTAINED IN OVERPACK. (D;D;D;D)		IF THERE ARE INDICATIONS OF A LEAK WHEN REMOVING THE [illegible]ER DRUM, DONOT REMOVE THE VERMICULITE.
3 I D	HWG / HW*	HWRSF GLOBAL (INTERNAL AND EXTERNAL) EVENTS	LIGHTNING STRIKES STORAGE BUILDING.	NOT A HAZARD. (D;D;D;D)	HWSRF EQUIPED WITH LIGHTNING RODS.	NONE
3 I D	HWG / HW*	HWRSF GLOBAL (INTERNAL AND EXTERNAL) EVENTS	HIGH WINDS	NO HAZARD. (D;D;D;D)	ENCLOSED STORAGE STRUCTURE.	NONE
3 I D	HWG / HW*	HW GLOBAL (INTERNAL AND EXTERNAL) EVENTS	LIGHTNING STRIKES STORAGE BUILDING.	NOT A HAZARD. (D;D;D;D)	EQUIPPED WITH LIGHTNING RODS.	NONE
3 I D	DU17 / HWTF	REDUCTION OF URANIUM HYDROXIDE BY SODIUM THIOSULFATE TO URANIUM DIOXIDE (DEPLETED URANIUM PROCESS)	SPILLS DURING REDUCTION, DECANTING, OR TRANSFER OF LIQUIDS OR SEDIMENT.	MINOR WORKER EXPOSURE AND FACILITY CONTAMINATION. (D;D;D;D)	NONE	NONE
3 I D	DU17 / HWTF	REDUCTION OF URANIUM HYDROXIDE BY SODIUM THIOSULFATE TO URANIUM DIOXIDE (DEPLETED URANIUM PROCESS)	SLURRY SPILLED DURING CEMENTATION PROCESS (I.E., OVERFILL, TIPPED OVER, ETC...)	MINOR CONTAMINATION IN TREATMENT ROOM. (D;D;D;D)	NONE	NONE
3 I D	LIH9 / HWTF	PRIMARY WASTE DRUM IS GROUNDED AND OPENED USING NON-SPARK TOOLS	LITHIUM HYDRIDE ENTRAINMENT IN THE VENT SYSTEM WHEN PRIMARY DRUM OPENED.	HEPA/SCRUBBER CONTAMINATION WITH LIH AND DEPLETED URANIUM. (D;D;D;D)	NONE	DESIGN/OPERATE HOOD VENT SUCH THAT LIH ENTRAINMENT NOT POSSIBLE.
3 II C	LIH4 / HWTF	YARD FORKLIFT DELIVERS LITHIUM HYDRIDE TO TREATMENT ROOM DOOR.	FORKLIFT ACCIDENT DURING TRANSPORT BETWEEN BUILDINGS.	SPILL OF DRUM CONTENTS, WORKER CONTAMINATION (LIH AND DEPLETED URANIUM).	NONE	(1) MOVE ONLY ONE PALLET AT A TIME, (2) RESTRICT OTHER VEHICLE DURING

HAZARD ANALYSIS REPORT BY RISK

R---F---C	ACT/FAC	ACTIVITY NAME	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
				ALSO FACILITY (TA) CONTAMINATION. (D;D;C;C)		TRANSPORT, (3)BREATHING APPARATUS AVAILABLE TO DRIVER, WITHIN REACH, (4) NO TRANSPORTS DURING WET WEATHER CONDITIONS.
3 II C	HW4A / HW*	HWRSF FLAMMABLES (GROUP 4A)	SPILL OF LOW FLASH POINT CHEMICALS (ACETHALHEHYE(-38F), FURAN (-32F), ANHYDROUS ETHYL (-49F)) DUE TO FORKLIFT ACCIDENT, CRANE ACCIDENT OR CORROSION.	WORKER EXPOSED TO TOXIC FUMES. (D;D;C;D)	CARBON ABSORBTION BED IN HEPA FILTER, FIRE SUPPRESSION SYSTEM.	INSTALL GAS ANALYZER WITH ALARM.
3 II C	HW4A / HW*	HWRSF FLAMMABLES (GROUP 4A)	SPILL OF LOW FLASH POINT CHEMICALS (ACETHALHEHYE(-38F), FURAN (-32F), ANHYDROUS ETHYL (-49F)) DUE TO FORKLIFT ACCIDENT, CRANE ACCIDENT OR CORROSION. FIRE SUPPRESSION SYSTEM OPERATIONAL.	IGNITION OF FLAMMABLE VAPORS LEADS TO CONTAINED FIRE IN THE STORAGE AREA. (D;D;C;D)	(1) FIRE SUPPRESSION SYSTEM, (2) CARBON ABSORBTION BED IN HEPA FILTER, AND SCRUBBING SYSTEM.	(1) TREAT HIGHLY FLAMMABLE MATERIALS ON AN PRIORITY BASIS, DO NOT ALLOW ACCUMULATIONS OF LARGE INVENTORIES, (2) CONSIDER SPECIALLY DESIGNED STORAGE CONFIGURATION FOR THE MOST HAZARDOUS (LOW FLASH POINT) FLAMMABLE WASTES, (3) INSTALL GAS DETECTOR AND ALARM, (4) CONSIDER ADDING A FLARE TO THE SCRUBBER SYSTEM, (5) CONSIDER INERT FIRE SUPPRESSION SYSTEM, (E.G., INERT THE ROOM WITH N2 WHEN THE GAS ANALYZERS ALARM).
3 II C	HW4A / HW*	HW FLAMMABLE STORAGE (GROUP 4A)	FREEZING TEMPERATURES CAUSES RUPTURE OF DRUM AND SPILL OF FLAMMABLE MATERIALS.	WORKER EXPOSED TO TOXIC FUMES. (D;D;C;D)	NONE	NONE
3 II C	HW4A / HW*	HW FLAMMABLE STORAGE (GROUP 4A)	SPILL OF LOW FLASH POINT CHEMICALS (ACETHALHEHYE(-38F), FURAN (-32F), ANHYDROUS ETHYL ETHER (-49F)) DUE TO FORKLIFT ACCIDENT OR CORROSION. FIRE SUPPRESSION SYSTEM OPERATIONAL.	IGNITION OF FLAMMABLE VAPORS LEADS TO CONTAINED FIRE IN THE STORAGE AREA. (D;D;C;D)	FIRE SUPPRESSION SYSTEM.	NONE
3 II C	HW4A / HW*	HW FLAMMABLE STORAGE (GROUP 4A)	SPILL OF LOW FLASH POINT CHEMICALS (ACETHALHEHYE(-38F), FURAN (-32F), ANHYDROUS ETHYL ETHER (-49F)) DUE TO FORKLIFT ACCIDENT OR CORROSION.	WORKER EXPOSED TO CHEMICAL FUMES. (D;D;C;D)	NONE	NONE

HAZARD ANALYSIS REPORT BY RISK

R---F---C	ACT/FAC	ACTIVITY NAME	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
3 II C	MW2A / MW*	MWRSF REACTIVES (GROUP 2A)	WALK BEHIND FORKLIFT ACCIDENT OR OTHER EVENT CAUSES SPILL OF WATER REACTIVE WASTE.	WORKER EXPOSURE, CONTAMINATION OF STORAGE AREA. (D;D;C;D)	(1) DRY CHEMICAL FIRE SUPPRESSION SYSTEM, (2) SCRUBBER SYSTEM, (3) THE SUMP CAPACITY IS TEN PERCENT OF THE INVENTORY IN THE ROOM, EQUIVALENT TO THREE SPRINKLER HEADS DISCHARGING FOR 30 MINUTES.	NONE
3 II C	MW9 / MW*	MWRSF NONREGULATED WASTES (GROUP 9)	SPILL OF AMMONIUM BIFLORIDE DUE TO OVERHEAD CRANE OR FORKLIFT ACCIDENT.	POTENTIAL WORKER EXPOSURE. (D;D;C;D)	NONE	CONSIDER RELOCATION OF AMMONIUM BIFLORIDE TO ONE OF THE REGULATED AREAS, SUCH AS CAUSTIC(1A).
3 II C	MW9 / MW*	MW NONREGULATED WASTES (GROUP 9)	SPILL OF AMMONIUM BIFLORIDE DUE TO FORKLIFT ACCIDENT OR FREEZING.	POTENTIAL WORKER EXPOSURE. (D;C;C;D)	NONE	CONSIDER RELOCATION OF AMMONIUM BIFLORIDE TO ONE OF THE REGULATED AREAS, SUCH AS CAUSTIC(1A).
3 II C	MWBK / MW*	MWRSF BULKING ROOM	HUMAN ERROR DURING BULKING OPERATION LEADS TO WASTE SPILL.	WORKER EXPOSURE TO TOXIC CHEMICALS AND TOXIC FUMES. (D;D;C;D)	(1) WASTE IS OPENED AND REPACKAGED UNDER FUME HOOD, (2) USE OF NONSPARKING TOOLS, (3) PROTECTIVE GEAR, E.G. SUIT, FACE SHIELD.	NONE
3 II C	DU16 / HWTF	REACTION COMPLETE. SLURRY TRANSFERRED TO REDUCTION/SETTLING TANK (DEPLETED URANIUM PROCESS)	HUMAN ERROR (DEPLETED URANIUM PROCESS). MISALIGNMENT OF VALVES DURING TRANSFER OF URANIUM SLURRY TO REDUCTION/SETTLING TANK.	SLURRY ROUTED TO WASTE WATER TANK, CEMENTATION DRUM OR OTHER. FACILITY CONTAMINATION, MINOR WORKER EXPOSURE. (D;D;D;C)	NONE	NONE
3 II C	MWG / MW*	MW GLOBAL (INTERNAL AND EXTERNAL) EVENTS	INADVERTENT OPERATION OF THE FIRE SPRINKLERS OR RUPTURE OF WATER PIPING DUE TO CORROSION OR FREEZING (INCLUDING WATER FROM EXTERNAL SOURCES).	WATER INTRUSION INTO REACTIVE WASTE STORAGE DRUMS, GENERATION OF HYDROGEN GAS. (D;D;D;C)	NONE	(1) INSTALL SUMP HIGH LEVEL ALARMS, (2) PERIODIC WALKDOWN OF THE FACILITY.
3 II C	GC6 / HWTF	CYLINDER BREACHED	PRESSURE VESSEL INCORRECTLY SEALED (SUCH AS DOOR SEAL) OR SEAL FAILS CAUSING LEAKAGE.	LEAK OF MODERATELY TOXIC GAS FROM LEAKY SEALS. (D;D;C;D)	NONE	(1) PERFORM CHECK OF PRESSURE VESSEL SEAL BEFORE CUTTING OPERATION. (2) MINIMIZE TIME BETWEEN CUTTING AND DISPOSAL OR RECONTAINERIZATION. (3) LOCATE CONTROL PANEL AWAY FROM SKID.
3 II C	GC7 / HWTF	SAMPLE, ANALYZE, AND DISPOSE PRESSURE VESSEL CONTENTS	MISROUTING OF TOXIC GAS (E.G., GAS SENT TO ATMOSPHERE) DUE TO HUMAN ERROR OR MISINTERPRETATION OF SAMPLING RESULTS.	TOXIC GASES INADVERTENTLY VENTED TO ATMOSPHERE THROUGH SCRUBBER SYSTEM, MINOR EXPOSURE. (C;C;C;D)	HEPA AND SCRUBBER SYSTEM.	(1) VERIFY SYSTEM LINE-UP PRIOR TO ROUTING PRESSURE VESSEL CONTENTS.

HAZARD ANALYSIS REPORT BY RISK

R---F---C	ACT/FAC	ACTIVITY NAME	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
3 II C	GC7 / HWTF	SAMPLE, ANALYZE, AND DISPOSE PRESSURE VESSEL CONTENTS	INCOMPLETE VENTING OR SCRUBBING OF THE PRESSURE VESSEL DUE TO HUMAN ERROR.	WORKER EXPOSURE TO RESIDUAL TOXIC GASES UPON OPENNING THE PRESSURE VESSEL. (D;D;C;D)	NONE	(1) WORKER TO WEAR PROTECTIVE EQUIPMENT (INCLUDING SCBA) WHEN OPENNING PRESSURE VESSEL.
3 II C	DU18 / HWTF	OPEN REACTOR AND WASTE DRUM AND CHECK RESIDUAL CONTENTS	UNREACTED URANIUM FINES IGNITE IN PRESENCE OF OXYGEN WHEN INNER DRUM LID OPENED TO CHECK CONTENTS (DEPLETED URANIUM PROCESS).	FIRE IN DRUM. POSSIBLE WORKER INHALATION. (D;D;C;D)	NONE	WORKER SHOULD BE EQUIPED WITH RESPIRATORY PROTECTION.
3 II C	LIH13 / HWTF	LITHIUM HYDRIDE REACTED WITH WATER IN THE HUMIDIFIER	EXCESS MOISTURE INTRODUCED DUE TO HUMIDIFIER MALFUNCTION OR CONTROL FAILURES (E.G., THE INLET VALVE TO THE PACK COLUMN FAILS OPEN).	TEMPERATURE EXCURSION IN THE REACTOR BED. VERY HIGH GENERATION RATE OF HYDROGEN EXCEEDS DILUTION CAPABILITY OF THE EQUIPMENT. FORMATION OF EXPLOSIVE OR FLAMMABLE MIXTURE (H2 & AIR) IN THE EXHAUST DUCT OR THE HUMIDIFIER. POSSIBLE EXPLOSION/FIRE, WORKER INJURY AND FACILITY DAMAGE/CONTAMINATION. (D;D;C;C)	NONE	(1) INCREASE DESIGN HUMIDIFIER SAFETY (2) INSTALL HUMIDITY ANALYZER, TEMPERATURE ANALYZER, AND HYDROGEN ANALYZER
3 II C	LIH13 / HWTF	LITHIUM HYDRIDE REACTED WITH WATER IN THE HUMIDIFIER	OUT OF CONTROL REACTION DUE TO THE USE OF AIR INSTEAD OF INERT GAS IN THE REACTION PROCESS (LIH PROCESS).	LITHIUM HYDRIDE EVAPORATES AND CONTAMINATES THE SCRUBBING SYSTEM. (D;D;D;C)	NONE	(1) PROCESS SAFETY MEASURES ANS ADMINISTRATIVE CONTROLS (2) PROVIDE SPECIAL CONNECTORS FOR NITROGEN GAS
3 II C	LIH15 / HWTF	SULFURIC ACID ADDED TO LITHIUM HYDROXIDE	HUMAN ERROR LEADS TO H2SO4 SPILL.	WORKER INJURY DUE TO ACID BURN. (D;D;C;D)	NONE	NONE
3 III B	LIH4 / HWTF	YARD FORKLIFT DELIVERS LITHIUM HYDRIDE TO TREATMENT ROOM DOOR.	FORKLIFT ACCIDENT DURING TRANSPORT BETWEEN BUILDINGS.	SPILL OF DRUM CONTENTS, POSSIBLE FIRE AND LITHIUM HYDRIDE FUMES INHALED BY THE DRIVER. POSSIBLE DRIVER INJURY AND CONTAMINATION WITH DEPLETED URANIUM WASTE. (D;D;B;C)	NONE	(1) MOVE ONLY ONE PALLET AT A TIME, (2) RESTRICT OTHER VEHICLE DURING TRANSPORT, (3)BREATHING APPARATUS AVAILABLE TO DRIVER, WITHIN REACH, (4) NO TRANSPORTS DURING WET WEATHER CONDITIONS.
3 III B	LIH5 / HWTF	HWTF OVERHEAD CRANE DELIVERS LITHIUM HYDRIDE DRUM TO SAMPLE ROOM.	LITHIUM HYDRIDE WASTE DRUM DROPPED WHILE MOVING INTO SAMPLE ROOM.	CONTAINER BREACH WITH SPILL OF LIH POWDER. WORKER EXPOSURE/INHALATION OF LIH POWDER AND DEPLETED URANIUM. (D;D;B;D).	NONE	WORKER TO WEAR PROTECTIVE CLOTHING AND BREATHING APPARATUS DURING MOVEMENT OF DRUM WITH HOIST.
3 III B	LIH15 / HWTF	SULFURIC ACID ADDED TO LITHIUM HYDROXIDE	MIXING OF ACID (H2SO4) WITH PARTIALLY REACTED LIH (UNREACTED).	GENERATION OF HYDROGEN, POSSIBLE FIRE/EXPLOSION WITH WORKER INJURY AND FACILITY CONTAMINATION.	NONE	MIX UNDER NITROGEN ATMOSPHERE

