SAFETY EVALUATION

FOR

HIGH LEVEL WASTE TRANSFER SYSTEM

REV. 1

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HIGH LEVEL WASTE TRANSFER SYSTEM SAFTEY EVALUATION

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ACRONYMS AND ABBREVIATIONS

ACI	American Concrete Institute
AEDE	Annual Effective Dose Equivalent
AE	Architect Engineering
ALARA	As Low As Reasonably Achievable
AISC	American Institute of Steel Conctruciton
ARM	Area Radiation Monitor
CAMs	Continuous Air Monitors
CEDE	committed effective dose equivalent
CSS	Cement Solidification System
cm	centimeter
CRT	Cathode Ray Tube
DAC	derived air concentration
DBE	Design Basis Earthquake
DC	drum cell
DOE	U.S. Department of Energy
DOP	Dioctyl phthalate
DOT	Department of Transportation
EPA	U.S. Environmental Protection Agency
ft	feet
gpm	gallons per minute
h	hour
HEPA	High Efficiency Air Particulate
HLW	High Level radioactive Waste
HLWTS	High Level Waste Transfer System
hp	horsepower
Hv	Heating and Ventilation
ICCP	Idaho Chemical Processing Plant
IRTS	Integrated Radwaste Treatment System
kg	kilogram
km	kilometers
kw	kilowatt
lbs	pounds
LLL	Lawrence Livermore Laboratory
LLW	Low-level Waste
lpm	liters per minute
LWTS	Liquid Waste Treatment System

ACRONYMS AND ABBREVIATIONS (cont.)

MCC	Motor Control Center
mi	miles
m	meters
mR	milliroengten
NRC	Nuclear Regulatory Commission
NYS	New York State
NYSDEC	New York State Department of Environmental Conservation
P&ID	Piping and Instrument Diagram
PLC	Programmable Logic Controller
PVS	Permanent Ventilation System
rpm	revolutions per minute
SAR	Safety Analysis Report
scfm	standard cubic feet per minute
SE	Safety Evaluation
SMS	Sludge Mobilization System
SMWS	Sludge Mobilization Wash System
SPCP	Spill Prevention Control Plan
STP	Tandard Temperature Pressure
UBC	Uniform Building Code
VF	Vitrification Facility
V&S	Ventilation and Service
STS	Supernatant Treatment System
WNYNSC	Western New York Nuclear Service Center
WTF	Waste Tank Farm
WTFVS	Waste Tank Farm Ventilation System
WVDP	West Valley Demonstration Project
WVNS	West Valley Nuclear Services
χ/Q	relative dispersion

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Executive Summary

The purpose of this Safety Evaluation is to provide justification for the results of the High-Level Waste Transfer System (HLWTS) Unreviewed Safety Question Determination (USQD). This evaluation and the results of the Safety Review Screen, concludes that the HLWTS can be operated safely and within the approved authorization basis as defined in WVNS-SAR-004, "Safety Analysis Report for the Supernatant Treatment System," Rev. 7, as designed. The HLWTS has been designed to reduce hazards to acceptable levels by instrumented control of the process and by conducting operations remotely within sealed and shielded multiple containments.

Calculated doses to the maximally exposed off-site individual and operating personnel were determined for accident conditions. The bounding dose calculated to the maximally exposed off-site individual is <500 mrem for accidents associated with the HLWTS. This consequence is less than the bounding consequence of approximately 800 mrem analyzed in WVNS-SAR-004. Abnormal operations are expected to have minimal impact to off-site individuals. For routine operation, the doses are well within the requirements of DOE Order 5400.5, and ID Order 5400.5, "Radiation Protection of the Public and the Environment."

1.0 PRINCIPAL DESIGN CRITERIA

1.1 Purpose of the High-Level Waste Transfer System

The High-Level Waste Transfer System (HLWTS) is a key part of the overall Sludge Mobilization System (SMS). The SMS involves resuspending and transferring the high-level nuclear wastes to the Vitrification Facility (VF). The HLW remaining from the PUREX campaign, the THOREX campaign, and Phase I pretreatment operations at the WVDP are contained in Waste Tank Farm (WTF) underground storage tanks 8D-1, 8D-2, and 8D-4. The processing of the waste from these three tanks will occur in stages.

Tank 8D-2 contains a PUREX precipitate (sludge) and a dilute alkaline supernatant, tank 8D-4 contains a liquid acidic thorium nitrate waste (THOREX), and tank 8D-1 contains the spent cesium loaded zeolite from the Phase I STS liquid pretreatment process. The primary objective of the HLWTS is to remove the HLW from storage tanks 8D-1 and 8D-4. The first stage (covered by this safety evaluation) involving the HLWTS is to remove the wastes from tanks 8D-1 and 8D-4 and transfer the waste to tank 8D-2. Later the waste will be blended, to form a single radioactive slurry which will be fed to the VF.

The transfer and blending of the wastes in tank 8D-2 will be done in two phases. The first phase, involves removing the THOREX wastes and neutralizing the acidic thorium nitrate with the dilute alkaline 8D-2 PUREX supernatant. Neutralizing the THOREX consists of adding caustic to tank 8D-2 to elevate the pH above 13. Up to five mobilization pumps, currently installed, will be used to mix the contents of tank 8D-2. These pumps are long-shafted centrifugal pumps that extend into the tank through access sleeves called risers (Figure 1). These pumps are part of the Sludge Mobilization and Wash System (SMWS) and were used to resuspend the settled PUREX sludge during sludge washing. As the tank contents are continuously agitated, the acidic THOREX liquid will be slowly added to caustic rich 8D-2 in a manner which assures quick neutralization of any free acid and prevents localized pH excursions inside 8D-2. THOREX will be removed and transferred to tank 8D-2 in batches until all the waste is removed from tank 8D-4.

The neutralized THOREX may be washed using a dilute caustic solution and the resulting wash solutions treated through the STS to remove the salts from the waste feed to the VF. A dilute caustic solution will be added to the 8D-2 tank and the sludge mobilization pumps will be run to mix the contents. After the neutralized waste and dilute caustic solution are mixed, the pumps may be shut down and the solids allowed to settle. Once the solids settle, the STS supernatant feed pump (50-G-001), which is a floating suction pump, will be used to transfer the THOREX wash solution to the STS for decontamination. This operation is an extension of the SMWS operation covered in WVNS-SAR-004.

The STS will decontaminate the THOREX wash solution (remove the strontium, cesium, and plutonium) to a level that will permit the decontaminated wash solution to be sent to the Liquid Waste Treatment System (LWTS) and then to the Cement Solidification System (CSS) for solidification in cement as a low-level waste (LLW). The STS uses a separation process with a cesium-specific zeolite to ion exchange cesium from other species dissolved in the sludge wash solutions and, when needed, a Ti-treated zeolite to retain the plutonium. Details on the STS can be found in WVNS-SAR-004. Details for the LWTS can be found in WVNS-SAR-005. Details of the CSS can be found in WVNS-SAR-008.

The second phase of the transfer operation involves removing the spent zeolite generated by the STS operations from tank 8D-1, size reducing the zeolite and transferring it to tank 8D-2. The radioactive species retained from STS processing are temporarily stored as loaded zeolite (ion exchange media) at the bottom of tank 8D-1 under a water cover. Zeolite Mobilization Pumps will be installed in tank 8D-1 and employed to resuspend the zeolite using the water cover to generate a slurry suspension. This slurry will be pumped from the tank using a separate removal pump and fed to a grinder housed in the pump pit on top of the 8D-2 vault. The size reduced zeolite is then discharged to the 8D-2 tank through a pipe extending down the 8D-2 removal pump riser (M-9). The zeolite will be removed from tank 8D-1 until the level is lowered to approximately three feet above the tank bottom. Additional liquid must be added to tank 8D-1 to slurry the remaining zeolite from the Tank. Tank 8D-2 liquid could be decanted back to tank 8D-1 using the STS supernatant removal pump (50-G-001) in tank 8D-2 or fresh process water from STS could be added. This procedure may be repeated until the majority of zeolite is removed from tank 8D-1.

The HLWTS consists of the removal pumps, the pump pits and utility pits on the tank vaults, the transfer trench which contains the tank-to-tank transfer piping, the utility system, and the control station to regulate and monitor the transfer operations.

Details pertaining to the HLWTS design presented in this and subsequent chapters of this Safety Evaluation (SE) are based on the most recent Pump Support Design Conditions (Ebasco, 1985), Design Criteria, Remote Riser Installation System (Schiffhauer, 1986), tank 8D-1 and 8D-2 Waste Mobilization Pump Specifications

(Schiffhauer, 1987), Civil Design Criteria Sludge Mobilization Transfer System (Ebasco 1992), and the Design Criteria, Sludge Mobilization Waste Removal System (Schiffhauer, 1992).

1.1.1 HLWTS Functions

After STS sludge wash water processing, the three storage tanks will contain the following: 1) tank 8D-2 containing washed PUREX sludge; 2) tank 8D-4 containing THOREX waste in dilute nitric acid solution; and 3) tank 8D-1 contain_rg cesium loaded (spent) zeolite.

The method of processing the contents of these three tanks is to mix them together in tank 8D-2 and then ultimately deliver the waste mixture to the Vitrification Facility (VF). The advantage of combining the wastes in tank 8D-2 is that the vitrification process feed stream will not vary in composition nearly as much as if three separate streams of vastly different compositions are processed. Processing a combined waste stream will significantly simplify vitrification operations.

The major processing functions of the HLWTS are summarized below and are described in detail in Section 3.0. A generalized flow diagram is represented schematically in Figure 2.

1.1.1.1 THOREX Solution Transfer

To effectively neutralize the THOREX from tank 8D-4 and maintain corrosion control of tank 8D-2, an appropriate level of caustic will be added to 8D-2 prior to transfer. The sodium hydroxide will be added to the 8D-2 waste to precipitate the THOREX metal ions and neutralize the nitric acid in the THOREX solution. A vertical turbine pump installed in tank 8D-4 is to be used to remove the liquid THOREX waste from the tank. The THOREX transfer pump and piping requires operational flexibility for future service. The ability to transfer waste materials from Tank 8D-4 to either Tank 8D-2 or the Vitrification Facility during vitrification operations was incorporated into the equipment design. However, the removal pump and piping are over-designed for the low flow rates to be used during THOREX neutralization, so the removal pump will operate in a recycle mode within Pump Pit 8Q-4 and a bypass line in the pit will deliver the THOREX to Tank 8D-2 at the low flow rate desired (<5 gpm). The 8Q-4 recycle loop will recirculate THOREX back to Tank 8D-4 at approximately 30 gpm. The waste is transferred through pump pit 8Q-2 and on to tank 8D-2 through double walled piping supported within a concrete trench. The THOREX removal pump is supported from the tank riser in pump pit 8Q-4, which is supported on the tank vault.

Instrumentation within the pump pit will allow monitoring of temperature, pressure and flow. As the THOREX is added it may be blended with the washed 8D-2 PUREX sludge using the sludge mobilization pumps. Once the THOREX waste is transferred all process lines shall be flushed to remove residual waste.

1.1.1.2 Zeolite Slurry Transfer

The spent zeolite resulting from supernatant treatment and sludge wash solution processing will be stored at the bottom of tank 8D-1. This zeolite must be resuspended with water, pumped from tank 8D-1 and transferred to tank 8D-2. Five long shafted centrifugal pumps, called zeolite mobilization pumps, mounted at strategic locations in the tank will be used to resuspend the zeolite. A vertical turbine pump in tank 8D-1 is to be used to remove the spent zeolite waste from the tank and transfer it through double wall piping supported in the same concrete trench housing the THOREX piping. The zeolite slurry is transferred to pump pit 8Q-2 and delivered to a grinder for size reduction. Once the slurry is passed through the grinder, the size-reduced slurry is sent to the 8D-2 tank.

1.1.1.3 Waste Grinder

An inline multiple-stage dispersing machine may be used to size reduce the zeolite discharged from tank 8D-1. The dispersing machine is equipped with a rotor-stator rotated on a motor driven shaft. The zeolite slurry is pumped into the unit axially with outflow radially analogous to a centrifugal pump. Material movement in the unit is effected by the rotor with shearing forces generated on the periphery of a perforated stator which crushes the particles. All parts contacting the slurry are made of stainless steel. This equipment is housed in the 8Q-2 pump pit. The discharge of the unit feeds to the pipe contained in the 8Q-2 pump pit riser and discharges into tank 8D-2.

1.1.1.4 Pump Pits

The HLWTS is composed of single pump pits for each of the respective HLW storage tanks. Each pit accommodates the physical process equipment required to control the flow of waste out of the tanks. The pits are reinforced concrete structures internally lined with stainless steel. These pits contain the removal pump discharge piping and flow monitoring equipment for controlling waste transfer operations. The tank access riser for each of the respective waste removal pumps penetrates the pump pit floor. The piping to equipment connections within the pits are made through remote PUREX connectors. These sections of transfer piping are referred to as jumpers.

Each pit also provides for the required radiation shielding and contamination control features. Equipment access is gained through pit cover hatches which are removable. All valve operations involving waste transfer are manual. Valve handles extend through plugs in the pit cover hatches. Valve funnels are provided on each of the manual valves for easier handling and installation through the pit covers.

1.1.1.5 Utility Flush Tank

A permanent transfer line flush system is provided to each pit to permit prompt flushing and cleaning of the HLW transfer lines, thereby reducing the potential for line plugging. A break tank is used to hold utility water for flushing service to all pump pit and trench transfer lines. The tank is connected to a centrifugal pump to provide utility water flow into all transfer lines through utility pits attached to each of the three pump pits. Line flush would be performed to clean the transfer lines as needed after a transfer operation, or be used to clear line plugs if they occur. The flush system also provides a means to decontaminate removable equipment to minimize contamination and personnel exposure.

1.1.1.6 Zeolite and Sludge Mobilization Pumps

Long-shafted centrifugal pumps are supported from 15 m (50 ft) long segmented, tubular stainless steel columns that house the pump drive shaft. The mobilization pumps are positioned near the bottom of tanks 8D-1 and 8D-2 approximately 30 cm from the tank floor and have two opposed nozzles. These pumps provide agitation by using the fluid in the tank to resuspend and mix the spent zeolite in 8D-1 and the insoluble solids in 8D-2. The pumps operate at a flow rate of 2300 Lpm (600 gpm) out of each nozzle. These nozzles are continuously rotated 360 degrees at a rotational speed of 0.5 rpm. Each pump is operated with a 110 kW (150 hp) motor which is housed outside the tank.

1.1.1.7 Mobilization Pump Controllers

The mobilization pumps are operated from a 110 kW (150 hp) adjustable frequency invertor drive. These controllers will allow the pumps to be operated over a range of 900 rpm to 2,000 rpm. The controllers are housed in a separate building known as the Ventilation & Service (V&S) Building. Using variable speed drives allows the pumps to be "soft" started at a reduced speed while maintaining a constant torque.

1.1.1.8 Mobilization Pump Support Structures

The pump support structure consists of steel trusses on concrete piers and spread footing foundations. The complete mobilization pump assembly is supported off the external steel truss above the 8D-1 and 8D-2 vaults. None of the mobilization pump loads are imparted to the top of the original tank or its concrete vault.

1.1.1.9 Mobilization Pump Enclosure Buildings

Heated, fiberglass buildings containing the required utilities for pump operations enclose each mobilization pump. The buildings protect the pumps from the outdoor elements and also provide freeze protection for the utilities.

1.1.1.10 Removal Pump Controllers

Each of the removal pumps are operated from an adjustable frequency invertor drive. These controllers will allow the pumps to be operated over a range of 900 rpm to 1,800 rpm. The controllers are housed in the V&S Building with the mobilization pump controllers. Variable speed drives on the removal pumps are used to control the flow of material transferred through the transfer piping. The maximum flow from the THOREX and Zeolite removal pumps is 30 gpm and 75 gpm respectively.

1.1.2 HLWTS Feeds

There are to be six major feeds to the HLWTS:

- THOREX solution from tank 8D-4.
- Zeolite slurry from tank 8D-1.
- Chemical additives to tank 8D-2 for corrosion control adjustments when necessary. (See Section 3.4)
- Water from the utility break tank to flush HLW transfer lines to tanks 8D-1, 8D-2 or 8D-4 when necessary.
- Air to push flush wash out of the piping when necessary.
- Caustic to tank 8D-2 for THOREX neutralization.

1.1.3 HLWTS Products and By-products

The two products of the HLWTS are THOREX wash solution (which will be transferred to the STS) and the mixed waste solids (washed, neutralized THOREX precipitate, washed PUREX sludge, and spent zeolite) that remains at the bottom of tank 8D-2. By-products include radiologically contaminated backflush waters and mobilization pump seal water (which are processed in the STS with THOREX wash solution flows or the vitrification process with waste feed), and contaminated air treated by the PVS and the WTFVS. Residual waste heels may remain in tanks 8D-1 and 8D-4 after flushing and may be handled and treated during post vitrification operations.

1.2 Structural and Mechanical Safety Criteria

1.2.1 Use of Original Equipment and Facilities

Consistent with overall WVDP philosophy, original equipment and facilities have been used to the extent practical for the HLWTS. Original equipment and facilities are those that existed at the West Valley site before the WVDP. The mobilization and waste removal pumps are located within the original spare HLW storage tanks 8D-1, 8D-2, and 8D-4. Tank 8D-1 functions as a temporary storage reservoir for the ion-exchange medium (zeolite) until this material is transferred to tank 8D-2. The zeolite mobilization pumps in tank 8D-1 are used to resuspend the zeolite at the bottom of the tank so it can be removed as a slurry using a separate removal pump. Tank 8D-2 will continue to function as the main HLW storage tank after THOREX and zeolite transfer operations are completed. The three blended waste types will be stored in tank 8D-2 until the start of vitrification operations when this blended waste will be transferred to the VF for use as melter feed. The sludge mobilization pumps reside in tank 8D-2 to resuspend the solids and mix the tank waste.

Tank 8D-2 and 8D-1 and their vaults were modified to create additional access risers (Figure 3) for the installation of both removal and mobilization pumps and tank monitoring equipment. Details of the modifications, equipment used, and method of installation can be found in "Safety Analysis Report for Remote Riser Installation and Penetration of Tank 8D-2" (Brown, 1986). Structural modifications to these original structures were analyzed by various engineering design organizations to verify the structural integrity of the tank and its vault (Tank Roof Analysis [Rockwell, 1984]; Vault Roof Analysis [Rockwell, 1985]; STS 8D-1 Tank Vault Top Slab Design Evaluation [Ebasco, 1986]; and Vault 8D-1/8D-2

Finite Element Analysis [Ebasco, 1990]. In addition to these analyses, an assessment and evaluation of the reserve capacity of the tank and its vault were performed (Gates, 1991) under design basis loading conditions.

Jet impingement loads from a plugged mobilization pump nozzle (e.g., the worst hypothetical jet force generated by the pump under abnormal operating conditions) were applied analytically to the pipe column support of the 8D-1/8D-2 tank roof system. The force generated by one nozzle having all the flow discharging from it (i.e., one of the two nozzles plugged) has been calculated to be 212 kg (468 lbs) at the nozzle. The structural connections at the bottom of both tanks (Figure 4), designed to stiffen the tank roof, consists of 4 cm (1.5 in) diameter staybolts welded to the tank floor on 15 cm (6 in) diameter pads that are attached to a series of 2.5 cm (1 in) thick A283C plates. These plates support an I-beam in which 20 cm (8 in) diameter schedule 80 pipes rest. The 20 cm (8 in) pipes are attached to the tank roof. As a worst case scenario it has been assumed that the 212 kg (468 lbs) is directed perpendicular to a plate. This scenario was used to estimate the maximum stress in both the plate and staybolt. In addition, the plate with a single staybolt was used in the base analysis. The stresses in the staybolt are the governing stresses and are 68% of the allowable in the conservative calculation.

Typically the bottom structure is supported by as many as five staybolts and the nearest plate is 46 cm (18 in) away from a jet. In all cases the plates that are in close proximity to the jets have a minimum of three staybolts. It is also important to note that the pump jet can not directly impinge a plate during operation. Although there are approximately 70,000 expected operating cycles during the life of the Project, fatigue of the structure is not an issue since the actual stresses are not high enough to warrant this consideration.

The worst case geometry between a mobilization pump nozzle stream and the vertical plate fins (gridwork members under the horizontal column support beams at the bottom of the tanks) showed a margin of safety against yielding of the plate or its supporting staybolts much greater than four times the abnormal jet impingement loading. Collapse or failure of a single staybolt and supporting fin would have no influence on the overall vertical load-carrying integrity of the column and its supporting beam system. All of the plate fins and staybolts under a single column would have to be sheared out by the impinging pump nozzle stream to cause a local roof column collapse. None of the nozzles can apply a load sufficient to cause a complete column collapse under the worst case scenario. Thus, this mode of potential failure has been shown to be highly improbable.

Cyclic fatigue failure of either tank roof column support system is also unlikely considering the very low stress levels induced in the structural system under normal operating conditions.

The analysir of the abnormal operating condition of the mobilization pumps has been described by Gates (1991).

A removal pump will be inserted in the tank 8D-4 access riser and will be used to remove and transfer the THOREX waste. Although modifications to the tank or vault were not required as in the case of tanks 8D-1 and 8D-2, the original access riser was modified for 8Q-4 pump pit construction. Details of the modifications, equipment used, and method of installation can be found in WVNS-SAR-020, "Tank 8D-4 Steam Jet Removal and Riser Modification." Analysis of the 8D-4 vault with the addition of the concrete pit was performed (Ebasco, 1990a) to verify the structural integrity. In addition to these analyses, an assessment and evaluation of the reserve capacity of the tank and its vault were performed (Gates, 1993) under design basis loading conditions.

During HLWTS operations, the original WTFVS will continue to provide ventilation for contamination control and air treatment support for tanks 8D-1, 8D-2, 8D-3, and 8D-4.

The original Waste Tank Farm Ventilation System (WTFVS) will continue to provide routine ventilation to Tanks 8D-2 and 8D-4. Air is removed from the tanks at approximately 150 scfm at standard temperature and pressure and is passed through a condenser and knock out drum. The air is then heated before passing through a HEPA filter coupled with a blower. The filter and the blower have a redundant, parallel system as a standby in case of failure. The exhaust lines are connected to the main plant stack.

During equipment installation, the Permanent Ventilation System (PVS), usually used for the ventilation the Supernatant Treatment System (STS), is used to provide additional ventilation to the HLW tanks and pump pits. Air leaving the PVS is filtered by two sets of HEPA filters, in series, after passing a mist eliminator, heater, and roughing filter to entrap moisture and particulate. Following off-gas treatment, the air is discharged through the PVS stack. The air is continuously sampled to monitor for radioactive material releases.

The PVS will be used to provide additional ventilation to Tank 8D-2 during THOREX transfer operations. By using the PVS, larger volumes of air can be passed through the tank and maintain the NO_x gas concentrations at a minimum. Secondly, using the PVS allows the NO_x gases to bypass the tank farm ventilation system and its condenser. Since the condensers would cool the gas and condense water vapor, it would be beneficial to avoid that system during the neutralization process. Thirdly, bringing a large volume of outside air through the tank would tend to reduce the tank humidity and temperature since the incoming air is cooler and below saturation. This will assist in reducing the condensate in the tank vapor space. Typical relative humidity during PVS operation is 15 percent.

1.2.2 Existing Facilities

Existing facilities are those previously constructed and utilized to carry out other WVDP activities. The HLWTS will utilize existing facilities to perform certain support operations which include:

- V&S Building, which houses the mobilization and removal pump motor controllers, support electrical feeds, HLWTS control station, as well as the utility flush system.

- Pump support structure, which carries the loads of the zeolite and sludge mobilization pumps and support equipment.

- The PVS, which provides ventilation for the STS support building, is also used for the HLWTS. The PVS is used during the installation of pumps in tanks 8D-1 and 8D-2. It may also be used for contamination control during cover removal for the retrieval of components in any of the pump pits and to provide greater ventilation during transfers. The PVS is located in the V&S Building near tank 8D-1 in the WTF.

1.2.3 New Facilities and Structures

In addition to the original and existing facilities described above, operation of the HLWTS required additional new facilities. The major HLWTS components will be located within newly constructed concrete pump pits 8Q-1, 8Q-2, and 8Q-4 placed on their respective tank vault roofs. Utilities to the pump pits are regulated from utility pits abutting the supporting pump pit. Transfer piping to and from each of the pits is housed in a concrete trench. The concrete trench with steel structure supports has been erected within the tank farm. It provides containment and structural support for the double wall pipe runs between the pump pits 8Q-1, 8Q-2, and 8Q-4.

Figure 5 provides a simple schematic of the HLWTS that identifies existing, new facilities and modified original structures.

1.2.4 Codes and Standards

Codes and standards used in the design of the HLWTS are given in Design Criteria WVNS-DC-046, "Sludge Mobilization Waste Removal System" (Schiffhauer, 1992) and Civil Design Criteria Sludge Mobilization Transfer System (Ebasco, 1992). The HLWTS Design Criteria were based on DOE Order 6430.1A General Design Criteria. DOE Order 6430.1A has been used as the "Primary Guidance" for Architect Engineering (AE) design and preparation of specific task design criteria. The specific task design criteria contains more detailed design criteria to specific tasks. The criteria in these documents are based on applicable DOE Orders, including DOE-ID supplements, and on the national consensus codes and standards.

Codes and standards that are being used in the design and construction of HLWTS facilities (new and modified) are discussed in Section 2.2.3 and summarized in Tables 3 and 4.

Information on loads and the combinations that were used to assess the integrity of HLWTS structures under design basis loadings and severe natural phenomena events and the results of these analyses are presented in Section 4.3. Additional information on the design of HLWTS structures and confinement barriers, (new and modified) can be found in Gates, 1987, 1991, and 1993.

1.3 Safety Protection Systems

1.3.1 General

The HLWTS has been designed to allow for safe operation. Control of radioactivity is the primary safety concern. Specific safety protection systems are described in the following subsections.

1.3.2 Multiple Confinement Barriers and Systems

The major HLWTS processing components that are in radioactive service are located within the HLW tanks 8D-1, 8D-2, 8D-4, pump pits 8Q-1, 8Q-2, 8Q-4, and the HLW pipe trench. HLWTS processing components consist of the sludge and zeolite mobilization pumps, THOREX removal pump, zeolite removal pump, sludge removal pump, grinder, and transfer piping. Figure 2 provides a schematic of these components.

Any leakage that could result from failure of an installed component in any of the three HLW Tanks would be contained within the respective tank. Tanks 8D-1 and 8D-2 are contained separately within approximately 61 cm (2 ft) thick concrete vaults. Each of the tank atmospheres is maintained under negative pressure relative to surrounding areas by the WTFVS to ensure air leakage is into, rather than out of, the tank. This exhausted air is processed and filtered by the WTFVS as described in Sections 2.4.2. Tank 8D-4 is enclosed in a common concrete vault 30 feet long by 17 feet wide shared by tank 8D-3. This tank is also maintained under a negative pressure relative to the external atmosphere and the air exhausted is processed through the same WTFVS.

Processing components contained within the pump pits are structurally supported by a reinforced concrete pit erected on the respective tank vault with the loads transferred into the ground via the vault substructure. A stainless steel pit liner provides secondary containment for the HLWTS components contained in the pit and for piping runs between the components of the pit and the wall penetrations. The pit walls are approximately 61 cm (2 ft) thick and are surrounded by backfill to grade level. Concrete pit covers provide shielding and containment from the semi-remotely operated valves and associated HLWTS components within the pit. The pit components are equipped with PUREX connectors for remote replacement. Control of these components during operations is directed from the control station located in the V&S Building with selected local control (e.g., THOREX or zeolite transfer).

Piping used to transfer the THOREX or zeolite from tanks 8D-4 or 8D-1 to tank 8D-2 is double-walled, i.e., the primary pipeline containing the waste is fully encased and supported inside a corrosion resistant, leak tight pipe having the same integrity as the primary line, and enclosed within the reinforced concrete transfer trench. The piping runs are supported in the trench to maintain a gradient such that any leakage from the primary pipe, or secondary pipe, would be drained and collected at a low point piping in the pump pits. The collected leakage would then be returned to the tanks via the pit drains. The encasement line permits detection of any leakage from the primary line (conductivity probes) and permits sampling and periodic leak testing as required.

Block valve(s) and check valves are used on the in-pit utility jumpers to prevent contamination from entering the utility feed lines in the utility pits. Utility piping entering the pits are equipped with manual block and bleed valving immediately outside the pump pit wall to prevent migration of any contamination beyond the utility pit which could leak through the block valve.

Table 1 identifies the specific primary confinement barriers and associated support barriers for each major structure/component in the HLWTS. The table follows the sequence of waste transfer flow from tank 8D-4 to tank 8D-2.

Structural and design considerations for these barriers are presented in Section 2.2.3. Table 2 summarizes the confinement barriers and associated support barriers for the sequence of waste transfer flow from tank 8D-1 to tank 8D-2.

The existing nuclear fuel reprocessing plant constructed in the mid-1960s at West Valley was designed to the 1961 Uniform Building Code. This facility predated DOE/NRC development of seismic design criteria for non-reactor nuclear facilities. The designers conservatively selected the Uniform Building Code Seismic Zone 3 (the highest seismic zone for earthquake design) as the basis for earthquake design at West Valley.

When WVNS took on the responsibility for decommissioning the nuclear fuel reprocessing plant and removing the high-level nuclear wastes from the storage tanks, it was accepted by the DOE that the existing facilities would not be upgraded to existing seismic design standards (Ploetz, 1989). However, where new facilities were constructed on existing facilities, or adjacent to existing facilities, all new construction was to be designed in such a manner as to not diminish the seismic capacity of the existing structures. Furthermore, safety-related facilities involved in the storage, transfer, and processing of low-or high-level nuclear wastes were to be designed in the initial stages of Project development to the current Uniform Building Code with varying levels of importance factor which depends on the degree of the safety required based on the potential risks from seismic failure. Table 3 of this SE illustrates the design codes or standards used and the types of seismic importance factors employed for various structural components constructed adjacent to and over the HLW tanks as part of the HLWTS. Table 4 lists the Design Codes and Standards for the HLWTS confinement systems.

As the Project evolved from a research-oriented test facility to a production-oriented low-and high-level waste decommissioning facility, seismic standards following DOE 6430.1A guidelines were developed using probabilistic, site-specific studies to assess the appropriate ground motion for the design basis event. The design basis event selected for design of safety-related facilities has a return period of approximately 1,000 years for a peak ground acceleration at the 84th percentile of 0.1g (annual frequency of exceedance of 10^{-3}). Response spectra for the Design Basis Earthquake was selected from NRC Regulatory Guide 1.60 and the associated damping values from Regulatory Guide 1.61.

All major structures, process vessels and piping serving as primary barriers for the high-level nuclear waste storage, transfer, or processing have been designed or reviewed under the Design Basis Earthquake, as either part of the original design or part of the confinement barrier integrity review. Most of these analyses have involved dynamic rather than pseudo-dynamic analysis.

Analyses were performed to assess the integrity of HLWTS confinement barriers under various design basis conditions (manmade and natural phenomena). The primary confinement barriers will survive extreme environmental loading (e.g., design basis earthquake and tornado events), without structural failure and leakage of HLW into the environment because there is sufficient reserve capacity inherent in the original construction as well as in the conservative design of the construction. Any structural modifications to the original underground storage tanks were reanalyzed to verify that their structural integrity was not compromised. The loadings and combinations that were considered and the results of these analyses are summarized in Section D.9.3 of WVNS-SAR-004. Additional information on the design of HLWTS confinement barriers and on the barrier integrity analysis can be found in Gates, 1986, 1986b and in Gates, 1992, 1993, respectively.