HAZARD ANALYSIS REPORT BY RISK

R---F---C	ACT/FAC	ACTIVITY NAME	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
				(D;D;B;C)		
3 III B	HW5A / HW*	HWRSF CYANIDES AND SULFIDES (GROUP 5A)	EXTERNAL FIRE CAUSES CYANIDE COMPOUNDS (CYANOGEN BROMIDE) TO DECOMPOSE.	THERMAL DECOMPOSITION OF CYANIDE LEADING TO TOXIC GAS RELEASE (E.G., HCN AND CYANOGEN), LOW LEVEL RADIOACTIVE CONTAMINATION IN FACILITY. (D;D;B;C)	FIRE SUPPRESSION (AT FIRE INITIATION LOCATION) AND SCRUBBING SYSTEM.	PROVIDE HCN ANALYZER AND ALARM.
3 III B	HW5A / HW*	HWRSF CYANIDES AND SULFIDES (GROUP 5A)	MERCURY OXYCYANIDE DETONATES DUE TO HEATING, FROM SHOCK OR FRICTION (E.G., FORKLIFT ACCIDENT).	SMALL EXPLOSION LEADING TO TOXIC GAS RELEASE. SEVERE WORKER INJURY DUE TO TOXIC GAS EXPOSURE. (D;D;B;C)	SCRUBBING SYSTEM.	DEVELOP AND ENFORCE POLICY NOT TO STORE EXPLOSIVE AND SHOCK SENSITIVE MATERIALS AT TA-63.
3 III B	HW5A / HW*	HWTF CYANIDES AND SULFIDES STORAGE	EXTERNAL FIRE CAUSES CYANIDE COMPOUNDS (E.G., CYANOGEN BROMIDE) TO DECOMPOSE.	THERMAL DECOMPOSITION OF CYANIDE LEADING TO TOXIC GAS RELEASE (E.G., HCN AND CYANOGEN). (D;D;B;C)	NONE	PROVIDE HCN ANALYZER AND ALARM.
3 III B	HW2A / HW*	HWRSF REACTIVES (GROUP 2A)	WALK BEHIND FORKLIFT ACCIDENT OR OTHER EVENT CAUSES SPILL OF WATER REACTIVE WASTE INTO THE SUMP WITH WATER PRESENT IN THE SUMP.	HYDROGEN EVOLUTION, POTENTIAL FIRE/EXPLOSION IN SUMP. POSSIBLE RELEASE OF TOXIC METAL FUMES. LOW LEVEL RADIOACTIVE CONTAMINATION THROUGHOUT THE FACILITY. (D;D;B;C)	(1) DRY CHEMICAL FIRE SUPPRESSION SYSTEM, (2) SCRUBBER SYSTEM, (3) THE SUMP CAPACITY IS TEN PERCENT OF THE INVENTORY IN THE ROOM, EQUIVALENT TO THREE SPRINKLER HEADS DISCHARGING FOR 30 MINUTES, (4) SUMP SHOULD BE MAINTAINED FREE OF WATER, (5) RESTRICT USE OF WATER IN THIS STORAGE AREA.	(1) INSTALL HYDROGEN ANALYZER AND ALARM.
3 III B	HW2A / HW*	HWRSF REACTIVES (GROUP 2A)	ACCIDENT CAUSES SIMULTANEOUS SPILL OF WATER REACTIVE WASTE AND INCOMPATIBLE WASTE DUE TO MISLABELING. (E.G., REACTIVE WASTE MIXED WITH, SULFURIC ACID(1B), NAOH(1A), PERCHLORIC ACID(6A) OR TRICHLORA ETHYLENE(4A))	PRODUCTION OF HYDROGEN GAS, POTENTIAL FIRE AND/OR EXPLOSION AND PRODUCTION OF TOXIC FUMES. SEVERE WORKER INJURY, AND LOW LEVEL RADIOACTIVE CONTAMINATION THROUGHOUT THE FACILITY. (D;D;B;C)	FIRE PROTECTION SYSTEM, SCRUBBER SYSTEM.	NONE
3 III B	HW2A / HW*	HW REACTIVES (GROUP 2A)	WATER INTRUSION INTO THE STORAGE DRUM (THROUGH EXISTING BREACH IN DRUM) DUE TO HUMAN ERROR OR RUPTURE OF WATER LINE IN THIS AREA.	RUPTURE OF DRUM DUE TO HYDROGEN EVOLUTION, POTENTIAL FIRE/EXPLOSION. POSSIBLE RELEASE OF TOXIC METAL FUMES. (C;C;B;D)	NONE	(1) RESTRICT USE OF WATER IN THE REACTIVES STORAGE AREA, (2) ENCLOSE THE BUILDING FOR WATER CONTROL AND FIRE SUPPRESSION EFFICIENCY.
3 III B	HW7A / HW*	HWRSF GASES (GROUP 7A)	BREACH OF CYLINDER (NON-LEGACY) DUE TO ACCIDENTAL CAUSES (E.G., CYLINDER DROPPED AND REGULATOR LINE BREAKS).	RELEASE OF MODERATELY TOXIC GASES (H2S, NO2, AND OTHERS). WORKER EXPOSURE. (C;C;B;D)	HEPA AND SCRUBBING SYSTEM.	(1) TRANSPORT AND STORE CYLINDERS SECURELY, (2) CONSIDER INSTALLATION OF A FLARE AND/OR A SPECIAL SCRUBBER FOR THIS

HAZARD ANALYSIS REPORT BY RISK

R---f f	ACT/FAC	ACTIVITY NAME	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
						FACILITY, (3) INSTALL GAS DETECTORS AND ALARMS, (4) CONSIDER SECONDARY CONTAINMENT FOR MOST HAZARDOUS CYLINDERS, (5) GAS CYLINDERS TO BE PROCESSED WITH HIGH PRIORITY, (6) WORK IN THIS AREA TO BE PERFORMED WITH PROTECTION (I.E., WEAR SCBA, OPERATE UNDER THE BUDDY SYSTEM), (7) PROTECTIVE CAP FOR CYLINDER REGULATORS SHOULD BE IN PLACE AT ALL TIMES., (8) STORE GAS CYLINDERS IN AN ENCLOSED AREA.
3 III B	HW7A / MW*	MWRSF GASES (GROUP 7A)	EXTERNAL FIRE (INITIATED WITHIN THE MWRSF BUILDING).	PRESSURIZATION AND RUPTURE OF GAS CYLINDERS. MODERATELY TOXIC GAS RELEASE AND POTENTIAL CYLINDER MISSILE GENERATION. (C;C;B;C)	(1) FIRE PROTECTION SYSTEM, (2) HEPA AND SCRUBBING SYSTEM, (3) FUSIBLE PRESSURE RELIEF.	STORE GAS CYLINDERS IN AN ENCLOSED AREA.
3 III B	HW7A / MW*	MW GASES (GROUP 7A)	BREACH OF CYLINDER (NON-LEGACY) DUE TO ACCIDENTAL CAUSES (E.G., CYLINDER DROPPED AND REGULATOR LINE BREAKS).	RELEASE OF MODERATELY TOXIC GASES (H2S, NO2, AND OTHERS). WORKER EXPOSURE. (C;C;B;D)	NONE	(1) TRANSPORT AND STORE CYLINDERS SECURELY, (2) CONSIDER SECONDARY CONTAINMENT FOR MOST HAZARDOUS CYLINDERS, (3) GAS CYLINDERS TO BE PROCESSED WITH HIGH PRIORITY, (4) WORK IN THIS AREA TO BE PERFORMED WITH PROTECTION (I.E., WEAR SCBA, OPERATE UNDER THE BUDDY SYSTEM), (5) PROTECTIVE CAP FOR CYLINDER REGULATORS SHOULD BE IN PLACE AT ALL TIMES, (6) CONSIDER STORING GAS CYLINDERS IN ENCLOSED ROOM IN AN INCLOSED BUILDING.
3 III B	HW7A / MW*	MW GASES (GROUP 7A)	EXTERNAL FIRE.	PRESSURIZATION AND RUPTURE OF GAS CYLINDERS. MODERATELY TOXIC GAS RELEASE AND POTENTIAL CYLINDER MISSILE GENERATION. (C;C;B;C)	FIRE PROTECTION SYSTEM, FUSIBLE PRESSURE RELIEF.	(1) INITIATE FIRE SUPPRESSION SPRINKLERS GIVEN FIRE IN ADJACENT AREAS, (2)STORE GAS CYLINDERS IN AN ENCLOSED AREA.
3 III B	HW1A / MW*	MWRSF CAUSTICS (GROUP 1A)	SODIUM AZIDE EXPLODES DUE TO SEVERE SHOCK, HEAT OR FRICTION.	EXPLOSION AND RELEASE OF TOXIC GAS (NOX). (D;D;B;C)	FIRE PROTECTION AND SCRUBBER SYSTEM.	DO NOT ACCEPT/ALLOW SODIUM AZIDE IN THE MWSRF.

HAZARD ANALYSIS REPORT BY RISK

R---F---C	ACT/FAC	ACTIVITY NAME	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
3 III B	HW1A / HW*	HWRSF CAUSTICS (GROUP 1A)	EXTERNAL FIRE	RELEASE OF MODERATELY TOXIC GASES. WORKER INJURY. (D;C;B;C)	FIRE PROTECTION AND SCRUBBER SYSTEM.	NONE
3 III B	HW1A / HW*	HW CAUSTICS (GROUP 1A)	SODIUM AZIDE EXPLODES DUE TO SEVERE SHOCK, HEAT OR FRICTION.	EXPLOSION AND RELEASE OF TOXIC GAS (NOX). (C;C;B;C)	FIRE PROTECTION SYSTEM.	DEVELOP AND ENFORCE STRICT POLICY NOT TO STORE EXPLOSIVES OR SHOCK SENSITIVE MATERIALS IN THIS BUILDING.
3 III B	HW1A / HW*	HW CAUSTICS (GROUP 1A)	FORKLIFT ACCIDENT OR FREEZING CAUSING SIMULTANEOUS SPILL OF CAUSTIC MATERIAL AND INCOMPATIBLE MATERIAL(E.G., H2SO4(1B), NITROBENZENE(4A), PERCHLORIC ACID(6A), METAL CYANIDE(5A),LITHIUM HYDRIDE(2A)) DUE TO MISLABELING.	POTENTIAL FIRE, EXPLOSION, HYDROGEN GAS PRODUCTION AND HEAVY METAL FUME GENERATION. WORKER INJURY/EXPOSURE. (C;C;B;C)	FIRE SUPPRESSION SYSTEM.	ENCLOSE THE HWTF STORAGE BUILDING TO PREVENT FREEZING.
3 III B	HW1A / HW*	HW CAUSTICS (GROUP 1A)	EXTERNAL FIRE	RELEASE OF MODERATELY TOXIC GASES. WORKER INJURY. (C;C;B;C)	FIRE PROTECTION SYSTEM.	NONE
3 III B	HW1B / HW*	HWRSF ACIDS (GROUP 1B)	SPILL OF A SINGLE ACID WASTE DRUM DUE TO CORROSION OR CRANE ACCIDENTS.	TOXIC GAS RELEASE (E.G., HF). WORKER EXPOSURE AND INJURY DUE TO CONTACT WITH GAS/LIQUIDS. (D;D;B;D)	(1) SCRUBBER SYSTEM. (2) THE SUMP CAPACITY IS TEN PERCENT OF THE INVENTORY IN THE ROOM, EQUIVALENT TO THREE SPRINKLER HEADS DISCHARGING FOR 30 MINUTES.	(1) VERIFY CONSTRUCTION MATERIAL OF STORAGE CONTAINER AND THE SUMP SYSTEM, (2) FREQUENT INSPECTIONS, (3) INSTALL GAS DETECTORS, (4) DO NOT PERFORM ANY UNNECESSARY ACTIVITIES WHILE THE SCRUBBER IS DOWN, (5) REVIEW/CONSIDER STORING HF IN GAS CYLINDER AREA (GROUP 7A).
3 III B	HW1B / HW*	HWRSF ACIDS (GROUP 1B)	SPILL OF A SINGLE ACID WASTE DRUM DUE TO CORROSION OR CRANE ACCIDENTS. SRCUBBER NOT OPERATIONAL, BUT BLOWER IS WORKING.	TOXIC GAS RELEASE (E.G., HF OR HCL). WORKER EXPOSURE AND INJURY. (C;C;B;D)	THE SUMP CAPACITY IS TEN PERCENT OF THE INVENTORY IN THE ROOM, EQUIVALENT TO THREE SPRINKLER HEADS DISCHARGING FOR 30 MINUTES.	(1) VERIFY CONSTRUCTION MATERIAL OF STORAGE CONTAINER AND THE SUMP SYSTEM, (2) FREQUENT INSPECTIONS, (3) INSTALL GAS DETECTORS, (4) DO NOT PERFORM ANY UNNECESSARY ACTIVITIES WHILE THE SCRUBBER IS DOWN.
3 III B	HW1B / HW*	HWRSF ACIDS (GROUP 1B)	EXTERNAL FIRE	RELEASE OF MODERATELY TOXIC GASES. WORKER INJURY. (D;C;B;C)	FIRE PROTECTION AND SCRUBBER SYSTEM.	NONE
3 III B	HW1B / HW*	HW ACIDS (GROUP 1B)	SPILL OF A SINGLE ACID WASTE DRUM DUE TO CORROSION, FREEZING OR CRANE ACCIDENTS.	TOXIC GAS RELEASE (E.G., HF OR HCL). WORKER EXPOSURE AND INJURY. (C;C;B;D)	NONE	(1) VERIFY CONSTRUCTION MATERIAL OF STORAGE CONTAINER AND THE SUMP SYSTEM, (2) FREQUENT

HAZARD ANALYSIS REPORT BY RISK

R---F---C	ACT/FAC	ACTIVITY NAME	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
						INSPECTIONS, (3) ENCLOSE THE HWTF STORAGE BUILDING.
3 III B	HW18 / HW*	HW ACIDS (GROUP 18)	EXTERNAL FIRE INITIATED WITHIN THE BUILDING.	RELEASE OF MODERATELY TOXIC GASES (E.G.,HF). WORKER INJURY. (C;C;B;C)	FIRE PROTECTION SYSTEM.	STORE WASTE IN ENCLOSED BUILDING TO PROVIDE SCRUBBING OF RELEASE AND MINIMIZE PUBLIC AND COLOCATED WORKER EXPOSURE.
3 III B	HW9 / HW*	HWRSF NONREGULATED WASTES (GROUP 9)	ACCIDENTAL SPILL OF INCOMPATIBLE WASTES ROUTINELY STORED IN NONREGULATED AREA (E.G., MISLABLED, TEMPORARY STORAGE, OR DO NOT BELONG IN OTHER DEFINED REGULATED AREAS)	FIRE AND RELEASE OF TOXIC GASES. (C;C;B;C)	FIRE PROTECTION AND SCRUBBER SYSTEMS.	(1) CONSIDER ELIMINATING THIS AREA, (2) CLASSIFY AND STORE ALL NONREGULATED WASTES IN COMPATIBLE REGULATED AREAS, (3) ENCLOSE THE NONREGULATED AREA.
3 III B	HWBK / HW*	HWRSF BULKING ROOM	OPERATOR OPENS MISLABELED WASTE CONTAINER.	POTENTIAL WORKER EXPOSURE TO HIGHLY TOXIC CHEMICALS AND TOXIC FUMES, POTENTIAL FIRE. (D;D;B;C)	(1) WASTE IS OPENED AND REPACKAGED UNDER FUME HOOD, (2) USE OF NONSPARKING TOOLS, (3) PROTECTIVE GEAR, E.G. SUIT, FACE SHIELD.	WORKER SHOULD WEAR PROTECTIVE EQUIPMENT.
3 III B	HWBK / HW*	HWRSF BULKING ROOM	INCOMPATIBLE WASTE ARE MIXED DURING REPACKAGING PROCESS DUE TO MISLABELING OR OPERATOR ERROR.	VIOLENT REACTION, RELEASE OF TOXIC GAS WITH WORKER EXPOSURE AND FACILITY CONTAMINATION. (D;D;B;C)	(1) FUME HOOD AND FIRE SUPPRESSION SYSTEM, (2) FULL PROTECTIVE GEAR, E.G. SUITS, FACE SHIELDS).	WORKER SHOULD WEAR PROTECTIVE EQUIPMENT.
3 III B	HWG / HW*	HWRSF GLOBAL (INTERNAL AND EXTERNAL) EVENTS	INADVERTENT OPERATION OF THE FIRE SPRINKLERS OR RUPTURE OF WATER PIPING DUE TO CORROSION, IN THE BULKING ROOM DURING BULKING OPERATION.	WATER MIXING WITH WATER REACTIVES OR ACIDS COULD CAUSE WORKER INJURY. (D;D;B;D)	NONE	(1) DO NOT LEAVE OPEN WASTE CONTAINERS IN BULKING ROOM, (2) CONSIDER USE OF DRY CHEMICAL FIRE SUPPRESSION SYSTEM IN THE BULKING ROOM.
3 III B	LIN10 / HWTF	CONTENTS OF LIH WASTE DRUM VISUALLY INSPECTED AND SAMPLED	LIH PRIMARY DRUM OPENED AND LEFT OPEN FOR AN EXTENDED PERIOD OF TIME.	POTENTIAL LITHIUM HYDRIDE FIRE WITH SAMPLE ROOM CONTAMINATION AND WORKER INHALATION. (D;D;B;C)	NONE	MINIMIZE THE TIME THAT THE LITHIUM HYDRIDE MAY BE EXPOSED TO AIR. ROOM HUMIDITY SHOULD BE MONITORED/CONTROLLED.
3 III B	LIN12 / HWTF	MANUALLY LOAD HUMIDIFIER TRAYS WITH LITHIUM HYDRIDE	SPILL OF LITHIUM HYDRIDE WHILE LOADING HUMIDIFIER TRAYS	POSSIBLE LITHIUM HYDRIDE FIRE, WORKER EXPOSURE/INHALATION. (D;D;B;D)	NONE	(1) WORKER SHOULD WEAR PROTECTIVE CLOTHING AND BREATHING APPARATUS (2) ENCLOSE WORKER AREA (3) PROVIDE VENTILLATION
3 III B	LIN12 / HWTF	MANUALLY LOAD HUMIDIFIER TRAYS WITH LITHIUM HYDRIDE	EXCESS LITHIUM HYDRIDE (AFTER HUMIDIFIER TRAYS FILLED) NOT RESEALED IN THE PARTIALLY FILLED	POSSIBLE LITHIUM HYDRIDE FIRE, WORKER EXPOSURE/INHALATION. (D;D;B;D)	NONE	(1) WORKER SHOULD WEAR PROTECTIVE CLOTHING AND BREATHING APPARATUS (2) ENCLOSE LOADING AREA (3)

HAZARD ANALYSIS REPORT BY RISK

R---F---C	ACT/FAC	ACTIVITY NAME	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
			DRUM.			PROVIDE VENTILATION
3 III B	LIN1 / MWRSF	TRUCK ENTERS FACILITY AND DRIVES TO MWRSF DOCK (LIH PROCESS)	TRUCK ACCIDENT WITH FIRE AND BREACH OF LITHIUM HYDRIDE WASTE CONTAINER.	LITHIUM HYDRIDE RELEASE TO ATMOSPHERE DUE TO BURNING OF LIH POWDER. TRUCK DRIVER EXPOSURE TO LIH/DU AND MINOR DEPLETED URANIUM CONTAMINATION WITHIN THE FACILITY. (D;D;B;D).		ADMINISTRATIVE CONTROLS SUCH AS (1) ANNOUNCEMENT OF DELIVERY, (2) DRIVER TRAINING, (3) RESTRICT OTHER TRAFFIC DURING DELIVERY, (4) NO WET WEATHER DELIVERIES.
3 III B	LIN1 / MWRSF	TRUCK ENTERS FACILITY AND DRIVES TO MWRSF DOCK (LIH PROCESS)	TRUCK ACCIDENT AND BREACH OF MULTIPLE CONTAINERS OF INCOMPATIBLE WASTES.	H2 GAS RELEASED AND DISPERSED. POSSIBLE FIRE, DRIVER EXPOSED TO LIH/DU AND MINOR DEPLETED URANIUM CONTAMINATION WITHIN THE FACILITY. (D;D;B;D).		ADMINISTRATIVE CONTROLS SUCH AS (1) ANNOUNCEMENT OF DELIVERY, (2) DRIVER TRAINING, (3) RESTRICT OTHER TRAFFIC DURING DELIVERY, (4) NO WET WEATHER DELIVERIES, (5) DO NOT TRANSPORT INCOMPATIBLE WASTES TOGETHER (6) TRANSPORT ONE DRUM AT A TIME
3 III B	LIN6 / HWTF	OVERPACK DRUM IS OPENED AND INNER LIH DRUM IS LIFTED WITH CRANE	DRUM CONTENTS SPILLED DUE TO: (1) CLAMP COMES LOOSE, OR (2) LID FALLS OFF; AND IGNITION OF LIH POWDER.	SPILL OF DRUM CONTENTS WITH FIRE. WORKER EXPOSURE TO LIH AND DEPLETED URANIUM POWDER AND INHALATION OF FUMES. (D;D;B;D)	NONE	OPERATORS SHOULD USE SELF CONTAINED BREATHING APPARATUS.
3 III B	LIN9 / HWTF	PRIMARY WASTE DRUM IS GROUNDED AND OPENED USING NON-SPARK TOOLS	OPERATOR FAILS TO FOLLOW PROCEDURE WHILE OPENING LIH INNER WASTE DRUM (I.E., USES WRONG TOOLS, DRUM NOT GROUNDED, MISPOSITIONING OF THE VENT HOOD, ETC...).	SHORT DURATION HYDROGEN FIRE UPON OPENING THE PRIMARY WASTE DRUM. POSSIBLE LIH IGNITION. WORKER EXPOSURE TO LIH AND DEPLETED URANIUM, INHALATION OF FUMES. (D;D;B;C)	NONE	WORKERS SHOULD WEAR PROTECTIVE CLOTHING, AND USE SELF CONTAINED BREATHING APPARATUS.
3 III B	LIN11 / HWTF	PRIMARY LITHIUM HYDRIDE DRUM TRANSFERED TO SKID WITH CRANE.	DRUM CONTENTS SPILLED DUE TO: (1) CLAMP COMES LOOSE, (2) LID FALLS OFF, (3) CRANE ACCIDENT.	WORKER EXPOSURE/INHALATION OF LITHIUM HYDRIDE POWDER AND DEPLETED URANIUM. (D;D;B;C)	NONE	WORKER TO WEAR PROTECTIVE CLOTHING AND BREATHING APPARATUS DURING MOVEMENT OF DRUM WITH HOIST.
3 III C	CY11 / HWTF	PLATING WASTE CONTAINER TRANSFERED TO SKID WITH CRANE OR MANUALLY.	CONTAINER CONTENTS SPILLED DUE TO: (1) CLAMP COMES LOOSE, (2) CAP FALLS OFF, OR (3) CONTAINER IS DROPPED. (PLATING WASTES)	SPILL OF WASTE CONTAINER CONTENTS. POTENTIAL WORKER EXPOSURE AND INJURY. (D;D;C;D)	NONE	NONE
3 III C	LIN2 / MWRSF	WALK BEHIND FORKLIFT TRANSFERS LITHIUM HYDRIDE WASTE DRUM TO ENCLOSED STORAGE ROOM.	LITHIUM HYDRIDE WASTE DRUM PUSHED OFF DOCK OR TRUCK BY FORKLIFT.	CONTAINER BREACH, LIH/DU SPILL IN DOCK AREA, CONTACT WITH WATER, POSSIBLE FIRE AND WORKER INJURY (D;D;C;C).	NONE	ENSURE THAT THE LOADING/UNLOADING AREA, INCLUDING THE SUMP IS DRY PRIOR TO DELIVERY.

HAZARD ANALYSIS REPORT BY RISK

R---F---C	ACT/FAC	ACTIVITY NAME	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
3 III C	LIN2 / MWRSF	WALK BEHIND FORKLIFT TRANSFERS LITHIUM HYDRIDE WASTE DRUM TO ENCLOSED STORAGE ROOM.	FORKLIFT DRIVES OFF DOCK OR TRUCK WHILE TRANSPORTING LITHIUM HYDRIDE WASTE DRUM.	CONTAINER BREACH, IGNITION OF LIH/DU SPILLED IN DOCK AREA DUE TO CONTACT WITH WATER OR INCOMPATIBLE WASTES, POSSIBLE FIRE AND WORKER INJURY (D;D;C;C).	NONE	H2O SPRINKLER SYSTEM IS NOT RECOMMENDED.
3 III C	LIN3 / MWRSF	WALK BEHIND FORKLIFT MOVES LITHIUM HYDRIDE DRUM TO DOCK FROM ENCLOSED STORAGE ROOM	LITHIUM HYDRIDE WASTE DRUM PUSHED OFF DOCK BY FORKLIFT.	CONTAINER BREACH, LIH SPILL IN DOCK AREA, CONTACT WITH WATER, POSSIBLE FIRE AND WORKER INJURY (D;D;C;C).	NONE	ENSURE THAT THE LOADING/UNLOADING AREA, INCLUDING THE SUMP IS DRY PRIOR TO DELIVERY.
3 III C	LIN3 / MWRSF	WALK BEHIND FORKLIFT MOVES LITHIUM HYDRIDE DRUM TO DOCK FROM ENCLOSED STORAGE ROOM	FORKLIFT DRIVES OFF DOCK WHILE TRANSPORTING LITHIUM HYDRIDE WASTE DRUM.	CONTAINER BREACH, IGNITION OF LIH SPILLED IN DOCK AREA DUE TO CONTACT WITH WATER OR INCOMPATIBLE WASTES, POSSIBLE FIRE AND WORKER INJURY (D;D;C;C).	NONE	H2O SPRINKLER SYSTEM IS NOT RECOMMENDED.
3 III C	LIN4 / HWTF	YARD FORKLIFT DELIVERS LITHIUM HYDRIDE TO TREATMENT ROOM DOOR.	FORKLIFT ACCIDENT NEAR DOCK AREA.	SPILL OF LIH IN THE DOCK AREA MIXED WITH WATER IN THE SUMP, POSSIBLE FIRE AND WORKER INJURY. (D;D;C;C)	NONE	(1) MOVE ONLY ONE PALLET AT A TIME, (2) RESTRICT OTHER VEHICLE DURING TRANSPORT, (3)BREATHING APPARATUS AVAILABLE TO DRIVER, WITHIN REACH, (4) NO TRANSPORTS DURING WET WEATHER CONDITIONS, (5) ENSURE THE SUMP AND DOCK AREA ARE DRY PRIOR TO MOVING WASTE DRUMS.
3 III C	DU2 / MWRSF	WALK BEHIND FORKLIFT TRANSFERS DRUM TO ENCLOSED STORAGE ROOM	FORKLIFT DRIVES OFF DOCK WHILE TRANSPORTING DEPLETED URANIUM WASTE DRUM. SPRINKLER SYSTEM IS OPERABLE.	CONTAINER BREACH, IGNITION OF URANIUM CHIPS IN DOCK AREA. MINOR FIRE, POSSIBLE WORKER INJURY AND EXPOSURE TO DEPLETED URANIUM. (D;D;C;D)	NONE	NONE
3 III C	DU3 / MWRSF	WALK BEHIND FORKLIFT MOVES DRUM OF DEPLETED URANIUM WASTE TO DOCK	DRUM PUNCTURED BY FORKLIFT.	CONTAINER BREACH, MINOR WORKER EXPOSURE. (D;D;C;D)	NONE	NONE
3 III C	DU3 / MWRSF	WALK BEHIND FORKLIFT MOVES DRUM OF DEPLETED URANIUM WASTE TO DOCK	FORKLIFT DRIVES OFF DOCK WHILE TRANSPORTING DRUM, WITH SPRINKLER SYSTEM OPERABLE.	CONTAINER BREACH, IGNITION OF URANIUM CHIPS IN DOCK AREA. MINOR FIRE, WORKER INJURY AND EXPOSURE TO DEPLETED URANIUM. (D;D;C;D)	NONE	CONSIDER INSTALLATION OF A CURB TO PREVENT DRIVING THE FORKLIFT OFF DOCK.
3 III C	MW2A / MW*	MWRSF REACTIVES (GROUP 2A)	WALK BEHIND FORKLIFT ACCIDENT OR OTHER EVENT CAUSES SPILL OF DEPLETED URANIUM WASTE.	BURNING OF THE DEPLETED URANIUM DUE TO PROLONGED EXPOSURE TO AIR, RELEASE OF TOXIC FUMES AND	DRY CHEMICAL FIRE SUPPRESSION SYSTEM, SCRUBBER SYSTEM.	NONE