1.3.3 Protection by Equipment and Instrument Design and Selection

All equipment and instrumentation for the HLWTS were selected and purchased in compliance with the WVNS Quality Assurance Program described in Section A.12 of WVNS-SAR-001. The quality levels of the individual components for the HLWTS are presented in Section 1.4. Specific examples of safety protection provided by the equipment and instrumentation design are as follows:

- The HLWTS is a remote operation designed for minimum access, the instrumentation is designed to allow for both electronic and administrative verification for a given transfer route. The only controlled parameter in the transfer operation is the flow of material through the transfer piping. There is at least one other sensor of a dissimilar operating parameter that can be used in the event of failure of the flow sensor to establish operation status.

- The zeolite and sludge mobilization pumps are contained within the tanks 8D-1 and 8D-2 respectively. The pump system is designed to permit semi-remote removal and replacement.

- The process equipment involved in the transfer operations of the HLWTS are fail-safe by character in the event that failure of a primary control device occurs. If the mobilization pumps fail, the tank contents will not be agitated but remain in the tank. If a removal pump fails the material passively drains to the tanks.

- Key process and equipment variables of the HLWTS are monitored. Those variables that could affect the safety of operations have both an audible alarm and a visual on a CRT monitor at the control station. Examples of these process variables are: leak detection in containment piping; leak detection in pump pits; high pressure on removal pump discharge; high radiation alarm on the pump pit utility line; radiation monitors on ventilation stack discharge lines; and high current on removal pump motor. These alarms are shown in Figures 15 through 19. A graphic display is used on the control panel (control room) to minimize operator error.

- Key mobilization pump equipment variables will be monitored. Those variables (i.e, pump motor amperage, tank 8D-2 liquid temperature, WTFVS off-gas temperature, pump seal water pressure, low flow to pump columns, pump enclosure temperature) that could affect the safety of operations may be wired to automatically shut down the mobilization pumps if a component fails.

- The HLWTS has sufficient instrumentation and controls such that it can be monitored and manually shutdown from the centralized control station.

1.3.4 Nuclear Criticality Safety

FISSILE MATERIAL INVENTORY FOR TANK 8D-2

Nuclide	Fissile Mass in Tank 8D-2 (g)
U-233	720
U-235	43,400
Pu-239	27,250
Pu-241	646

Based upon criticality assessments (Caldwell, 1990), the additional mass of fissile isotopes which will be added to tank 8D-2 from tank 8D-4 is negligible. The k_{eff} of tank 8D-2 after THOREX addition is calculated to be less than 0.1. At 10 times the nominal fissile isotope mass the k_{eff} is less than 0.7. The addition of THOREX from tank 8D-4 to tank 8D-2 is intrinsically safe under conditions of homogeneity.

In addition, the THOREX waste is well within the allowable fissile solution concentrations defined in OSR-GP-7 "Criticality Safety for Liquid Transfers." The fissile U concentration is approximately 0.048 g/L and the fissile Pu concentration is approximately 0.005 g/L.

1.3.5 Radiological Protection

Radiological protection systems consist of those facilities and equipment that ensure the confinement of radioactivity and the control of general exposure rates. These systems have been designed to provide positive confinement of radioactivity. The major radiological protection systems inherent in the design of the HLWTS include the following:

- The shielded HLW transfer pipe trench.
- The containment and shielding provided by tanks 8D-1, 8D-2, 8D-4 and their vaults.
- The shield structure (pump pits) erected above the 8D-1, 8D-2 and 8D-4 vaults.
- The WTFVS and PVS.
- Radiation monitoring systems and analytical support systems.
- Compacted soil embedment external to the tank vaults, pit walls, and trench walls.

Shielding has been installed (pump pits, transfer trench) to maintain radiation exposure ALARA. The design objective is to limit exposure rates in any full-time occupancy area to 0.1 mR/h. Radiological areas for the HLWTS have been established, per WVDP-010, "Radiological Controls Manual" requirements, as follows:

Process - Equipment normally in radioactive service, accessible only after decontamination (e.g., pump pits, transfer trench). These are Controlled Areas posted as High or Very High Radiation Areas. No occupancy is expected during normal operations.

Support - Systems that are normally not used in radioactive service, and/or services accessible during normal operations for controlled periods (e.g., on top of the pump pits, utility pits and over transfer trench). These are High Radiation Areas or Radiation Areas. Intermittent occupancy, under controlled access, is expected during normal operations.

Control Station/
Utility Area - Controls and equipment never used in radioactive service are accessible at all times (routine occupancy during normal operations). These areas are Low-Level Radiation Areas.

The HLWTS design objective was to limit exposure rates in any controlled occupancy access area to <2.5 mR/h. During pump installation, the radiation dose rates may exceed 2.5 mR/h. Directly over the tank 8D-2 access openings the radiation dose rate may be >150 mR/h while the shield plug is removed from the riser. Tank 8D-1 riser opening during removal pump installation would be lower than 8D-2 but may be higher during mobilization pump installation at the riser location near the STS ion-exchange columns. Dose rates in this area may be as high as 50,000 mR/h. Tank 8D-4 riser opening dose rate may be 9,000 mR/h. However, radiation protection controls and procedures and ALARA principles will be maintained through the use of these semi-remote installation techniques.

The process system itself is the primary confinement for radioactivity (processing components, valves, piping, and tanks). Ventilated and monitored secondary confinements (encasement pipes, liners, and tank risers) are designed to inhibit, contain, and eliminate possible contamination (in trenches, utility pits and piping, etc.).

In order to minimize the potential for contamination by leaks, the transfer system designed to routinely carry HLW is hard-piped and welded. Valves, pumps, grinder, piping, and other sources with a high probability of contamination are enclosed by ventilated and monitored secondary confinements.

A goal of radiological protection design is to prevent the backflow of radioactivity into nonradioactive systems and areas through chemical and instrument lines. For those chemical and instrument lines potentially exposed to process pressure, means of isolation (e.g., block and bleed valves) with double check valves have been incorporated to prevent pressure transmission to normally nonradioactive systems.

An additional design feature of the HLWTS that enhances control of radioactivity is a dynamic graphic display on the control station CRT monitor to minimize operator error. This display provides operators with information regarding system valve alignments and transfer operation status.

1.3.6 Fire and Explosion Protection

The HLWTS has fire detection, alarm, and suppression systems commensurate with needs as determined by the WVNS Facility Engineering. Fire protection systems are installed, maintained, and tested in accordance with the requirements of DOE-ID Order ID 12044, "Operational Safety Design Criteria Manual." Information relating to fire protection systems for the HLWTS can be found in Section 2. A telephone is located in the V&S Building and an intercom system connected to the 812 System (emergency all-page) is also installed in the building.

1.3.7 Radioactive Waste Handling and Storage

From the perspective of secondary waste management, the HLWTS has been designed as a self-contained, closed system. Secondary waste streams are reused whenever possible and/or returned to tanks 8D-1, 8D-2 or 8D-4. Specific examples of the "closed" nature of the HLWTS are provided below:

- Transfer line flush water is returned to tank 8D-1, 8D-2 or 8D-4.
- The fluid or wash solution never leaves tank 8D-2 during agitation to wash the neutralized THOREX.
- THOREX wash solutions are sent to the STS for processing.
- Tank 8D-1 liquids used to slurry zeolite to tank 8D-2 are returned to tank 8D-1 for reuse.
- The zeolite, neutralized THOREX, and washed PUREX sludge mixture in tank 8D-2 will be transferred to the VF for vitrification.

The HLWTS design philosophy includes the capability for either remote removal and replacement of failed components or the use of installed spares (e.g., piping in the transfer trench). Should components previously in radioactive service require replacement, they will be overpacked as required upon removal before being transferred for waste disposal.

The mobilization pump design includes the capability of semi-remote removal and replacement of failed pumps. Should radioactively contaminated pumps require replacement, they will be decontaminated and overpacked as required upon removal before being transferred for waste disposal.

Air exhausted from HLWTS pump pits and storage tanks is treated by the PVS during component replacement. Under operating conditions, air exhausted from tanks 8D-1, 8D-2 and 8D-4, and the associated pump pits, is treated by the WTFVS. Details pertaining to this system can be found in Sections 2 of this SE.

1.3.8 Industrial and Chemical Safety

The administrative controls for industrial and chemical safety implemented for the HLWTS are presented in the WVNS Industrial Hygiene and Safety Manual (WVDP-011). Additionally, the relevant requirements for industrial and chemical safety contained in DOE-ID Order ID 12044, "Operational Safety Design Criteria Manual" have been incorporated into HLWTS procedures and facilities. The HLWTS design also incorporated relevant requirements from ID Appendix 0550, "Standard Operational Safety Requirements" into operating procedures. Cold chemical process systems are discussed in Section 3.

The caustic solution will be shipped in federal/NYS Department of Transportation authorized truck tank trailers, each having a capacity of approximately 19,000 L (5,000 gals.) or smaller sized tote tanks having a capacity of approximately 2,100 L (550 gals.). The container in which caustic is shipped may, in turn, serve as the temporary storage tank on-site in compliance with federal EPA/NYSDEC Chemical Bulk Storage Regulations (6 NYCRR). If the caustic truck tank trailer is to be emptied over an extended period of time, it shall be positioned within the Caustic Storage/Truck Unload/Transfer Station at the WTF. The Caustic Storage/Truck Unload/Transfer Station will consist of a graded base (to include a sand overlay), concrete traffic barriers, and secondary spill containment within the traffic barriers.

Recognizing that major or even minor spills could result in hazards to WVDP personnel, the public, and the environment, the WVDP has implemented an Oil, Hazardous Substances, and Hazardous Wastes Spill Prevention, Control and

Countermeasures Plan (WVDP-043, November 1989). This operating plan reviews, in detail, release flow paths, sources, system design, and the containment of possible spills or releases as well as prevention, preparedness, response, and notification procedures. Specifically, the plan conforms to the requirements of 40 CFR Part 112 and Part 151 (proposed), both dealing with facilities having a potential for hazardous substances releases.

1.4 Safety Classification of Structures, Components and Systems

The WVDP Safety Classification System, which complies with DOE Order 6430.1A, "General Design Criteria," consists of three safety classes listed in decreasing order of importance: Safety Class A, Safety Class B, and Safety Class C. Class N is not important to radiological safety in comparison to Safety Classes A, B, and C. Table 5 indicates the safety classifications for the structures, systems, and components associated with the HLWTS. The criteria and procedures used to determine safety class designation are presented in Section A.4.4 of WVNS-SAR-001.

Since the dose to the maximally exposed off-site individual as the result of any credible accident considered for the HLWTS does not exceed 500 mrem annual effective dose equivalent (AEDE) (see Section 4.2), none of the structures, systems or components require a Safety Class A or B.

Because the primary function of the HLWTS is to transfer HLW, any item whose failure could result in workers coming into close contact with radioactive process streams requires a safety classification of C (since the potential would exist for a worker exposure in excess of 3 rem). Components and facilities that function as confinement systems for HLW and ventilation systems that confine radioactivity require Safety Class C since failure of these components could result in the loss of radioactive material confinement. Additionally, instrumentation systems whose function is to monitor, measure and/or control radioactivity or radiation levels also are designed as Safety Class C since their failure could result in undetected exposures. All other items are classified N.

1.5 Design Considerations for Decontamination and Decommissioning

The HLWTS has been designed in a manner to facilitate eventual decontamination and decommissioning (D&D). Specific design details include the following:

- Pumps installed in the original HLW tanks have been designed to permit semi-remote removal and replacement.

- Installed in the HLW tank access risers are a series of spray nozzles that can be used to wash the exterior of a pump as it is removed from the tank.

- All piping and components in radioactive service can be flushed to minimize contamination prior to removal from service.

- Components in pump pits (valves, instruments, and jumpers) can be remotely replaced following remote decontamination via flushing of equipment and pipes.

- Pumps, valves, and associated piping connections are designed to minimize "collection pockets" and slope to the tanks for ease of decontamination, maintenance and replacement.

- All components and lines are capable of handling a wide range of decontamination fluids.

- The material of construction is 300-series stainless steel to minimize incorporation of contamination into surface corrosion products.

- Pump volutes are fitted with a volute flush line that allows flushing the volute, impeller, and pump suction screen.

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2.0 HLWTS FACILITY DESIGN

2.1 Summary Description of the HLWTS

2.1.1 Location and Facility Layout

The HLWTS is located on the WVDP WTF. Figure 5 presents the location of the HLWTS structures and facilities in relationship to the WVDP site.

Radioactive operations of the HLWTS operations are conducted within the original underground storage tanks 8D-1, 8D-2, and 8D-4; pump pits 8Q-1, 8Q-2, and 8Q-4 on top of the respective storage tank vaults; within interconnecting piping contained in the HLW transfer trench adjacent to the pump pits; and within the original WTF Ventilation System. The major transfer equipment in radioactive service is located in each of the tanks or the respective pump pits. The HLW transfer trench connects the individual pump pits. The WTF Ventilation System is near tank 8D-2 and is housed in the original equipment shelter. The existing PVS, used for equipment installation in tanks 8D-1 and 8D-2 and to provide greater ventilation during transfers is located in the V&S Building located at the northwest perimeter of tanks 8D-1 and 8D-2. Table 6 lists the location of the major components of the HLWTS.

THOREX neutralization operations will be conducted within the modified HLW tank 8D-2 with the mixing equipment supported on an existing truss system spanning the 8D-2 tank vault. Zeolite mobilization operations will be conducted within the modified HLW tank 8D-1 with the equipment supported on a similar truss system spanning the tank vault. Figure 6 is a plan view of the Mobilization Pumps in tanks 8D-1 and 8D-2. The electrical support equipment for the HLWTS, 8D-2 mixing equipment, and the Zeolite Mobilization operations is housed within the V&S Building. HLWTS nonradioactive support operations (i.e., utility services) are conducted in the V&S Building. The V&S Building also houses the HLWTS control station and the mobilization pump controls. The WVDP site boundary, exclusion area, restricted area, and layout/location of site utility supplies are noted in Section B.5.1.2 of WVNS-SAR-002.

2.1.2 Principle Features of the HLWTS

The primary objective of the HLWTS is to pretreat and transfer the high-level nuclear wastes to the Vitrification Facility. The transfer and pretreatment of the high-level waste from the West Valley tank farm underground storage tanks 8D-1, 8D-2, and 8D-4, prior to delivery to the VF, will occur in stages.

First, when the processing of the PUREX supernatant and sludge wash solutions from tank 8D-2 is completed through the Supernatant Treatment System, the THOREX waste stored in tank 8D-4 will be removed and transferred to tank 8D-2 using the HLWTS where it will be neutralized with caustic. The caustic is added to the tank 8D-2 before THOREX addition using the existing SMWS Caustic Addition System. Washing of the resulting THOREX precipitate consists of adding water to 8D-2, mixing the precipitate with the solution, and decanting the wash water solutions for processing using the Supernatant Treatment System. This operation removes salts from the THOREX waste using the STS equipment as described in WVNS-SAR-004.

The majority of the cesium and a fraction of the plutonium and strontium originally contained in tank 8D-4, dissolved from the THOREX precipitate during THOREX washing, will be loaded onto an inorganic zeolite within the STS ion-exchange system and will be stored at the bottom of tank 8D-1. The loaded ion-exchange medium (zeolite) will be mobilized and transferred from tank 8D-1 back to tank 8D-2, blended with the washed sludge and the THOREX precipitate from tank 8D-4 remaining at the bottom of tank 8D-2. Section 3.0 presents detailed discussions of HLWTS and Operations. The blended waste will ultimately be transferred from tank 8D-2 to the VF for use as melter feed.

Within the STS the THOREX wash solutions may be "decontaminated" into a salt solution of relatively low radioactivity that will be transferred to the LWTS for volume reduction and concentration. The cement will be disposed of as a LLW (see WVNS-SAR-008, "Low-Level Class B and Class C Radioactive Waste Handling, Storage, and Disposal Operations for the Radwaste Treatment System Drum Cell").

After STS operations, tank 8D-1 will contain cesium loaded zeolite. This zeolite will be resuspended with water to form a slurry. The zeolite solids will be slurred by mobilization pumps installed in the 8D-1 tank and the slurry will be removed and transferred into tank 8D-2.

Once the zeolite is transferred to tank 8D-2, the contents will be thoroughly mixed to obtain a relatively homogeneous mixture using the sludge mobilization pumps installed in the tank. The mixture may be processed through the grinder for homogenization and size reduction. The mixed waste will be stored for feed to the concentrator feed makeup tank in the Vitrification Facility for concentration and the addition of glass formers during the vitrification campaign. This transfer stage of the HLWTS operation will be covered in the future Vitrification SAR (WVNS-SAR-003).

In order to perform these waste operations in the tank farm, mobilization pumps, transfer pumps, size reduction equipment, a pump pit for each of the respective tank removal pumps, transfer piping, instrumentation, a containment system, and necessary utilities will be required. These facilities and equipment make up the principle features of the HLWTS.

HLWTS utility supplies are directed from the main plant, with local control exercised from the V&S Building, or from the SMWS Mobilization Pump Enclosure Buildings. The original WTFVS, which will continue to supply ventilation to tanks 8D-1, 8D-2, and 8D-4 for contamination control during HLWTS operations, exhausts through the main processing plant stack along with exhausted air from other Project activities. Section D.7.4.2 of WVNS-SAR-004 discusses the WTFVS. The PVS exhausts effluent air from a small 10-meter stack (33 ft) located on the WTF. Section D.7.4.1 of WVNS-SAR-004 presents a detailed discussion of the PVS.

2.2 HLWTS Buildings and Structures

2.2.1 Modifications to Original Facilities

Modifications have been made to the HLW tanks and their vaults in order to install the necessary SMWS and HLWTS equipment to carry out the waste pretreatment and removal objectives. The major equipment that is in radioactive service and installed within tanks 8D-1, 8D-2 and 8D-4 is the pumps. A THOREX transfer pump will be installed in tank 8D-4. The Sludge Mobilization Pumps are installed in tank 8D-2 and the sludge transfer pump will be installed. Three of the five Zeolite mobilization pumps are installed in tank 8D-1 with two additional mobilization pumps and the zeolite removal pump to be installed in the tank.

On-site development and testing using a one-sixth scale model (Schiffhauer, 1987) has shown that the zeolite can be resuspended and removed from the 8D-1 tank bottom and that the PUREX sludge can be resuspended in tank 8D-2 using five mobilization pumps. Sludge washing results has validated the scale model test results by demonstrating successful mixing in tank 8D-2 using five mobilization pumps.

2.2.1.1 Modifications to Original Tanks 8D-1 and 8D-2

Modifications have been made to the storage tanks 8D-1 and 8D-2 and their respective vaults for the installation of the HLWTS removal and mobilization pumps. Tank 8D-1 is used as a storage reservoir for the loaded zeolite (ion exchange material) produced by the STS process. Tank modifications for the HLWTS were made to 8D-1 for the installation of the zeolite mobilization and removal pumps that will be used to slurry the loaded zeolite from the tank bottom and transfer it to the 8D-2 tank. Additional modifications to tank 8D-1 were necessary for the STS to permit equipment installation. For both purposes, holes were cut through the vault and roof of tank 8D-1.

Similar modifications were also performed on tank 8D-2 for the installation of the sludge mobilization pumps and the 8D-2 waste transfer pump.

Tanks 8D-1 and 8D-2 are reinforced carbon steel, approximately 8 m (27 ft) high by 21 m (70 ft) in diameter, with 20 cm (8 in) channels on 38 cm (15 in) centers skip welded to the exterior of the roof. The vessel is fully contained within a 61 cm (2 ft) thick reinforced concrete vault.

The modifications to tanks 8D-1 and 8D-2 included the following major steps and activities:

- Excavation to expose a portion of the tank vault concrete roof.

- Penetration of the vault roof.

- Removal of rafter sections from the tank roof and installation, on tank 8D-1 only, of cross channel beams.

- Installation of riser assemblies between the vault and tank roof. These risers are carbon steel and are welded to the tank roof.

- Penetration of the tank roof within the riser assemblies.

- Installation of shield plugs or pumps.

Figures 7 and 8 depict the locations of the mobilization and removal pump penetrations in tanks 8D-1 and 8D-2 roofs, respectively. A detailed explanation of the remote riser installation can be found in Section D.5.2.1 of WVNS-SAR-004. Discussions of the safety and environmental aspects of modifications to tank 8D-2 for installation of access risers are provided by Brown (1986). The structural analysis performed for tanks 8D-1 and 8D-2 modifications are described in Sections 2.2.3.1 and 2.2.3.2 respectively of this SE.

Additionally, in a similar remote manner, removal pumps will be installed within tanks 8D-1 and 8D-2.

2.2.1.2 Modifications to Original Tank 8D-4

Modifications have also been made to tank 8D-4 to accommodate the THOREX removal pump and 8Q-4 pump pit. The 8D-4 tank has one existing riser to provide removal pump access. An existing steam jet was partially removed and the existing riser modified to accommodated the removal pump and the new pump pit. Analysis was performed on the 8D-4 vault to assure its integrity was not compromised (Ebasco 1989a).

Detailed discussions of the safety and environmental aspects of the modifications to tank 8D-4 for riser modifications are provided in WVNS-SAR-020. The modifications of tank 8D-4 included the following major steps and activities:

- Excavation to expose a portion of the concrete vault roof.
- Cutting the steam jet and removing the upper portion from the tank and securing the remainder in the tank.
- Removing the original riser and attaching a new riser connection at the vault roof interface.
- Installation of a shield plug.

2.2.1.3 Modifications to the WTF Ventilation System

As an added measure of protection, the WTFVS knockout drum reservoir would be charged with caustic pellets. The knockout drum collects condensed water vapor after separation and collects in the bottom of the drum, overflows across a baffle, and discharges back to Tank 8D-2. Adding the caustic provides a source to neutralize any nitric acid vapors which may condense from the off-gas stream after the PVS is taken off-line.

2.2.2 New Facility Construction

In addition to the previously described modifications to the original HLW tanks, the new facilities or structures were erected for the HLWTS and are described in the following sections.

2.2.2.1 Pump Pits

Other than the pumps and double wall piping, all transfer system components that are in radioactive service are installed in the newly constructed pump pits.

Pump pits 8Q-1, 8Q-2, and 8Q-4 rest on their respective tank vaults. These pits are below grade up to the top of the pit wall allowing for pit access. The thickness of the pump pit reinforced concrete structure is dictated by the shielding requirements for the tank farm area. Each pump pit is serviced by an adjoining utility pit. The concrete trench and pipe interfaces at each pump pit wall where the HLW transfer line jumper exits to move the waste through the pit.

A tank riser penetrates the pit floor for removal pump access into the tank, in each of the pump pits. The removal pump mounts to the riser flange. Any additional riser load from the removal pump are applied to the vault roof. Stainless steel plates line the pit floor and walls. These liners are sealed to the penetrating riser to provide secondary containment for the HLW transfer jumpers between the removal pump discharge line and the double wall pipe penetration in the pit wall at the HLW transfer trench interface. The liner slopes to a low point drain connected to the removal pump riser. Any leakage into the pit from the components will be detected by a conductivity probe, and then can be drained to the tank through a drain line.

The pump pits contain single wall pipes called jumpers. Figure 10 gives a schematic representation of pump pit 8Q-2. These jumpers are connected to equipment or pit wall penetrations through PUREX connectors. The PUREX connector allows for remote removal and replacement of the jumper. Figure 11 shows a typical jumper with the connector.

The pump pits are covered with interlocking concrete covers which are removable for equipment access. The covers are gasketed and supported by pit walls. The underside of the pit covers exposed to the pit environment are sealed with an epoxy coating. These pit covers are also two feet thick and reinforced. Shielded access plugs are provided in the covers for valve extension handles to manually operate the valves installed in the jumpers, (see Figure 12 for a typical cover).

2.2.2.2 HLW Transfer Trench and Piping

In addition to the pump pits, a reinforced concrete pipe trench connecting each of the pits has been constructed. Removable concrete shield covers, supported from the trench walls, are placed on the trench to complete the shield structure.

Figure 13 provides the layout of the HLWTS on the tank farm. This concrete trench supports and provides shielding for the HLW transfer lines carrying tank wastes. Transfer piping supported in the trench is double walled stainless steel. The outer pipe provides secondary containment for the transfer piping. Leak detection is provided at the low point of each of the pipe segments. Any leakage in the outer pipe is purposely held up for sampling. An outer pipe jumper drain line exists in the pump pit to allow drainage to the pit drain line if necessary.

2.2.2.3 Utility Pits

Adjoining each pump pit is a reinforced concrete underground compartment coupled to the pump pit wall called the utility pit. Inside the utility pit are the isolation valves for the pit utility jumpers and supply utilities. The utility pit is covered with a removable sheet metal roof. All utility (nonradioactive) piping within the HLWTS is single-walled.

Adjacent to tanks 8D-1 and 8D-2 is the existing V&S Building which contains the HLWTS utility flush system and the control station for operation of the HLWTS and the mobilization pumps in tank 8D-1 and 8D-2. The orientation/layout of the utility flush system and the control station relative to the HLWTS is shown in Figure 9.

2.2.2.4 Ventilation & Service Building

The V&S Building is an existing sheet metal building constructed to support STS heating and ventilation operations as well as SMWS operations. This building contains the PVS and SMWS motor controllers, in addition to the STS auxiliary power diesel generator. The building also houses the HLWTS flush water break tank and control station for transfer operation. All electrical power distribution and motor controllers are contained in the V&S Building.

2.2.3 Structural Specifications and Analysis Performed

Existing nuclear and commercial industry codes and standards have been used in the design, construction and installation of the HLWTS. Loads considered in the design analysis were dead load (D), live load (L), thermal load (T_o), seismic load (E_{SSE}, E_{UBC}), seismic displacement loads (D_{SSE}), and internal pressure (P_o), soil pressure load (H_{static}, $H_{dynamic}$), wind load (W), tornado load (W_t), and differential settlement (D_y). A ground acceleration of 0.1g horizontal with design spectra and damping according to NRC Reg Guide 1.60 and 1.61 respectively, and a vertical component of 0.067g for the seismic load (E_{SSE}) definition. A geotechnical investigation was performed in the tank farm area, near the proximity of the HLWTS trench, to assess dynamic soil properties for use in the structural design seismic studies (Semple, 1992).

The choice of construction materials, design approaches and construction methods are well tested and have been used in many other nuclear facilities. This provides a high degree of confidence that structures/systems will behave in a predictable manner. Engineering codes, construction codes, and standards used in the design and construction of the HLWTS components are given in Table 7.

2.2.3.1 Structure Analysis of Original Tank 8D-1 for the HLWTS

2.2.3.1.1 Tank 8D-1 Concrete Vault Integrity Analysis

Verification of vault structure integrity for the STS components, mobilization pump access risers and construction loads was performed. The American Concrete Institute (ACI) Standard 318-77, appropriate loads and load combinations from ACI 349, the UBC Zone III, and importance factor 1.0 for seismic load definition were used. The loads considered in the analysis were dead loads, live loads, thermal loads, seismic loads (applied as a horizontal static load as part of the dynamic soil pressure loads for below ground structures), static soil pressure, buoyant uplift due to hydrostatic pressure, equipment and piping loads, hydrostatic loads, and construction loads.

Detailed documentation of the concrete tank vault flotation during the original construction period along with mitigative action has been documented by Barnstein (1965 and 1966). An extensive program of soil investigation was carried out using a series of shafts under the tank vaults to identify the state of cracking in the vault slabs as well as the voids that had developed under it. The entire tank area was grouted and brought to a nearly level alignment, slightly twisted out of original tank orientation. The vault ceiling and bottom have cracked. This crack pattern was mapped by Bechtel. The cracking was factored into the vault analysis.

The analysis performed by Lawrence Livermore Laboratory (LLL, 1978) was used to prorate and verify the calculated dynamic soil pressure. The soil pressure established for 0.1 g seismic ground acceleration was translated into an equivalent static force using a Mononobe-Okabe formula. Soil properties used in the analysis were verified by additional borings and sample testing (Gates, 1986).

These loads were applied to the vault in several different combinations and entered into the Stardyne Static Finite Element Analysis computer program. The computer output was reviewed and the most critical stress elements were then used to verify the vault reinforcement and stresses within the concrete. Based on the assessment under the load conditions and combinations discussed above, it was assessed that the 8D-1 vault integrity will be maintained and will comply with ACI-318 during construction and operation of the STS and mobilization activities (Ebasco, 1986a). This is discussed in more detail in the WVNS-SAR-004 (Section D.5.2.3.1.3).

The tank 8D-1 concrete vault was reanalyzed to verify the vault structure integrity due to the loads from the HLWTS pump pit (i.e., dead loads, pump and piping loads in conjunction with other pre-existing loads). This assessment found that the modifications resulting from the addition of the 8Q-1 pit did not adversely impact the structural adequacy of the vault (Ebasco, 1989).

In summary, based on the assessments under load conditions and combinations discussed above, the 8D-1 vault integrity will be maintained and will comply with ACI-318 during the HLWTS operation.

2.2.3.1.2 Tank 8D-1 Modifications

Since the steel roof girders were not cut and loads on the channel rafters after cutting were locally transferred to the roof girders, the steel tank as a whole was not reanalyzed dynamically or statically. The pumps suspended inside tank 8D-1 are structurally isolated from the carbon steel tank roof. The access risers connected to the carbon steel tank are supported on the concrete vault. This structural modification approach did not cause additional stress on the original steel tank.

2.2.3.2 Structure Analysis of Original Tank 8D-2 for the HLWTS

2.2.3.2.1 Tank 8D-2 Concrete Vault Integrity Analysis

The tank 8D-2 concrete vault was analyzed to verify that vault integrity would be maintained with the removal of concrete cutouts for the addition of tank risers and carry the loads from these new access risers. The resulting loads in the concrete vault were calculated and compared to the limits given in API-318. The assessment under the dead and live load conditions of the new risers was determined such that the seismic resistance of the vault will not be altered and the tank 8D-2 vault integrity will be maintained (Rockwell, 1985). This analysis used the Lawrence Livermore Laboratories analysis results to predict that the new risers will not alter the seismic resistance of the concrete vault. Based on the results of the structural assessment analysis performed on the 8D-1 vault, the modification and pump pit addition do not impact the structural adequacy of the vault, the same conclusion is also valid for the 8D-2 vault which has less discontinuities and superimposed loads than 8D-1 (Ebasco, 1989).

2.2.3.2.2 Tank 8D-2 Modifications

The tank top was analyzed assuming the steel roof girders had not been cut and a maximum of two channel rafters had been cut. The steel tank as a whole was reanalyzed statically. The steel risers connecting the carbon steel tank were pulled in tension and supported on the vault, this results in the same roof loads as existed before modifications.

Rockwell (1984) conducted the static analysis for tank 8D-2 to substantiate the adequacy of the tank roof when two of the steel roof rafters were cut for remote installation of the new pump risers. This analysis demonstrated the adequacy of the modification to the tank under gravity loads and this structural modification approach does not cause additional stress on the original steel tank roof.

A dynamic interaction analysis between the steel tank, interconnecting pump access risers and concrete vault was not performed. However, dynamic analysis by Lawrence Livermore Laboratories (1978) indicated horizontal relative movement at the tank roof under twice the design basis earthquake would be relatively small. Furthermore, considering the very low relative stiffness associated with the risers as compared to the entire tank and its surrounding vault, engineering judgment would conclude that little transfer of force and thus insignificant interaction effects would be induced in the tank due to riser attachment. The risers are not anchored laterally to the tank vault but are permitted to slide on a steel pipe casing, thus isolating them from forces that might have been produced by the relative motion between the steel tank roof and the vault roof under earthquake conditions. A separation gap of 25 mm (1 in) is provided for construction tolerance requirements around the installed risers. This gap will also accommodate relative movements that might be induced in an earthquake. Gates (1986 and 1991) has shown analytically that the pump access riser welded at the top of the tank could withstand four times the design basis earthquake before rupturing.

2.2.3.2.3 Tank 8D-4 Riser Modifications

The tank 8D-4 concrete vault was analyzed for the maintenance of the vault integrity as a result of loads with the addition of the new pump pit (i.e., dead loads), under equipment loads and reactions and, with at rest and dynamic soil pressures and found to be structurally acceptable (Ebasco, 1989a).