HAZARD ANALYSIS REPORT BY RISK

R---F---C	ACT/FAC	ACTIVITY NAME	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
				RADIOACTIVITY. WORKER EXPOSURE AND LOW LEVEL RADIOACTIVE CONTAMINATION THROUGHOUT THE FACILITY. (D;D;C;C)		
3 III C	MW1B / MW*	MWRSF ACIDS (GROUP 1B)	SPILL OF A SINGLE ACID WASTE DRUM DUE TO CORROSION OR CRANE ACCIDENTS.	RELEASE OF ACID FUMES (E.G., HCL). WORKER EXPOSURE AND INJURY DUE TO CONTACT WITH GAS/LIQUIDS. (D;D;C;D)	(1) SCRUBBER SYSTEM, (2) THE SUMP CAPACITY IS TEN PERCENT OF THE INVENTORY IN THE ROOM, EQUIVALENT TO THREE SPRINKLER HEADS DISCHARGING FOR 30 MINUTES.	(1) VERIFY CONSTRUCTION MATERIAL OF STORAGE CONTAINER AND THE SUMP SYSTEM, (2) FREQUENT INSPECTIONS, (3) INSTALL GAS DETECTORS, (4) DO NOT PERFORM ANY UNNECESSARY ACTIVITIES WHILE THE SCRUBBER IS DOWN.
3 III C	CY2 / MWRSF	WALK BEHIND FORKLIFT TRANSFERS WASTE DRUM TO STORAGE AREA (PLATING WASTES)	FORKLIFT DRIVES OFF DOCK WHILE TRANSPORTING CYANIDE PLATING WASTE CONTAINER (CARBOY, POLYPACK OR OTHER).	CARBOY, POLYPACK OR OTHER CONTAINER BREACH IN DOCK AREA, WORKER EXPOSURE TO CYANIDE. (D;D;C;D).	NONE	NONE
3 III C	CY3 / MWRSF	WALK BEHIND FORKLIFT MOVES CYANIDE WASTE DRUM TO DOCK	FORKLIFT DRIVES OFF DOCK WHILE TRANSPORTING CYANIDE PLATING WASTE CONTAINER (CARBOY, POLYPACK OR OTHER).	CARBOY, POLYPACK OR OTHER CONTAINER BREACH IN DOCK AREA, WORKER EXPOSURE. (D;D;C;C)	NONE	NONE
3 III C	CY4 / HWTF	YARD FORKLIFT TRANSPORTS CYANIDE PLATING WASTE TO TREATMENT ROOM DOOR	FORKLIFT ACCIDENT WITH THE SPILL OF A SINGLE DRUM OF PLATING WASTE. RELEASE OF 55 GALLONS.	WORKER EXPOSURE TO CYANIDE, POSSIBLE INJURY, MINOR FACILITY CONTAMINATION. (D;D;C;D)	NONE	NONE
3 III C	CY5 / HWTF	HWTF CRANE DELIVERS CYANIDE PLATING WASTE DRUM TO SAMPLE ROOM	PLATING WASTE DRUM DROPPED WHILE MOVING TO HWTF SAMPLE ROOM USING CRANE.	CARBOY, POLYPACK OR OTHER CONTAINER BREACH IN SAMPLE ROOM, POSSIBLE WORKER EXPOSURE. (D;D;C;D)	NONE	NONE
3 III C	CY6 / HWTF	OVERPACK DRUM IS OPENED AND INNER CYANIDE DRUM IS LIFTED WITH CRANE	OPERATOR FAILS TO FOLLOW PROCEDURE WHILE OPENING THE CYANIDE OVERPACK (I.E., USES WRONG TOOLS, DOES NOT GROUND DRUM, MISPOSITIONING OF THE VENT HOOD, ETC...).	SHORT DURATION HYDROGEN FIRE UPON OPENING THE OVERPACK. POSSIBLE WORKER INJURY. (D;D;C;D)	NONE	OPERATORS SHOULD USE SELF CONTAINED BREATHING APPARATUS
3 III C	CY6 / HWTF	OVERPACK DRUM IS OPENED AND INNER CYANIDE DRUM IS LIFTED WITH CRANE	DRUM CONTENTS SPILLED DUE TO: (1) CLAMP COMES LOOSE, OR (2) LID FALLS OFF.	SPILL OF DRUM CONTENTS. WORKER EXPOSURE TO CYANIDE WASTE. (D;D;C;D)	NONE	OPERATORS SHOULD USE SELF CONTAINED BREATHING APPARATUS.
3 III C	DU15 / HWTF	BLEACH IS ADDED TO CIRCULATING WATER	CAUSTIC LINE LEAK DUE TO CORROSION.	POSSIBLE WORKER INJURY. (D;D;C;D)	NONE	NONE
3 III C	DU15 / HWTF	BLEACH IS ADDED TO CIRCULATING WATER	CIRCULATING LINE RUPTURE DUE TO CORROSION, PUMP	URANIUM SLURRY RELEASED IN THE TREATMENT ROOM.	NONE	NONE

HAZARD ANALYSIS REPORT BY RISK

R---F---C	ACT/FAC	ACTIVITY NAME	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
			DIAPHRAM LEAK OR CONNECTIONS.	POSSIBLE WORKER CONTACT BY SPRAY AND ROOM CONTAMINATION. (D;D;C;C)		
3 III C	MW8 / MW*	MWRSF PCB (GROUP 8)	MISLABELED DRUM RESULTS IN PCB DRUM BEING STORED NEAR FLAMMABLE WASTE. ACCIDENTAL BREACH OF THE CONTAINERS LEADS TO FIRE AND BURNIG OF PCB WASTE.	BURNING OF PCB WASTE FILTER THROUGH THE BUILDING SCRUBBER SYSTEM. (C;C;C;C)	FIRE PROTECTION AND SCRUBBER SYSTEMS.	NONE
3 III C	MWG / MW*	MWRSF GLOBAL (INTERNAL AND EXTERNAL) EVENTS	INADVERTENT OPERATION OF THE FIRE SPRINKLERS OR RUPTURE OF WATER PIPING DUE TO CORROSION.	IF FLOOD SOURCE NOT MITIGATED, COULD CAUSE WATER INTRUSION INTO REACTIVE WASTE AREA, GENERATION OF HYDROGEN GAS AND RADIOACTIVE CONTAMINATION IN THE FACILITY. (D;D;D;C)	(1) DRY CHEMICAL FIRE SUPPRESSION SYSTEM IN WATER REACTIVE(GROUP 2A) STORAGE AREA, (2) PERIODIC WALKDOWNS OF THE FACILITY ARE PERFORMED, (3) OPERATION OF SPRINKLERS WILL INITIATE A 911 ALARM.	(1) INSTALL SUMP HIGH LEVEL ALARMS, (2) DESIGN STORAGE AREA TO PREVENT INTRUSION OF WATER TO THE WATER REACTIVE WASTE AREA.
3 III C	DU17 / HWTF	REDUCTION OF URANIUM HYDROXIDE BY SODIUM THIOSULFATE TO URANIUM DIOXIDE (DEPLETED URANIUM PROCESS)	LINE RUPTURE IN THE CIRCULATING SLURRY LOOP DUE TO CORROSION.	CONTAMINATION OF THE TREATMENT ROOM AND POSSIBLE WORKER CONTAMINATION/INJURY. (D;D;C;C)	NONE	NONE
3 III C	DU9 / HWTF	INNER DRUM IS GROUNDED AND OPENED USING NON-SPARK TOOLS	OPERATOR FAILS TO FOLLOW PROCEDURE WHILE OPENING DEPLETED URANIUM INNER WASTE DRUM (I.E., USES WRONG TOOLS, MISPOSITIONING OF THE VENT HOOD, ETC...).	SHORT DURATION HYDROGEN FIRE UPON OPENING THE OVERPACK. POSSIBLE WORKER INJURY. (D;D;C;D)	NONE	NONE
3 III C	CY13 / HWTF	INTRODUCTION OF REAGENTS TO THE REACTOR	REAGENTS ADDED TO THE PROCESS IN THE WRONG SEQUENCE (PLATING WASTE PROCESS).	UNPLANNED REACTIONS LEAD TO EXCESSIVE GENERATION OF GASES. CAN OVERLOAD SKID SCRUBBER BUT WILL VENT TO ROOM SCRUBBER. MINOR LEAK OF TOXIC GASES TO ROOM THROUGH LEAKS IN PIPING AND DUCTWORK. POTENTIAL FOR MINOR WORKER INJURY. (D;D;C;D)	NONE	NONE
3 III C	CY13 / HWTF	INTRODUCTION OF REAGENTS TO THE REACTOR	INSTRUMENTATION FAILURE LEADS TO INCORRECT REAGENT/AMOUNTS OF REAGENTS ADDED TO REACTOR (PLATING WASTE PROCESS).	UNPLANNED REACTIONS LEAD TO RELEASE OF TOXIC GAS TO THE SCRUBBER. (D;D;C;D)	NONE	NONE
3 III C	CY14 / HWTF	LIQUIDS PACKAGED AND SENT TO TA-50-1	THE REACTION IS INCOMPLETE DUE TO INSTRUMENTATION FAILURE OR HUMAN ERROR (PLATING WASTE PROCESS).	UNTREATED MIXED WASTE SENT TO TA-50-1. (D;D;D;C)	PHYSICALLY SAMPLE LIQUID PRIOR TO TRANSPORTATION TO TA-50-1.	NONE

HAZARD ANALYSIS REPORT BY RISK

R---F---C	ACT/FAC	ACTIVITY NAME	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
3 III C	LIH6 / HWTF	OVERPACK DRUM IS OPENED AND INNER LIH DRUM IS LIFTED WITH CRANE	OPERATOR FAILS TO FOLLOW PROCEDURE WHILE OPENING THE LIH OVERPACK (I.E., USES WRONG TOOLS, DOES NOT GROUND DRUM, MISPOSITIONING OF THE VENT HOOD, ETC...).	SHORT DURATION HYDROGEN FIRE UPON OPENING THE OVERPACK. POSSIBLE WORKER INJURY. (D;D;C;D)	NONE	OPERATORS SHOULD USE SELF CONTAINED BREATHING APPARATUS
3 III C	LIH6 / HWTF	OVERPACK DRUM IS OPENED AND INNER LIH DRUM IS LIFTED WITH CRANE	DRUM CONTENTS SPILLED DUE TO: (1) CLAMP COMES LOOSE, OR (2) LID FALLS OFF.	WORKER EXPOSURE TO LITHIUM HYDRIDE AND DEPLETED URANIUM. (D;D;C;D)	NONE	OPERATORS SHOULD USE SELF CONTAINED BREATHING APPARATUS.
3 III C	DU6 / HWTF	OVERPACK DRUM IS OPENED AND DRUM LIFTED WITH CRANE	OPERATOR FAILS TO FOLLOW PROCEDURE WHILE OPENING THE DEPLETED URANIUM OVERPACK (I.E., USES WRONG TOOLS, MISPOSITIONING OF THE VENT HOOD, ETC...).	SHORT DURATION HYDROGEN FIRE UPON OPENING THE OVERPACK. POSSIBLE WORKER INJURY. (D;D;C;D)	NONE	NONE
3 III C	CY1 / HWRSF	TRUCK ENTERS FACILITY AND DRIVES TO DOCK (PLATING WASTES).	TRUCK ACCIDENT WITH THE SPILL OF A SINGLE DRUM OF PLATING WASTE. RELEASE OF 55 GALLONS.	WORKER EXPOSURE TO CYANIDE AND POSSIBLE INJURY, RADIATION CONTAMINATION, MINOR ONSITE CONTAMINATION. (D;D;C;C)	NONE	ADMINISTRATIVE CONTROLS; (1) ANNOUNCEMENT OF DELIVERY, (2) DRIVER TRAINING, (3) RESTRICT OTHER TRAFFIC DURING DELIVERY.
3 IV A	CY9 / HWTF	PRIMARY WASTE DRUM IS GROUNDED AND OPENED USING NON-SPARK TOOLS (PLATING WASTES).	RELEASE OF TOXIC GAS DUE TO UNEXPECTED MATERIALS IN CYANIDE WASTE DRUM (PHOSGEN, HYDROGEN SULFIDE, CHLORINE, ETC...).	WORKER INJURY, POSSIBLE FATALITY. (D;D;A;D)	NONE	OPERATORS SHOULD USE SELF CONTAINED BREATHING APPARATUS.
3 IV A	LIH2 / HWRSF	WALK BEHIND FORKLIFT TRANSFERS LITHIUM HYDRIDE WASTE DRUM TO ENCLOSED STORAGE ROOM.	LITHIUM HYDRIDE WASTE DRUM PUSHED OFF DOCK OR TRUCK BY FORKLIFT.	CONTAINER BREACH, SPILL OF LIH/DU AND CONTACT WITH WATER IN SUMP, EXPLOSION DUE TO EXPLOSIVE MIXTURE, POSSIBLE WORKER FATALITY. (D;D;A;C)	NONE	ENSURE ..AT THE LOADING/UNLOADING AREA, INCLUDING THE SUMP IS DRY PRIOR TO DELIVERY.
3 IV A	LIH2 / HWRSF	WALK BEHIND FORKLIFT TRANSFERS LITHIUM HYDRIDE WASTE DRUM TO ENCLOSED STORAGE ROOM.	FORKLIFT DRIVES OFF DOCK OR TRUCK WHILE TRANSPORTING LITHIUM HYDRIDE WASTE DRUM.	CONTAINER BREACH, SPILL OF LIH/DU AND CONTACT WITH WATER IN SUMP, EXPLOSION DUE TO EXPLOSIVE MIXTURE, POSSIBLE WORKER FATALITY. (D;D;A;C)	NONE	ENSURE THAT THE LOADING/UNLOADING AREA, INCLUDING THE SUMP IS DRY PRIOR TO DELIVERY.
3 IV A	LIH3 / HWRSF	WALK BEHIND FORKLIFT MOVES LITHIUM HYDRIDE DRUM TO DOCK FROM ENCLOSED STORAGE ROOM	LITHIUM HYDRIDE WASTE DRUM PUSHED OFF DOCK BY FORKLIFT.	CONTAINER BREACH, SPILL OF LIH AND CONTACT WITH WATER IN SUMP, EXPLOSION DUE TO EXPLOSIVE MIXTURE, POSSIBLE WORKER FATALITY.	NONE	ENSURE THAT THE LOADING/UNLOADING AREA, INCLUDING THE SUMP IS DRY PRIOR TO DELIVERY.

HAZARD ANALYSIS REPORT BY RISK

R---F---C	ACT/FAC	ACTIVITY NAME	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
				(D;D;A;C)		
3 IV A	LIH3 / MWRSF	WALK BEHIND FORKLIFT MOVES LITHIUM HYDRIDE DRUM TO DOCK FROM ENCLOSED STORAGE ROOM	FORKLIFT DRIVES OFF DOCK WHILE TRANSPORTING LITHIUM HYDRIDE WASTE DRUM.	CONTAINER BREACH, SPILL OF LIH AND CONTACT WITH WATER IN SUMP, EXPLOSION DUE TO EXPLOSIVE MIXTURE, POSSIBLE WORKER FATALITY. (D;D;A;C)	NONE	ENSURE THAT THE LOADING/UNLOADING AREA, INCLUDING THE SUMP IS DRY PRIOR TO DELIVERY.
3 IV A	LIH4 / HWTF	YARD FORKLIFT DELIVERS LITHIUM HYDRIDE TO TREATMENT ROOM DOOR.	FORKLIFT ACCIDENT NEAR DOCK AREA.	SPILL OF LIH INTO THE SUMP. EXPLOSION/FIRE DUE TO EXPLOSIVE MIXTURE, POSSIBLE FATALITY. (D;D;A;C)	NONE	(1) MOVE ONLY ONE PALLET AT A TIME, (2) RESTRICT OTHER VEHICLE DURING TRANSPORT, (3)BREATHING APPARATUS AVAILABLE TO DRIVER, WITHIN REACH, (4) NO TRANSPORTS DURING WET WEATHER CONDITIONS, (5) ENSURE THE SUMP AND DOCK AREA ARE DRY PRIOR TO MOVING WASTE DRUMS.
3 IV A	MW5A / MW*	MWRSF CYANIDES AND SULFIDES (GROUP 5A)	FORKLIFT ACCIDENT CAUSES SIMULTANEOUS SPILL OF CYANIDE AND OTHER NONCOMPATIBLE WASTE (E.G., H2SO4(1B), OR PERCHLORIC ACID(6A)) DUE TO MISLABELING, AND FAILURE OF THE SCRUBBER SYSTEM WITH THE VENT BLOWER WORKING.	RELEASE OF TOXIC GASES (E.G., HCN AND CYANOGEN) AND POSSIBLE EXPLOSION AND FIRE. SEVERE WORKER INJURY, AND LOW LEVEL RADIOACTIVE CONTAMINATION IN THE FACILITY. (C;B;A;C)	(1) USE OF SMALL "WALK BEHIND" FORKLIFTS, (2) DRUMS ARE STORED ONLY ONE LEVEL HIGH.	(1) PROVIDE HCN ANALYZER AND ALARM, (2) DO NOT PERFORM ANY UNNECESSARY ACTIVITIES IF THE SCRUBBER IS NONOPERATIONAL, (4) ADD ALARMS TO MONITOR SCRUBBER OPERATION.
3 IV A	CY2 / MWRSF	WALK BEHIND FORKLIFT TRANSFERS WASTE DRUM TO STORAGE AREA (PLATING WASTES)	FORKLIFT ACCIDENT BREACHES DRUMS OF INCOMPATIBLE WASTES ON THE TRUCK OR IN THE DOCK AREA.	CYANIDE AND ACID WASTES CAUSE LETHAL HCN MIXTURE. POSSIBLE WORKER FATALITY. MINOR ONSITE CONTAMINATION. (D;D;A;C)	DRUMS NOT STORED IN DOCK AREA. ONLY MATERIAL AT RISK IS ON THE TRUCK.	NONE
3 IV A	CY3 / MWRSF	WALK BEHIND FORKLIFT MOVES CYANIDE WASTE DRUM TO DOCK	FORKLIFT ACCIDENT BREACHES DRUMS OF INCOMPATIBLE WASTES ON THE TRUCK OR IN THE DOCK AREA.	CYANIDE AND ACID WASTES CAUSE LETHAL HCN MIXTURE. POSSIBLE WORKER FATALITY. (D;D;A;C)	DRUMS NOT STORED IN DOCK AREA. ONLY MATERIAL AT RISK IS ON THE TRUCK.	NONE
3 IV A	CY4 / HWTF	YARD FORKLIFT TRANSPORTS CYANIDE PLATING WASTE TO TREATMENT ROOM DOOR	FORKLIFT ACCIDENT WITH BREACH OF MULTIPLE WASTE CONTAINERS LEADING TO MIXING OF NONCOMPATIBLE WASTE MATERIALS. MISLABELED WASTE RESULTS IN MOVEMENT OF INCOMPATIBLE ACIDS WITH CYANIDE WASTES.	POSSIBLE PRODUCTION OF HCN. WORKER(S) EXPOSED TO HCN GAS WITH POSSIBLE FATALITIES, AND SEVERE INJURY TO COLOCATED WORKERS. FACILITY AND ONSITE CONTAMINATION. (C;B;A;C)	NONE	(1) MOVE ONLY ONE PALLET AT A TIME, (2) CONSIDER MOVING ONLY ONE DRUM AT A TIME.
3 IV A	CY6 / HWTF	OVERPACK DRUM IS OPENED AND INNER CYANIDE DRUM IS LIFTED WITH CRANE	RELEASE OF TOXIC GAS DUE TO UNEXPECTED MATERIALS IN CYANIDE WASTE DRUM	WORKER INJURY, POSSIBLE FATALITY. (D;D;A;D)	NONE	OPERATORS SHOULD USE SELF CONTAINED BREATHING APPARATUS.

HAZARD ANALYSIS REPORT BY RISK

R---F---C	ACT/FAC	ACTIVITY NAME	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
			(PHOSGEN, HYDROGEN SULFIDE, CHLORINE, ETC...).			
3 IV A	HWB / HW*	MWRSF PCB (GROUP 8)	LARGE EXTERNAL FIRE WITH BREACH OF BUILDING OR THE SCRUBBER SYSTEM.	POTENTIAL SPILL AND BURNING OF PCB WASTE. DISPERSION OF PCB WASTE TO THE ENVIRONMENT. (B;B;B;A)	(1) FIRE PROTECTION SYSTEM, (2) HEPA/SCRUBBER WITH CARBONBED.	CONSIDER STORING PCB WASTE AWAY FROM FLAMMABLES.
3 IV A	HWB / HW*	MWRSF PCB (GROUP 8)	SPILL OF PCB WASTE DRUM DUE TO FORKLIFT ACCIDENT, RELEASE TO THE SUMP.	POTENTIAL RELEASE TO THE ENVIRONMENT THROUGH THE SUMP SYSTEM. ENVIRONMENTAL CONTAMINATION. (D;D;D;A)	(1) INSTALL PROCEDURES TO DETECT SUMP LEVELS, (2) TEST SUMP CONTENTS BEFORE DISCHARGE, (3) SUMP SYSTEM.	NONE
3 IV A	HWB / HW*	HW PCB (GROUP 8)	LARGE EXTERNAL FIRE.	POTENTIAL SPILL AND BURNING OF PCB WASTE. DISPERSION OF PCB WASTE TO THE ENVIRONMENT. (B;B;B;A)	FIRE PROTECTION SYSTEM.	CONSIDER STORING PCB WASTE AWAY FROM FLAMMABLES.
3 IV A	HWG / HW*	MWRSF GLOBAL (INTERNAL AND EXTERNAL) EVENTS	LOW INTENSITY SEISMIC EVENT WITH HORIZONTAL ACCELERATION OF 0.1 G.	EXPLOSION OF SHOCK SENSITIVE MATERIALS (E.G., NITRO METHANE, SODIUM AZIDE). STRUCTURAL DAMAGE TO BUILDING, FIRE AND RELEASE OF TOXIC GASES. (A;A;A;A)	NONE	(1) DEVELOP AND ENFORCE POLICY NOT TO STORE EXPLOSIVE OR SHOCK SENSITIVE MATERIAL IN THIS BUILDING, (2) PROCESS SHOCK SENSITIVE MATERIALS IMMEDIATELY.
3 IV A	HWG / HW*	MWRSF GLOBAL (INTERNAL AND EXTERNAL) EVENTS	HIGH INTENSITY SEISMIC EVENT WITH HORIZONTAL ACCELERATION OF 0.3 G OR GREATER.	STRUCTURAL COLLAPSE OF BUILDING, BREACH OF MULTIPLE DRUMS, MAJOR FIRE, RELEASE OF TOXIC GAS TO ENVIRONMENT AND RADIOACTIVE CONTAMINATION. (A;A;A;A)	NONE	(1) REVIEW SEISMIC DESIGN CRITERIA, (2) MINIMIZE STORAGE TIME OF MOST FLAMMABLE/ TOXIC MATERIALS.
3 IV A	HWG / HW*	MWRSF GLOBAL (INTERNAL AND EXTERNAL) EVENTS	EXTERNAL FIRE	FIRE PENETRATES THE MWRSF, MAJOR FIRE RELEASES TOXIC GAS TO THE ENVIRONMENT AND RADIOACTIVE CONTAMINATION. (A;A;A;A)	(1) AREA SURROUNDING THE MWRSF IS CLEARED OF COMBUSTIBLE MATERIAL, (2) BUILDING IS DESIGNED TO RETARD FIRE.	NONE
3 IV A	HWG / HW*	HW GLOBAL (INTERNAL AND EXTERNAL) EVENTS	HIGH INTENSITY SEISMIC EVENT WITH HORIZONTAL ACCELERATION OF 0.3 G OR GREATER.	STRUCTURAL COLLAPSE OF BUILDING, BREACH OF MULTIPLE DRUMS, MAJOR FIRE, RELEASE OF TOXIC GAS TO ENVIRONMENT. (A;A;A;A)	NONE	(1) REVIEW SEISMIC DESIGN CRITERIA, (2) MINIMIZE STORAGE TIME OF MOST FLAMMABLE/ TOXIC MATERIALS.
3 IV A	HWG / HW*	HW GLOBAL (INTERNAL AND EXTERNAL) EVENTS	EXTERNAL FIRE	FIRE PENETRATES THE MWRSF, MAJOR FIRE RELEASES TOXIC GAS TO THE ENVIRONMENT. (A;A;A;A)	(1) AREA SURROUNDING THE MWRSF IS CLEARED OF COMBUSTIBLE MATERIAL, (2) BUILDING IS DESIGNED TO RETARD FIRE.	NONE

HAZARD ANALYSIS REPORT BY RISK

R---F---C	ACT/FAC	ACTIVITY NAME	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
3 IV A	GC3 / MWRSF	GAS CYLINDER TRANSPORTED FROM MWRSF DOCK STORAGE AREA	BREACH OF CYLINDER DUE TO ACCIDENTAL CAUSES (E.G., CYLINDER DROPPED AND REGULATOR LINE BREAKS).	RELEASE OF HIGHLY TOXIC GASES (PHOSPHINE, PHOSGEN, ARSINE, AND OTHERS), WORKER FATALITY. (C;C;A;D)	HEPA AND SCRUBBING SYSTEM.	(1) TRANSPORT AND STORE CYLINDERS SECURELY, (2) INSTALL GAS DETECTORS AND ALARMS, (3) CONSIDER SECONDARY CONTAINMENT FOR MOST HAZARDOUS CYLINDERS, (4) PROTECTIVE CAP FOR CYLINDER REGULATORS SHOULD BE IN PLACE AT ALL TIMES.
3 IV A	GC4 / MWRSF	TRANSPORT GAS CYLINDER FROM MWRSF STORAGE TO THE HWTF TREATMENT ROOM	BREACH OF CYLINDER DUE TO ACCIDENTAL CAUSES (E.G., CYLINDER DROPPED AND REGULATOR LINE BREAKS).	RELEASE OF HIGHLY TOXIC GASES (PHOSPHINE, PHOSGEN, ARSINE, AND OTHERS), WORKER FATALITY. (A;A;A;D)	NONE	(1) TRANSPORT AND STORE CYLINDERS SECURELY, (2) CONSIDER SECONDARY CONTAINMENT FOR MOST HAZARDOUS CYLINDERS, (4) PROTECTIVE CAP FOR CYLINDER REGULATORS SHOULD BE IN PLACE AT ALL TIMES.
3 IV A	GC5 / HWTF	TRANSFER CYLINDER INTO SKID PRESSURE VESSEL	CYLINDER DROPPED DURING TRANSFER INTO PRESSURE VESSEL.	POTENTIAL RELEASE OF TOXIC GAS, WORKER EXPOSURE AND FATALITY. (D;D;A;D)	CYLINDER IS NOT TRANFERRED USING OVERHEAD CRANE.	(1) WORKER SHOULD WEAR PROTECTIVE EQUIPMENT, INCLUDING RESPIRATOR.
3 IV A	DU6 / HWTF	OVERPACK DRUM IS OPENED AND DRUM LIFTED WITH CRANE	RELEASE OF TOXIC GAS DUE TO UNEXPECTED MATERIALS IN DEPLETED URANIUM WASTE DRUM (PHOSGEN, HYDROGEN SULFIDE, CHLORINE, ETC...).	WORKER INJURY, POSSIBLE FATALITY. (D;D;A;D)	NONE	OPERATORS SHOULD USE SELF CONTAINED BREATHING APPARATUS, LEAVE ROOM IF ANYTHING OUT OF THE ORDINARY IS OBSERVED.
3 IV A	DU9 / HWTF	INNER DRUM IS GROUNDED AND OPENED USING NON-SPARK TOOLS	RELEASE OF TOXIC GAS DUE TO UNEXPECTED MATERIALS IN DEPLETED URANIUM INNER WASTE DRUM (PHOSGEN, HYDROGEN SULFIDE, CHLORINE, ETC...).	WORKER INJURY, POSSIBLE FATALITY. (D;D;A;D)	NONE	OPERATORS SHOULD USE SELF CONTAINED BREATHING APPARATUS, LEAVE ROOM IF ANYTHING OUT OF THE ORDINARY IS OBSERVED.
3 IV A	LIN6 / HWTF	OVERPACK DRUM IS OPENED AND INNER LIN DRUM IS LIFTED WITH CRANE	RELEASE OF TOXIC GAS DUE TO UNEXPECTED MATERIALS IN LIN WASTE DRUM (PHOSGEN, HYDROGEN SULFIDE, CHLORINE, ETC...).	WORKER INJURY, POSSIBLE FATALITY. (D;D;A;D)	NONE	OPERATORS SHOULD USE SELF CONTAINED BREATHING APPARATUS.
3 IV A	LIN9 / HWTF	PRIMARY WASTE DRUM IS GROUNDED AND OPENED USING NON-SPARK TOOLS	RELEASE OF TOXIC GAS DUE TO UNEXPECTED MATERIALS IN LIN PRIMARY WASTE DRUM (PHOSGEN, HYDROGEN SULFIDE, CHLORINE, ETC...).	WORKER INJURY, POSSIBLE FATALITY. (D;D;A;C)	NONE	WORKERS SHOULD WEAR PROTECTIVE CLOTHING, AND USE SELF CONTAINED BREATHING APPARATUS.
3 IV B	DU2 / MWRSF	WALK BEHIND FORKLIFT TRANSFERS DRUM TO	FORKLIFT DRIVES OFF DOCK WHILE TRANSPORTING	CONTAINER BREACH, IGNITION OF URANIUM CHIPS		NONE