A seismic analysis on the steel tank was performed at 0.1g peak ground acceleration. The loading conditions consist of a static dead and hydrostatic loads and a dynamic analysis to demonstrate the adequacy of the modifications (Gates 1993).

2.2.3.2.4 Mobilization Pump Support Structures

A Uniform Building Code (UBC) static seismic load analysis was performed for the design of the mobilization pump support structure. A clearance gap between the pumps (pump column) and waste tank structures (tank access risers on 8D-1 and 8D-2) was not established for seismic purposes. The gap was established as a result of construction tolerances.

Although the basis for seismic loading used in the design of the mobilization pumps, support structures, and the tank access risers was a UBC static lateral loading, an independent dynamic interaction analysis was performed (Gates, 1991) to evaluate the clearance gap under a 0.1 g design basis earthquake (DBE) using the NRC Regulatory Guide 1.60 response spectra and NRC Regulatory Guide 1.61 damping values. The results of the analysis indicate that impact may occur between the tank 8D-2 riser and the M-1 pump column at earthquake motions slightly greater than half the DBE. However, no failure of the pump column or surrounding tank riser will occur until earthquake motions exceed four times the DBE. The tank 8D-2 M-1 riser is the one original riser on the tank used for the SMWS. Impact between the pump column and the pump access risers installed for the mobilization of zeolite and mixing of 8D-2 waste was shown not to occur until motions exceeded the DBE.

The loads and load combinations described in Section 2.2.3, (Ebasco 1985) were utilized in the design of the steel and concrete structures. However, for seismic load definition, the UBC Zone III with an importance factor of 1.5 was used in the analysis. The steel truss framing system was designed to carry the pump loads and transmit them to the ground.

Dynamic loads from the operation of the mobilization pumps were also analyzed. The mobilization pump operating frequencies are approximately 30 Hz at 1800 rpm. Startup frequencies could be as low as 10 Hz under transient conditions. The pump support structure was specifically designed to act as a relatively stiff platform under lateral seismic loads to minimize the potential of pump column impact with risers and tank bottom obstructions (Ebasco 1986). Furthermore, to minimize resonance with the pump operating frequencies, a 10-Hz separation was provided as the design objective of the support structure. Independent dynamic analysis of the pump support structure and its flexible foundation system (Gates, 1991a) shows that the fundamental translational modes of the truss in the horizontal and vertical directions are on the order of 2.5 to 4 Hz. Horizontal translation perpendicular to the longitudinal axis (e.g., transverse translation) has a natural frequency of 2.5 Hz. Thus, a separation between the fundamental truss frequencies and the operating frequency of the motor has been provided that exceeds the design objective of 10 Hz. Higher modal flexural frequencies of the truss in its fundamental transverse and longitudinal modes are in the range of 4 to 5 Hz, still well below the operating frequency of the pump motors. No restrictions have been imposed on the operating frequencies of the pumps to minimize resonance that might result from multiple pump operations. The riser loads are applied to the vault roof. Traditional analysis methods were utilized in the design of both reinforced concrete and structural steel members (Ebasco 1986).

2.2.3.2.5 Design of Concrete HLWTS Structures

The loads and load combinations described in Sections 2.2.3, (Ebasco 1992) and Schiffhauer (1992) were utilized in the design of the reinforced concrete pump pits and trenches that have been erected for the HLWTS. The American Concrete Institute (ACI) Standard 318-77, appropriate loads and load combinations from ACI 349 were used in the design of the reinforced concrete portions of the HLWTS. A typical trench section was used in the analysis which is representative of the entire trench. The trench is partitioned in segments approximately 50 feet long by SE foam and waterstops. Trench to pit interface connections are handled with the same method. This segmenting accommodates the relative displacements and wave propagation effects caused by the design basis seismic event. The structural steel framing used in the trench for the HLW lines pipe supports was designed to the 1980 edition of American Institute of Steel Construction (AISC) Code, to carry piping loads and transmit them to the trench or pit walls through embedded plates. In addition, construction loads were used in the design of the reinforced concrete portions of the HLWTS. The roof of the trench and pits are made up of removal panels supported by the walls. Traditional analytical methods were used in the design of both the trench and pit structures. (Ebasco 1989b, and 1989c)

2.2.3.2.6 HLW Transfer Piping and Supports

The loads considered in the piping design were dead load (D), live load (L), thermal load (T_o), seismic load (E_{SSE}, E_{UBC}), seismic displacement loads (D_{SSE}), and internal pressure (P_o). Allowable stresses for the piping systems were taken from ANSI/ASME B31.3. Standard Analytical Methods were used in the piping analysis (Ebasco 1992 and 1992a). Independent verifications of the design was performed and safety measures provided for the piping and support (Gates 1993).

2.3 HLWTS Support Systems

2.3.1 Ventilation

Operation of the HLWTS is supported by two separate and independent ventilation systems: the original WTFVS and the existing PVS. These two systems are described in detail in Sections D.5.4.1 and D.5.4.2 of WVNS-SAR-004, respectively.

The original WTFVS will continue to exhaust air for contamination control from the HLW tanks (8D-1 through 8D-4) during normal transfer operations along with air sweep through the new pump pits, during all HLW transfer and THOREX neutralization operations. Following off-gas treatment the exhaust air is combined with effluents from other project activities and monitored at the main Processing Plant Stack prior to release to the environment. Sections B.5.4 of WVNS-SAR-002 provides additional information on the WTFVS. Modifications to the original WTFVS may be required to provide adequate ventilation to the HLW tanks and pump pits.

The PVS supports the HLWTS during pump installation in tanks 8D-1 and 8D-2 and during pump pit cover removal maintenance activities. The PVS may also be used to provide greater ventilation to the HLW tanks during transfers. Tank ventilation is diverted from the original WTFVS to the PVS, treated and discharged through the PVS stack. Major components of the PVS are contained and protected from the weather in the V&S Building located on the tank Farm near tank 8D-1 and 8D-2. The PVS is described in detail in Section D.5.4.1 of WVNS-SAR-004.

The primary filters have local low/high pressure alarms that sound a trouble annunciator at the PVS control station in the Ventilation and Service Building, adjacent to the THOREX transfer control station. In response to low/high differential alarms, the parallel and redundant filtering train will be automatically activated. This redundancy ensures continuous and adequate air filtration and treatment should filter failures occur.

As an added measure of protection, the WTFVS knockout drum reservoir would be charged with caustic pellets. The knockout drum collects condensed water vapor after separation and collects in the bottom of the drum, overflows across a baffle, and discharges back to Tank 8D-2. Adding the caustic provides a source to neutralize any nitric acid vapors from the off-gas stream which may condense after the PVS is taken off-line.

2.3.2 Monitoring and Leak Detection Systems

Operation of the HLWTS is supported by various monitoring and leak detection systems for process control and to assure that on-site and off-site exposures to radiation and radioactive materials are maintained ALARA. These systems are described in this section and in detail within other sections of this SE as referenced below.

2.3.2.1 Environmental Monitoring Systems

Effluent releases from the operation of the HLWTS are monitored via the existing on-site and off-site monitoring program that has been in place since the inception of the WVDP in 1981. This program is described in Section A.8.6.1 of WVNS-SAR-001. Minor modifications have been made to this program to meet the specific monitoring requirements associated with operation of the HLWTS.

Details and results of the WVDP on-going monitoring program are available in annual reports. It is envisioned that the current program will be continued by DOE until the WVDP is completed.

The PVS, located in the tank Farm near tanks 8D-1 and 8D-2, is locally monitored by an additional effluent sampling system similar to that used for continuous monitoring of exhausts from the original WTFVS at the Main Processing Plant Stack.

The specifics regarding instrumentation and methods used to continuously monitor radioactivity in airborne effluents from the PVS are described in Section D.8.6.1, WVNS-SAR-004. Effluents from the WTFVS will continue to be monitored at the stack along with effluents from other Project activities as described in Section B.5.4.1.2.2 of WVNS-SAR-002.

2.3.2.2 On-Site Exposure Control

The Health Physics and Radiation Protection Programs for the HLWTS is the same as for other Project activities and is operated in accordance with the requirements of the WVNS Radiological Controls Manual, WVDP-010.

Workers are individually monitored for external radiation exposure via thermoluminescent dosimeters (TLDs) that are exchanged and analyzed on a routine basis. Area Radiation Monitors (ARMs) and Continuous Air Monitors (CAMs) are appropriately located within occupied areas of support building and the V&S Building, which provides audible and visual alarms should external radiation levels or airborne radioactivity levels exceed pre-established set points.

The Health Physics program for the Project is described in Section A.8.5 of WVNS-SAR-001. Additional information on radiation detection instrumentation for worker protection during HLWTS operations is presented in Section D.8.3.4 of WVNS-SAR-004.

2.3.2.3 Process Control

Radiation monitoring instruments (on-line monitors) are also used in the HLWTS to monitor the radioactivity within contained systems such as utility lines entering pump pits. During system on-line operations readouts of these devices are continuously monitored at the HLWTS control station. Alarm indications are provided at the control station if pre-established limits are exceeded. The use of radiation monitors, ensures that radioactivity is not transferred to areas not intended to receive such material, i.e. utility pits, mobilization pump columns, etc.

Mobilization pump seal performance will be routinely monitored to determine if any contamination is migrating into the pump column.

The STS Pneumatic Transfer System is presently used to routinely extract liquid samples from tank 8D-2 for off-line analysis. These samples are remotely removed from the STS Valve Aisle and transferred to the analytical cell in the main processing facility for various radiochemical analyses. Analyses of process samples during THOREX neutralization operations will use this system.

Sampling system and procedures for HLWTS THOREX process control are described in detail in Section 3.7.

2.3.2.4 Leak Detection Systems

In addition to the environmental and radiation monitoring systems previously described in this section, several leak detection systems are used in the HLWTS to identify the occurrence of leakage of process liquids both during waste transfer and storage.

A liquid level detection system exists (as NFS, Inc. original equipment) in both the tank 8D-1 and 8D-2 pans to identify leakage from the HLW tanks. (An examination of the vault/pan/tank design makes it clear that the pans function more to facilitate leak detection than to serve as secondary containment. This latter function is served by the concrete vaults.) Leaked fluids can be returned from the pans to the tanks via pumps.

The immediate area surrounding HLW tanks 8D-1 and 8D-2 has a series of water monitoring and injection wells. These wells allow measurement of groundwater level and water sampling for radioactive contamination analysis. Monitoring and trending on these many wells has indicated uniform groundwater levels between wells and no radioactive contamination has been discovered.

Currently, per Standard Operating Procedure, a monitoring well within the WTF area is monitored for groundwater level, three times daily, and radioactivity, weekly and prior to pumping out of groundwater.

The groundwater level surrounding the vaults is maintained at a minimum elevation (above the bottom of the 8.2 m [27 ft] HLW Tanks) of 7.6 m (25 ft) by way of a level indicating controller which allows water to be injected into wells. The 2,300,000 L (600,000 gals.) working capacity of each HLW Tank corresponds to a 6.7 m (22 ft) height, which is lower than the minimum ground water elevation. Since at least 1982, no water injection has been necessary to maintain this minimum groundwater level. This is due to the high ground water table at the site. WVNS is forced to pump ground water out of a dewatering well and sump from underneath the vault to maintain the ground water level within a desired range

(7.6 m [25 ft] to 10.3 m [34 ft]). The frequency of pumping depends on the seasonal climatology; however, the well is typically pumped between one and four times per month throughout the year.

The carbon steel pan in the 8D-2 vault has been tested, and it is apparent that a leak exists that allows water to pass between the pan and vault. The pan itself cannot, therefore, be considered as either containment or reliable for the detection of small leaks from tank 8D-2. However, the liquid level detection system in 8D-2 continues to be a viable detection system for potential tank leaks whose rate of outflow exceeds that of the pan or whose volume would be large enough to register on the pan level detector.

The pan contents in the 8D-1 vault are still isolated from the vault. When water is pumped from the pan, the vault level does not change. The water that does collect in the pan is analyzed for radioactivity prior to release.

If either tank were to leak, the vault and silty till soil around the vault provide the containment to prevent leakage to the accessible environment. Water can be injected around the outside of the vaults to maintain a piezometric potential greater than the level that would exist if the entire contents of either tank 8D-1 or 8D-2 were released to their respective vaults. The head on the outside of the vault would cause the leakage to be from the outside to the inside. The water on the outside of the vaults also keeps the silty till wet and highly impermeable (very low migration rates ~ 10^{4} cm/s) to water flow. A review of the injection well water addition records for the past year has shown that no water needed to be added to the system. This is indicative of the "tightness" of the soils in which the tanks are situated and of the fact that natural infiltration is typically sufficient to maintain the desired degree of soil saturation. A review of the tank 8D-1 and 8D-2 pans sample records indicate water does infiltrate into the pans. No records are kept as to the volume of water pumped from the pans. The level instruments that exist in each vault have high-level alarms that are set to keep this water off the bottom of the waste tanks.

A large seismic event, in excess of the design basis event, could hypothetically rupture the tank and the vault. However, the inward piezometric gradient and the highly impermeable nature of the surrounding soils make the release of HLW to the accessible environment highly unlikely. The high clay content and over consolidated nature of the surrounding, undisturbed silty till are, in effect, a highly durable "bathtub" for the 8D-1/8D-2 vault complex. Since much of the water is effectively "locked up" in the clay fraction of the till, it is highly unlikely that it could be lost during a seismic event. Furthermore, even if water in the system were to be lost or head differentials were to equilibrate, additional water could easily be added to the system. This could be accomplished via the injection system or, failing that, through the standpipes that surround both vaults and are in direct hydraulic communication with the gravel layer that underlies the vaults.

Leak detection equipment is installed within the annular space between each of the HLWTS primary and secondary pipe segments residing in the transfer trench. The leak detection equipment is installed at the low point of each continuous pipe segment. Leaked fluids will drain to a low point at the pit wall where a conductivity probe will initiate an alarm. The secondary pipe is connected to a drain line which is maintained closed by a valve in the pump pit and can be opened to allow drainage by gravity to one of the pits. A summary of leak detection and mitigation capabilities for the major structures/barriers of the HLWTS is presented in Table 8.

Each pump pit has a leak detection probe installed at its drain. A drain plug device is installed which allows air flow to the tank but maintains liquid holdup at the drain so small leaks can be detected. A conductivity alarm at this drain identifies the leakage condition. The drain plug can be operated from outside the pit to drain liquids back to the tank as necessary.

All operating procedures for transferring liquids require that the start of the transfer process be monitored to ensure that corresponding volume increases and decreases occur as expected so that the transfer can be secured immediately.

2.3.2.5 Waste Tank Containment Metal Corrosion

WVNS has a program in place for monitoring and control of corrosion in carbon steel HLW tanks 8D-1 and 8D-2.

Tank wall thicknesses of tanks 8D-1 and 8D-2 were last measured in 1982 using ultrasonics. There was no evidence of thinning of the tank walls through general corrosion. Visual inspection of internal and external tank surfaces indicated loose surface scale and pitting. The design corrosion allowance for these HLW tanks is 6.4 mm (0.250 in).

Corrosion is controlled in carbon steel HLW tank 8D-1 by the addition of corrosion inhibitors (i.e., caustic for pH control and sodium nitrate).

The carbon steel HLW tanks were stress-relieved by heat treatment after fabrication. However, it is difficult to say today what the stress condition is because of the effects of differential settlement. Nevertheless, stress corrosion cracking has never been observed in corrosion coupons removed from either tank 8D-1 or 8D-2.

Tank 8D-4 is a stainless steel tank since it contains an acidic THOREX waste. Inspection of corrosion coupons, which were removed in 1987, indicated minimal thinning (i.e., at least an order of magnitude less than that in tank 8D-2 - 0.003 mm [0.12 mils] total of corrosion over a 7.5 year time span). The design corrosion allowance for the stainless steel HLW tanks is 1.8 mm (0.07 in).

The corrosion-resistant stainless steel tank is relied upon as a passive means of controlling corrosion in tank 8D-4. The low corrosion rates observed support this approach.

2.3.3 Auxiliary Power

Requirements for auxiliary power for the HLWTS are necessary for maintaining vital services, including service building lighting, ventilation and monitoring systems. The operational safety requirements for auxiliary power distribution to the HLWTS are described in OSR/GP-5 "WVDP Emergency Power Requirements." HLWTS electrical systems are discussed in Section 2.4.4.

Should a power outage occur during HLWTS operations, the HLWTS and mobilization pumps would shut down and would not be restarted until complete system control and normal power is restored. The WTFVS would continue to provide tank ventilation since it is on auxiliary power.

2.4 Description of Service and Utility Systems

2.4.1 V&S Building Heating and Ventilation System

The V&S Building system is designed to provide area temperature control. Local unit heaters provide the final space temperature control. Unit heaters are provided with individual limit thermostats for automatic control. A manual switch is provided with every heater to allow for manual operations if required.

2.4.1.1 Transfer Pit Ventilation and the WTFVS

The original WTFVS will continue to provide routine ventilation to tanks 8D-1, 8D-2, 8D-3, 8D-4, and the new pits on these tanks. Section B.5.4 and Figure B.5.4-6 of WVNS-SAR-002 provide additional information on the WTFVS.

Air is removed from the tanks at approximately 0.07 m^3/s at standard temperature and pressure (STP) (150 scfm) and is passed through a condenser and knock out drum. The air is then heated before passing through a HEPA filter coupled with a blower. The filter and the blower have a redundant, parallel system as a standby in case of failure. The exhaust lines are connected to the main plant stack. Before release, the exhausted air is monitored to ensure radioactive releases are being maintained ALARA. (See Sections D.7.4 and D.8.6.1 of WVNS-SAR-004 for descriptions of the WTFVS and Monitoring Program.)

2.4.1.2 Safety Considerations and Control Interfaces Between Clean and Contaminated Areas

Should it be necessary, temporary containment enclosures will be provided for entry into contaminated pump pit areas. These enclosures will be maintained under negative pressure to ensure that air flows from clean to contaminated areas. The PVS may be employed to provide for the pit ventilation during entry into any of the pump pits.

2.4.1.2.1 PVS Air Filtration

Air leaving contaminated pit areas is filtered in the PVS by two sets of HEPA filters in series (see Figure 14) after passing a mist eliminator, heater, and roughing filter to entrap moisture and particulates. HEPA filters are in a housing to provide contamination control during changeout. Filters will be changed with bag out/bag in procedures. The exhaust fans (PVS blowers) provide the system draft and are rated for 100% flow capacity of the STS HV system with all the filters at the changeout pressure drop. Both exhaust blowers are electrically operated. The backup will automatically activate if the primary blower fails or if primary power is lost. Provisions have been made to allow DOP testing of the installed filters. The differential pressure is measured across each filter holder in the HV system. The primary filter holder has local low/high pressure alarms that sound a trouble annunciator at the PVS control station in the V&S Building. A remote trouble alarm in the STS control room would alert operators of a problem with the PVS.

In response to low/high differential alarms, the parallel and redundant filtering train will be automatically activated. This redundancy ensures continuous and adequate air filtration and treatment should filter failures occur.

Following off-gas treatment, the ventilation air has passed through the blower and discharged through the STS PVS stack (see Section D.7.4 of WVNS-SAR-004). Air is continuously sampled to assess radioactive material releases (see Section D.8.6.1 of WVNS-SAR-004).

2.4.2 Electrical System and Auxiliary Power Supply

The primary and back up power systems for the WVDP are described in Section B.5.4 of WVNS-SAR-002. Electrical power for the HLWTS is supplied from the main plant utility services (480 volt, three phase), to a motor control center (MCC). From the MCC, the power is distributed to the HLWTS equipment and control panels through conduits run on the support structures, embedded in HLWTS facility floors and walls, or placed in cable trays. Normal electrical power requirements for operation of the HLWTS are 425 kW (570 hp) to 445 kW (600 hp). The HLWTS is designed so that all valves and equipment fail safe in case of electrical power failure. The pumps may shut down (stop) in the case of electrical power failure and the waste will drain back to the tank.

Auxiliary power backup is supplied to lighting, ventilation, and monitoring systems. Electrical power requirements for the HLWTS are presented in Table 9.

2.4.3 Compressed Air

Utility air and instrument air are required by the HLWTS to operate instruments, valves, and pumps. This air is supplied from either the main plant system (described in Section B.5.4.3 of WVNS-SAR-002) or from the air compressor located on the V&S Building. The HLWTS is designed to fail-safe during loss of air pressure. Air requirements for the HLWTS are presented in Table 9.

2.4.4 Water Supply

The plant water supply system is described in Section B.5.4.5 of WVNS-SAR-002. This provides water for the HLWTS line flushing, grinder cooling and equipment seals. Water requirements for the HLWTS are provided in Table 9. Flush water and grinder cooling controls are monitored in the utility pits. Mobilization pump seal water pressure and flow are monitored at the pump utility board.

2.4.5 Steam Supply

There is no steam used in the HLWTS.

2.4.6 Sanitary Facilities

Operators use the facilities within the main process building or office complex.

2.4.7 Safety Communications and Alarms

The HLWTS is provided with instrumentation to monitor flow, pressure, temperature, and radiation levels to ensure system operations are controlled and system limitations are not exceeded. Pumps are operated remotely from controls located in the V&S Building. In the event of abnormal conditions, the process equipment can be manually shut off. Safety related systems (e.g., ventilation system) are designed to achieve a safe condition automatically should off-normal conditions occur (i.e., loss of filter, backup fan starts, etc.). Automatic controls for all subsystems are provided with manual override capabilities.

The HLWTS has instrumentation and controls to allow the system to be started, operated, monitored, and shut down from the control station. The control panel is equipped with a dynamic graphic display to reduce the likelihood of operator error. The instrumentation indicates or alarms (or both) under abnormal or undesirable conditions that could adversely affect system or equipment performance or which would inadvertently affect interfaces with other systems. During emergency conditions, external communications can be through the plant telephone or intercom systems.

Examples of safety related systems that provide alarm indications at the HLWTS control station include:

- Ventilation System differential pressures
- Radiation Monitoring Systems
- Effluent Monitoring Systems
- Leak Detection Systems
- Fire Protection System (Section 2.4.8)

2.4.8 Fire Protection Systems

A fire in the HLWTS is considered highly unlikely. The pump pits and the transfer trench are constructed of concrete and steel and the waste is nonflammable. The only potential fire hazards are the electrical wire insulation, grease in the pump motors, and the small amount of wipes used during sample collection, which shall be kept in fire-resistant containers. None of these are a high risk fire hazard.

The V&S Building has fire detection equipment, alarm systems, and suppression systems commensurate with needs as determined by WVNS Radiation and Safety. This includes fire extinguishers, emergency exit lighting and fire suppression systems installed in the V&S Building. Fire prevention and fire fighting procedures for the HLWTS are in accordance with existing WVDP procedures (see Section B.5.4.4, WVNS-SAR-002).

WVNS maintains a highly reliable alarm detection system through a semi-annual site fire detection and alarm system inspection. In addition, the services of a Fire Protection Engineering firm are subcontracted annually to do a thorough survey of the WVDP Fire Protection Program. This serves as an audit of the WVNS systems and programs to ensure compliance with the "improved risk" level of protection required by DOE. The WVDP Fire Protection Plan is contained in Chapter 5 of "Industrial Hygiene and Safety Manual" (WVDP-011).

2.4.9 Maintenance Systems

The HLWTS has been designed for remote operation. All equipment not required to be located in radioactive process areas is located in "cold" areas to permit contact maintenance. Contact maintenance will be performed on equipment previously used in radioactive service only after sufficient decontamination in accordance with existing WVNS procedures (WVDP-010, "Radiological Controls Manual"). Where this is not feasible, equipment is be remotely removed and replaced.

All equipment and piping in radioactive service is drained and flushed to reduce radiation levels before any personnel enter process areas such as the pump pits or transfer trench. Instruments in "cold" areas are designed to permit isolation for periodic maintenance. HLWTS equipment and components are located in pits and shielded to minimize radiation exposure to plant personnel should maintenance be necessary. Equipment and component removal from pump pits may be performed remotely using a remote crane and gantry type lifting devices.

HLWTS design considerations for equipment and component decontamination were additionally discussed in Section 1.5.

2.4.10 Cold Chemical Systems

The cold chemical systems used as part of the HLWTS operations (i.e. caustic addition, tank corrosion control) are described in Section D.6.3.1, WVNS-SAR-004 (Cold Chemical Receiving and Handling).

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3.0 HLWTS PROCESS SYSTEM

3.1 HLWTS Process Description

Production of vitrified high-level waste (HLW) requires many operating systems to complete the overall task. The HLWTS provides equipment and piping to support several phases of HLW handling to meet the overall goal of HLW production.

The sequential nature of the HLWTS operations lends itself to the documentation of its discrete phases. This description presents the HLWTS process information relative to the following two different phases of operation:

- THOREX Transfer and Neutralization
- Zeolite Mobilization and Transfer

The HLWTS processes have been designed to remove THOREX Waste from storage tank 8D-4 and spent zeolite from tank 8D-1 and transfer these wastes to tank 8D-2. The THOREX waste transfer process involves neutralizing the acidic thorium nitrate wastes in tank 8D-2 using caustic. The caustic will be added to the tank 8D-2 contents and then mixed using the 8D-2 Mobilization Pumps. The acidic THOREX (< 0.1 molar HNO_3) waste will be slowly added to caustic-rich tank 8D-2 in a manner which assures quick neutralization of any free acid and avoidance of localized pH excursions inside tank 8D-2. After neutralization, a dilute caustic solution will be added and the THOREX precipitate will be washed of its salts using the SMWS as described in WVNS-SAR-004. Once the THOREX precipitate is washed and the resulting solutions processed through STS, the spent zeolite will also be transferred to tank 8D-2. The zeolite may be sized reduced prior to being sent to the storage tank 8D-2.

The following sections describe the individual transfer operations of the HLWTS as they are related to this SE.

3.1.1 THOREX Waste Transfer

The acidic THOREX waste will be slowly added to caustic-rich 8D-2 in a manner which assures quick neutralization of any free acid and prevents localized pH excursions inside 8D-2. The THOREX removal and transfer portion of the thorium neutralization operation includes the transfer pump (55-G-013) installed in tank 8D-4 and piping to deliver the thorium waste to 8D-2. The SMWS mobilization pumps in tank 8D-2 will be in operation as the THOREX transfer occurs. The transfer system will also provide the connections to allow water flushing of the transfer lines and tank 8D-4.

A large excess of caustic, approximately 1,000 gallons of 20% NaOH, will be added to tank 8D-2 before the acidic THOREX waste is pumped over from tank 8D-4 using the SMWS Caustic Addition System. Once the caustic is added, homogenization of the tank 8D-2 contents is provided by the SMWS equipment via the use of the low-pressure, high-flow, long-shafted centrifugal pumps as described in WVNS-SAR-004. After caustic addition, the tank will be sampled to establish that sufficient excess caustic is present. THOREX transfer to tank 8D-2 will be carried out using THOREX removal pump (55-G-013) inserted in the tank 8D-4 riser. The pump assembly is supported from the vault roof and located in the 8Q-4 concrete pump pit.

Since the THOREX waste is a solution, agitation in tank 8D-4 is not required during this waste transfer operation, although, as subsequently described, there may be some mixing from pump recycle. The THOREX transfer system can be valved within the 8D-4 pump pit for waste recycle back to tank 8D-4. The THOREX waste removal pump would be energized with its discharge returned directly back to the tank at a rate on the order of 20 to 30 gallons per minute. Using this arrangement the 8D-4 waste will be mixed. Instrumentation within the THOREX removal pump pit will allow monitoring of the solution temperature, pressure and flowrate. To remove the THOREX from tank 8D-4 and transfer this waste to tank 8D-2 the following piping/valving system is installed for the transfer.

The transfer route is from pump pit 8Q-4 through the double walled piping in the transfer trench to pump pit 8Q-1. A dedicated jumper in 8Q-1 carries the THOREX through the pit. The double walled piping continues in the transfer trench to pump pit 8Q-2. Once in 8Q-2, flow is through dedicated jumpers and then to the discharge line which carries the THOREX into tank 8D-2. The THOREX will enter tank 8D-2 at less than five gallons per minute in a two-inch diameter transfer pipe. The transfer pipe extends below the surface to approximately ten feet from the tank floor. In the 8Q-2 pit, the dedicated jumper is a flow instrument which provides the information to the process control room for regulation of the variable speed pump in the 8Q-4 pit to achieve the desired transfer rate. Valve positions are verified both manually and through position switches mounted on the valves. The valve position is manually verified on the pit cover and is locked into position through the use of the valve extension handle. The position switch mounted on the valve inside the pit sends a signal to the PLC also verifying the valve position. A schematic of the transfer routes is shown in Figure 2.

The level of excess caustic in 8D-2 will be closely monitored during the transfer operation. As needed, additional caustic will be added to 8D-2. The mobilization pumps simultaneously operating in 8D-2 will ensure mixing of the neutralized thorium waste into the existing waste.

As noted above, the THOREX solution will be removed from Tank 8D-4 and transferred to Tank 8D-2 in batches. The acidic THOREX waste, < 0.1 molar HNO_3, will be slowly added slowly (up to five gallons per minute) to the caustic-rich (0.1 - 0.2 molar NaOH) 8D-2 solution to assure full and rapid neutralization of the free acid. Agitation of 8D-2 will be employed using the mobilization pumps to ensure that the THOREX is quickly neutralized and that the tank contents are kept as a homogeneous mixture.

THOREX neutralization must be conducted prior to introduction of zeolite into tank 8D-2. During the neutralization process, excess caustic at levels as high as 0.2 molar will be established in 8D-2. If zeolite were to be present, the required level of 0.2 molar caustic could not be established, since zeolite reacts with excess caustic above 0.1 molar.

Since the THOREX waste is in the form of an acid solution, the contents of Tank 8D-4 will be easily removed. A vertical turbine pump installed in 8D-4 will be used to remove and transfer the waste. The waste will be transferred to Pump Pit 8Q-2 through two inch, double walled, stainless steel piping supported within the concrete trench. The removal pump is supported from the tank riser in Pump Pit 8Q-4, which is supported on the tank vault. Instrumentation within the pump pit will allow monitor the temperature, pressure, and flow rate of the THOREX during transfer.

The THOREX transfer pump and piping requires operational flexibility for future service. The system was therefore designed to be able to transfer of waste materials from Tank 8D-4 to either Tank 8D-2 or the Vitrification Facility during vitrification operations. As a result, the removal pump and piping are over designed for the low flow rates to be used during THOREX neutralization. During THOREX transfer, the removal pump will operate in a recycle mode within Pump Pit 8Q-4 and a bypass line in the pit will deliver the THOREX to Tank 8D-2 at the low flow rate desired. The 8Q-4 recycle loop will recirculate THOREX back to Tank 8D-4 at approximately 30 gpm.

As an added measure of assuring there will be no excursions of free acid within tank 8D-2 during THOREX addition, the tank 8D-2 addition pipe will be submerged in the tank 8D-2 solution. The elevation of the tank 8D-2 liquid level is lower than the liquid level in tank 8D-4. As a result, the recycle line back to Tank 8D-4 is designed to discharge above the tank 8D-4 liquid level. Having this line end above the liquid level provides a means to interrupt a potential siphoning effect induced by the submerged addition line in tank 8D-2 after shutdown of the removal pump.

Since the planned THOREX transfer rate is slow for a two-inch pipe, a 3/8-inch flow meter is installed in the pit 8Q-2 jumper. The smaller diameter flow meter will allow stable flow control at the low flows employed during THOREX transfer. Automatic flow control will be provided by varying the speed of the THOREX removal pump. This closed loop control scheme consists of setting the desired flow rate set point at the flow indicating controller, measuring the actual flow rate at the flow meter, comparing the actual flow against the set point, and transmitting a signal to the pump speed controller to take the required corrective action. The flow element measuring THOREX flow is installed in a 8Q-2 jumper. The flow meter signal will also be taken to a flow totalizer at the control panel. Prior to start-up, the total batch volume of THOREX to be transferred will be set at the flow totalizer.