HAZARD ANALYSIS REPORT BY RISK

R---F---C	ACT/FAC	ACTIVITY NAME	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
		ENCLOSED STORAGE ROOM	DEPLETED URANIUM WASTE DRUM. SPRINKLER SYSTEM FAILS TO OPERATE.	IN DOCK AREA. SIGNIFICANT FIRE AND POSSIBLE WORKER INJURIES, EXPOSURE TO DEPLETED URANIUM AND FACILITY CONTAMINATION. (D;D;B;C)		
3 IV B	DU3 / MWRSF	WALK BEHIND FORKLIFT MOVES DRUM OF DEPLETED URANIUM WASTE TO DOCK	FORKLIFT DRIVES OFF DOCK WHILE TRANSPORTING DRUM, WITH FAILURE OF SPRINKLER SYSTEM.	CONTAINER BREACH, IGNITION OF URANIUM CHIPS IN DOCK AREA. SIGNIFICANT FIRE, WORKER INJURIES AND EXPOSURE TO DEPLETED URANIUM, AND FACILITY CONTAMINATION. (D;D;B;C)	NONE	CONSIDER INSTALLATION OF A CURB TO PREVENT DRIVING THE FORKLIFT OFF DOCK.
3 IV B	MW2A / MW*	MWRSF REACTIVES (GROUP 2A)	WATER INTRUSION INTO THE STORAGE DRUM DUE TO HUMAN ERROR.	RUPTURE OF DRUM DUE TO HYDROGEN EVOLUTION, POTENTIAL FIRE/EXPLOSION. POSSIBLE RELEASE OF TOXIC METAL FUMES. (D;D;B;C)	DRY CHEMICAL FIRE SUPPRESSION SYSTEM, SCRUBBER SYSTEM.	NONE
3 IV B	MW7A / MW*	MWRSF GASES (GROUP 7A)	SIMULTANEOUS RUPTURE OF TWO INCOMPATIBLE (E.G., FLORINE AND H2S) GAS CYLINDERS (DUE TO MISHANDLING, FORKLIFT ACCIDENT, ETC...)	FIRE IN STORAGE AREA OR VENT SYSTEM DUE TO MIXING OF INCOMPATIBLE GASES. TOXIC GAS RELEASE. SEVERE WORKER INJURY. (C;C;B;C)	(1) FIRE PROTECTION AND (2) HEPA AND SCRUBBING SYSTEM.	NONE
3 IV B	MW1A / MW*	MWRSF CAUSTICS (GROUP 1A)	OVERHEAD CRANE ACCIDENT CAUSING SIMULTANEOUS SPILL OF CAUSTIC MATERIAL AND INCOMPATIBLE MATERIAL(E.G., H2SO4(1B), TETRAHYDRO FURAN(4A), NITRIC ACID(6A), METAL CYANIDE(5A),LITHIUM HYDRIDE(2A)) DUE TO MISLABELING.	POTENTIAL FIRE, EXPLOSION, HYDROGEN GAS PRODUCTION AND HEAVY METAL FUME GENERATION. WORKER INJURY/EXPOSURE. (D;D;B;C)	FIRE SUPPRESSION AND SCRUBBER SYSTEM.	NONE
3 IV B	MW1B / MW*	MWRSF ACIDS (GROUP 1B)	OVERHEAD CRANE ACCIDENT CAUSING SIMULTANEOUS SPILL OF ACID MATERIAL AND INCOMPATIBLE MATERIAL (E.G., NAOH(1A), PYRIDINE(4A), HYDROGEN PEROXIDE(6A), METAL CYANIDE(5A), LITHIUM HYDRIDE(2A)) DUE TO MISLABELING.	POTENTIAL FIRE, EXPLOSION, HYDROGEN GAS PRODUCTION AND TOXIC GAS GENERATION. SEVERE WORKER INJURY/EXPOSURE. (D;D;B;C)	FIRE SUPPRESSION AND SCRUBBER SYSTEM.	NONE
3 IV B	GC1 / MWRSF	LOAD CYLINDER FROM TA-54 ONTO TRANSPORT VEHICLE AND MOVE TO TA-63	RUPTURE OF FLAMMABLE GAS CYLINDER DURING HANDLING NEAR OTHER GAS CYLINDERS.	FLAMMABLE GAS IGNITES AND EXPOSES MULTIPLE CYLINDERS TO HIGH TEMPERATURE RESULTING IN RELEASE OF MULTIPLE GAS CYLINDERS. (C;C;B;C)	(1) WORKER HAS TIME TO RESPOND TO THE FIRE PRIOR TO RUPTURE OF OTHER CYLINDERS, (2) STORAGE FACILITY IS LOCATED AT A REMOTE SITE.	(1) VALVE COVERS SHOULD BE IN PLACE ON ALL CYLINDERS, (2) TRAIN WORKERS TO EVACUATE IN UPWIND DIRECTION, AND LOCATE GAS MASKS IN UPWIND DIRECTION, (3)

HAZARD ANALYSIS REPORT BY RISK

R---F---C	ACT/FAC	ACTIVITY NAME	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
						INSTALL A WIND SOCK FOR CONTINUOUS WIND DIRECTION INDICATION..
3 IV B	GC3 / MWRSF	GAS CYLINDER TRANSPORTED FROM MWRSF DOCK STORAGE AREA	BREACH OF CYLINDER DUE TO ACCIDENTAL CAUSES (E.G., CYLINDER DROPPED AND REGULATOR LINE BREAKS).	RELEASE OF MODERATELY TOXIC GASES (H2S, NO2, AND OTHERS). WORKER EXPOSURE. (C;C;B;D)	HEPA AND SCRUBBING SYSTEM.	(1) TRANSPORT AND STORE CYLINDERS SECURELY, (2) INSTALL GAS DETECTORS AND ALARMS, (3) CONSIDER SECONDARY CONTAINMENT FOR MOST HAZARDOUS CYLINDERS, (4) PROTECTIVE CAP FOR CYLINDER REGULATORS SHOULD BE IN PLACE AT ALL TIMES.
3 IV B	GC4 / MWRSF	TRANSPORT GAS CYLINDER FROM MWRSF STORAGE TO THE HWTF TREATMENT ROOM	BREACH OF CYLINDER DUE TO ACCIDENTAL CAUSES (E.G., CYLINDER DROPPED AND REGULATOR LINE BREAKS).	RELEASE OF MODERATELY TOXIC GASES (H2S, NO2, AND OTHERS). WORKER EXPOSURE. (C;C;B;D)	NONE	(1) TRANSPORT AND STORE CYLINDERS SECURELY, (2) CONSIDER SECONDARY CONTAINMENT FOR MOST HAZARDOUS CYLINDERS, (4) PROTECTIVE CAP FOR CYLINDER REGULATORS SHOULD BE IN PLACE AT ALL TIMES.
3 IV B	GC6 / HWTF	CYLINDER BREACHED	FLAMABLE CYLINDER BREACHED WITOUT INERTING PRESSURE VESSEL ATMOSPHERE.	FIRE OR EXPLOSION, POTENTIAL PRESSURE VESSEL DAMAGE. RELEASE OF GASES TO ATMOSPERE, WORKER INJURY. (D;D;B;C)	VESSEL DESIGNED TO CONTAIN FIRE AND EXPLOSION.	VERIFY PRESSURE VESSEL ATMOSPHERE BEFORE CUTTING CYLINDER.
3 IV B	LIH9 / HWTF	PRIMARY WASTE DRUM IS GROUNDED AND OPENED USING NON-SPARK TOOLS	OPERATOR FAILS TO FOLLOW PROCEDURE (CAUSES SPARK) AND IGNITES HYDROGEN IN LIH WASTE DRUM.	DISPERSAL OF LIH/DEPLETED URANIUM POWDER DUE TO EXPLOSION/FIRE. SEVERE WORKER INJURY. (D;D;B;C)	NONE	WORKERS SHOULD WEAR PROTECTIVE CLOTHING, AND USE SELF CONTAINED BREATHING APPARATUS.
3 IV B	LIH11 / HWTF	PRIMARY LITHIUM HYDRIDE DRUM TRANSFERED TO SKID WITH CRANE.	DRUM CONTENTS SPILLED DUE TO: (1) CLAMP COMES LOOSE, (2) LID FALLS OFF, (3) CRANE ACCIDENT.	LIH SPILLED AND CONTACTS WATER IN SUMP, POSSIBLE FIRE, WORKER EXPOSURE AND INHALATION OF FUMES AND DEPLETED URANIUM. (D;D;B;C)	NONE	WORKER TO WEAR PROTECTIVE CLOTHING AND BREATHING APPARATUS DURING MOVEMENT OF DRUM WITH HOIST. ENSURE THAT THE SUMP IN THE TREATMENT ROOM IS PUMPED DRY IF POSSIBLE.
3 V A	CY11 / HWTF	PLATING WASTE CONTAINER TRANSFERED TO SKID WITH CRANE OR MANUALLY.	CRANE ACCIDENT SPILLS CYANIDE WASTE DRUM CONTENTS WITH INCOMPATIBLE WASTE(ACIDS). BOTH DRUMS BREACHED.	MIXING OF INCOMPATIBLE WASTES RESULTS IN LETHAL HCN GAS. (D;D;A;D)	NONE	NONE
4 II D	DU6 / HWTF	OVERPACK DRUM IS OPENED AND DRUM LIFTED WITH CRANE	DRUM CONTENTS SPILLED DUE TO: (1) CLAMP COMES LOOSE, (2) CORROSION OF INNER DRUM, (3) LID FALLS OFF.	LIMITED SPILL OF DEPLETED URANIUM WASTE DRUM CONTENTS, MINOR CONTAMINATION. (D;D;D;D)	NONE	NONE

HAZARD ANALYSIS REPORT BY RISK

R---F---C	ACT/FAC	ACTIVITY NAME	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
4 II D	CY10 / HWTF	CONTENTS OF PLATING WASTE DRUM INSPECTED VISUALLY	SPILL OF CYANIDE LIQUID DURING SAMPLING AND VISUAL INSPECTION.	MINOR WORKER INJURY/EXPOSURE. (D;D;D;D)	NONE	IF UNEXPECTED CONTENTS FOUND, CONTACT SUPERVISOR.
4 II D	LIN16 / HWTF	LISO4 SOLUTIONS FILTERED (LITHIUM HYDRIDE PROCESS)	LEAK OF SOLUTIONS FILTERED FROM LIH PROCESS.	MINOR WORKER EXPOSURE. (D;D;D;D)	NONE	NONE
4 II D	DU4 / HWTF	YARD FORKLIFT DELIVERS DEPLETED URANIUM WASTE DRUM TO TREATMENT ROOM DOOR	FORKLIFT ACCIDENT DURING TRANSPORT BETWEEN BUILDINGS.	SPILL OF DRUM CONTENTS WITHOUT FIRE. (D;D;D;D)	NONE	MOVE ONLY ONE PALLET OR DRUM AT A TIME, RESTRICT OTHER VEHICLE DURING TRANSPORT.
4 II D	DU11 / HWTF	DEPLETED URANIUM WASTE DRUM TRANSFERED TO TREATMENT SKID WITH OVERHEAD CRANE	DRUM CONTENTS SPILLED DUE TO: (1) CLAMP COMES LOOSE, (2) CORROSION OF INNER DRUM, (3) LID FALLS OFF.	LIMITED SPILL OF DEPLETED URANIUM WASTE DRUM CONTENTS, MINOR CONTAMINATION. (D;D;D;D)	NONE	NONE
4 II D	HW5A / HW*	HWRSF CYANIDES AND SULFIDES (GROUP 5A)	SPILL OF CYANIDE DUE TO WALK BEHIND FORKLIFT ACCIDENT OR CORROSION.	CONTAMINATION OF THE STORAGE AREA, MINOR WORKER EXPOSURE. NO TOXIC GAS RELEASED DUE TO LOW VOLATILITY. (D;D;D;D)	NONE	NONE
4 II D	HW5A / HW*	HWTF CYANIDES AND SULFIDES STORAGE	SPILL OF CYANIDE DUE TO YARD FORKLIFT ACCIDENT OR CORROSION.	CONTAMINATION OF THE STORAGE AREA, MINOR WORKER EXPOSURE. NO TOXIC GAS RELEASED TO LOW VOLATILITY. (D;D;D;D)	NONE	NONE
4 II D	DU14 / HWTF	OIL DRAINS TO WASTE OIL DRUM (DEPLETED URANIUM PROCESS)	OVERFILL OF OIL DRUM CAUSED BY OPERATOR ERROR (I.E., INSUFFICIENT VOLUME OR DRUM NOT IN POSITION).	MINOR CONTAMINATION PROBLEM. (D;D;D;D)	NONE	NONE
4 II D	HW6A / HW*	HWRSF OXIDIZERS (GROUP 6A)	SPILL OF OXIDIZERS DUE TO WALK BEHIND FORKLIFT OR OVERHEAD CRANE ACCIDENTS.	LOW LEVEL TOXIC SPILL. WORKER EXPOSURE. (D;D;D;D)	HEPA FILTER AND SCRUBBING SYSTEM.	NONE
4 II D	HW6A / HW*	HW OXIDIZERS (GROUP 6A)	SPILL OF OXIDIZERS DUE TO FREEZING, YARD FORKLIFT OR OVERHEAD CRANE ACCIDENTS.	LOW LEVEL TOXIC SPILL. WORKER EXPOSURE. (D;D;D;D)	NONE	NONE
4 II D	HW1A / HW*	HWRSF CAUSTICS (GROUP 1A)	SPILL OF A SINGLE CAUSTIC WASTE DRUM.	MINOR WORKER EXPOSURE. (D;D;D;D)	NONE	NONE
4 II D	HW1A / HW*	HW CAUSTICS (GROUP 1A)	SPILL OF A SINGLE CAUSTIC WASTE DRUM CAUSED BY HUMAN ERROR, FORKLIFT ACCIDENT OR FREEZING.	MINOR WORKER EXPOSURE. (D;D;D;D)	NONE	NONE
4 II D	CY2 / HWRSF	WALK BEHIND FORKLIFT TRANSFERS WASTE DRUM TO STORAGE AREA (PLATING	CARBOY, POLYPACK OR OTHER PLATING WASTE CONTAINER PUSHED OFF DOCK OR TRUCK	CONTAINER BREACH, PLATING WASTE SPILL IN DOCK AREA. MINOR WORKER EXPOSURE AND	NONE	NONE

HAZARD ANALYSIS REPORT BY RISK

R---F---C	ACT/FAC	ACTIVITY NAME	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
		WASTES)	BY FORKLIFT.	FACILITY CONTAMINATION. (D;D;D;D)		
4 II D	CY3 / MWRSF	WALK BEHIND FORKLIFT MOVES CYANIDE WASTE DRUM TO DOCK	CARBOY, POLYPACK OR OTHER PLATING WASTE CONTAINER PUSHED OFF DOCK BY FORKLIFT.	CONTAINER BREACH, PLATING WASTE SPILL IN DOCK AREA. (D;D;D;D)	NONE	NONE
4 II D	CY12 / HWTF	INSTALL PUMPING ASSEMBLY TO THE TOP OF THE CYANIDE WASTE DRUM	RESIDUAL PLATING WASTE/REAGENTS LEFT IN PROCESS LINES DUE TO IMPROPER PURGE AFTER LOADING OF PREVIOUS WASTE CONTAINER. PLATING WASTE PROCESS.	HCN, H2S OR NH3 GAS GENERATED AND RELEASED TO SCRUBBER. (D;D;D;D)	NONE	ENSURE SCRUBBER OPERATION DURING ALL PHASES OF TREATMENT.
4 II D	CY8 / HWTF	VERMICULITE REMOVED AND BAGGED (PLATING WASTE PROCESS)	VERMICULITE CONTAMINATED WITH CYANIDE PLATING WASTE FROM LEAKY INNER PACK.	POSSIBLE CONTAMINATION WITH CYANIDE PLATING WASTE, MINOR WORKER EXPOSURE. (D;D;D;D)	NONE	IF THERE ARE INDICATIONS OF A LEAK WHEN REMOVING THE INNER DRUM, DO NOT REMOVE THE VERMICULITE.
4 II D	HW8 / HW*	MWRSF PCB (GROUP 8)	SPILL OF PCB WASTE DRUM DUE TO FORKLIFT ACCIDENT.	CONTAMINATION OF THE STORAGE AREA. (D;D;D;D)	SUMP SYSTEM.	NONE
4 II D	HW8 / HW*	HW PCB (GROUP 8)	SPILL OF PCB WASTE DRUM DUE TO FORKLIFT ACCIDENT.	CONTAMINATION OF THE STORAGE AREA. (D;D;D;D)	SUMP SYSTEM.	NONE
4 II D	DU18 / HWTF	OPEN REACTOR AND WASTE DRUM AND CHECK RESIDUAL CONTENTS	LOSS OF INERT GAS COVER LEADS TO SLOW BURN OF RESIDUAL URANIUM IN DRUM (DEPLETED URANIUM PROCESS).	POSSIBLE RELEASE OF URANIUM OXIDE TO SCRUBBER SYSTEM. (D;D;D;D)	NONE	INSPECT DRUM FOR RESIDUAL URANIUM AFTER OXIDATION PROCESS BEFORE END OF SHIFT.
4 II D	LIN8 / HWTF	VERMICULITE REMOVED AND BAGGED (LIN PROCESS)	VERMICULITE CONTAMINATED WITH LIN AND DEPLETED URANIUM FROM LEAKY INNER PACK.	POSSIBLE CONTAMINATION WITH LIN/DU, AND MINOR WORKER INHALATION. (D;D;D;D)	NONE	IF THERE ARE INDICATIONS OF A LEAK WHEN REMOVING THE INNER DRUM, DONOT REMOVE THE VERMICULITE.
4 III D	DU2 / MWRSF	WALK BEHIND FORKLIFT TRANSFERS DRUM TO ENCLOSED STORAGE ROOM	DEPLETED URANIUM DRUM PUSHED OFF DOCK BY FORKLIFT.	CONTAINER BREACH, URANIUM CHIP SPILL IN DOCK AREA. (D;D;D;D)		NONE
4 III D	DU12 / HWTF	HYDRAULIC PUNCTURE OF DRUM USING HOLLOW SPIKES	FAILURE TO INERT THE REACTOR WITH NITROGEN.	CONTAINED FIRE IN THE REACTOR. NO RELEASE BEYOND FILTERS AND SCRUBBER. (D;D;D;D)	NONE	INTERLOCK THE OXYGEN DETECTION WITH THE HYDRAULIC PRESS, SO DRUM IS NOT PUNCTURED IF OXYGEN IS PRESENT.
4 III D	DU13 / HWTF	CLOSED LOOP CIRCULATION OF WATER THROUGH REACTOR	WATER REACTIVE MATERIAL (I.E., LIN) PRESENT DUE TO MISLABELING NOT DETECTED BY VISUAL INSPECTION.	H2 GAS PRODUCTION AND RELEASE TO SCRUBBER. NO FIRE SINCE REACTOR IS INERTED WITH NITROGEN. (D;D;D;D)	NONE	NONE
4 III D	CY2 / MWRSF	WALK BEHIND FORKLIFT TRANSFERS WASTE DRUM TO STORAGE AREA (PLATING	CARBOY, POLYPACK OR OTHER PLATING WASTE CONTAINER PUNCTURED BY FORKLIFT.	CONTAINER BREACH, PLATING WASTE SPILL IN DOCK AREA. (D;D;D;D)	NONE	NONE

HAZARD ANALYSIS REPORT BY RISK

R---F---C	ACT/FAC	ACTIVITY NAME	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
		WASTES)				
4 III D	CY3 / MWRSF	WALK BEHIND FORKLIFT MOVES CYANIDE WASTE DRUM TO DOCK	CARBOY, POLYPACK OR OTHER PLATING WASTE CONTAINER PUNCTURED BY FORKLIFT.	CONTAINER BREACH, PLATING WASTE SPILL IN DOCK AREA. (D;D;D;D)	NONE	NONE
4 III D	DU15 / HWTF	BLEACH IS ADDED TO CIRCULATING WATER	LOSS OF COOLING WATER (DU PROCESS).	INCREASE IN TEMPERATURE AND INCREASED AMOUNT OF CHLORINE GAS DUE TO DECOMPOSITION OF BLEACH. (D;D;D;D)	NONE	NONE
4 III D	DU15 / HWTF	BLEACH IS ADDED TO CIRCULATING WATER	LOSS HEPA/SCRUBBING SYSTEM (DU PROCESS).	SMALL CHLORINE GAS RELEASE NEAR STACK OR SCRUBBING SYSTEM. (D;D;D;D)	NONE	NONE
4 III D	DU5 / HWTF	CRANE DELIVERS DRUM TO SAMPLE ROOM	DRUM DROPPED WHILE MOVING TO HWTF SAMPLE ROOM USING HOIST. SPRINKLER SYSTEM OPERABLE.	CONTAINER BREACH WITH SPILL OF URANIUM CHIPS AND POTENTIAL FIRE. MINOR WORKER EXPOSURE. (D;D;D;D)	NONE	NONE
4 IV C	DU6 / HWTF	OVERPACK DRUM IS OPENED AND DRUM LIFTED WITH CRANE	OPERATOR FAILS TO FOLLOW PROCEDURE (CAUSES SPARK) AND IGNITES HYDROGEN IN THE DEPLETED URANIUM WASTE DRUM.	EXPLOSION OF SMALL QUANTITY OF HYDROGEN RESTRICTED TO SPACE UNDER VENTILATION HOOD. (D;D;C;D)	NONE	NONE
4 IV C	DU6 / HWTF	OVERPACK DRUM IS OPENED AND DRUM LIFTED WITH CRANE	DRUM CONTENTS SPILLED DUE TO: (1) CLAMP COMES LOOSE, (2) CORROSION OF INNER DRUM, (3) LID FALLS OFF; AND IGNITION OF URANIUM CHIPS.	SPILL OF DRUM CONTENTS WITH URANIUM FIRE. (D;D;C;D)	NONE	NONE
4 IV C	CY9 / HWTF	PRIMARY WASTE DRUM IS GROUNDED AND OPENED USING NON-SPARK TOOLS (PLATING WASTES).	OPERATOR FAILS TO FOLLOW PROCEDURE WHILE OPENING CYANIDE PRIMARY WASTE DRUM (I.E., USES WRONG TOOLS, MISPOSITIONING OF THE VENT HOOD, ETC...). RELEASE OF FLAMMABLE GAS DUE TO UNEXPECTED CONTENTS.	SHORT DURATION FIRE UPON OPENING THE WASTE CONTAINER. POSSIBLE WORKER INJURY AND MINOR CONTAMINATION. (D;D;C;D)	NONE	NONE
4 IV C	LIH2 / MWRSF	WALK BEHIND FORKLIFT TRANSFERS LITHIUM HYDRIDE WASTE DRUM TO ENCLOSED STORAGE ROOM.	LITHIUM HYDRIDE WASTE DRUM PUNCTURED BY FORKLIFT.	POTENTIAL RELEASE/SPILL OF LIH/DU IN THE LOADING DOCK AREA. POTENTIAL WORKER EXPOSURE (LIH AND DU). (D;D;C;D)	NONE	DRIVER SHOULD HAVE BREATHING APPARATUS AVAILABLE (WITHIN REACH), BREATHING OF LIH POWDER IS HAZARDOUS.
4 IV C	LIH3 / MWRSF	WALK BEHIND FORKLIFT MOVES LITHIUM HYDRIDE DRUM TO DOCK FROM ENCLOSED STORAGE ROOM	LITHIUM HYDRIDE WASTE DRUM PUNCTURED BY FORKLIFT.	POTENTIAL RELEASE/SPILL OF LIH IN THE LOADING DOCK AREA. POTENTIAL WORKER EXPOSURE (LIH AND DU). (D;D;C;D)	NONE	DRIVER SHOULD HAVE BREATHING APPARATUS AVAILABLE (WITHIN REACH), BREATHING OF LIH POWDER IS HAZARDOUS.

HAZARD ANALYSIS REPORT BY RISK

R---F---C	ACT/FAC	ACTIVITY NAME	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
4 IV C	DU2 / HWRSF	WALK BEHIND FORKLIFT TRANSFERS DRUM TO ENCLOSED STORAGE ROOM	DEPLETED URANIUM DRUM PUNCTURED BY FORKLIFT.	CONTAINER BREACH, MINOR WORKER EXPOSURE. (D;D;C;D)		NONE
4 IV C	DU11 / HWTF	DEPLETED URANIUM WASTE DRUM TRANSFERED TO TREATMENT SKID WITH OVERHEAD CRANE	DRUM CONTENTS SPILLED DUE TO: (1) CLAMP COMES LOOSE, (2) CORROSION OF INNER DRUM, (3) LID FALLS OFF; AND IGNITION OF URANIUM CHIPS.	SPILL OF DEPLETED URANIUM WASTE DRUM CONTENTS WITH URANIUM FIRE. WORKER EXPOSURE TO DEPLETED URANIUM. (D;D;C;D)	NONE	NONE
4 IV C	DU13 / HWTF	CLOSED LOOP CIRCULATION OF WATER THROUGH REACTOR	ADDITION OF WATER OR BLEACH TO WATER REACTIVE MATERIAL (I.E., LIH) PRESENT DUE TO MISLABELING NOT DETECTED BY VISUAL INSPECTION. REACTOR NOT INERTED WITH NITROGEN.	LIMITED EXPLOSION IN REACTOR AND DUCT WORK OF SCRUBBER. LIMITED POTENTIAL FOR WORKER INJURY. FACILITY CONTAMINATION AND SOME RELEASE TO OTHER TECHNICAL AREAS ONSITE. (D;D;C;C)	NONE	ADD WATER VERY SLOWLY AT THE BEGINNING TO DETECT ANY H2 FORMATION.
4 IV C	DU15 / HWTF	BLEACH IS ADDED TO CIRCULATING WATER	LOSS OF COOLING WATER WITH LOSS OF SUCTION TO THE SCRUBBER (DU PROCESS).	INCREASED AMOUNT OF CHLORINE GAS LEAKED INTO THE TREATMENT ROOM DUE TO INCREASE IN TEMPERATURE. WORKER EXPOSURE TO CHLORINE AND DEPLETED URANIUM. (D;D;C;D)	NONE	NONE
4 IV C	CY6 / HWTF	OVERPACK DRUM IS OPENED AND INNER CYANIDE DRUM IS LIFTED WITH CRANE	OPERATOR FAILS TO FOLLOW PROCEDURE (CAUSES SPARK) AND IGNITES HYDROGEN IN THE CYANIDE WASTE DRUM.	EXPLOSION OF SMALL QUANTITY OF AVAILABLE HYDROGEN RESTRICTED TO SPACE UNDER VENTILATION HOOD. (D;D;C;D)	NONE	OPERATORS SHOULD USE SELF CONTAINED BREATHING APPARATUS.
4 IV C	DU5 / HWTF	CRANE DELIVERS DRUM TO SAMPLE ROOM	DRUM DROPPED WHILE MOVING TO HWTF SAMPLE ROOM USING HOIST. SPRINKLER SYSTEM NOT OPERABLE.	CONTAINER BREACH, SPILL OF URANIUM CHIPS WITH POTENTIAL FIRE LIMITED TO CONTENTS OF ONE DRUM. WORKER INJURY AND EXPOSURE TO DEPLETED URANIUM. (D;D;C;D)	NONE	NONE
4 IV C	DU9 / HWTF	INNER DRUM IS GROUNDED AND OPENED USING NON-SPARK TOOLS	OPERATOR FAILS TO FOLLOW PROCEDURE (CAUSES SPARK) AND IGNITES HYDROGEN IN DEPLETED URANIUM WASTE DRUM.	EXPLOSION OF SMALL QUANTITY OF HYDROGEN RESTRICTED TO SPACE UNDER VENTILATION HOOD. (D;D;C;D)	NONE	NONE
4 IV C	LIH6 / HWTF	OVERPACK DRUM IS OPENED AND INNER LIH DRUM IS LIFTED WITH CRANE	OPERATOR FAILS TO FOLLOW PROCEDURE (CAUSES SPARK) AND IGNITES HYDROGEN IN THE LIH WASTE DRUM.	EXPLOSION OF SMALL QUANTITY OF AVAILABLE HYDROGEN RESTRICTED TO SPACE UNDER VENTILATION HOOD. (D;D;C;D)	NONE	OPERATORS SHOULD USE SELF CONTAINED BREATHING APPARATUS.
4 IV D	DU3 /	WALK BEHIND FORKLIFT	DRUM PUSHED OFF DOCK BY	CONTAINER BREACH, URANIUM	NONE	NONE