3.1.2 Zeolite Mobilization

The spent zeolite resulting from supernatant treatment and sludge wash solution processing is stored at the bottom of Tank 8D-1. After completion of supernatant and sludge wash treatment, a water-covered pile of zeolite will be left in the bottom of the 8D-1 tank. It is estimated that there will be between 65,000 kg to 75,000 kg of zeolite in tank 8D-1 after processing is completed. Five long shafted centrifugal pumps, identical to those used in 8D-2, are mounted at strategic locations in the tank and may be used to resuspend the zeolite. These pumps are described in WVNS-SAR-004. Using these five pumps the zeolite pile may be resuspended and slurried inside 8D-1. The zeolite slurry will be delivered to tank 8D-2 through the pipe trench and pump pit 8Q-2 using a separate transfer pump. Scale model testing with actual zeolite has shown that with batch flushing of water, over 95% of the zeolite may be transferred to tank 8D-2 (Schiffhauer, 1987).

Starting with approximately five to seven feet of water in the tank the mobilization pumps will be operated to maintain the zeolite suspension. The 8Q-1 pump pit valving will be positioned to transfer the zeolite slurry to pit 8Q-2. The zeolite removal pump would be energized and the slurry transferred to 8Q-2 via the pipe trench. A schematic of the HLW transfer trench can be seen in Figure 13.

3.1.3 Zeolite Waste Transfer

After having been transferred to the 8Q-2 pit, the zeolite may be passed through an in-line grinder before being introduced into tank 8D-2. Particle size reduction is needed due to the difference in optimum zeolite size for STS processing and that for vitrification.

STS zeolite procurement specifications call for particles of sufficient size to pass through a 14 mesh screen and to be retained (at 99.6% by weight) on a 100 mesh screen. This range of particle sizes demonstrates good surface area exposure during use while keeping the fluid flow pressure drop down to reasonable values.

Size reduction tests indicate that zeolite particle sizes of less than 300 microns melt into a glass matrix at nearly the same rate. This translates into a requirement for the grinder to size-reduce the zeolite to pass through at least a 48 mesh screen. Therefore, before entry into tank 8D-2, the zeolite may be routed to an in-line grinder which will reduce the particle size of the zeolite.

The zeolite discharge pump (55-G-012) will transfer the zeolite slurry from tank 8D-1 out the 8Q-1 pump pit, through a in-line grinder in pit 8Q-2, and into tank 8D-2. Pump pits 8Q-1 and 8Q-2 valving would be arranged in a unique configuration to allow this transfer . Once the valving is arranged, and the zeolite suspension is accomplished, the zeolite removal pump would be energized to remove the zeolite slurry from tank 8D-1. The transfer will continue until the 8D-1 liquid level drops to approximately three feet.

Following this batch transfer, additional water would be added to tank 8D-1 to bring the level back to a approximately six feet and the zeolite batch transfer process would be repeated. The additional water added to 8D-1 for batch zeolite removal could be decanted from tank 8D-2. This could be accomplished using the STS supernatant transfer pump (50-G-001) described in WVNS-SAR-004.

These batch transfers to Tank 8D-2 will continue until about 90 percent or more of the zeolite is removed from 8D-1. Pumping the zeolite down from seven to two foot removes approximately 40 percent of the zeolite solids. This assumes an efficiency of 60% solids removal. Stated another way, 60% of the solids in ideally mixed slurry will be removed for any given volume of liquid transferred from the tank. Using a simple dilution model, and assuming five batch transfers from six to two feet of liquid, approximately 95% of the zeolite will be transferred to tank 8D-2.

After each batch transfer through the process lines, all lines which have contacted the slurry may be flushed back to the tanks to remove any residual zeolite. At least five zeolite batch transfers are planned, this would remove ≥95% of the zeolite inventory from tank 8D-1.

The SMS portion of the zeolite transfer operation includes the mobilization pumps in 8D-1, the transfer pump and piping to deliver the zeclite to 8D-2, the mobilization pumps in 8D-2 and the in-line grinder for zeolite size reduction.

3.2 Process Chemistry and Physical Chemical Principles

3.2.1 THOREX Waste Neutralization

The acidic THOREX (approximately 0.1 molar HNO_3) waste will be slowly added to caustic-rich 8D-2 in a manner which assures quick neutralization of any free acid and avoidance of localized pH excursions inside 8D-2. Agitation of 8D-2 using the mobilization pumps will be employed to assure a homogeneous mixture and quick neutralization. Addition of this acidic stream to the carbon-steel tank is unusual, but necessary. If neutralization were to be conducted inside stainless steel tank 8D-4, the solids that would form would settle to the bottom of 8D-4 and could not be pumped to 8D-2 without in-tank agitation.

Thorium neutralization must be conducted prior to introduction of zeolite into 8D-2. During the neutralization process, excess caustic at levels as high as 0.2 molar will be established in 8D-2. If zeolite were to be present, the required level of 0.2 molar caustic could not be established since zeolite will react with excess caustic above 0.1 molar.

The neutralization of the acidic THOREX wastes stored in Tank 8D-4 involves at least 39 individual sodium hydroxide reactions. The following neutralization reaction is the primary reaction that will occur when contents of 8D-4 are mixed with the contents of 8D-2:

$$HNO_3 + NaOH \rightarrow NaNO_3 + H_2O$$

In addition, when nitric acid is added to a solution of sodium or other nitrite salts, nitrous acid (HNO_2) is formed. Nitric oxide (NO) gas is then evolved when then HNO_2 decomposes. The equations for these reactions are:

$$HNO_3 + NaNO_2 \rightarrow NaNO_3 + HNO_2$$

$$3HNO_2 \rightarrow HNO_3 + 2NO + H_2O$$

Although the molarity of the $NaNO_2$ and the NaOH in the PUREX solution are nearly equal when the THOREX is being neutralized, the kinetics greatly favor the primary neutralization reaction. The slow rate of NO formation from this series of reactions results in a very modest release of nitric oxide during the neutralization process. As a further precaution to preventing NO generation, the volume of THOREX waste transferred to 8D-2 at any one time will depend on the current hydroxide (OH^-) concentration in Tank 8D-2.

The thorium neutralization phase of HLWTS process represents the start of the preparation of waste for vitrification. After the THOREX waste is transferred and neutralized, the resulting precipitate may be washed. This wash will remove most of the salts from the THOREX neutralization and provides better control ranges for the vitrification cold chemical additions. The process requirements for the thorium neutralization phase will remain the same whether performed during or after sludge washing.

NO_x Release Scenario

Background

If nitrite ions are present during the acid neutralization reaction, it is possible to produce some NO_x in a competing reaction with the hydroxide ion. There is concern that NO_x could be adsorbed on the wet walls in the free space of the 8D-2 tank and be partially converted to HNO_3, which would corrode the tank wall, threatening tank integrity. The following sections demonstrate that only minimal corrosion would occur if all of the free 8D-4 acid reacted to form NO_x.

NO_x Generation

The principal reactions anticipated during the THOREX neutralization are the formation of thorium and fission product hydroxide precipitates, sodium nitrate salts, and water. Should the very localized region where the THOREX is added become acidic relative to the bulk of the 8D-2 solution, the sodium nitrite in the 8D-2 liquid may react with the acid to form NO_x. These local conditions are unlikely, however, due to the slow rate of THOREX addition (<5 gpm) and the turbulent mixing from operation of the mobilization pumps.

A series of tests were conducted at WVNS and PNL to confirm previous test to determine the conservative, maximum NO_x generation rate from THOREX transfer. These tests used simulated and actual HLW solutions under accelerated neutralization conditions, i.e., higher than anticipated THOREX addition rates.

NO_x Conversion to HNO_3

Nitrous acid, a byproduct of the side reaction of nitric acid and sodium nitrite, decomposes to generate NO(g) and N_2O_4(g).

$$4HNO_2 \rightarrow N_2O_4 + 2NO + 2H_2O$$

Nitric oxide (NO) is only slightly soluble in water, and therefore cannot be efficiently absorbed in water to produce HNO_3. However, at low temperatures (< 150°C), NO reacts readily with oxygen to form nitrogen dioxide (NO_2), which is more soluble in aqueous solutions:

$$2NO(g) + O_2(air) \rightarrow 2NO_2(g)$$

In the gaseous and liquid states, nitrogen dioxide exists in equilibrium with its dimer, dinitrogen tetraoxide:

$$2NO_2(g) \rightarrow N_2O_4(g)$$

Subsequent absorption of NO_2 into aqueous solutions occurs as:

$$3NO_2(g) + H_2O(l) \rightarrow 2HNO_3(aq) + NO(g)$$

or

$$3/2\ N_2O_4 + H_2O(l) \rightarrow 2HNO_3(aq) + NO(g)$$

This second reaction is assumed to be the dominant mechanism in forming nitric acid in the condensate of Tank 8D-2. To efficiently produce nitric acid, these reactions are normally conducted with only NO and water initially present. However, in the three component system (NO_2, water, and air) present in the tank, under the extremely low NO_2 concentrations that would result if all of the free acid in the THOREX solution reacted to form NO_x, the rate of nitric acid formation reaction would be very slow, producing negligible amounts of acid on the tank walls.

Using different sets of assumptions, two separate corrosion scenarios were assessed to determine the maximum potential corrosion to 8D-2. The first scenario assumed that all of the free 8D-4 acid reacts with the nitrite portion of the PUREX waste (no neutralization by sodium hydroxide) and that all of the NO generated formed nitric acid uniformly on the exposed 8D-2 surfaces. The second case assumed that all of the NO predicted was released from the waste solution and converted to N_2O_4 and then nitric acid, and that the nitric acid concentration in any condensate in the 8D-2 tank vapor space was instantly at equilibrium with the NO_x gases.

The first assessment further assumed a THOREX free acid concentration of one molar. The result is that a maximum of six mils of 8D-2 steel could be consumed from uniform corrosion of exposed surfaces in the vapor space. This is highly conservative from at least two perspectives. The free acid measurements recently completed at West Valley indicate that the THOREX free acid is < 0.1 molar. Also, in THOREX neutralization testing performed at PNL, less than 0.4 percent of the acid reacted with PUREX nitrite ions under the expected operating conditions.

The uniform exposure of the tank surface to the corrosion assumption for this assessment is reasonable. The mechanism of acid formation in the condensate requires gas phase oxidation of the NO to NO_2 and then polymerization of the NO_2 to N_2O_4. The N_2O_4 gas is then absorbed into the liquid condensate before reacting with the water to form nitric acid. However, even with this assumption, the lack of significant NO generation would never lead to considerable corrosion.

The second, bounding corrosion analysis was designed to assess the condition where an undetermined volume of condensate is present at only a few locations in the 8D-2 system (i.e., localized rather than uniform corrosion conditions). By using the data from the first analysis and by measuring the equilibrium pH of the 8D-2 condensate, PNL was able to calculate the maximum corrosion potential for *any* steel surface exposed to acidic solution. They concluded that approximately five mils of steel would be removed at the bounding five gallon per minute THOREX transfer rate. This low rate proves that localized corrosion is not a credible mechanism for penetration of 8D-2 system elements.

The PNL test data also indicated that these corrosion potentials can be reduced by a factor of two if, during THOREX transfer, NaOH is added to 8D-2 to maintain the sodium hydroxide concentration at approximately 0.2 moles per liter.

Realistic Corrosion Estimate

To more accurately estimate the corrosion potential for directly neutralizing the THOREX with high pH PUREX in 8D-2, steel coupons were exposed to water and NO_2 gas under conditions similar to the second limiting corrosion assessment modeling case.

To confirm the PNL projections, steel coupons were suspended in simulated condensate. A mixture of nitrogen, oxygen, and NO_2 gases were passed through the experimental apparatus to equilibrate the water with the gas and then at 20 liters per hour for the 20 day coupon exposure period. The target NO_2 concentration for the first ten days was 100 ppm, 50 ppm for the next six days, and 0 ppm for the final four.

The test produced corrosion losses ranging from 0.5 to 1 mil per year for the coupons suspended in the vessel vapor space. The corrosion rate measurements for the coupons just covered with water to simulate the tank surface in contact with condensate indicated 4.8 to 5.5 mils per year. Coupons at the liquid/gas interface experienced a corrosion rate of 13.7 to 15.3 mils per year.

The actual THOREX neutralization and transfer procedure would be completed within a two month period. From this experiment, the total expected corrosion for 8D-2 system components exposed to condensate would range from 0.1 to 2.6 mils. This is small relative to the 0.25 inches of original corrosion allowance provided by the tank design and minimum wall thickness of 0.44 inches. As expected, this is significantly lower corrosion than was predicted by either of the two limiting corrosion potential assessments described earlier. It can therefore be concluded that failure of Tank 8D-2 due to NO_x-generated nitric acid is not credible.

In addition to the potential for condensing NO_x-generated acid vapor on the interior tank surfaces, three mechanisms for direct acid (8D-4) transport to the tank wall were considered and evaluated to assess the 8D-2 HLW tank integrity: physical splashing of nitric acid onto the tank walls; corrosion of the tank floor due to the difference in specific gravity between the PUREX and THOREX solutions; and splashing of the acid onto the tank walls from the heat released by the neutralization reaction.

Acid Splash Scenario

The current design of the THOREX transfer system has the the transfer pipe extending below the PUREX liquid level, in tank 8D-2, to eliminate any splashing. However, the following analysis evaluates acid splashing due to pipe failure above the liquid surface in tank 8D-2.

In order for "splashed acid" to reach the tank wall it must consist of sufficiently small diameter particles, so that they do not settle by gravity back to the liquid surface during the time of transport by any air currents within the tank.

The void tank volume, above the surface of the liquid to the tank top, is approximately 77,000 ft^3, which results in an air change in about 12 hours with the air flow through the tank estimated at 150 cfm. The cross sectional area of the gas space of the 70 ft diameter tank is about 1,400 ft^2, resulting in an air velocity on the order of 0.1 ft/minute. Velocities near the outlet would be higher but this would be at the top of the tank, approximately 15 ft horizontal distance from the M-9 riser and 20 ft above the liquid surface. It would not be anticipated that a higher flow rate would exist at the liquid surface in the vicinity of M-9 riser (the location of the sludge removal pump and the 8D-4 addition). There are no designed air inlets to the tank, only leakage from many points so that air flow has more of a "diffusion" nature, migrating toward the 12 inch ventilation outlet. From heat transfer considerations, whatever minor air currents there might be would tend to be downward at the tank wall, because of the colder wall effect, and slowly across the liquid surface toward the direction of the tank center.

As developed in the proceeding paragraph the probable, air flow is negligible or away from the tank wall in the vicinity of the M-9 riser location. Even if it were assumed that air is moving toward the wall at the 0.1 ft/min, the transport time for the 7 ft distance would be about one hour.

The settling rate of water particles in air is a function of their diameter. Even small particles of water in air settle significant distances in one hour. For example, a 10 micron particle settles 36 feet, and a 5 micron particle 10 feet in this time frame. Therefore for an acid particle to reach the 8D-2 tank wall the size would have be less than 5 microns in diameter.

The particle size distribution resulting from a stream falling to the liquid surface is not precisely known but an indication of limits can be developed from an analogy to nozzles designed to generate small water particles. The particle generation from a typical hollow cone, spray head (the most efficient spray head for small particle generation operating at 200 psi pressure with a 0.158 inch orifice produces only 0.01% of its weight at 10 microns or less, up to the 25 micron level only adds another 0.08%. It is characteristic of spray nozzles that if a maximum number of small particles are required that nozzles of the smallest orifice size practicable should be used and operated at the highest possible pressure. None of these conditions exist for a gravity drop to the 8D-2 liquid surface (a terminal velocity of approximately 14 ft/sec) so that only an extremely small fraction, if any, of small, e.g., 20 microns or less particles will be formed, certainly much less than the quoted spray nozzle data above. Further, a liquid splash from a liquid surface is primarily that of the "pool" liquid, not the falling liquid. Not withstanding the argument that only a small fraction of the small particles generated by a high pressure spray could be formed by the 8D-4 liquid drop, the nozzle spray data have been used in the following calculation to demonstrate that the 8D-2 tank wall integrity would not be significantly impaired.

Using this nozzle data, generation of less than 10 micron particles would be 0.01% of the total stream. Further, if it were assumed that this total quantity migrated to the wall (even though the above droplet settling rates indicate they would settle long before reaching the wall) a calculation has been made to demonstrate that negligible loss of tank wall integrity would result. It is assumed that all of this 0.01%, 9 pounds of the 8D-4 acid, reaches the tank wall.

This quantity of HNO_3, when reacted with the steel wall "dissolved" 4 pounds of iron. It is further assumed that this 9 pounds of acid deposits on a very small fraction of the 8D-2 tank wall, e.g. 4 ft^2, which would result in a wall penetration equivalent to 0.025 inches (versus a corrosion allowance of 0.25 inches) from the surface of the 0.5 inch thick 8D-2 tank wall.

This value is considered to be a maximum upper limit for there is negligible energy to generate the extremely fine particles which are required if any of the "splash" is to reach the wall. When the air flow patterns, the tank area affected, and the particle size distribution (based on the nozzle data) assumptions are considered the corrosion value is estimated to be overstated by several orders of magnitude. Another factor which would mitigate any acid deposit near the liquid/gas interface is the turbulence caused by the sludge mobilization pumps. However, this very conservative calculational approach demonstrates that the acid splash scenario is of no consequence to tank integrity.

Surface Boiling Scenario

Another potential way for acid to directly contact the tank wall during transfer is from uncontrolled surface boiling at the point of THOREX addition. The heat released from the neutralization reaction could potentially transport acid to the tank wall. The maximum energy release from the neutralization of acid 8D-4 THOREX solution with the basic HLW of 8D-2 tank was calculated using the enthalpy of the principle reactants; $Th(NO_3)_4$, HNO_3, NaOH, $NaNO_3$ in a dilute water solution. The water in the two tank solutions does not participate in the neutralization, but instead acts to absorb the heat released from the event. The more dilute the solutions, the lower the temperature rise will be. The heat release calculation was based on a summation of a four day neutralization cycle:

- Five gpm of 8D-4 THOREX HLW into 8D-2 (480 gallons total)
- Turn off mobilization pump for 16 hours to sample supernatant
- Repeat above two steps three more times for a four day cycle for a total of 1920 gallons of 8D-4 solution
- Add 15,500 L of 20% NaOH to raise the basic 8D-2 solution from an estimated 13 pH back to original 13.3 pH.

The NaOH is primarily used to convert nitrate salts to a precipitate so less energy is released from the neutralization reaction. In a four day cycle, approximately 15,500 L of 20% NaOH (8,300 lb), is used to neutralize the acid in the THOREX stream. The total heat release per cycle was estimated to be less than five million BTU. This energy, when adiabatically absorbed in 8D-2, will raise its temperature by about 3°F.

The reduction in pH over this four-day neutralization cycle is from 13.3 to 13.0. Approximately one-half of the "free" NaOH is reacted - equivalent to a decrease in molarity from 0.2M to 0.1M. If the 8D-4 acid stream locally consumed all of the available NaOH, the temperature rise would only be twice that of the above case, or approximately 6°F. Since the total energy (13.8 kcal/g mole) cannot be released unless the neutralization reaction is complete, significant higher local temperature effects are not credible. Therefore, dispersion of the 8D-4 acid stream as a result of the energy released from the neutralization reaction is not possible.

Contact of Unreacted THOREX with the Tank Wall

Since the specific gravity of the THOREX waste (1.6) is greater than that of the PUREX solution (1.1-1.2), the possibility of accumulating unreacted THOREX along the floor of the tank was analyzed.

The THOREX will enter tank 8D-2 at no more than five gallons per minute in a two-inch diameter transfer pipe extended below the PUREX liquid surface, approximately ten feet from the tank floor. At this flow rate, the transfer pipe will not be filled with fluid until it passes the PUREX liquid surface. The THOREX liquid will exist as a film on the interior surface of the pipe. The difference between the PUREX and THOREX specific gravity will initiate a flow in the submerged section of the pipe entering tank 8D-2, causing the fluid in this section of the pipe to be refreshed with PUREX solution. Several process factors make the chance of unreacted THOREX directly contacting the floor of tank 8D-2 an impossible event: the acid neutralization reactions are very rapid; the THOREX will be introduced into the PUREX liquid as either small particles broken from the flow along the pipe or as a ribbon; a flow distribution baffle is planned at the outlets of the pipe; and the flow conditions in the region surrounding the pipe will be highly turbulent from the output of the three sludge mobilization pumps directed at the mouth of the pipe.

3.3 HLWTS Mechanical Process Systems

3.3.1 THOREX Solution Transfer and Handling

Removal of the liquid THOREX waste solution from tank 8D-4 is accomplished by the vertical turbine pump 55-G-013. THOREX solution is pumped at approximately 80°F at a design flow rate of 30 gpm with THOREX solution in excess of the 5 gpm to tank 8D-2 being returned to tank 8D-4.

3.3.2 Zeolite Slurry Transfer and Handling

The spent zeolite generated by the STS is stored in tank 8D-1 prior to its removal and transfer to tank 8D-2. The storage system is described in WVNS-SAR-004. The removal of the spent zeolite will be accomplished by the vertical turbine pump 55-G-012. Zeolite slurry is pumped at a design flow rate of 75 gpm. The zeolite is transported to in-line size reduction grinding equipment designed for continuous operation. Grinding to the required particle size is accomplished on a single pass. The grinder consists of dispersion blades direct coupled to a standard three-phase 40 hp motor with an operating voltage of 460V, 60Hz.

3.3.3 HLWTS Utility Flush

A permanent transfer line flush system is provided to each of the three pump pits to permit prompt flushing of the HLW transfer lines. This flush system includes a 500 gallon break tank and a discharge pump to supply flush water to each of the pits for flushing the transfer lines in the trench or the pit jumpers. The utility flush system is connected to the STS utility air supply for air drying jumpers after flushing and prior to jumper removal. In the event of plugging or suspected plugging, this independent system will supply utility water to clear the line. However, each transfer line can be flushed with utility water to keep the transfer lines clean, thereby reducing the potential for line plugging. A minimum of two line volumes at a design flow rate of 80 gpm may be used in the flush.

3.3.4 8D-2 Sludge Mobilization Pumps

Five 15 meter (50 ft) long mobilization pumps have been installed at strategic locations within tank 8D-2 through tank risers. These pumps have been integral in the SMWS process for resuspending the PUREX settled sludge. The pumps do not remove material from the tank, but serve to resuspend the settled material and provide agitation by using the fluid in the tank to mix the contents. These pumps will be used for agitating the 8D-2 contents and mixing both the THOREX waste and spent zeolite which will be added to tank 8D-2. Specific details on the sludge mobilization pumps can be found in Section D.6.4 of WVNS-SAR-004.

3.3.5 8D-1 Zeolite Mobilization Pumps

The zeolite mobilization pumps installed in the 8D-1 tank are identical to the sludge mobilization pumps. Five zeolite mobilization pumps may also be used to resuspend the spent zeolite stored in tank 8D-1. Three of the five pumps have been used in the SMWS process to distribute the spent zeolite piles around the tank floor to maintain water cover and provide mixing of the corrosion inhibitors added to the tank. Section D.6.3.5 of WVNS-SAR-004 provides details on the zeolite mobilization pumps.

3.4 HLWTS Chemical Process Systems

THOREX waste transfer requires caustic addition to tank 8D-2. The Caustic Addition System used in the SMWS will be used in the same manner to add caustic to 8D-2 during the THOREX transfer operation. Section D.6.4 of WVNS-SAR-004 describes the Caustic Addition System.

3.5 HLWTS Process Support Systems

3.5.1 HLWTS Instrument and Control System

Instrumentation will be provided to monitor process variables and provide both automatic and manual control of the processing equipment. The majority of instruments will be connected to a Programmable Logic Controller (PLC) to provide local read-out and automatic control of key process variables at the HLWTS control station. Some local field instruments will be read by operations personnel during routine surveillance sweeps. Much of the HLWTS equipment consists of piping and valves to route HLW between tanks in the WTF. Valve position indicators on the pit jumpers will be reviewed both manually and via electronic signals before transfer of any fluids through the piping. Valve position switches indicate open or closed and provide electrical signals back to the PLC for interlock controls. Removal pumps will be operated with variable speed motor controllers to control the process flow of a waste transfer. In-line pressure switches and flow meters will be used to monitor the transfer of waste throughout the WTF.

At the control station the operator can remotely monitor all major aspects of the transfer operation. During emergencies, the removal pump can be manually shut down with emergency stop button at the control station or the variable speed controller and restarted through the normal startup sequence by the operators. The control station provides for safe operation with an alarm system that alerts the operators of any abnormal condition. The operator is able to monitor process conditions through panel mounted instrumentation. This includes a panel mounted graphic display flow diagram which indicates the position of all valves and the status of motors and storage tanks. Various electrical interlocks additionally ensure safe operation during any transfer operation. The P&ID's (Figures 15 through 19) show the instrumentation and control features associated with process control, process monitors, alarms, and their interrelationship. The control logic diagrams provide the details of the interlocks of the overall operation for the individual transfers.

Monitoring of the zeolite and sludge mobilization pumps will occur at the Motor Control Center (MCC) in the PVS building within the WTF. The mobilization pumps are operated using variable speed controllers to allow soft starting of the pumps. Appropriate interlocks have been supplied to stop the pump on loss of utility water, high seal water leakage, or high pump amperage.

3.5.2 Systems and Component Spares

Due to the single use nature of the THOREX and zeolite removal and transfer process, and the finite actual operating period expected (<1 year), problems associated with major component failure due to fatigue, wear, corrosion, etc. are expected to be minimal. However, the HLWTS process equipment in radioactive service are remotely replaceable and spares for select components particularly susceptible to failure, i.e., grinders, instrument jumpers, etc., are either maintained on-site as spares or installed redundancy exists in the system. The HLWTS equipment can be classified as either removable, non-contact service equipment and jumpers, permanently installed piping, or contact equipment.

Installed pit jumpers systems are connected to a water flush piping systems to reduce the contained contamination and minimize radiation exposure to operating staff should removal be required. Remote decontamination methods, such as rinsing pumps will be performed before removal is performed. No maintenance is forecast for this category of equipment.

Each permanently installed transfer line in the pipe trench has a redundant spare installed. Contact equipment, equipment not used in radioactive service, and vendor recommended spare parts are stored on-site for selected equipment.

3.6 HLWTS Control Room

The control station for the HLWTS is located within the V&S building which is located in the WTF. The SMWS controls consist of a series of variable speed controllers which have all pump monitored operating variables mounted on the controller doors.

3.7 HLWTS Sampling and Analytical Requirements

Capabilities for complete radiochemical analysis of tank 8D-2 solutions to monitor and control the THOREX transfer will be provided by the "Off-Line" Pneumatic Sample Transfer System (lab analysis) used for the STS process. Samples of 8D-2 solutions will be routinely extracted using the supernatant removal pump (50-G-001) and sampling ports in the STS valve aisle. Details of this sampling system are given in Section D.6.7 of WVNS-SAR-004. The HLWTS run plan will specify the sampling plan to be used by operations. This plan will provide the minimum sampling frequency to be used during the periods of THOREX addition to tank 8D-2. The limits for sample results and the appropriate actions required to control the process will be contained in the THOREX transfer procedures.

REFERENCES FOR SECTION 3.0

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4.0 ACCIDENT SAFETY ANALYSIS

4.1 Abnormal Operations

Abnormal events are events that could occur from the malfunctioning of systems, operating conditions or operator error. Abnormal events are only of potential consequence for those systems in the HLWTS which process, control or confine radioactivity.

Some possible abnormal events are not discussed either because they do not pose a radiological or industrial hazard or because the effects are similar to, or less than, the abnormal events described below.

In the hazardous materials spills evaluated in WVDP-096, "Safety Assessment of WVDP Hazardous Substances," a major spill sufficient to escape off-site is not considered credible. Recognizing that major or even minor spills could result in hazards to WVDP personnel, the public, and the environment, the WVDP has implemented an Oil, Hazardous Substances, and Hazardous Wastes Spill Prevention, Control and Countermeasures Plan (WVDP-043, November 1989). This operating plan reviews, in detail, release flow paths, sources, system design, and the containment of possible spills or releases as well as prevention, preparedness, response, and notification procedures. Specifically, the plan conforms to the requirements of 40 CFR Part 112 and Part 151 (proposed), both dealing with facilities having a potential for hazardous substances releases.

4.1.1 Leak in the HLWTS Pit/Trench

4.1.1.1 8D-4 Transfer Leakage

The piping system for the 8D-4 transfer to 8D-2 through the pipe trench and HLW tank pits has been reviewed above in 3.1 of this SE. It is possible that during the transfer operations, a leak could occur either in the trench piping or from the valves/manifold/jumpers in the tank pits 8Q-4, 8Q-1, or 8Q-2. The detection, mitigation, and consequences of these abnormal leakage events are reviewed below. The 2-inch stainless steel transfer lines connecting the tank pits are doubly contained in the trench areas by a concentric annular pipe which is sealed to the stainless steel inner face of the HLW tank pump pits. A drain line connected to this annular jacket with a radiation probe location and a leak/hydro test connection, transfers any leakage to either the 8Q-2 or the 8Q-4 pit, depending upon the leak location. In the floor of each pit is a 2-inch stainless steel drain which provides access to the HLW tank riser. There is an overflow lip on the drain which, as a result of the floor slope, will retain approximately 120 gallons of leakage before it overflows into the riser and then to the HLW tank.

Located in this "pooled" pit area is a liquid level sensor which is adjustable and will detect trace liquid levels, (e.g., 1/8, 1/2, 1 in) or a range of 1 to 5 gallons, and alarm this condition at the Control Station.

The source of the pit liquid, as alarmed, is not immediately determinable. The liquid could result from pit cover leaks (rain water), valve leaks into the pit from cold systems, process line leaks from the trench areas (via the secondary containment drains described above) or transfer equipment within the pit (either line leaks or jumper connectors).

An abnormal event would be a small leak of 8D-4 solution at one of the many jumper connectors on the transfer pathway. Such leaks would be more of a drip or very low flow and therefore the pit retention and alarm system would easily cope with this event.

It is possible that a small, drip-type leak in the pump pits, might be undetected for some period of time. Design considerations have been made to significantly reduce the possibility of an uncontrolled return of leaked liquids to the HLW tanks. The drains in each of the pump pits have drain line seal assemblies which are designed to retain leaked liquids in the pump pits. Also, liquid sensor probes have been installed to detect any liquids that may collect in any of the pump pits. These sensors alarm at the control station which then requires a sample of the contained leak to be taken. Radiation probes will be used to determine if the collected liquid is radioactive. After the characteristics of the collected liquid are known, corrective actions can be taken to assure that the liquids can be returned to the HLW tanks safely.

4.1.1.2 Misrouting Assessment

The 8D-4 transfer pathway to HLW tank 8D-2, through the 8Q-4, 8Q-1, and 8Q-2 pits, has been described above. The valve operation needed for the 8D-4 solution transfer is performed via the valve extension handles through the pit covers. The valve positions are indicated by both the extension handle status and by valve limit switches which indicate in the control station, i.e., valve open (red) or closed position (green). Therefore, there are two independent checks on the correctness of the flow pathway. A QA-QC confirmation of this important operating step is a 3rd independent check.

Possible operational errors could result in either a higher than anticipated pumping rate and/or a misrouting to another location. A high pumping rate through the normal flow path to the 8D-2 tank would not represent a serious operational problem. The total quantity pumped, not the rate, is a concern in order to assure satisfactory pH control in 8D-2. A higher than normal rate of transfer would be evident from the liquid level measurements taken at either tank

(8D-2 or 8D-4) or a reading from the transfer line flow meter. The total quantity of 8D-4 solution transferred in any given batch is estimated to consume only one half of the free NaOH in tank 8D-2. The combination of liquid level measurements of tank 8D-4 and 8D-2, the flow meter in the transfer line, and the 100% excess caustic available in tank 8D-2 ensures that an inadvertent high pumping rate would not create any safety hazard.

Transfer to "other" locations is much more speculative. First, from each of the manifolds in the tank pits and the utility pit 8Q-5, the connection to "cold" areas (via the utility lines air, and chemical addition) by back flow is prevented by two ball valves and two check valves in series. At the nominal pressure in the transfer line, as produced by the 8D-4 transfer pump, backward flow through these lines is not considered credible. If it were to occur, radiation alarms would be initiated and any transfer flows would be stopped.

The installed process lines from the 8Q-4 pit can only transfer to 8Q-1. In 8Q-1 no valving is required, as a jumper directly connects the line coming into the pit to the outgoing line to 8Q-2. Therefore, the manifold in the 8Q-1 pit is bypassed. The abnormal event of a leak at this location, or an incorrectly installed jumper, has been reviewed in the leakage scenario analysis in Section 4.1 of this SE.

It would be possible to transfer from the manifold in 8Q-2 to the 8Q-5 pit and to the VIT building or back to Tank 8D-3. These transfers would require multiple errors in the valving of 3 or more valves (which will be locked and tagged) and their operation would be an overt act rather than a simple operator error. With the multiple checks and balances, and the few number of transfer events, a transfer "out of the system" is not considered credible.

After one batch cycle of 8D-4 HLW solution is transferred to tank 8D-2, the pH of HLW tank 8D-2 will be raised from pH 13 back to pH 13.3 (NaOH molarity from 0.1 to 0.2) by the addition of 20% NaOH from a tanker truck pumped directly into the 8D-2 tank.

4.1.2 Cold Chemical Events

There are several abnormal events/accidents that can be hypothesized related to the transfer of the NaOH from the tanker truck to tank 8D-2. Those events which are assessed below include surface spills of NaOH, non-specification chemicals in the NaOH truck, and incorrect routine of the NaOH transfer line.

4.1.2.1 NaOH Delivery and Transfer Accidents

Surface spills of NaOH from the 4,000 gallon tanker truck can result from an incorrect connection, a leaking or ruptured transfer line, or a truck accident. Both the leak or the truck accident have a very low probability of occurrence. Should one of these events occur, the consequences, particularly for the higher probability, small leakage events, would be both local and minor. An analysis of this specific transfer operation follows. The general control of spills of and mitigation of the consequences for hazardous substances has been developed in the WVDP site document, "Oil, Hazardous Substances, and Hazardous Waste Spill Prevention, Control and Countermeasures Plan" (WVDP-043, Rev. 4).

Consider first a truck accident, which has a very low probability of occurrence and an even lower probability of leakage. Highway data on liquid carrying truck accidents indicate a major accident every 5 x 10^{5} miles (FEMA, 1989). During the total course of the 8D-4 transfer operation, there is estimated to be only eight NaOH truck deliveries for a total of on-site travel of less than two miles. Further, WVDP has a site speed limit of 5 and 15 mph, thereby reducing both the probability of an accident and significantly reducing the probabilities of a leak in the event of an accident. Truck accident data (FEMA, 1989) indicate that significant leaks occurred in only 20% of the highway accidents which, as indicated above, have a rate of 2 x 10^{6} accidents/mile. When this resultant event reduction factor is considered, in combination with the highway statistics, a major leaking truck accident is not considered credible, as the combination has less than a 10^{6} probability for the total of the WVDP transfer operations.

Every time a portable hose connection is made for a truck liquid transfer operation, it has been estimated that a leak/accident will occur once every 10^{4} deliveries (FEMA, 1989). This would suggest that there is approximately a 10^{-3} probability of a leak event for the total 8D-4 transfer operation. Because of the few deliveries at WVDP and the critical nature of this process step, management oversight, and QA/QC procedures and controls are more rigorous than for typical, uncontrolled deliveries. These WVDP procedures reduce the driver-only, low leak probability to an even lower level.

The probability of an environmental release from a transfer leak is further reduced by the design of the truck unloading station. This transfer location has been designed for spill containment should it occur. The truck is backed into a sloped and bermed plastic lined area. The pump/transfer operation is locally manned at all times by both the truck delivery personnel and by WVDP operators, hence, any leak would be immediately detected and the flow stopped. Only very minor surface spills can be hypothesized.

An accident, even one beyond that considered credible from the above data, would have a high probability of on-site containment, as has been reviewed in the WVDP Spill Prevention Control Plan. Sodium hydroxide is a nonvolatile hazardous substance so that the only environmental risk is via a surface water pathway. Because of the surface drainage distances and immediate WVDP response to any major spill, essentially all of the spill would be retained.

The environmental consequences of even a major spill are relatively low and are not long-term. This was demonstrated by a major NaOH spill of 3,000 gallons from a tanker truck accident, into the drainage path which flows through WVDP, on April 8, 1986. The tanker truck driver lost control on a hill, the truck overturned, and the contents drained onto the road and then flowed down an incline into Buttermilk Creek above the WVDP site. Buttermilk Creek subsequently flows through the WNYNSC before draining into Cattaraugus Creek at the northern site boundary. In the WVDP investigation of that off-site spill, dead fish were observed in Buttermilk Creek, but the pH level, 14 to 18 hours later, was in the normal range. There were no spill retention techniques off-site which were used to mitigate the consequences of this major spill event.

Based on spill probabilities, and possible consequences from this abnormal event, a surface NaOH spill is not considered to be a significant risk to this 8D-4 HLW transfer operation.

4.1.2.2 Chemical Addition Error

It can be hypothesized that the NaOH truck could have a different concentration or a different chemical. The several layers of administrative and equipment control make it extremely improbable that a non-specification chemical would be delivered to the site and then be pumped in the 8D-2 HLW tank. The principle concern would be that of an acid addition.

The steps controlling the 20% NaOH addition to the 8D-2 tank are as follows:

- 20% NaOH is the written order to the chemical supply company.

- The truck/trailer delivering NaOH is not suitable for an acid delivery.

- Prior to the hook-up and transfer, in addition to an invoice check, a physical sample is taken from this truck, the pH is determined and the specific gravity is correlated with that of 20% NaOH. A laboratory analysis is also done to confirm both that the principle chemical is NaOH and to determine other trace materials to verify assure conformance to the NaOH purchase specification.

The more probable delivery error would be that of an incorrect NaOH concentration. This error would be picked up by the specific gravity test, but, even if it occurred, the consequences would not be serious and would be identified in the subsequent independent laboratory check of 8D-2 molarity and pH. For details on an inadvertent acid addition to tank 8D-2 see Section D.9.1.9 of WVNS-SAR-004.

Only after all of the above steps have been completed, will the portable hose connection and transfer be permitted.

4.2 Accidents

4.2.1 Accidents Analyzed

Four hypothetical, bounding accidents were analyzed in detail for the HLWTS and are discussed in the following sections:

These accidents are:

1. Rupture of the THOREX transfer pipeline between tank 8D-4 and tank 8D-2.
2. Collapse of t.. tank 8D-4 roof and vault; unneutralized THOREX.
3. Collapse of the tank 8D-2 roof and vault after THOREX transfer; neutralized THOREX plus supernatant heel left from third wash of PUREX sludge.
4. Collapse of the tank 8D-2 tank and vault after THOREX and zeolite transfer; same source term as 3 above plus all Cs-137 in solution.

All four accidents assume a severe external event has caused major structural damage. Such an event would require at least 4 times the design basis natural phenomena postulated for the WVDP and the resistance of the HLWTS confinement barriers to the associated loads. Nevertheless, these scenarios are presented to illustrate boundary case analyses.

Radiological consequences were analyzed for airborne pathways only. The accidental release of HLW in liquid form from the HLWTS facilities to the environment has been determined to be unlikely, either as a result of internally induced/man-caused events or as a result of design basis natural phenomena (earthquake, tornado) events.

4.2.2 Source Terms

The source terms (quantity and distribution of radionuclide species released to the environment) used in the accident analysis depend on many factors, including the quantity and type of radioactive material available, ventilation conditions, and the performance of engineered and administrative barriers.

Tables 10 through 13 summarize the nature of the radioactive material and the nuclide distribution used in the analysis for each hypothetical accident scenario. All major radionuclides (those contributing >0.1% of the total CEDE) were used in the dose calculations. In the rupture of the THOREX transfer line (Accident 1) and the collapse of the tank 8D-4 roof and vault (Accident 2), the radioactive material is the unneutralized THOREX waste. In the collapse of the tank 8D-2 roof (Accident 3), the radioactive source material is the neutralized THOREX plus the supernatant heel that remains in tank 8D-2 after the third sludge wash. Accident 4 is the same scenario as accident 3 (8D-2 roof and vault collapse) with a larger source term inventory. The source term inventory for the fourth accident is the same as the third accident plus the addition of the Cs-137 loaded zeolite. For conservatism, it is assumed that all of the cesium loaded onto the zeolite comes into solution making it available for dispersion.

All four of these hypothetical, bounding accidents result in the off-site release of radioactivity. The released material would probably be in the form of an aerosol or entrained particles.

A two-hour release is assumed as the basis for calculating maximum site boundary doses following accidents because it will be possible to control the source and/or remove any potentially exposed individuals within that time. In addition, this duration provides conservatism in selecting a value for the relative dispersion (χ/Q) of airborne releases.

Of the four accidents described as bounding scenarios (see Tables 10 through 13), all are considered incredible and were described in order to emphasize the inherent safety of the operations. Accident 1 (rupture of THOREX transfer line) would require an earthquake 10 times the design basis of 0.1 g. Even this noncredible accident would result in a two-hour dose of 0.47 rem CEDE at the nearest residence. The dose from all other accidents would be significantly less. Accidents 2 (8D-4 roof and vault failure), 3, and 4 (8D-2 roof and vault failures) also requires extremely improbable events, including greater-than-design-basis natural phenomenon.

For the accidents involving evaporation of solutions (Accidents 1-4), airborne effluents are estimated by assuming a release partition coefficient (PC) (ratio of concentration in liquid to that in vapor phase) of 1,000 for nonvolatile compounds, 500 for semi-volatile compounds, and one for volatile compounds (ANSI, 1981).

For the rupture of the THOREX transfer line (Accident 1), it is assumed that the occurrence of a severe earthquake greater than 10 times the design basis (0.1 g) causes the trench cover to fall and break the transfer line. It is assumed the transfer pump continues to operate at full capacity (30 gpm) and pumps THOREX waste to the trench for a period of two hours. No mitigating credit was taken for the trench covers. This results in an evaporation rate of 52 L/h. The evaporation rate was calculated by assuming that the surface of the THOREX liquid was at 46°C (115°F), and had a surface area of 98.8 m^2 which was exposed to a 2 m/s wind speed. The evaporated THOREX solution is assumed to be released directly to the environment without any mitigating features or passing through any HEPA filters.

For the collapse of the tank 8D-4 roof and vault (Accident 2) and the collapse of 8D-2 roof and vault (Accidents 3 and 4), it is assumed the occurrence of a severe earthquake greater than 4 times the design basis causes the roofs of the vaults and tanks to collapse, exposing the entire surface area of the radioactive material contents to the atmosphere. This results in evaporation rates from tank 8D-4 of 35 L/h and from tank 8D-2 of 1,000 L/h. The evaporation rates were calculated by assuming, for conservatism, that the surface of the liquid was at 46°C (115°F) for tank 8D-4 and 80°C (203°F) for tank 8D-2, level with grade, and the entire surface area of the tanks were exposed to a 2 m/s wind at zero percent absolute humidity. These highly conservative assumptions exceed the consequences of any splashing and subsequent physical material spread to the environment that may occur during the collapse of the roofs. The evaporated THOREX solution and blended PUREX supernatant are assumed to be released directly to the environment without passing through any HEPA filters.

4.2.3 Radiation Doses

Assumptions for calculating radiation doses to workers and the public are presented in WVDP-065, "Radiological Parameters for Assessment of West Valley Demonstration Project Activities." In brief, the maximally exposed individual during an accident is assumed to be at the point on the perimeter where the largest airborne concentration of radioactivity would occur. The radioactivity concentration is based on the maximum sector χ/Q. The external and internal dose conversion factors are taken from DOE/EH-0070, "External Dose Rate Conversion

Factors for Calculation of Dose to the Public," and DOE/EH-0071, "Internal Dose Conversion for Calculation of Dose to the Public." These dose factors are consistent with DOE Order 5480.11.

Unit dose conversion factors are from a unit release (e.g., rem/Ci) of each isotope, as discussed in WVDP-065, and are used to calculate the total committed effective dose equivalent (CEDE). The total CEDE from a release is determined by summing the component doses received from each isotope in the source term. The dose conversion factors are in accordance with DOE Order 5480.11.

4.2.3.1 Radiation Doses to the Public

Using the source terms indicated in Section 4, the projected dose to the maximally exposed off-site individual is presented in this section for each of the three HLWTS hypothetical accident scenarios previously described. The meteorological dispersion and dose calculation methodology used is described in detail in "Radiological Parameters for Assessment of West Valley Demonstration Project Activities" (WVDP-065, 1990).

For all accident scenarios, a ground level release (≤10 m) was assumed to estimate meteorological dispersion.

Only those nuclides contributing greater than 0.1% of the dose to the maximally exposed off-site individual were included in the dose assessment. This was determined by multiplying the individual nuclide source term (Ci) by the appropriate dose conversion factor (WVDP-065, 1990 - rem/Ci released) to determine the dose contribution for the individual radionuclide. Tables 10 through 12 present dose estimates for the significant radionuclides released for all accidents. The worst case hypothetical accident is calculated to result in a CEDE of 0.47 rem.

4.2.3.2 Radiation Doses to Workers

Postulated HLWTS accidents involve releases directly to the environment and are considered to be the worst case scenarios for the HLWTS.

In no accident scenario is it considered credible that fundamental structural barriers are breached. There would be no direct external exposure of workers to HLW in an uncontrolled situation. (Mitigative measures and response actions would be accomplished in accordance with WVDP-010, "Radiological Controls Manual" and therefore potential external exposure would be controlled within WVNS limits.) Accordingly, the postulated effect on on-site personnel from the HLWTS accidents evaluated here is limited to inhalation (internal) exposures to the airborne release.

Tables 10 through 13 present the estimated CEDEs to an on-site individual who remains continuously at 100 meters from the point of release for two hours during the accident.

Conclusion

The consequence of the accidents analyzed is proportional to the concentration of the radioactivity or the total radioactivity contained within the component, the mode of failure, the path of release for the source term (direct to the environment or through a filtered ventilation system), and the release height. In other words, the initial conditions, within physical boundaries, for each of the major components is set to maximize the off-site dose, given an accidental failure of the component. No weight is given to the probability of failure, mode of failure, or initial conditions. All analyses are of a deterministic nature and are considered to be the worst case. Based on the results of this SE, the bounding dose calculated to the maximally exposed off-site individual (<500 mrem) is within the consequence of the bounding accident analyzed (<800 mrem) in the approved authorization basis WVNS-SAR-004.

REFERENCES FOR SECTION 4.0

ANSI, 1981. American National Standards Institute. July 1981. *Guidance for Defining Safety Related features of Nuclear Fuel Cycle Facilities.* ANSI N46.1-1980.

U.S. Department of Energy. June 17, 1992. DOE Order 5480.11: *Radiation Protection for Occupational Workers.*

West Valley Demonstration Project. WVDP-010: *Radiological Controls Manual.*

________________. WVDP-043: *Oil, Hazardous Substance, and Hazardous Wastes Spill Prevention, Control, and Countermeasures Plan.*

________________. WVDP-065: *Radiclogical Parameters for Assessment of WVDP Activities.*

________________. WVDP-096: *Safety Assessment for Hazardous Substances.*

________________. OSR-IRTS-1: *Maintenance of Carbon Steel Waste Tank Integrity.*

TABLE 1

TANK 8D-4 & TANK 8D-2 TRANSFER

No.	Structure or Component	Function	Primary Barrier	Support Barrier
1A	Tank 8D-4	THOREX High-level waste storage	Stainless steel tank Reinforced concrete vault and steel liner pan[1] Soil excavation in tight clay fill	Negative internal pressure via Waste Tank Farm Ventilation System Saturated clay fill prevents seepage
1B	THOREX Removal Pump and Tank 8D-4 Access Riser	Transition from Tank 8D-4 to Pump Pit 8Q-4 Penetration of tank top and vault roof for removal pump access	Pump column assembly and pump discharge line Stainless steel riser Reinforced concrete tank vault and steel liner pan[1] Reinforced concrete pump pit Soil excavation in tight clay fill	Negative internal pressure via waste tank farm ventilation system
2A	Pump Pit 8Q-4	THOREX waste transfer equipment containment	Single wall stainless steel pipes (jumpers)[2] Stainless steel liner pan Reinforced concrete Pump pit box[1] Partial soil embedment in clay backfill	Negative internal pressure via waste tank farm ventilation system
2B	Pump Pit 8Q-4 Wall	Transition from Pump Pit 8Q-4 to High Level Waste (HLW) Transfer Trench Penetration of pump pit wall	Double wall stainless steel pipe (dual barrier) Pit wall bulkhead with PVC water stop at pit to trench connection[3]	

TABLE 1 *(continued)*

No.	Structure or Component	Function	Primary Barrier	Support Barrier
3	High Level Waste (HLW) Transfer Trench	Support Structure and Passageway for THOREX waste transfer piping	Double wall stainless steel pipe (dual barrier) Reinforced concrete transfer pipe trench [1] Partial soil embedment of soil excavation and backfill	
4A	Pump Pit 8Q-1 Wall	Penetration of Pump Pit 8Q-1 wall HLW Transfer Trench Transition to Pump Pit 8Q-1	Double wall stainless steel pipe (dual barrier) Pit wall bulkhead with PVC water stop at pit to trench connection	
4B	Pump Pit 8Q-1	THOREX waste transfer pipe (jumper) containment[4]	Single wall stainless steel pipe (jumper) Stainless steel liner pan Reinforced concrete Pump pit box[1] Partial soil embedment in clay backfill	Negative internal pressure via Waste Tank Farm Ventilation System
4C	Pump Pit 8Q-1 Wall	Transition to HLW Transfer Trench Penetration of Pump Pit 8Q-1 wall	Double wall stainless steel pipe (dual barrier) Pit wall bulkhead with PVC water stop at pit to trench connection	
5	High Level Waste (HLW) Transfer Trench	Support Structure and Passageway for THOREX and zeolite waste transfer piping	Double wall stainless steel pipe (dual barrier) Reinforced concrete transfer pipe trench[1] Partial soil embedment of soil excavation and backfill	

TABLE 1 *(continued)*

No.	Structure or Component	Function	Primary Barrier	Support Barrier
6A	Pump Pit 8Q-2 Wall	Penetration of Pump Pit 8Q-2 wall HLW Transfer Trench Transition to Pump Pit 8Q-2	Double wall stainless steel pipe (dual barrier) Pit wall bulkhead with PVC water stop at pit to trench connection	
6B	Pump Pit 8Q-2	THOREX Process flow control	Single wall stainless steel pipes (jumpers) and valves Stainless steel lined pan Reinforced concrete pump pit box Partial soil embedment	Negative internal pressure via Waste Tank Farm Ventilation System
7A	Tank 8D-2 Access Riser	Penetration of tank top and vault roof for transfer line access Transition from Pump Pit 8Q-2 to Tank 8D-2	Tank entry line Carbon steel riser Reinforced concrete tank vault and steel liner pan[1] Soil excavation in tight clay fill	Negative internal pressure via tank farm ventilation system
7B	Tank 8D-2	Storage of Neutralized THOREX and Washed Sludge from SMWS process	Carbon steel tank Reinforced concrete vault and steel liner pan[1] Soil excavation in tight clay fill	Negative internal pressure via WTFVS Saturated clay fill prevents seepage

ENDNOTES

1. Highest barrier reliability for seismic.

2. THOREX flows in a single wall stainless steel pipe from the inside face of the pit wall (jumper), to a single wall pipe installed through the access riser into the 8D-2 tank. All barriers in this pathway have previously been defined.

3. THOREX waste flows into a double wall stainless steel pipe from the 8Q-4 Pump Pit on top of 8D-4 Tank Vault, through the pit wall into the transfer trench structure. As the double wall pipe transitions from the pit wall to the trench it passes through a pit to trench separation joint (e.g., expansion joint).

4. THOREX and zeolite waste transfer piping share a common trench section.

TABLE 2

TANK 8D-1 & TANK 8D-2 TRANSFER

No.	Structure or Component	Function	Primary Barrier	Support Barrier
1A	Tank 8D-1	High-level waste storage Cesium Loaded Zeolite	Carbon steel tank Reinforced concrete vault and steel liner pan[1] Soil excavation in tight clay fill	Negative internal pressure via Waste Tank Farm Ventilation System Saturated clay fill prevents seepage
1B	Zeolite Removal Pump and Tank 8D-1 Access Riser	Transition from Tank 8D-1 to Pump Pit 8Q-1 Penetration of tank top and vault roof for removal pump access	Pump column assembly and pump discharge line Carbon steel riser Reinforced concrete tank vault and steel liner pan[1] Reinforced concrete pump pit Soil excavation in tight clay fill	Negative internal pressure via waste tank farm ventilation system
2A	Pump Pit 8Q-1	Zeolite waste transfer process flow control and equipment containment	Single wall stainless steel pipes (jumpers)[2] Stainless steel liner pan Reinforced concrete Pump pit box[1] Partial soil embedment in clay backfill	Negative internal pressure via waste tank farm ventilation system

TABLE 2 *(continued)*

No.	Structure or Component	Function	Primary Barrier	Support Barrier
2B	Pump Pit 8Q-1 Wall	Transition from Pump Pit 8Q-1 to High Level Waste (HLW) Transfer Trench Penetration of pump pit wall	Double wall stainless steel pipe (dual barrier) Pit wall bulkhead with PVC water stop at pit to trench connection[3]	
3	High Level Waste (HLW) Transfer Trench	Support Structure and Passageway for Zeolite waste transfer piping	Double wall stainless steel pipe (dual barrier) Reinforced concrete transfer pipe trench [1] Partial soil embedment of soil excavation and backfill	
4A	Pump Pit 8Q-2 Wall	Penetration of Pump Pit 8Q-2 wall HLW Transfer Trench Transition to Pump Pit 8Q-2	Double wall stainless steel pipe (dual barrier) Pit wall bulkhead with PVC water stop at pit to trench connection	
4B	Pump Pit 8Q-2	Remote piping (jumpers) and equipment (grinder) containment	Single wall stainless steel pipes (jumpers) and valves Stainless steel lined pan Reinforced concrete pump pit box Partial soil embedment	Negative internal pressure via Waste Tank Farm Ventilation System

TABLE 2 *(concluded)*

No.	Structure or Component	Function	Primary Barrier	Support Barrier
5A	Tank 8D-2 Access Riser	Penetration of tank top and vault roof for transfer line access Transition from Pump Pit 8Q-2 to Tank 8D-2	Tank entry line Carbon steel riser Reinforced concrete tank vault and steel liner pan[1] Soil excavation in tight clay fill	Negative internal pressure via tank farm ventilation system
5B	Tank 8D-2	Storage of size reduced Zeolite, Neutralized THOREX and Washed Sludge from SMWS process	Carbon steel tank Reinforced concrete vault and steel liner pan[1] Soil excavation in tight clay fill	Negative internal pressure via WTFVS Saturated clay fill prevents seepage

ENDNOTES

1. Highest barrier reliability for seismic.

2. Zeolite flows in a single wall stainless steel pipe from the inside face of the pit wall (jumper), to a single wall pipe installed through the access riser into the 8D-2 tank. All barriers in this pathway have previously been defined.

3. Zeolite waste flows into a double wall stainless steel pipe from the 8Q-1 Pump Pit on top of 8D-1 Tank Vault, through the pit wall into the transfer trench structure. As the double wall pipe transitions from the pit wall to the trench it passes through a pit to trench separation joint (e.g., expansion joint).

4. THOREX and zeolite waste transfer piping share a common trench section.

TABLE 3

DESIGN CODES AND STANDARDS FOR HLWTS STRUCTURAL COMPONENTS

System	Structural Component	Design Code and Standard	Seismic Factor	Footnote
Mobilization Pump	Pump, Column & Motor	1985 UBC	Z=3 I=1.5	(1) (2)
	- Steel	AISC 8th Edition 1980		
	- Welding	AWS Section D1.1 ASME Section VIII, V, IX		
	- Steel Pipe, Valves and Fittings	ANSI, B16.5, B16.11, B16.34, B31.3, 1980 Edition		
Pump Support Structure (Truss & Footings)	- Structural System	1985 UBC	Z=3 I=1.5	(1)
	- Steel Truss	AISC 8th Edition 1980 AWS D1.1-84 ANSI A56.1 - 1982	I=1.07 Exp=C	(3)
	- Concrete	ACI 318-77		
	- Footings	Dames & Moore, 1986 Foundation Recomm.		
Trench/Pits	- Concrete	ACI 318-77	0.1g Horz. Reg Guide 1.60/1.61	
	- Steel Supports	AISC-1980		
Piping	- Steel Pipe and Fittings	ANSI B16.0 ANSI/ASME B31.1, 1987		
	- Welding	AWS D1.1-88 ASME Section VIII, V, IX		

(1) Tornado wind and missile loading was not a design requirement for the Mobilization Pump Components.

(2) Design codes and standards for the Mobilization Pumps are referenced in WVNS-EQ-202, Rev. 5, October 1990.

(3) Design codes and standards for the Mobilization Pump Support Structure are referenced in WVNS-EBAR-735, 735A and 534.

TABLE 4

DESIGN CODES AND STANDARDS FOR HLWTS CONFINEMENT SYSTEMS

Structure or Confinement	Confinement Barrier	Design Code or Standard	Seismic Factors	Foot-note
Tanks 8D-1 and 8D-2	Carbon steel tank	API 650 (1961 version)	None	
	Reinforced concrete tank vault	1961 UBC	Z=III	(1)
		1956 ACI, Building Code Requirements for R/C, 318-56		
	Soil excavation and backfill	Bechtel construction specifications - 1963		
Tank 8D-4	Stainless steel tank	API 650 (19xx version)	xx	x
	Reinforced concrete tank vault	1961 UBC		
	Soil excavation and backfill	Bechtel construction specifications - 1963		
Riser	Carbon Steel Pipe	1982 UBC ANSI B31.3, 1980	Z=3 IF=1.0	(2) (3) (4)
	Shield Plug or	ANSI B31.3, 1980	None	
	Stainless Steel Pump Column	1985 UBC ASME Section VIII	Z=3 IF=1.5	
Pump Pit	Jumpers	1985 UBC ANSI/ASME B31.3, 1987	Z=3 IF=1.5	(5)
	Stainless Steel Liner	Reg Guide 1.60/1.61 AISC - 1980	0.1g Horz	(6)
	Reinforced Concrete Box	Reg Guide 1.60/1.61 ACI 318-77	0.1g Horz	
	Soil Excavation and Backfill	Construction Specification WVNS-CS-194		
HLW Transfer Piping	Stainless Steel Primary Pipe	Reg Guide 1.60/1.61 ANSI/ASME B31.3, 1987	0.1g Horz	(6)
	Stainless Steel Secondary Pipe	Reg Guide 1.60/1.61 ANSI/ASME B31.3, 1987	0.1g Horz	
	Reinforced Concrete Trench	Reg Guide 1.60/1.61 ACI 318-77	0.1g Horz	
	Soil Excavation and Backfill	Construction Specification WVNS-CS-194		

Footnotes

(1) Seismic zone, Z=III, of the 1961 Uniform Building Code (UBC) is slightly different from the 1982 and 1985 UBC, Z=3.

(2) Design codes and standards for the Remote and Manual Riser Penetrations of Tank 8D-2 are referenced in WVNS-DC-026, Rev. 0, June, 1986.

(3) Tornado wind and missile loading was not a design requirement for the Mobilization Pump equipment.

(4) Design codes and standards for the Pump Column are referenced in WVNS-EQ-XXX, Rev. 1, Feb., 1993.

(5) Design codes and standards for the HLWTS are referenced in WVNS-DC-046, Rev. 0, July, 1992.

(6) Design codes and standards for Trench and Piping are referenced in Ebasco Civil Design Criteria Sludge Mobilization System, Rev. 2, April, 1992, EBAR 1665

TABLE 5

SAFETY CLASSIFICATION OF IMPORTANT STRUCTURES, SYSTEMS AND COMPONENTS ASSOCIATED WITH THE HLW TRANSFER SYSTEM

Component or System	Safety Class	Quality Level
STRUCTURES		
- High-Level Waste (HLW) Tank Vault (8D-1)	C	C
- HLW Tank Vault (8D-2)	C	C
- HLW Tank Vault (8D-4)	C	C
- Connecting Transfer Pipe Trench (Pits 8Q-1 to 8Q-2 and 8Q-4)	C	C
- Mobilization Pump Support Structure		
- Pump Pits (8Q-1, 8Q-2, and 8Q-4)	C	C
- Sheet Metal Building (V&S Building)	C	C
- Mobilization Pump Weather enclosures	N	N
	N	N
HLW TRANSFER OPERATIONS		
- High-level Waste (HLW) Storage Tanks		
• HLW Tank 8D-1 (Modifications to provide tank access)	C	C
• HLW Tank 8D-2 (Modifications to provide tank access)		
• HLW Tank 8D-4 (Modifications to access riser)	C	C
• Tank Access Riser		
	C	C
	C	C
- HLWST Tanks		
• Flush Water Break Tank	N	C
- Pumps		
• THOREX Removal Pump	C	C
• Zeolite Removal Pump	C	C
• Flush Water Break Tank Pump	N	C
• Zeolite Mobilization Pumps	C	C
• Sludge Mobilization Pumps	C	C
• Grinder	C	C
- Material Handling System		
• Mobile Cranes (as needed)		

TABLE 5 (continued)

SAFETY CLASSIFICATION OF IMPORTANT STRUCTURES, SYSTEMS AND COMPONENTS ASSOCIATED WITH THE HLW TRANSFER SYSTEM

Component or System	Safety Class	Quality Level
-Process Piping		
• THOREX Transfer Trench	C	C
• Zeolite Transfer Trench	C	C
• HLW Transfer Jumpers	C	C
• Water Flush	N	C
- Valves		
• HLW Transfer Jumpers	C	C
• Zeolite Jumpers	C	C
• Water Flush	N	C
• Utility Services	N	C
MONITORING SYSTEMS, CONTROLS AND INSTRUMENTATION		
- Area Radiation Monitors		
• Process Radiation Monitoring	C	C
• Ventilation Monitoring System and Alarms	C	C
- Communications Equipment	N	N
- Electronic Systems and Controls		
• Control Panel	C	C
• Instruments and Sensing Elements	C	C

TABLE 5 (concluded)

SAFETY CLASSIFICATION OF IMPORTANT STRUCTURES, SYSTEMS AND COMPONENTS ASSOCIATED WITH THE SUPERNATANT TREATMENT SYSTEM

Component or System	Safety Class	Quality Level
UTILITIES AND SUPPORTING SYSTEMS		
- Electrical Power Systems		
* Motor Control Center	C	C
* Conduits and Trays	C	C
* Lightning Protection	C	C
- Utility Systems		
* Utility Air	N	N
* Instrument Air	N	N
* Fire Detection and Protection	N	N

NOTE: At boundaries between items of differing Safety Classification, interfaces appropriate to the higher Safety Class must be provided.