HAZARD ANALYSIS REPORT BY RISK

R---F---C	ACT/FAC	ACTIVITY NAME	CAUSE/SCENARIO	CONSEQUENCES	PROTECTIVE FEATURES	ACTIONS
	HWRSF	MOVES DRUM OF DEPLETED URANIUM WASTE TO DOCK	FORKLIFT.	CHIP SPILL IN DOCK AREA, NO WORKER EXPOSURE DUE TO DISTANCE FROM SPILL. (D;D;D;D)		
4 IV D	DU13 / HWTF	CLOSED LOOP CIRCULATION OF WATER THROUGH REACTOR	HUMAN ERROR; BLEACH INTRODUCED WITHOUT CIRCULATION OF WATER (DEPLETED. SCRUBBER FAILURE.	CHLORINE GAS RELEASE THROUGH STACK. (D;D;D;D)	NONE	NONE
9	DU10 / HWTF	CONTENTS OF DRUM INSPECTED VISUALLY	CONTENTS OF DEPLETED URANIUM WASTE INNER DRUM VISUALLY INSPECTED.	POTENTIAL HAZARDS COVERED UNDER ACTIVITIES WHERE OVERPACK AND INNER DRUM ARE OPENED.	NONE	IF UNEXPECTED CONTENTS FOUND, CONTACT SUPERVISOR.
9	CY7 / HWTF	OVERPACK DRUM IS DISCARDED TO CRUSHER OR USED FOR CEMENTATION (PLATING WASTE PROCESS).	TRANSPORT OF EMPTY OVERPACK DRUM (PLATING WASTE PROCESS) TO CRUSHER OR CEMENTATION FACILITY.	NONE	NONE	NONE
9	DU16 / HWTF	REACTION COMPLETE. SLURRY TRANSFERRED TO REDUCTION/SETTLING TANK (DEPLETED URANIUM PROCESS)	PLUGGING OF CIRCULATION LINE DUE TO ACCUMULATION OF SMALL UNREACTED URANIUM CHIPS (DEPLETED URANIUM PROCESS). MAY BE DUE TO BREACH OF THE PACTICLE SCREEN.	OPERATIONAL PROBLEM. NOT A HAZARD.	NONE	NONE
9	DU7 / HWTF	OVERPACK DRUM IS DISCARDED TO CRUSHER OR USED FOR CEMENTATION.	TRANSPORT OF EMPTY OVERPACK DRUM (DEPLETED URANIUM PROCESS) TO CRUSHER OF CEMENTATION FACILITY.	VERMICULITE IS REMOVED, DRUM IS TESTED FOR CONTAMINATION PRIOR TO DISPOSAL.	NONE	NONE
9	LIH7 / HWTF	OVERPACK DRUM IS DISCARDED TO CRUSHER OR USED FOR CEMENTATION (LIH PROCESS).	TRANSPORT OF EMPTY OVERPACK DRUM (LITHIUM HYDRIDE PROCESS) TO CRUSHER OR CEMENTATION FACILITY.	NONE	NONE	NONE

APPENDIX E
RESUMES OF PRELIMINARY HAZARDS ANALYSIS TEAM MEMBERS

M. KENT SASSER

Staff Member, Engineering & Safety Analysis Group, (505) 665-2540
Los Alamos National Laboratory, MS-K557

Skills

Management
Nuclear Oversight and Inspection
Reactor Systems & Safety
Probabilistic Risk Assessment
Nuclear Operations, Maintenance, & Testing
Nuclear Power Plant Procedures
Health Physics

Professional Experience

Eighteen years experience, summarized as follows:

- Manager, nuclear safety oversight staff at a commercial PWR (>15 staff)
- Manager, procedures upgrade at a commercial PWR (>60 staff)
- NRC resident inspector, 3 unit Babcock & Wilcox commercial PWR
- Senior Reactor Operator (SRO) certification, Westinghouse PWR
- Pre-operational test director, commercial reactor
- Nuclear safety analyst, probabilistic risk assessment, human factors
- DOE project manager, spent fuel storage and waste management projects
- Health physics inspector, DOE Savannah River Site

Employment History

Los Alamos National Laboratory

Staff Member, N-6, Engineering & Safety Analysis Group, April 1990 to present. Technical staff member. Analytical studies and assessments of reactor and non-reactor facilities. Nuclear safety, human factors, probabilistic risk analysis. Project Leader for DOE K Reactor and TA-55 Plutonium Laboratory PRAs.

Tennessee Valley Authority (TVA), Watts Bar Nuclear Plant

Manager, Procedures Upgrade Program, 1989-1990.
Manager of program to upgrade plant procedures, technically and to meet NRC/INPO requirements. Staff 60+

SRO Certification for Managers, 1988

Nine month program for senior reactor operator certification per ANS 3.1. Rigorous study of reactor theory, systems, accident analysis, and operating skills on a plant simulator.

Manager, Plant Operations Review Staff, 1986-1988

Organized and staffed multi-disciplinary nuclear safety oversight organization. Staff responsible for (1) assessment of programs against industry/regulatory requirements, (2) investigation and reporting of abnormal events, and (3) preparation Licensee Event Reports. Plant interface with external Nuclear Safety Review Board (NSRB) and Plant Operations Review Committee (PORC). Technical support for Sequoyah Nuclear plant restart. Staff of >15.

Pre-operational Test Director, 1982-1984

Testing of reactor nuclear systems following completion of construction but prior to operations. Responsible for integrated Hot Functional Testing as well as tests of various reactor safety systems.

Nuclear Regulatory Commission, Region II, Atlanta, Georgia

Resident Inspector (Operations), Oconee Nuclear Power Station, 1984-1986. Certified resident inspector for all aspects of operations, maintenance, testing, and health physics at a three unit commercial reactor. Interfaced with utility personnel (operators, technicians, plant managers and VPs), NRC Administrators, Division Directors, and Headquarters staff.

Department of Energy, Savannah River Operations Office

Project Manager, Spent Fuel Project Office, 1979-1982.
Managed technical program to implement DOE spent fuel storage program. Forerunner of Monitored Retrievable Storage (MRS) program. Developed and supported technologies for spent fuel storage such as on-site cask storage and transportation of spent fuel.

Health Physicist, Safety & Environment Division, 1975-1978

Inspected HP program in all Savannah River production reactors, chemical separations, tritium facilities, laboratory, and waste management operations.

Education

M.S., Public Health, Environmental Sciences & Engineering Department, Health Physics Program, UNC-Chapel Hill, 1975
B.S., Nuclear Engineering, North Carolina State University, 1973

Other Training (Partial Listing)

Pathway Analysis/Risk Assessment for Environmental Compliance and Dose Reconstruction, March 1992
Safety and Risk Assessment Methods for Nonreactor Nuclear Facilities, September 1991
Supervisory Development Training, Tennessee Valley Authority, June 1987
Management Oversight and Risk Tree (MORT), Accident/Incident Investigation Workshop, 1987

Active Q Clearance

COREY K. MCDANIEL

Summary

Graduate Research Assistant with Los Alamos National Laboratory with more than 4 yr of experience in the nuclear industry. Three years with Safety Systems & Analysis Section and 1 yr with Probabilistic Safety Assessment Section specializing in Probabilistic Risk Assessment. Performed safety analysis using Transient Reactor Analysis Code (TRAC) on SRL K-reactor and developed database of federal codes and regulations for meeting DOE requirements for future site development. Areas of expertise include reactor safety analysis, human factors engineering, hazardous and mixed waste management, software development, risk assessment, and engineering systems and design.

Education

M.S., Nuclear Engineering, University of New Mexico, 1994
B.S., Nuclear Engineering, Purdue University, 1993

MOHSEN SHARIRLI

Background

Fifteen years of experience in various areas of Reliability, Availability, and Maintainability (RAM) studies, Probabilistic Risk Assessment (PRA), and Safety Technology. This involved areas of safety, system analysis, PRA, reliability studies, availability analysis, maintainability analysis, unavailability studies, reliability centered maintenance (RCM) programs, failure modes and effects analysis, criticality studies, hazard analysis, system unavailability monitoring programs, surveillance and monitoring studies, trend analysis, condition monitoring programs, risk management, economic feasibility, cost benefit analysis, design analysis, safety analysis reports, various requirements, orders, and standards. This includes development, applications, methodologies, and studies and their implementations to commercial nuclear plants, commercial power plants, space programs, processing plants, accelerators, storage facilities, and other commercial and defense facilities and installations.

Education

B.S., Nuclear Engineering, University of Arizona, Tucson, Arizona, 1978
B.S., Physics, Texas Southern University, Houston, Texas, 1979
MS., Nuclear Engineering, University of Maryland, College Park, Maryland, 1983
Ph.D., Nuclear Engineering, University of Maryland, College Park, Maryland, 1985

JOHN P. KINDINGER

Summary

Senior Consultant with PLG specializing in safety analysis, risk assessment, and management consulting for the nuclear and process industries. Experience includes both participation in and the management of risk assessments as well as the design and construction of nuclear and fossil fueled power plants.

Experience

Project manager and key technical contributor for the DOE-sponsored probabilistic risk assessment (PRA) of the high level waste storage tanks at Hanford, Washington. Key technical contributor to the independent review of PRAs of the DOE N Reactor and Savannah River K Reactor. Principal technical contributor to risk assessment of the new Secondarily Contained Tritium Handling and Process System at the Lawrence Livermore National Laboratory to satisfy Safety Analysis Report requirements per DOE Order 5481.1 B. Manager of the Pilgrim and Bellefonte PRAs and participant in the Pilgrim safety enhancement program, including evaluations of operating procedures and their improvements. Key contributor to the "Seabrook Project Management Prudence Audit" and the innovative cost model used in that study. With Consumers Power Company, was senior/staff engineer, Midland Project Engineering Department. Project manager of Midland Nuclear Power Plant PRA project. Administered and directed consultant activities and directed the architect-engineer and nuclear steam supply system supplier team performing this study. Senior engineer, Midland Nuclear Safety Task Force, responsible for identifying and evaluating safety concerns arising from the Three Mile Island Unit 2 accident and recommending resolutions to senior management. Additional responsibilities included preparation of the Midland Final Safety Analysis Report and participation in the design verification program. Designed mechanical and energy conversion systems for the Midland nuclear plant, the J. H. Campbell Unit 3 coal-fired plant, and the D. E. Karn Units 3 and 4 oil-fired plants. Also designed transmission substations ranging from 46-kV to 345-kV, and coordinated substation projects engineered by consultants.

Education

M.S., Management of Technology, Massachusetts Institute of Technology, 1985 0.5., Mechanical Engineering, Michigan State University, 1971

Memberships. Licenses, and Honors

Registered Professional Engineer, Michigan
American Nuclear Society
American Society of Mechanical Engineers
Society for Risk Analysis

SUBODH R. MEDHEKAR

Summary

Consultant and chemical engineer with more than 5 yr of industry and consulting experience in the design, operation, risk, and hazards analysis of various chemical, petrochemical, and refinery facilities.

Experience

Currently involved in safety and risk assessment of chemical, petrochemical, and U.S. Department of Energy facilities. Lead technical contributor for more than five Risk Management and Prevention Programs IRMPP). Responsible for preparation of the RMPP technical documents including hazard analysis and offsite consequence analysis sections. Led hazard and operability (HAZOP) studies for various chemical processes and units including hydrotreater, sulfur recovery, penex plus, ammonia handling system, reformate splitter, and liquid sulfur dioxide handling and storage facility. Led preliminary hazards analysis (PHA) for hazardous waste treatment facility, ash immobilization facility, and mixed waste storage facility. Primary author of PLG's HAZMAN software to support the performance of HAZOP and PHA.

Served as an expert witness providing deposition pertaining to a risk assessment of a HF alkylation facility in the South Coast Basin. Recently involved as a lead technical contributor in establishing risk-based financial liability and premiums for self insurance funds for an Alaskan Oil Company. Served as a lead technical contributor to provide a basis for the selection of a risk-based cost-effective alternative to minimize financial exposure. Developed a risk model to prioritize various pipelines for a major oil company enabling the allocation of improvement funds in accordance with the risk reduction gains. Developed application of Thomas models for assessing failure frequency of pipelines and storage vessels for hydrofluoric acid handling and storage systems. Key technical contributor for a sulfuric acid plant risk assessment and petrochemical plant demolition project.

Prior to joining PLG, had 5 yr of extensive research experience. During graduate tenure at University of California, Santa Barbara, worked concurrently at Center for Risk Studies and Safety on safety-related thermal-hydraulic problems. Analyzed the potential for and dynamics of steam explosions using complex multiphase fluid flow simulations on CRAY-XMP along with high pressure shock tube experiments. Also aided in the instruction of undergraduate "Chemical Processes/Plant Safety" course.

Prior to graduate work, had 2 yr of industrial experience working as a process engineer at an oil refinery and as a project engineer at a Union Carbide plant.

Education

Ph.D., Chemical Engineering, University of California, Santa Barbara, 1991
M.S., Chemical Engineering, University of California, Santa Barbara, 1988
B. Tech, Chemical Engineering, Indian Institute of Technology, New Delhi, 1984

Memberships, Licenses, and Honors

American Institute of Chemical Engineers
Society for Risk Analysis
Principal Investigator of Computational Project, NSF Supercomputer, San Diego, 1988
Administrative Vice President, Graduate Student Association, UCSB, 1988
President Chemical Engineering Society, IIT, New Delhi, India, 1983–1984
J. N. Tata Endowment Scholarship, 1985
Aryabhatta Science Talent Award, 1977
Ramanujam Math Talent Award, 1977

THOMAS J. MIKSCHL

Summary

Consultant with PLG, with more than 8 yr of experience in safety analysis probabilistic risk assessment (PRA). Primary analysis experience in the areas of model quantification, systems analysis, and the integration of seismic, fire, and other external events into internal events PRA models for evaluation of total plant risk. Expert in the use of PRA-related software.

Experience

Has participated in PRAs for more than 18 plants. Performed systems analyses for the Diablo Canyon, Beznau, Bellefonte, Browns Ferry, Sequoyah, and Watts Bar PRAs. Model quantification task leader on the South Texas Project, Seabrook Station, Diablo Canyon, and Beznau PRAs. Principal analyst in the update of the Beznau PRA and in the conversion of the complete Beznau PRA to the state-of-the-art PLG PRA software. Participated in the modeling and quantification of seismic events for a number of PRAs. Has participated in the development and quantification of containment response models for several Level 2 PRAs. Key technical contributor to the probabilistic risk assessment of the newly constructed, secondarily-contained tritium processing system at Lawrence Livermore National Laboratory. Performed systems analyses and was a key contributor to the PRA of a Modular High Temperature Gas-Cooled Reactor designed by CEGA Corporation. Involved in the programming and development of PLG's PRA software, including event tree quantification and linking, seismic fragility quantification, and room heatup calculation codes.

Education

B.S., Environmental Engineering, Humboldt State University, 1982

DATE FILMED

8/4/94

END