TABLE 6

LOCATION OF MAJOR HLWTS COMPONENTS

Removal and Mobilization Pumps	Original Tanks 8D-1, 8D-2 and 8D-4.
Process Valves and Instruments	Pump Pits 8Q-1, 8Q-2, and 8Q-4.
Interconnecting Double Wall Piping	Waste Transfer Trench (shielded structure) communicating with Pits 8Q-1, 8Q-2, and 8Q-4.
Auxiliaries and Controls (Nonradioactive Service)	Existing V&S Building in the WTF.
Existing PVS	Existing V&S Building in the WTF.
Utilities	Existing V&S Building in the WTF and Utility Pits adjoining Pump Pits 8Q-1, 8Q-2, and 8Q-4

TABLE 7

ENGINEERING CODES/STANDARDS FOR NLWTS

Vessels	ASME Section VIII, Division I, 1983 Edition
Piping	ANSI B31.3, 1980 and 1987 Edition
Symbols for Welding and Nondestructive Testing	AWS A.2.4-1979
Dimensions and Tolerances	ANSI Y 14.5, 1973 Edition
Effluent and Process Control	ANSI N 13.1, 1969 Edition
	ANSI N 42.18, 1974 Edition
Structural	New York State Building Code
	AISC 1980 Edition
	ANSI A58.1-1982
	UBC, 1982 AND 1985 Edition
	NRC Reg Guide 1.60
Ventilation	ERDA 76-21, Nuclear Air Cleaning Handbook
Structural Welding	AWS D1.1, 1988 Edition
Electrical/Instrumentation	National Electrical Code, ANSI/NFPA-70
	NFPA National Fire Codes
	ANSI Standards
	NEMA Standards
	Institute of Electrical and Electronics Engineers (IEEE)
	Standards Underwriters Laboratories, Inc. (UL) Standards and Product Directories
	Department of Labor, "Occupational Safety and Health Standards," Title 29, Code of Federal Regulations (CFR), Part 1910 Electrical and Electronics Graphic Symbols and Reference Designations, ANSI/IEEE Y32E
	National Electric Safety Code, ANSI-C2
	Instrumentation Society of America, ISA-S5.1-73
Machined Surfaces	ANSI B46.1, 1978 Edition
Material Specification	ASME Section II
Nondestructive Examination (NDE)	ASME Section V
Qualifying Welders and Welding Procedures	ASME Section IX
Design	INEL Architectural Engineering Standards, Rev. 6, October, 1986
	DOE 6430.1A, "General Design Criteria Manual," April, 6, 1989
	Operational Safety Design Criteria Manual, ID-12044
Quality Assurance	ANSI/ASME NQA-1-1986

TABLE 8

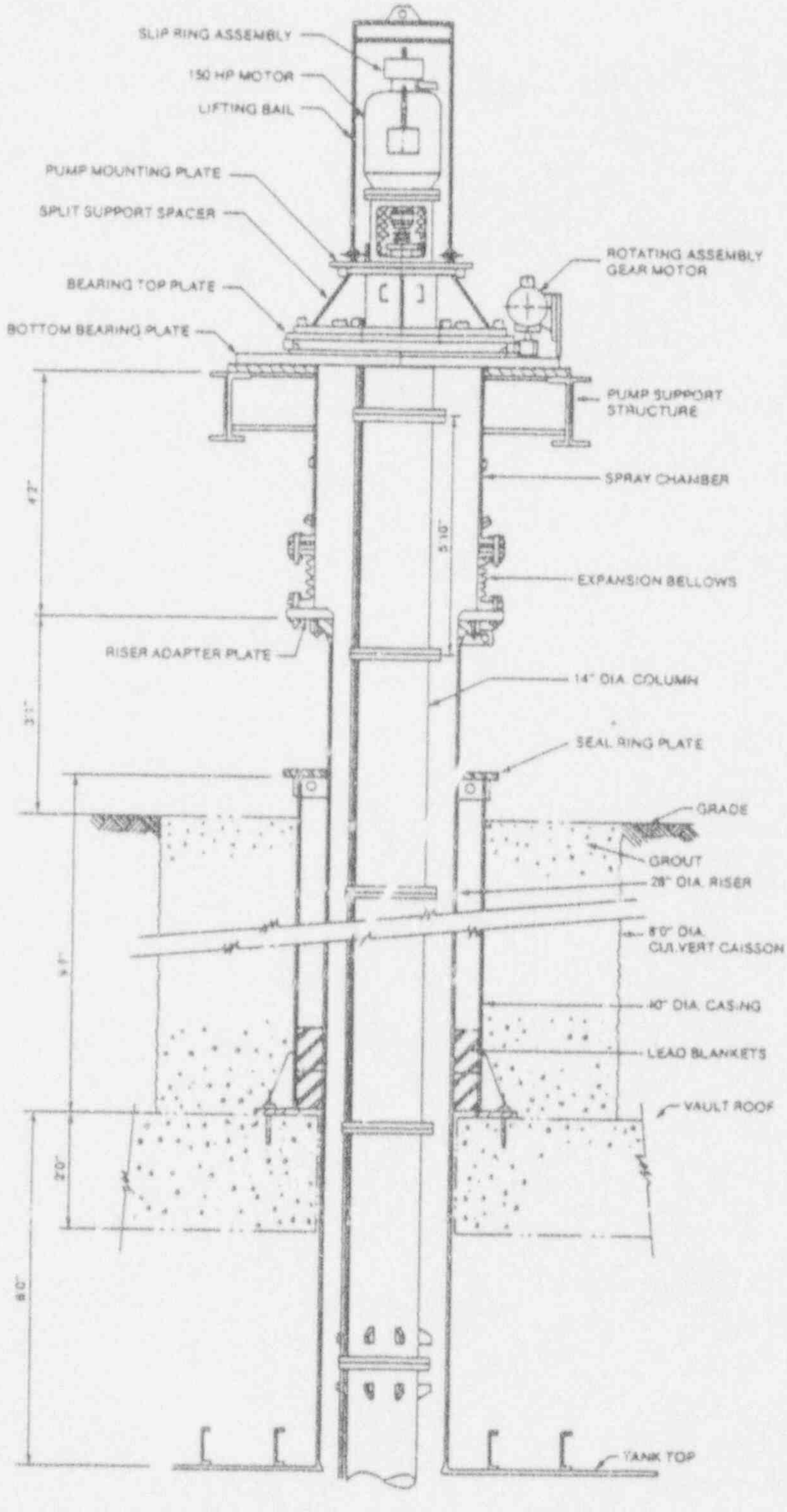
HLWTS LEAK DETECTION SYSTEMS

Structure Barrier	Nature of Leak	Detected By	Mitigation
Tanks 8D-1, 8D-2 and 8D-4	Tank leaks into vault	Leak detection system in vault pan	Can pump fluids from pan/vault back to tank; can pump fluids to other identical tank/vault system.
Pump Pits	Leak from Transfer jumper (single wall in pit) into pit	Leak detected by conductivity probe, alarms at HLWTS control station	Gravity drain into Tanks through pit drains
HLW Transfer Piping	HLW Transfer piping (double walled within trench) leaks into secondary pipe	Conductivity probe in annular space between pipe walls	Drain pipe in secondary pipe; gravity drain back to Tanks through pit drains
Components in Pits	Fluids leak from components into pit	Leak detected by conductivity probe, alarms at HLWTS control station	Gravity drain into Tanks through pit drains
Utility Pits	HLW Transfer leaks into utility flush feed line	On-line radiation monitors	Block and bleed valving drains to Pump Pit, gravity drain into Tanks through pump pit drains

TABLE 9

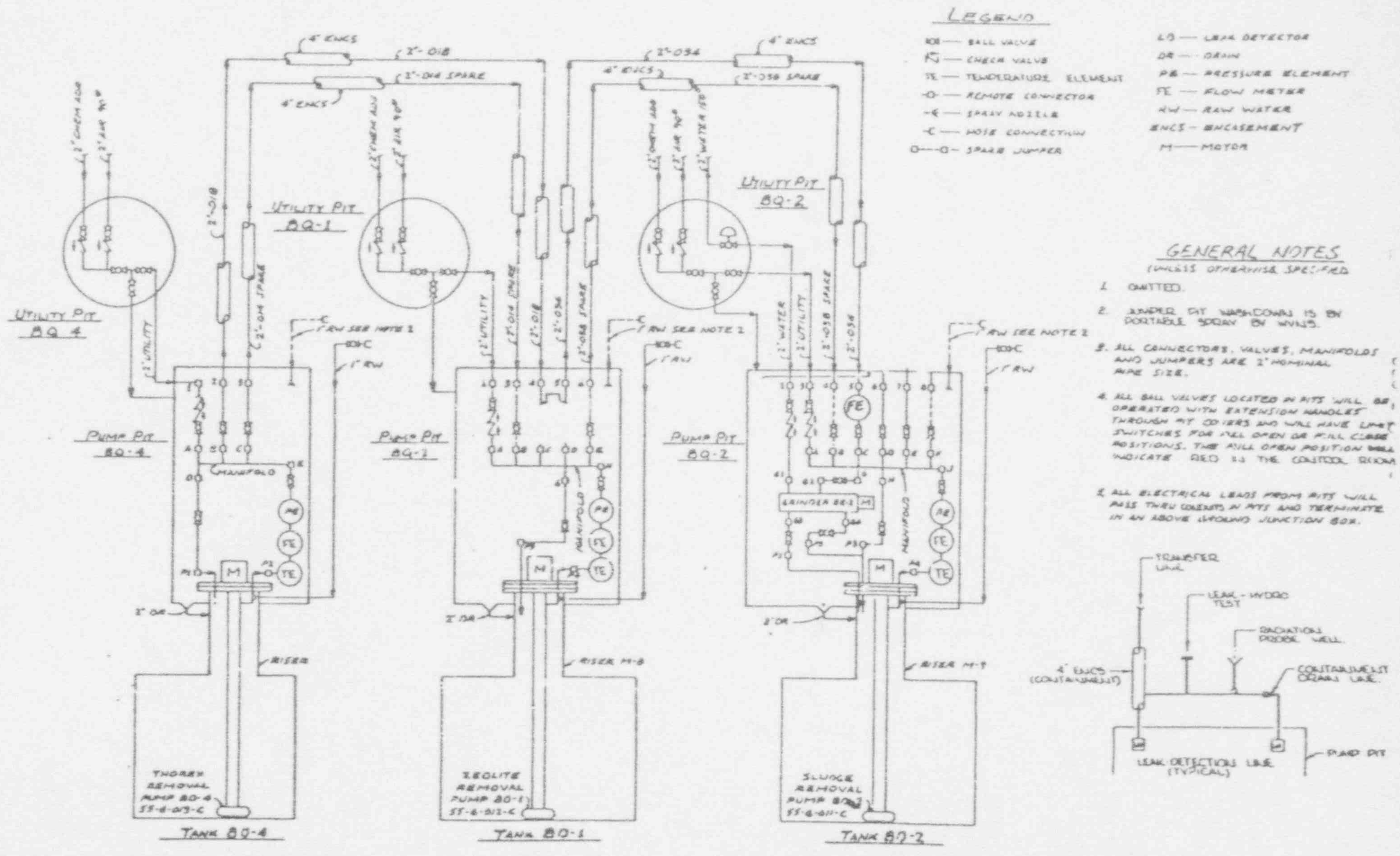
HLWTS UTILITIES REQUIREMENTS

Utility	Flow	Pressure (psig)	Service
Instrument Air	25 SCFM	50	Solenoid Valves
Utility Air	50 SCFM	90	Utility Station
Utility Water	75 GPM	90	Flush Water Break Tank
Electrical Power	190 to 200 kW at 480 Volts, 3-phase		Pumps and Grinder,



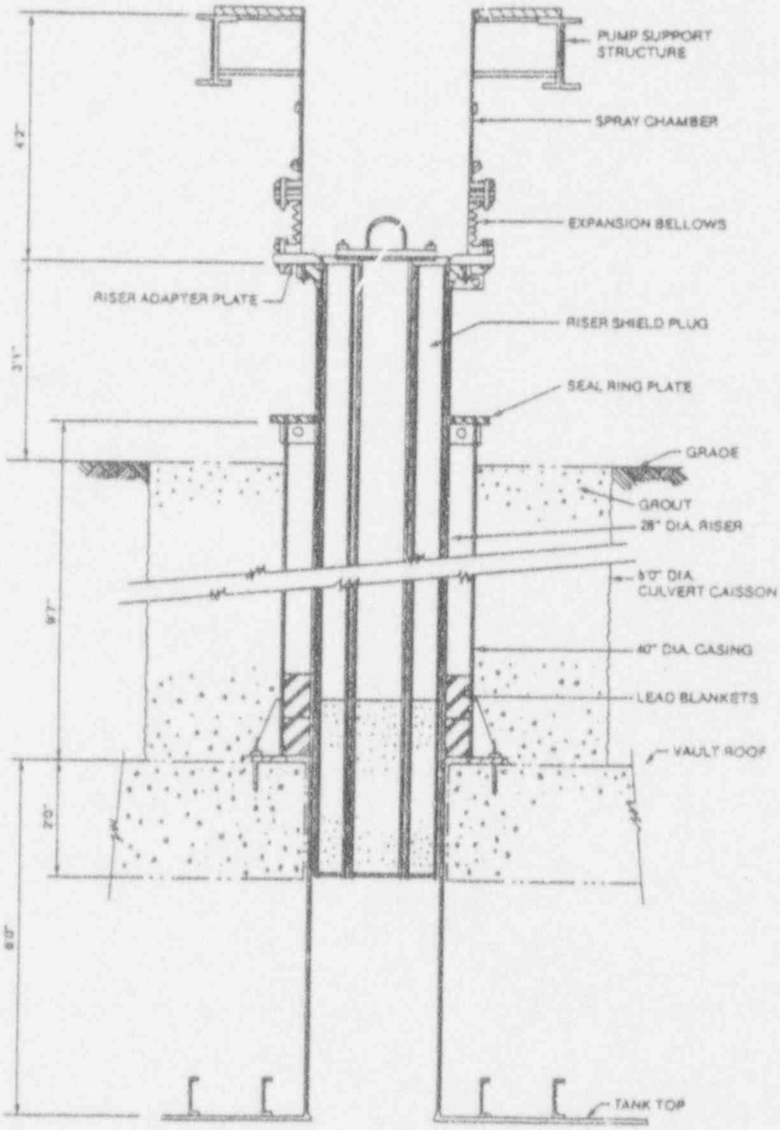
Waste Mobilization Pump Installed For Operation

Figure 1



Flow Diagram Tank 8D-4 & 8D-1, To 8D-2

Figure 2



Waste Tank Mobilization Pump Riser

Access Riser

Figure 3

TANK 8D-1/8D-2
PLAN AND ELEVATION
ABOVE INTERNAL GRIDWORK

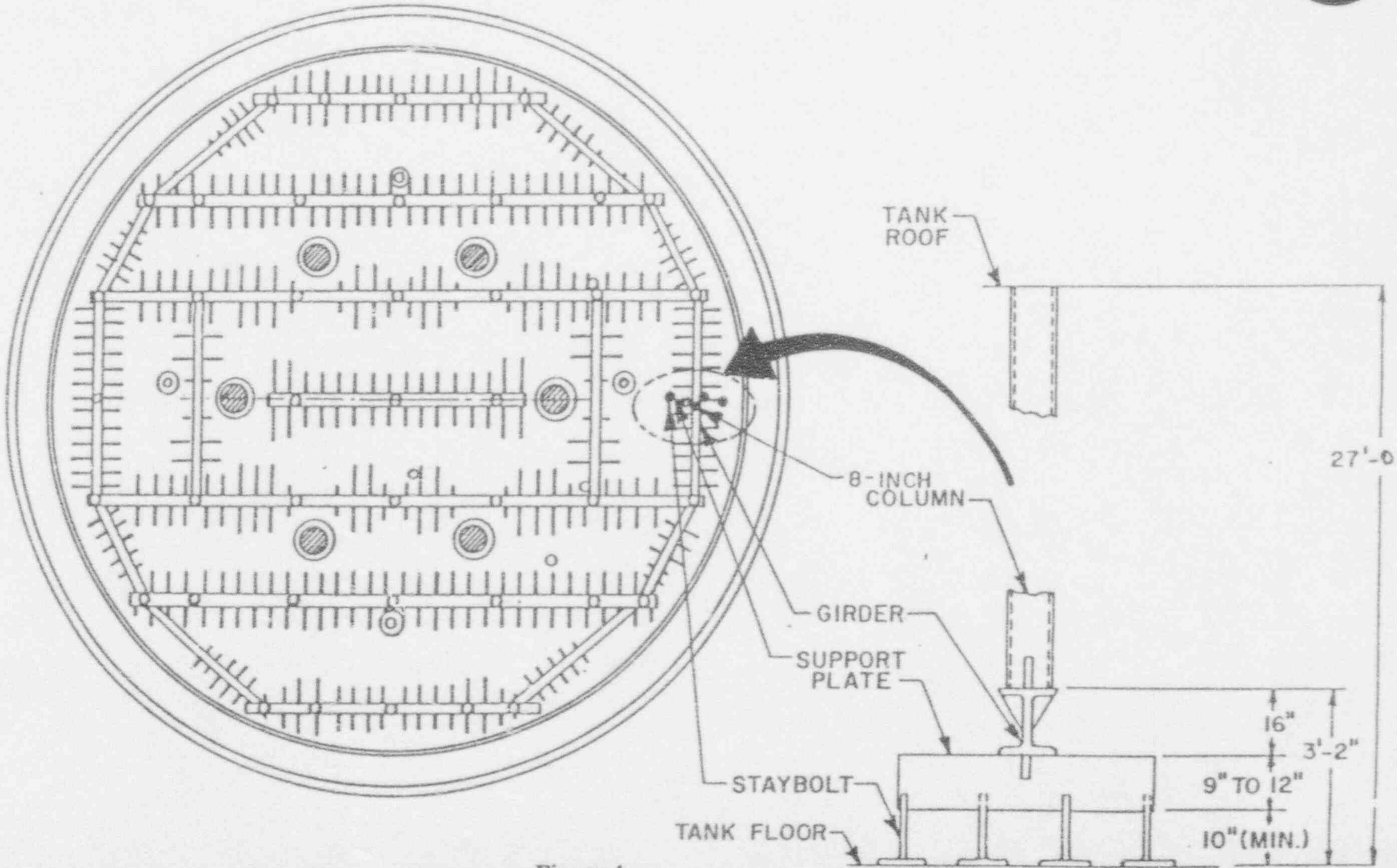


Figure 4

HLWTS FACILITIES LAYOUT

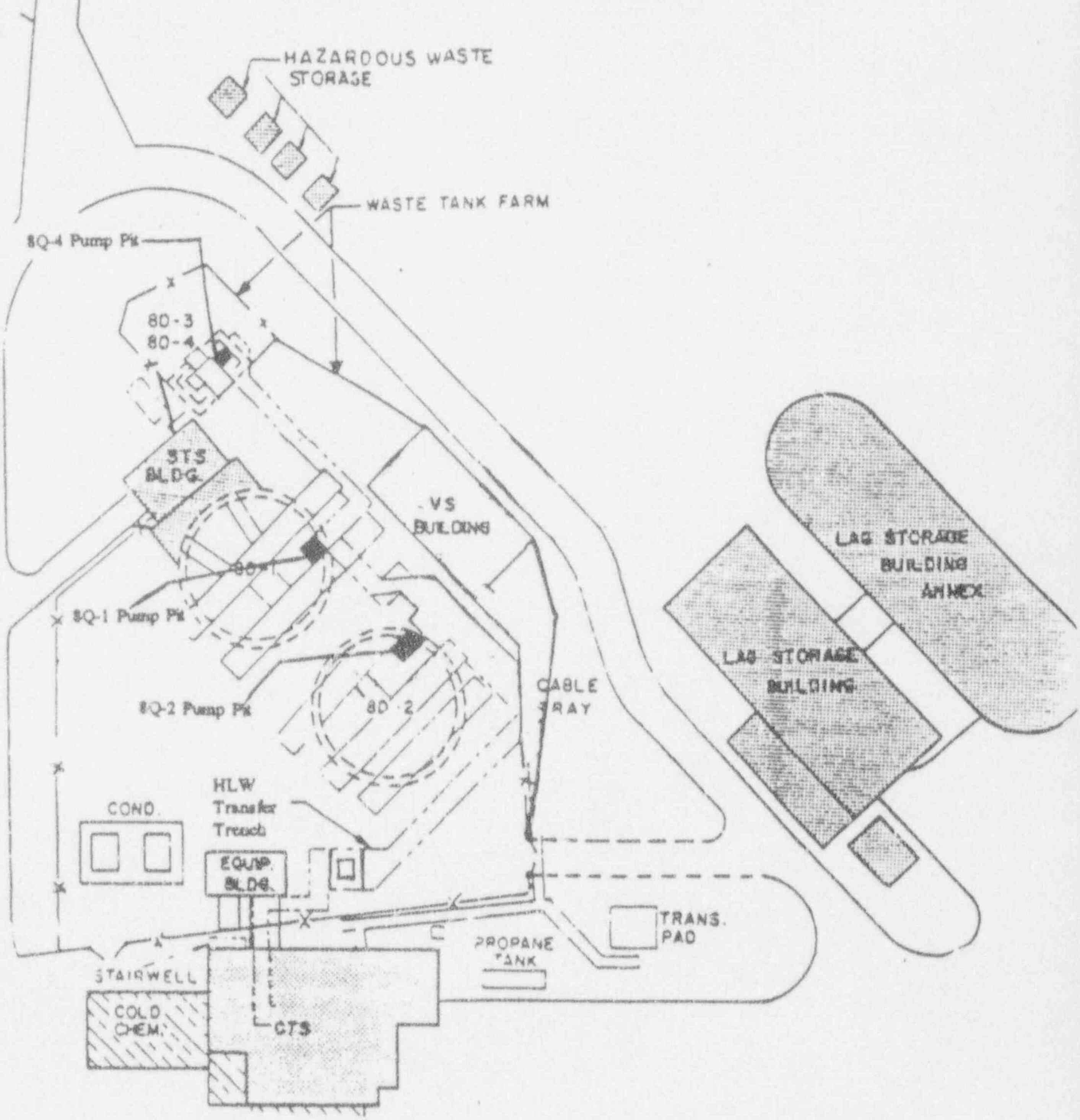


Figure 5

8D-1 & 8D-2 MOBILIZATION PUMP TANK FARM LAYOUT

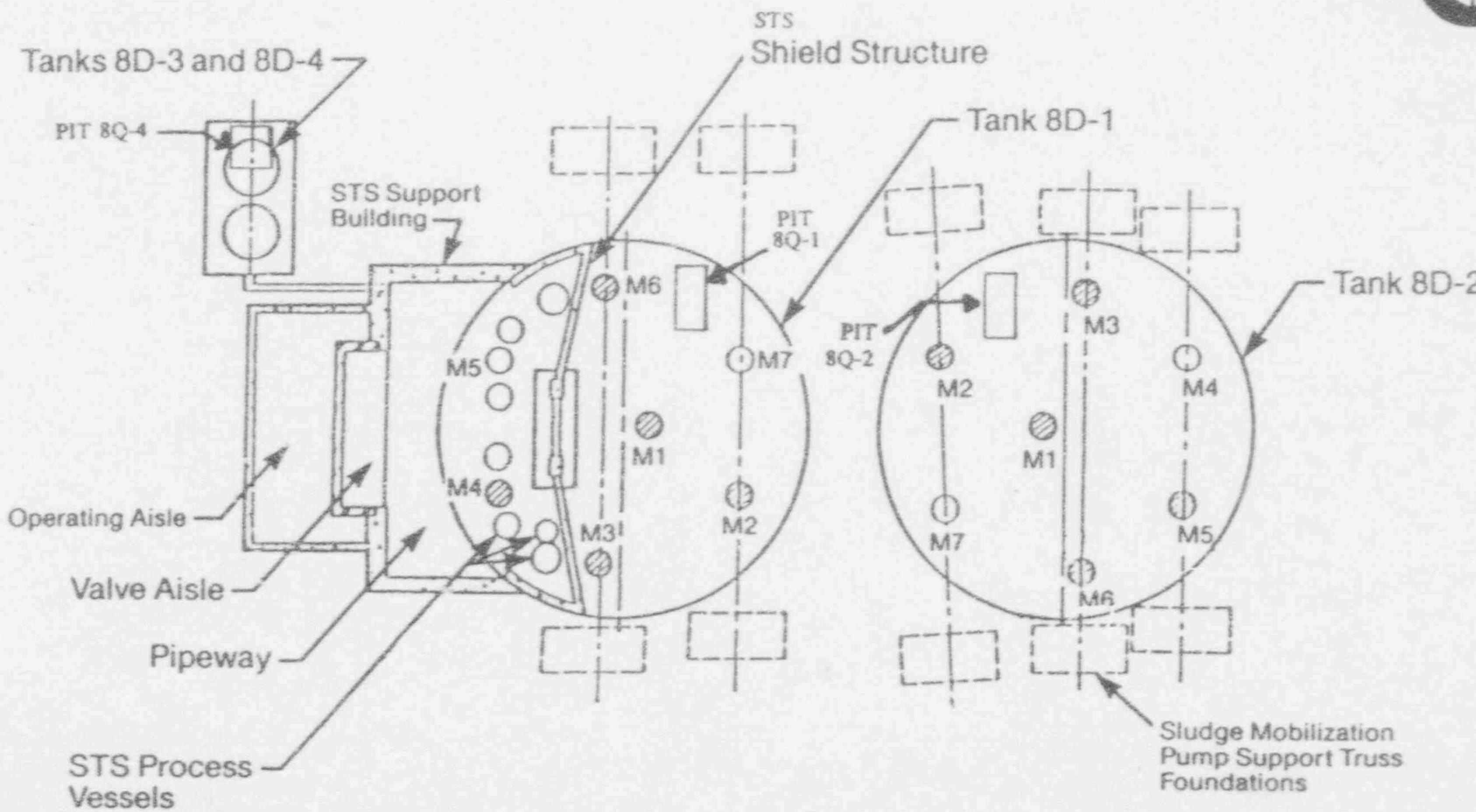


Figure 6

Moblilization Pump Locations

ZEOLITE MOBILIZATION PUMPS AND ZEOLITE REMOVAL PUMP LOCATION

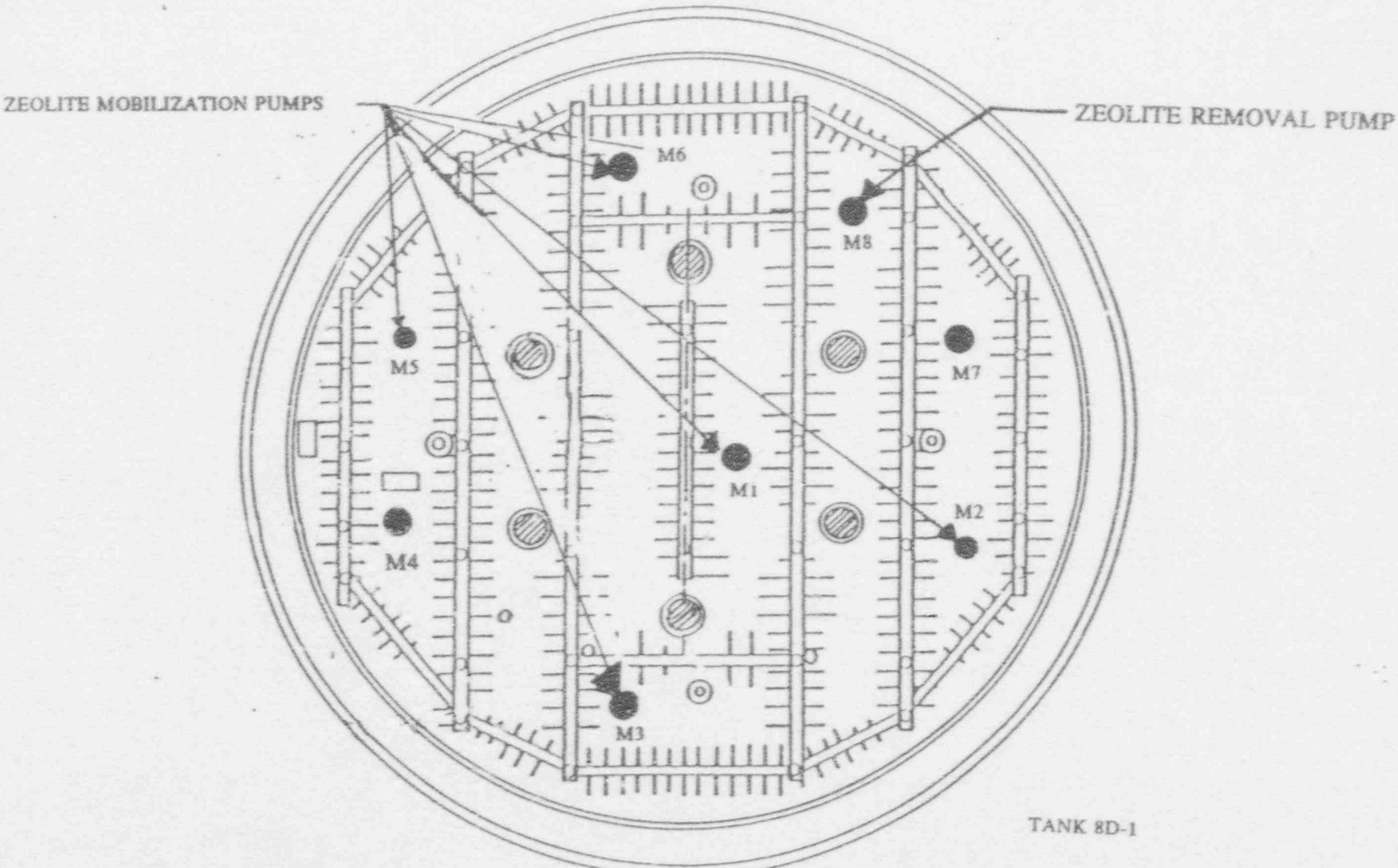


Figure 7

SLUDGE MOBILIZATION PUMPS AND SLUDGE REMOVAL PUMP LOCATION

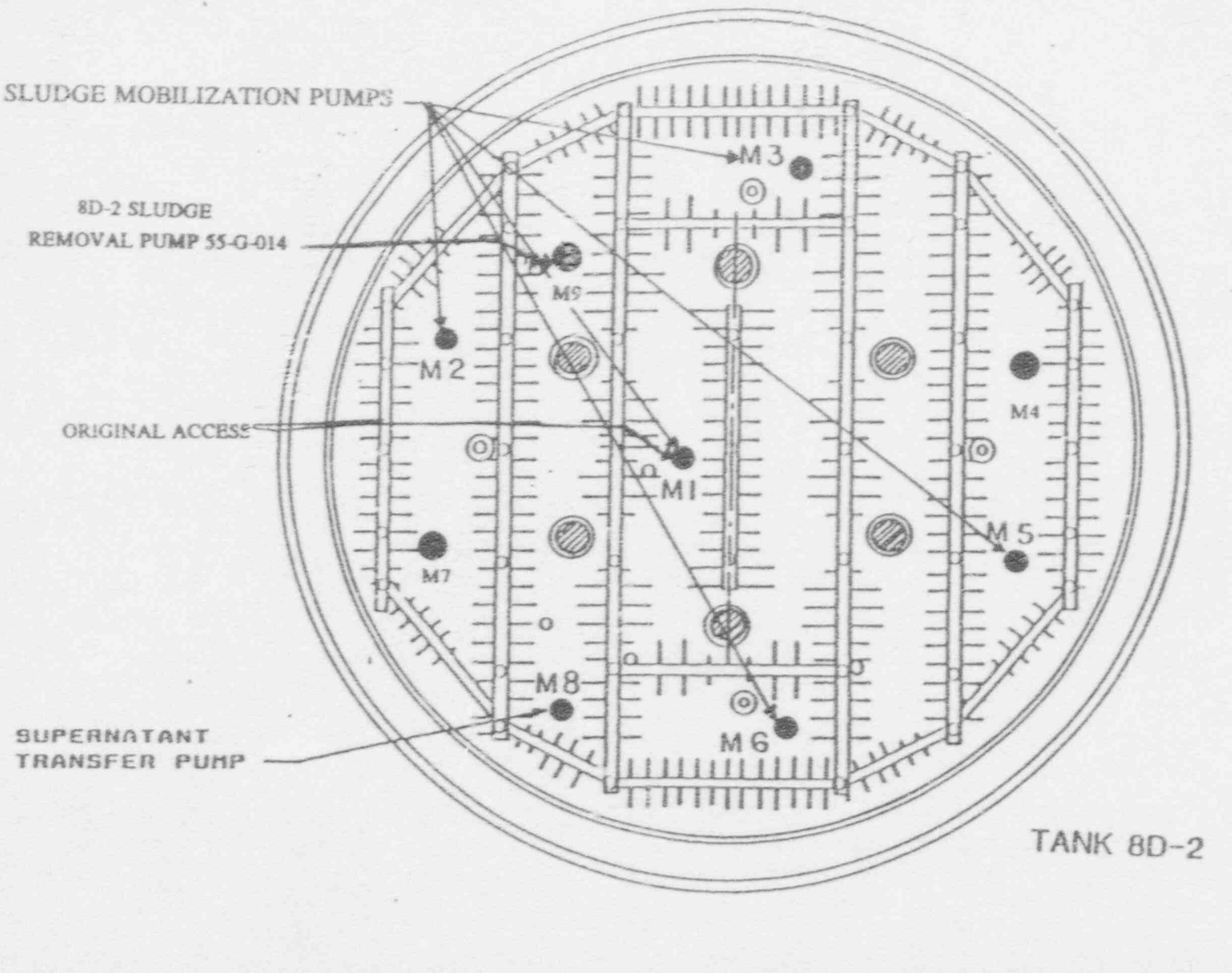
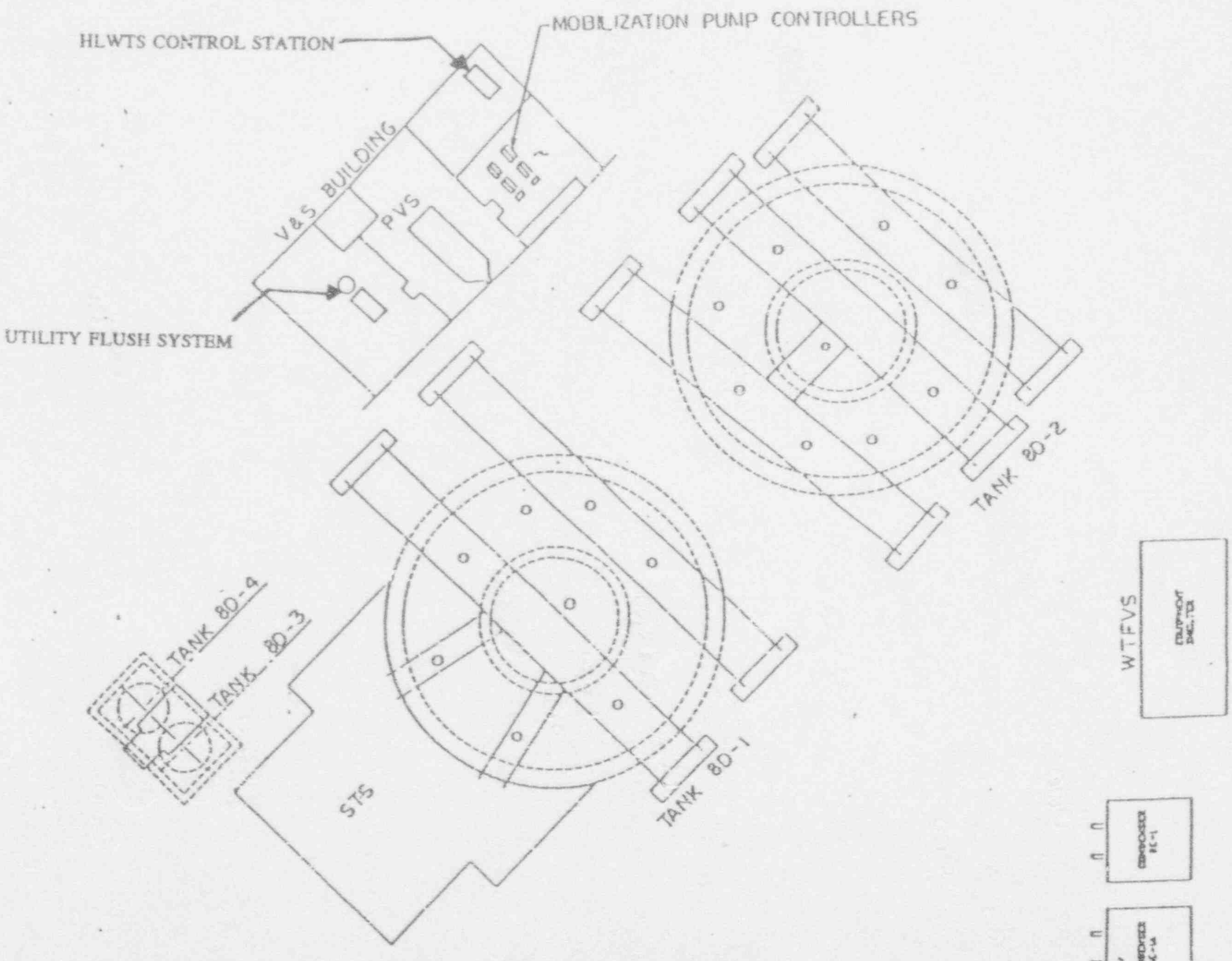


Figure 8



UTILITY FLUSH SYSTEM AND HLWTS CONTROL STATION

PUMP PIT 8Q-2

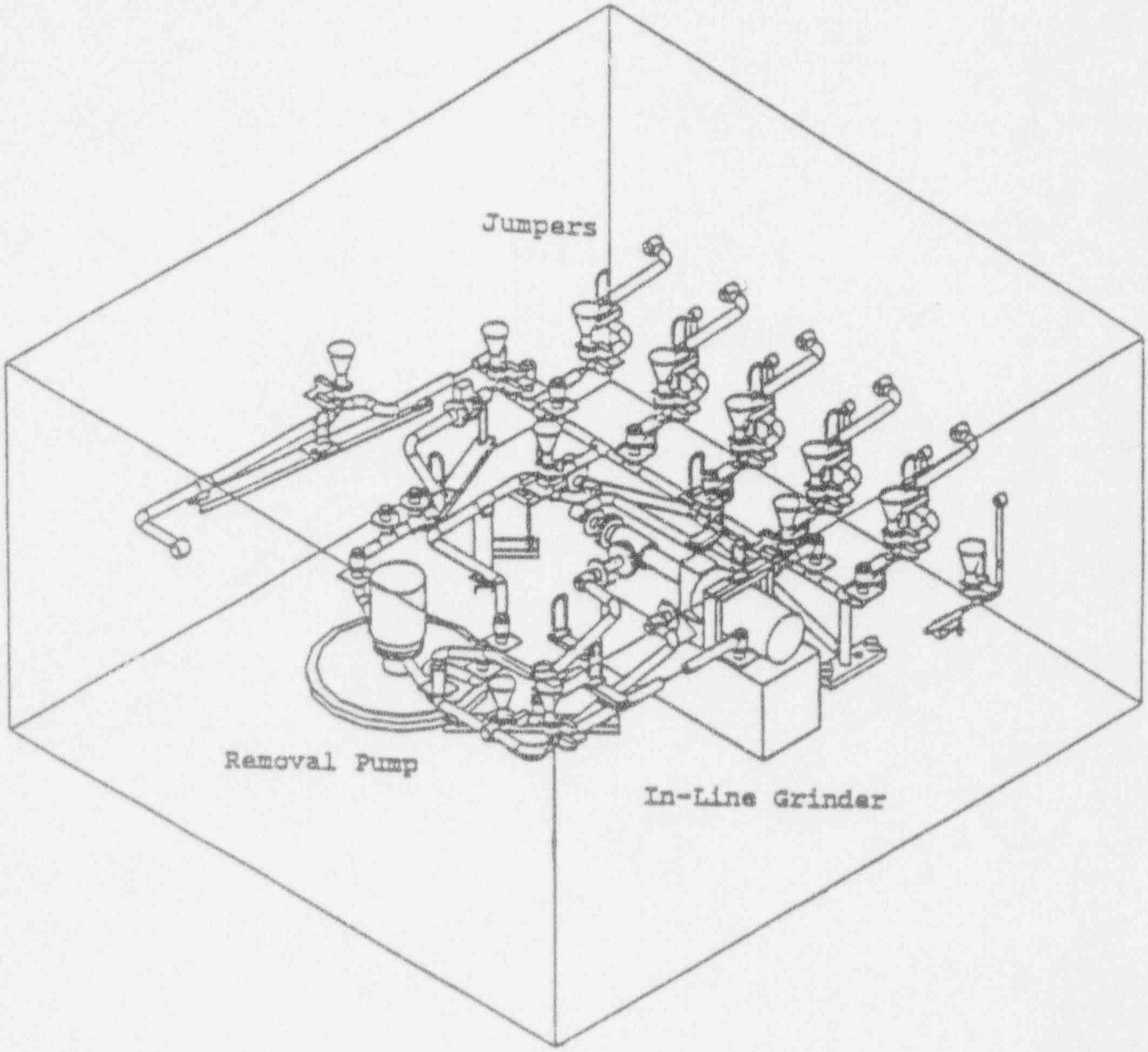


Figure 10

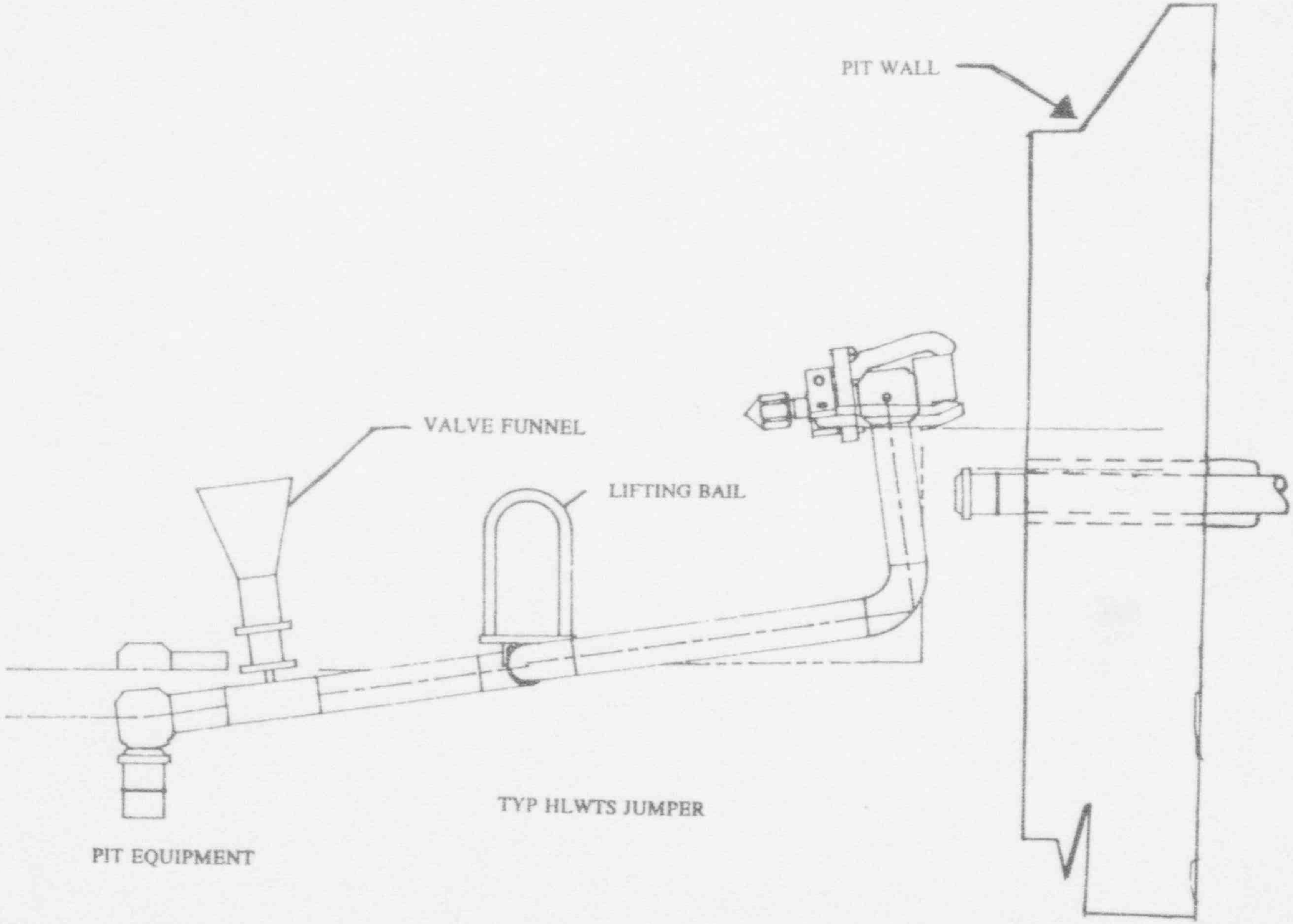
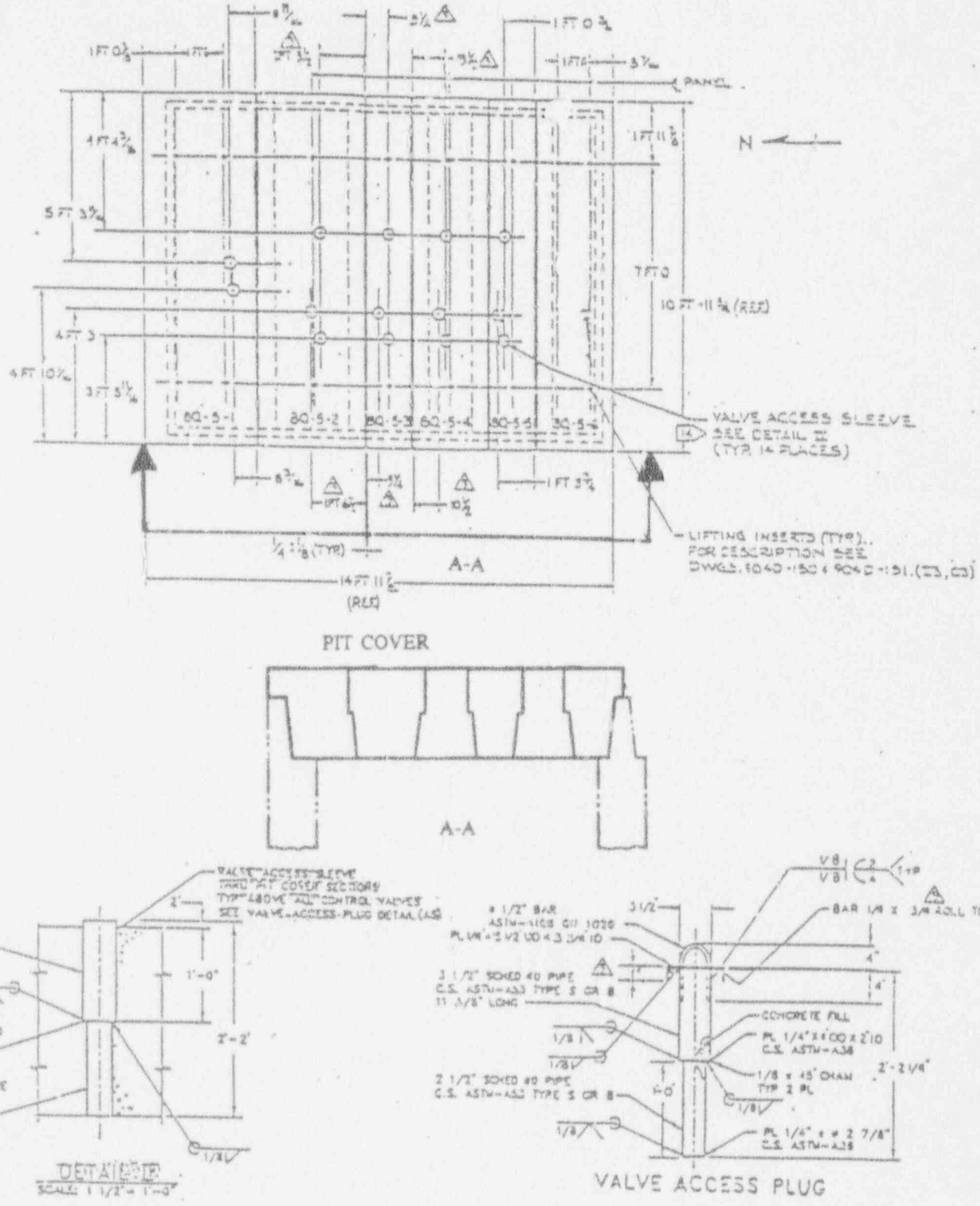

PIT WALL
VALVE FUNNEL
LIFTING BAIL
TYP HLWTS JUMPER
PIT EQUIPMENT

Figure 11



TYPICAL PIT COVER

Figure 12

HLW TRANSFER TRENCH LAYOUT

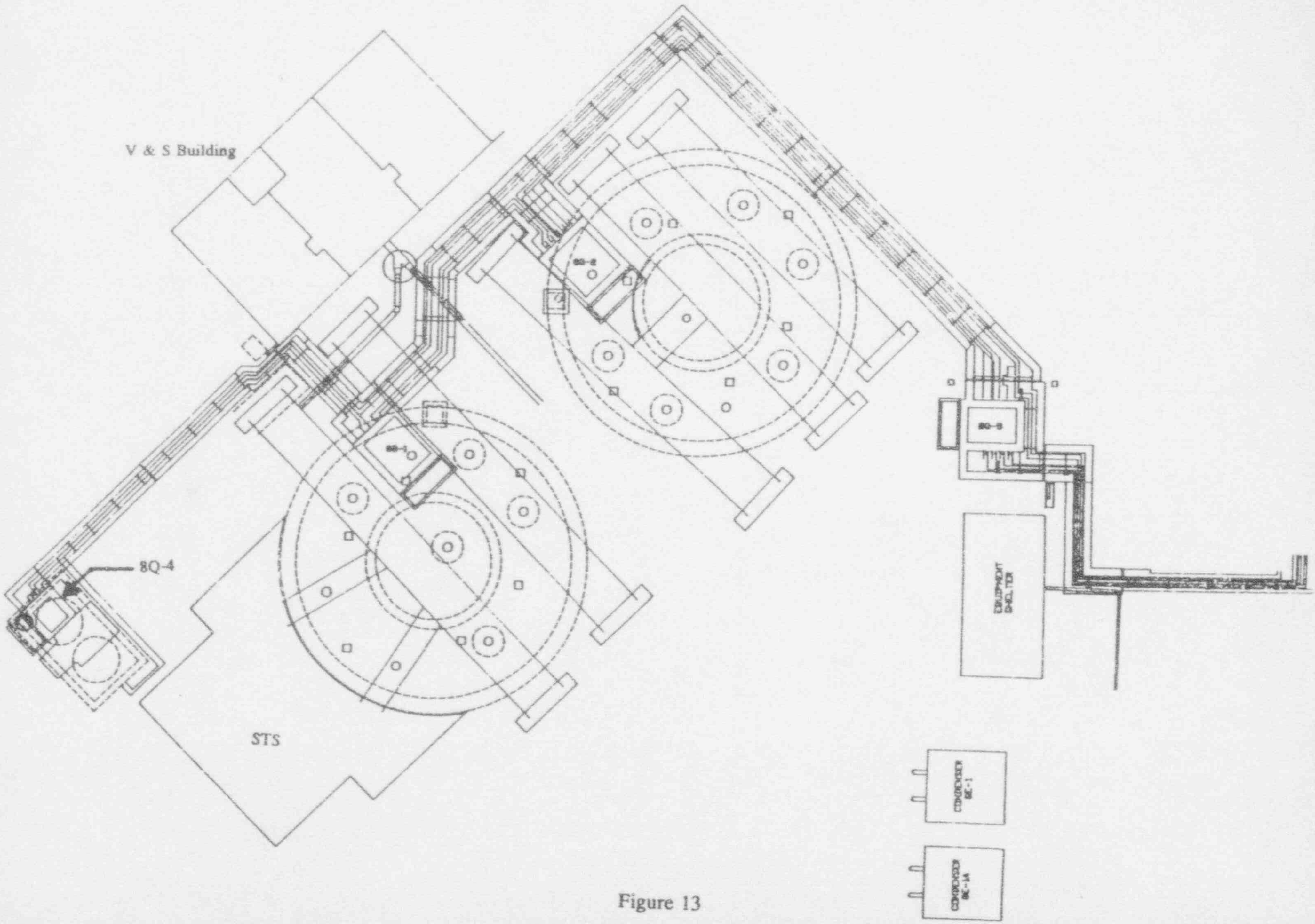


Figure 13

HLWTS AND TANK FARM VENTILATION

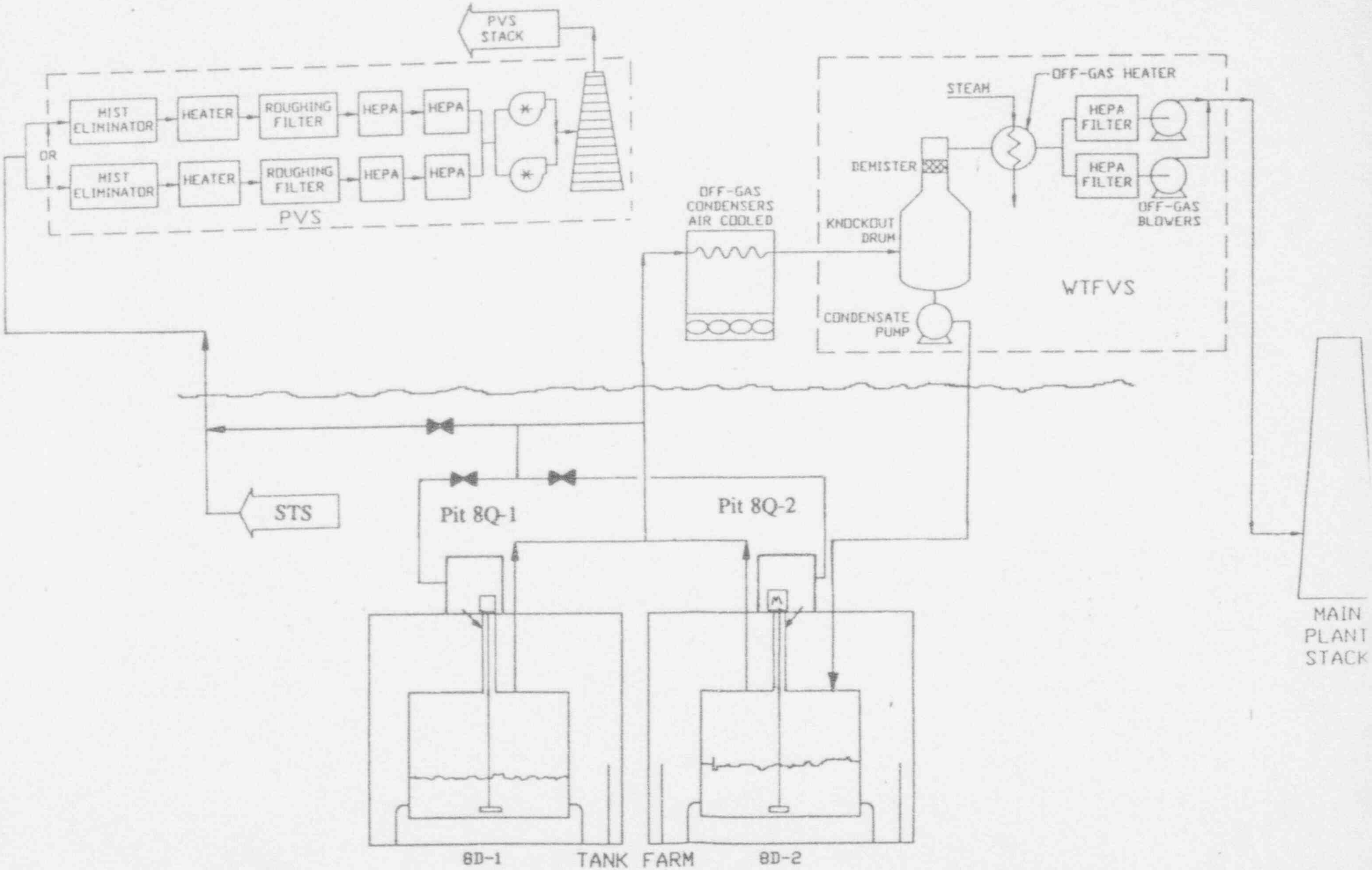
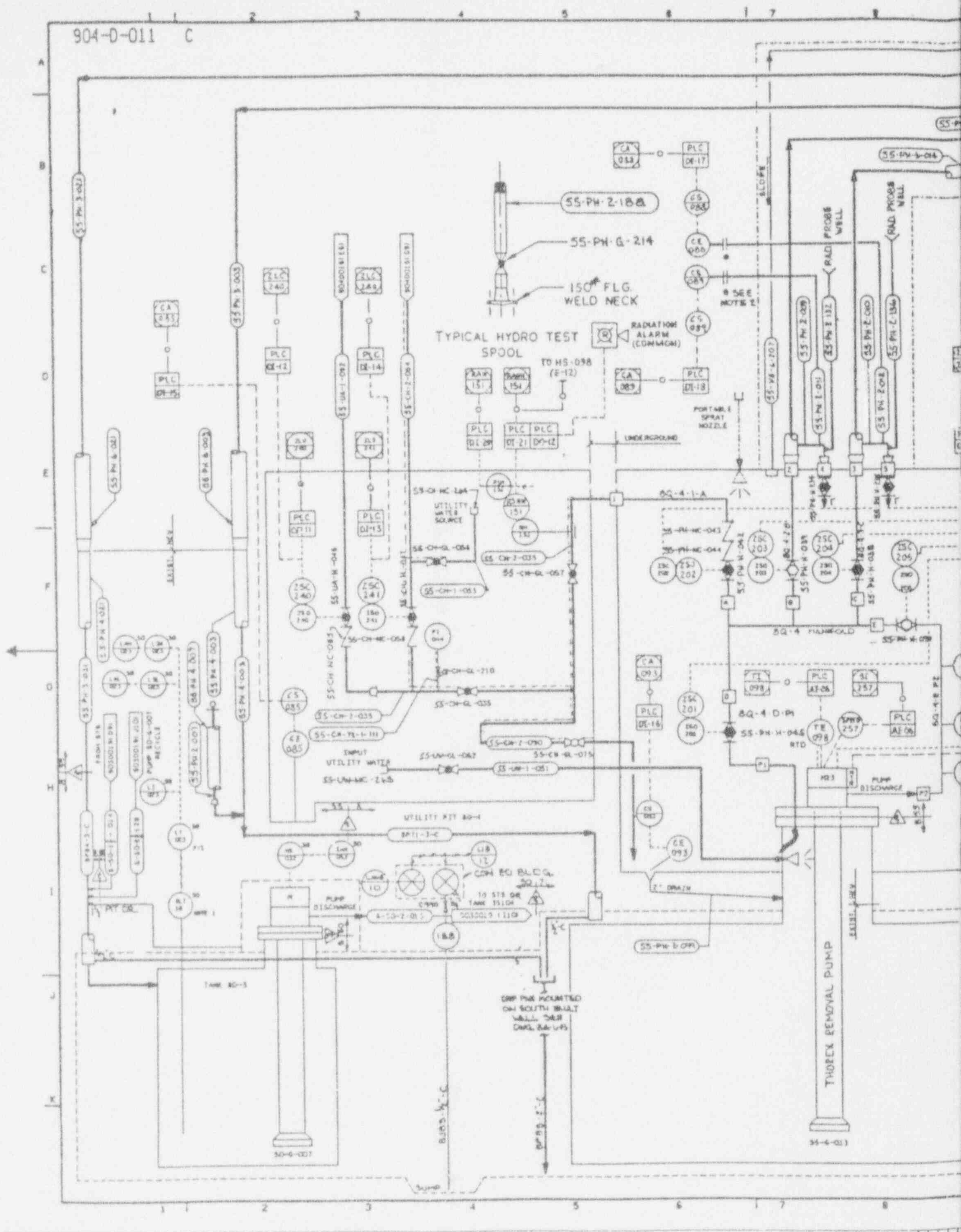
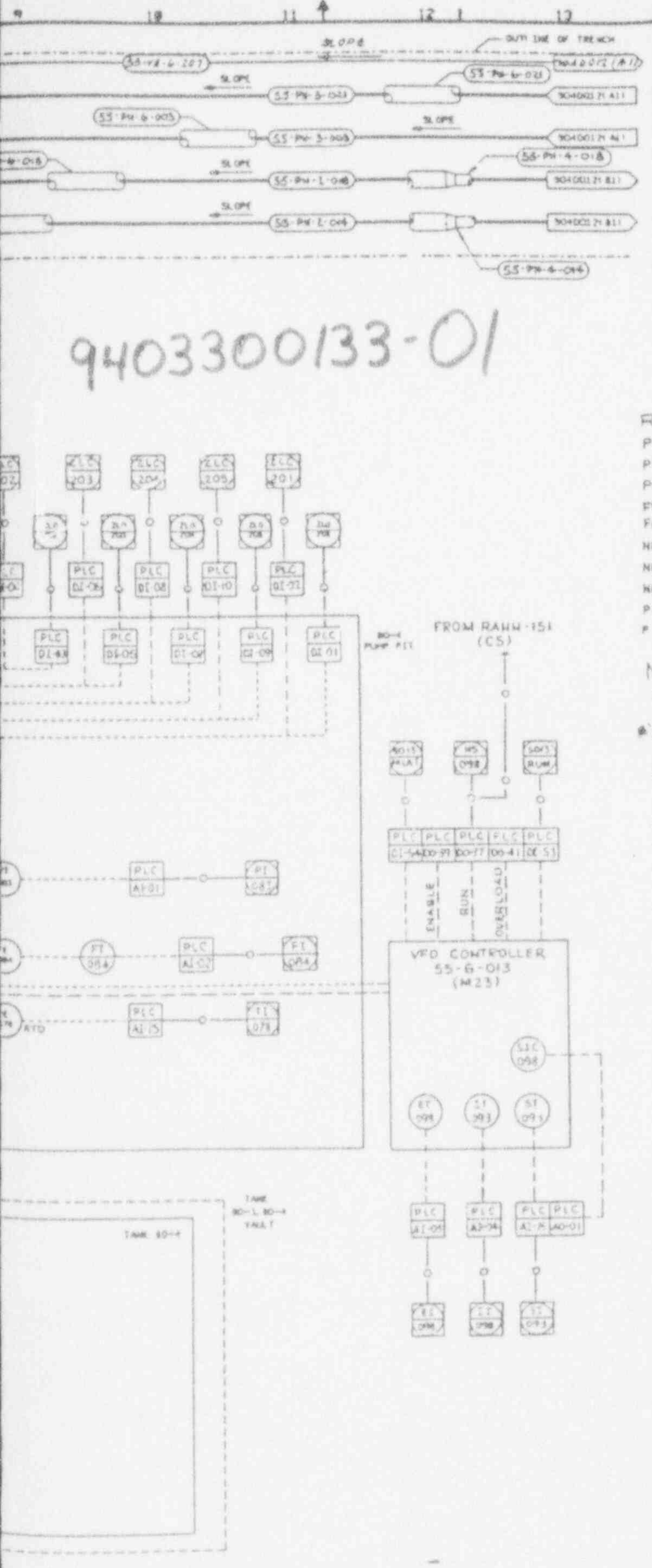


Figure 14



904-D-011 C
55-PH-2-188
55-PH-G-214
150# FLG. WELD NECK
TYPICAL HYDRO TEST SPOOL
RADIATION ALARM (COMMON)
TO HS-098 (E-12)
PORTABLE SPRAY NOZZLE
UNDERGROUND
RAD. PROBE WELL
SLOPE
8Q-4 MANIFOLD
8Q-4-1-A
8Q-4-D-PI
RTD
PUMP DISCHARGE
INPUT UTILITY WATER
UTILITY WATER SOURCE
UTILITY PIT 8Q-1
CON 8Q BLDG.
TANK 8Q-5
DRIP PAN MOUNTED ON SOUTH BUILT WALL SEE DWG. 84-U45
THOREX REMOVAL PUMP
PIT DR.
2" DRAIN
SUMP

9403300133-01



NO.	DATE	REVISION	DR	CK	APPROVED		
C	2-21-90	GENERAL REVISION					
0	3/14/90	ER1807					
1	4-11-90	GEN. REV. PER ECN 3370	CGR				
2	10-22-90	REV/ECN 3931					
3	12-6-91	GEN. REV PER ECN 4639					
4	7-6-92	REV PER ECN 5225		HB			
5	7-21-92	REV PER ECN 5229	JH	HB			
6	8-18-92	REV/ECN 5234					
7	10-21-92	REV PER ECN 5588		HB			
8	12-11-92	REV/ECN 5685	PD	HB			

REF. DWG'S:

P&ID SMS 8D-4 PIT	904D-012
P&ID SMS CHEM. UTILITY WTR. & SEAL WTR. SYS.	904D-015
P&ID SMS UTILITY AIR SYSTEM	904D-014
FLOW PIPING & INST. DIAGRAM WASTE TANK FARM SPENT FUEL REPRO. PLANT	8R-A-1
NOTES, SYMBOLS & LEGEND	900-D-1306
NOTES, SYMBOLS & LEGEND	900-D-1307
NOTES, SYMBOLS & LEGEND	900-D-1308
PIPING & INST. DIAG. CON ED WASTE	8R-A-4
P & ID STS FINAL FILTRATION & STORAGE	903-D-019

NOTES:

1. FOR EXISTING TANK EQUIPMENT SEE DWG. 8R-A-4 P&ID DIAGRAM (CON ED WASTE STORAGE).
2. USE LEAK DETECTION LINE FOR HYDRO TESTING, SEE TYPICAL HYDRO TEST SPOOL.
3. THE SYSTEM DESIGNATION FOR THE SMS IS 55. ALL INSTRUMENT LOOP NUMBERS ARE PRECEDED BY A 55- UNLESS OTHERWISE NOTED.
4. ELECTRICAL HEAT TRACE
5. SOFTWARE OR DATA LINK SIGNAL

WVNS APPROVAL

COG. MGR.
COG. ENGR.
DRFT SUPR.
Q.A. MGR.
R & S MGR.
PROJ. MGR.

FOR DRAWING INDEX SEE DRAWING NO.

EBASCO SERVICES INCORPORATED

WEST VALLEY NUCLEAR SERVICES COMPANY, INC
WEST VALLEY, NEW YORK

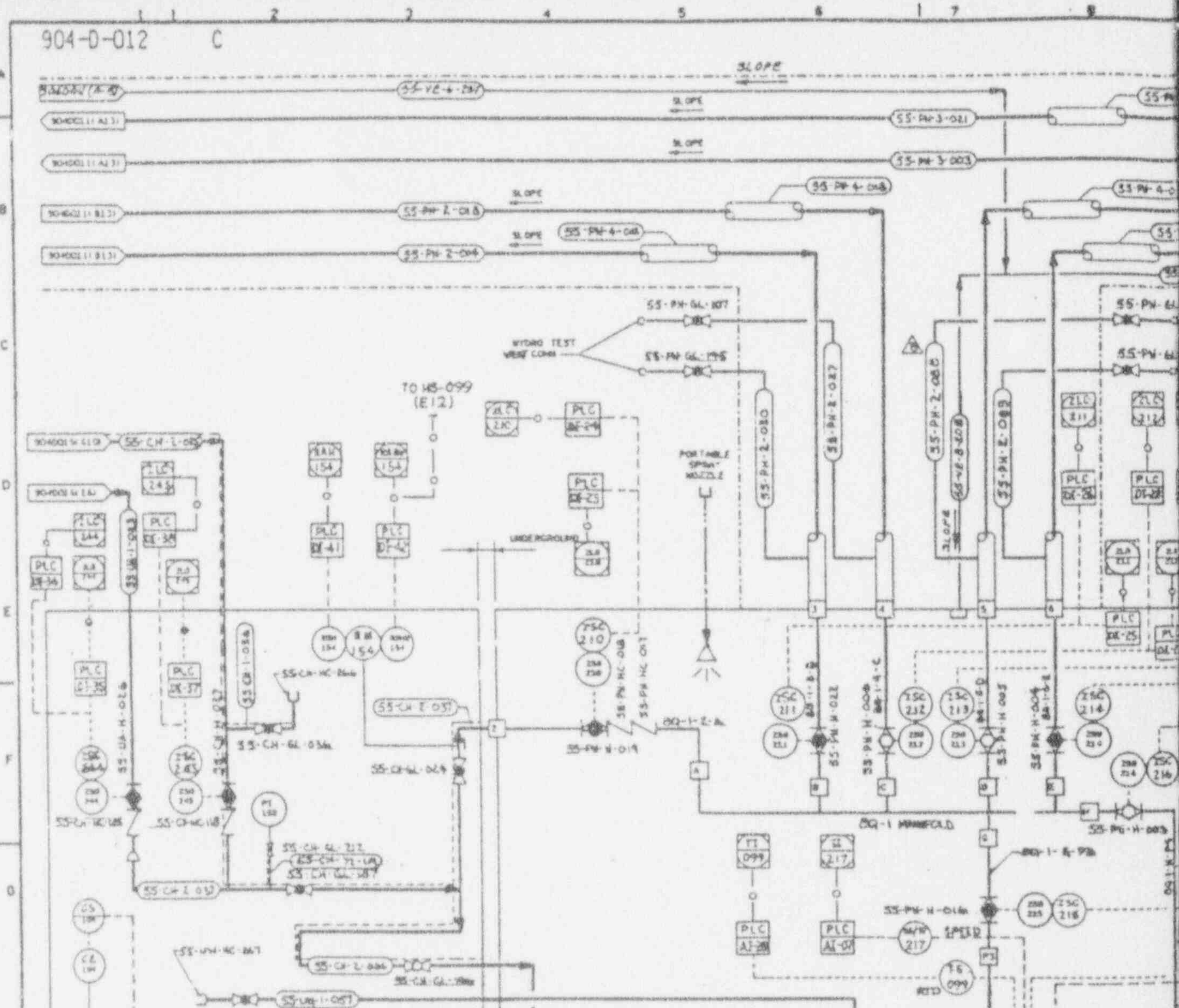
WEST VALLEY DEMONSTRATION PROJECT

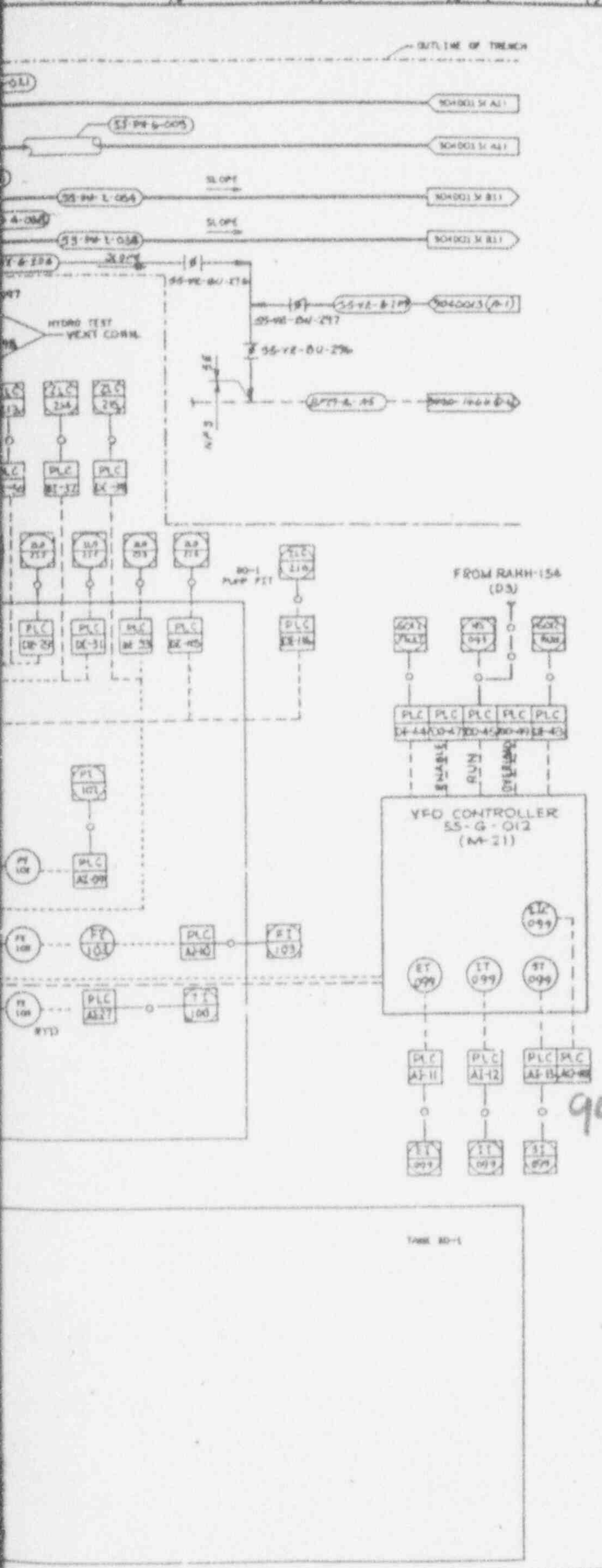
P & ID
SLUDGE MOBILIZATION SYSTEM
8D-4 PIT

SIZE D | DRAWING NO. 904D-011 | REV. 8

A/E SHEET NO. 904-D-011

Figure 15


904-D-012
C
SLOPE
HYDRO TEST VENT CONN
TO HS-099 (E12)
PORTABLE SPRAY NOZZLE
UNDERGROUND
UTILITY PIT
BQ-1 MANIFOLD
PUMP DISCHARGE
2" DRAIN
M-8 RISER
ZEOLITE REMOVAL PUMP



NO.	DATE	REVISION	DR	CH	APPROVED		
B	10-10-89	GENERAL REVISION					
C	1-21-90	GENERAL REVISION					
0	3/14/90	EK 1807					
7	12-14-92	GEN REV/ECN 5685	PD				
8	12-2-93	REV PER ECN 7099	PD				
3	7-6-92	REV PER ECN 5225					
4	7-21-92	REV PER ECN 5229	JH				
5	8-18-92	REV/ECN 5234					
6	10-21-92	REV PER ECN 5588					

REFERENCE DRAWINGS:

P&ID SMS 8D-4 PIT	9040-011
P&ID SMS 8D-2 PIT	9040-013
P&ID SMS COOL. W.R. & SEAL WTR. SYS.	9040-015
FLOW PIPING & INST. DIAG. WASTE TANK FARM	
SPENT FUEL REPROCESSING PLANT	8R-A-1
PIPING & INST. DIA. COOL. SD. WASTE	8R-A-4
P&ID SMS UTILITY AIR SYSTEM	9040-016
WASTE MOB. PUMP PROCESS & INSTR. DIA. 8D-1-A6	9040-2318, SH 1
WASTE MOB. PUMP PROCESS & INSTR. DIA. 8D-1-A6	9040-2318, SH 2
WASTE MOB. PUMP PROCESS & INSTR. DIA. 8D-1-A3	9040-2318, SH 3
WASTE MOB. PUMP PROCESS & INSTR. DIA. 8D-1-A2	9040-2318, SH 4
WASTE MOB. PUMP PROCESS & INSTR. DIA. 8D-1-A1	9040-2318, SH 5
P&ID STS PERMANENT VENTILATION SYSTEM	9000-1666

NOTES:

1. FOR NOTES SEE DWG. 9040-011
2. FOR EXISTING TANK 8D1 EQUIPMENT SEE DWG 8R-A-1 P&ID
3. —o—o— SOFTWARE OR DATA LINK SIGNAL

9403300133-02

WVNS APPROVAL

COG. MGR.
COG. ENGR.
DRFT. SUPR.
Q.A. MGR.
R & S MGR.
PROJ. MGR.

FOR DRAWING INDEX SEE DRAWING NO.

EBASCO SERVICES INCORPORATED

A/E & F.S. NO. 1200 TASK ORDER 015

FOR

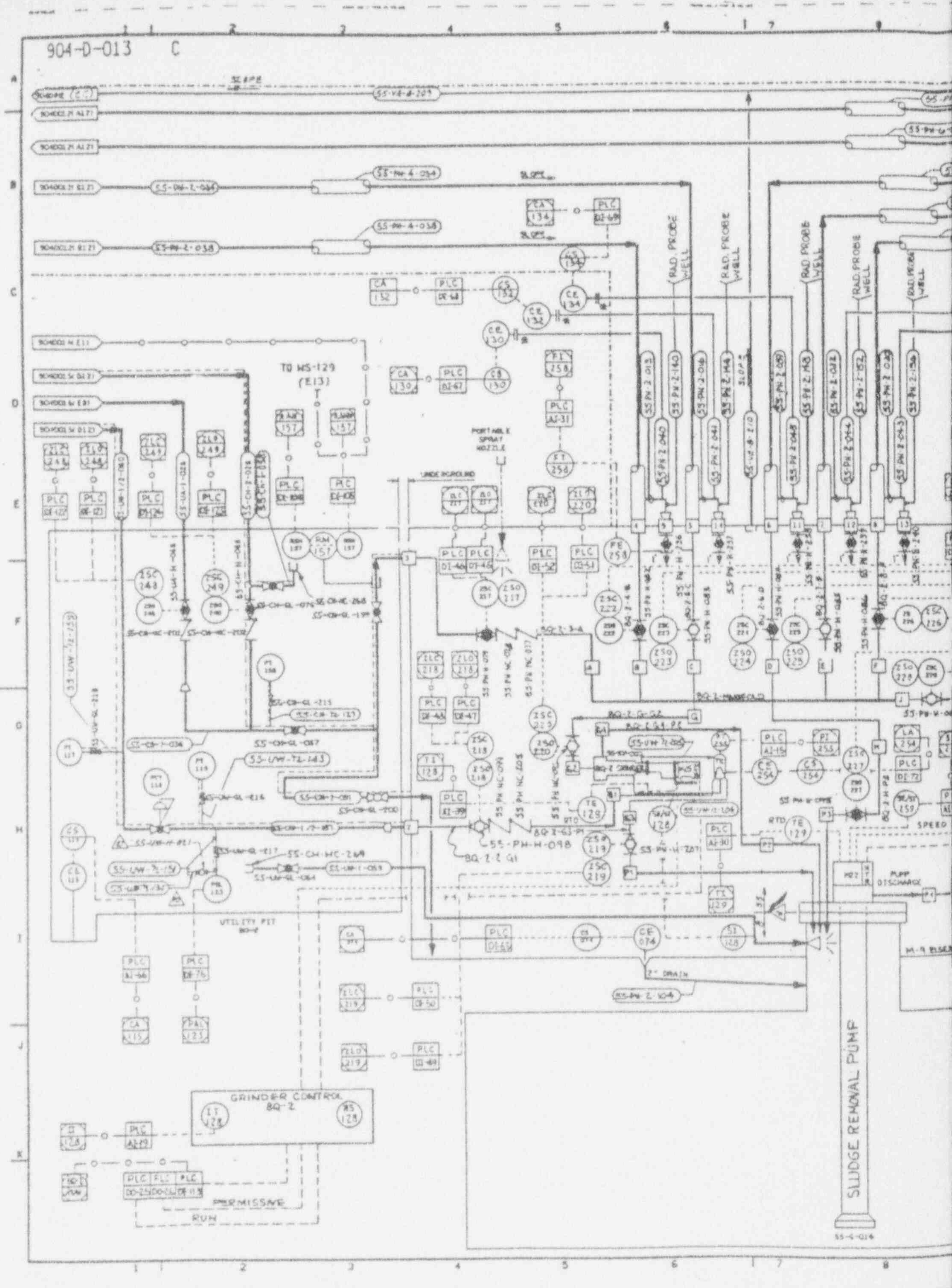
WEST VALLEY NUCLEAR SERVICES COMPANY, INC
WEST VALLEY, NEW YORK

WEST VALLEY DEMONSTRATION PROJECT

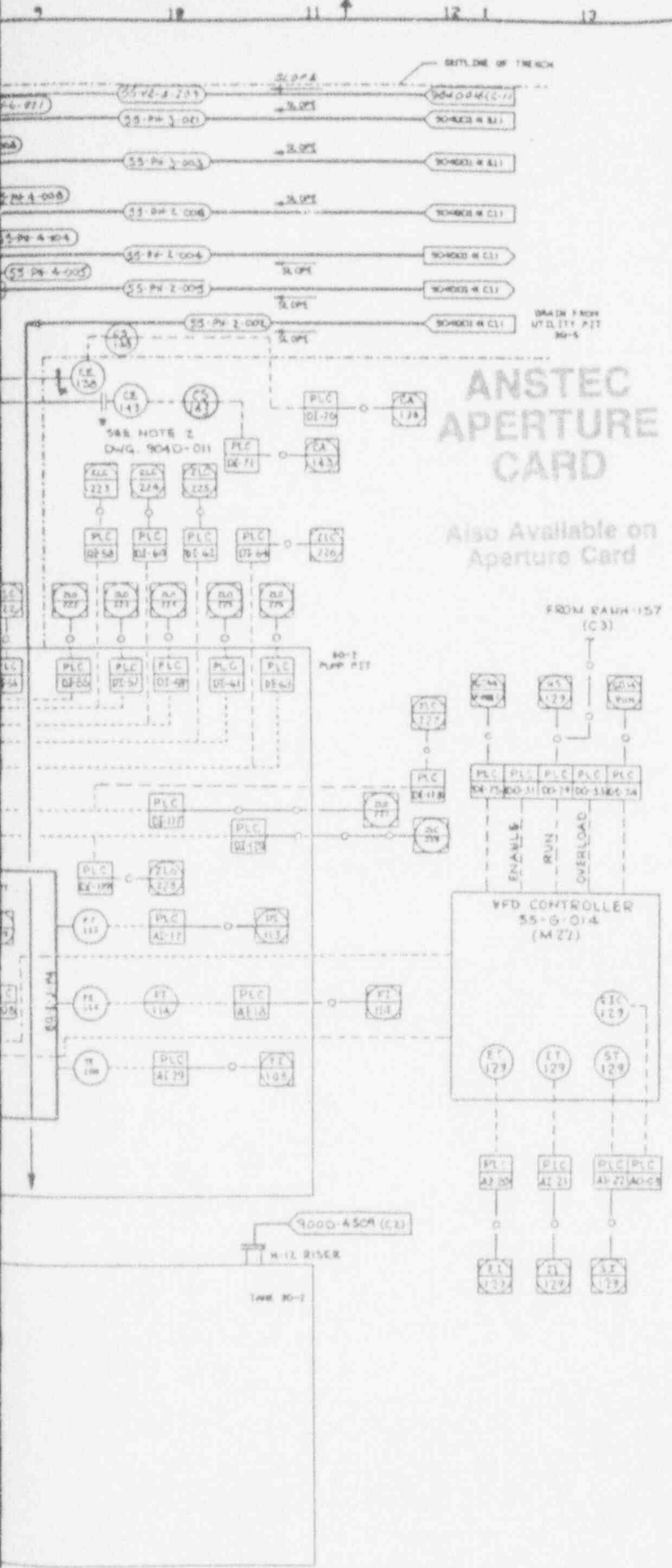
P & ID
SLUDGE MOBILIZATION SYSTEM
8D-1 PIT

SIZE D
DRAWING NO. 904D-012
REV. 8
SCALE NONE
A/E SHEET NO. 904-D-012 C

Figure 16



904-D-013 C
SLOPE
SS-VE-B-209
SS-PW-4-034
SS-PW-2-034
SS-PW-4-038
SS-PW-2-038
RAD. PROBE WELL
TO HS-129 (E13)
PORTABLE SPRAY NOZZLE
UNDERGROUND
BQ-2-MANIFOLD
SS-PH-H-098
BQ-2-2 G1
UTILITY PIT BQ-2
2" DRAIN
SS-PW-2-104
PUMP DISCHARGE
SPEED
GRINDER CONTROL BQ-2
PERMISSIVE
RUN
SLUDGE REMOVAL PUMP



NO.	DATE	REVISION	DR	CH	APPROVED		
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		GENERAL REVISION					
C	2-21-90						
		GENERAL REVISION					
0	3/12/90	E2180?					
1	4/ /91	GEN REV. PER ECN 3570	CGR	DRS			
2	12-9-91	GEN REV PER ECN 4639	CW	HAB			
3	7-6-92	REV PER ECN 5225		HB			
4	7-21-92	REV PER ECN 5229	JH	HB			
5	8-20-92	REV/ECN 5234		DRS			
6	10-21-92	REV PER ECN 5528	CW	HB			
7	11-11-92	REV PER ECN 5603	CW	HB			
8	12-15-92	GEN REV/ECN 5685	PD	HB			
9	8-3-93	REV PER ECN 6605	CW	HB	PB		
10	2-18-94	REV/ECN 7430		HB	PB		

NOTES:

1. FOR NOTES SEE DWG. 904D-011
2. —o—o— SOFTWARE OR DATA LINK

REF. DWGS.:

P&ID SMS 8Q-1 PIT	904D-012
P&ID SMS 8Q-5 PIT	904D-014
P&ID SMS CHEM., UTILITY WTR. & SEAL WTR. SYS.	904D-015
P&ID SMS UTILITY AIR SYSTEM	904D-016
FLOW PIPING & INSTRUMENT DIAG. WASTE TANK FARM SPENT FUEL REPROC. PLANT	8R-A-1
PIPING & INST. DIAG. CON ED WASTE	8R-A-4
WASTE MOB. PUMP PROCESS & INSTR. DWG. 8D-2-M6	904D-238 SH. 6
WASTE MOB. PUMP PROCESS & INSTR. DWG. 8D-2-M5	904D-238 SH. 7
WASTE MOB. PUMP PROCESS & INSTR. DWG. 8D-2-M3	904D-238 SH. 8
WASTE MOB. PUMP PROCESS & INSTR. DWG. 8D-2-M2	904D-238 SH. 9
WASTE MOB. PUMP PROCESS & INSTR. DWG. 8D-2-M1	904D-238 SH. 10

WVNS APPROVAL

COG. MGR.
COG. ENGR.
DRFT. SUPR.
Q.A. MGR.
R & S MGR.
PROJ. MGR.

FOR DRAWING INDEX SEE DRAWING NO.

EBASCO SERVICES INCORPORATED

A/E S.F.S. NO. 7398 TASK ORDER 013

FOR

WEST VALLEY NUCLEAR SERVICES COMPANY, INC
WEST VALLEY, NEW YORK

WEST VALLEY DEMONSTRATION PROJECT

P & ID
SLUDGE MOBILIZATION SYSTEM
8Q-2 PIT

SIZE: D

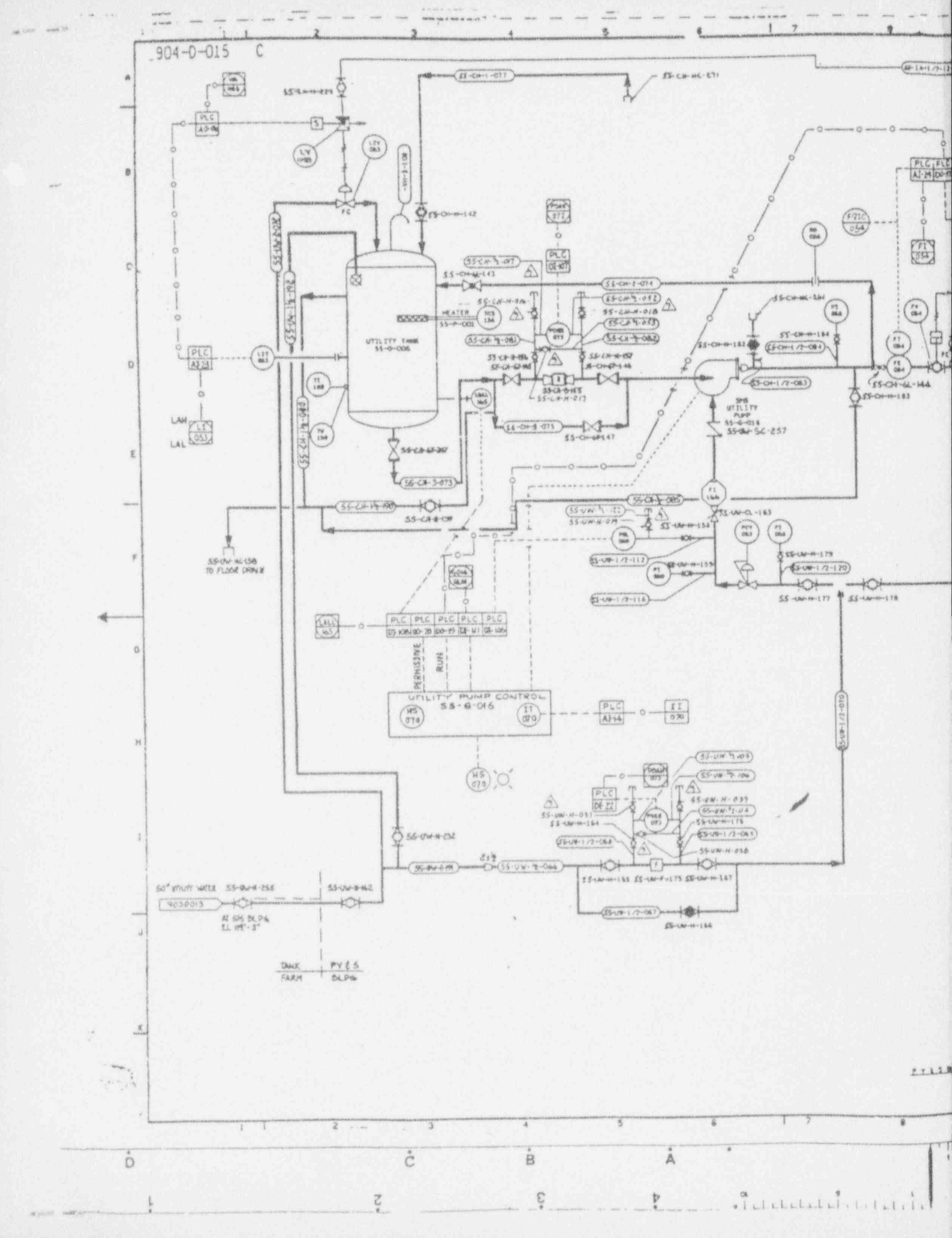
DRAWING NO. 904D-013 REV. 10

SCALE: NONE

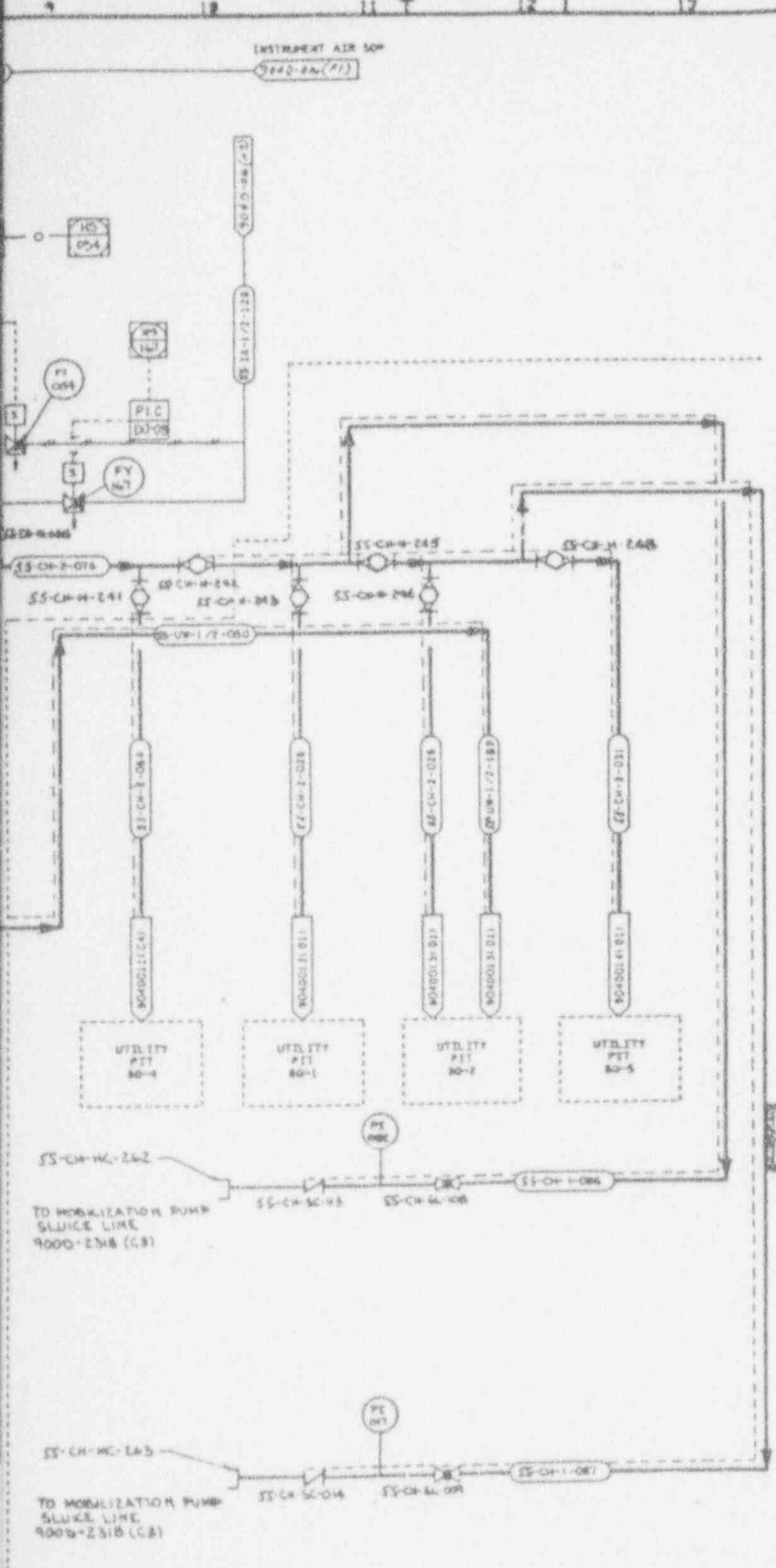
A/E SHEET NO. 904-D-013 C

Figure 17

9403300133-03



904-D-015 C
UTILITY TANK
HEATER
LAH
LAL
TO FLOOR DRAIN
UTILITY PUMP CONTROL
PERMISSIVE
RUN
PLC
TANK
FARM
BLDG



NO.	DATE	REVISION	DR	CH	APPROVED		
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C	2-21-90	GENERAL REVISION					
0	3/16/90	ER 1807					
9	2-21-94	REV/ECN 7430					
1	11-5-90	REV PER ECN 4011					
3	12-10-91	GEN REV PER ECN 4639					
4	2-7-92	REV PER ECN 5225					
5	9-29-92	REV PER ECN 5523					
6	11-6-92	REV/ECN 5627					
7	12-15-92	GEN REV/ECN 5685	PD				
8	12-2-92	REV/ECN 7099	PD				

REFERENCE DRAWINGS:

P&ID SMS 8D-4-PIT	904D-011
P&ID SMS 8D-1-PIT	904D-012
P&ID SMS 8D-2-PIT	904D-013
P&ID SMS 8D-5-PIT	904D-014
P&ID SMS UTILITY AIR SYSTEM	904D-016
WASTE MOBILIZATION PUMP PROCESS & INSTRUMENT DIAGRAM	9000-2318

NOTES:

1. FOR NOTES SEE DWG 904D-011
2. —o—o— SOFTWARE OR DATA LINK

Figure 18

ECN(S) PENDING
#7543

WVNS APPROVAL
COG. MGR.
COG. ENGR.
DRFT. SUPR.
Q.A. MGR.
R & S MGR.
PROJ. MGR.

FOR DRAWING INDEX SEE DRAWING NO.

EBASCO SERVICES INCORPORATED

WEST VALLEY NUCLEAR SERVICES COMPANY, INC
WEST VALLEY, NEW YORK

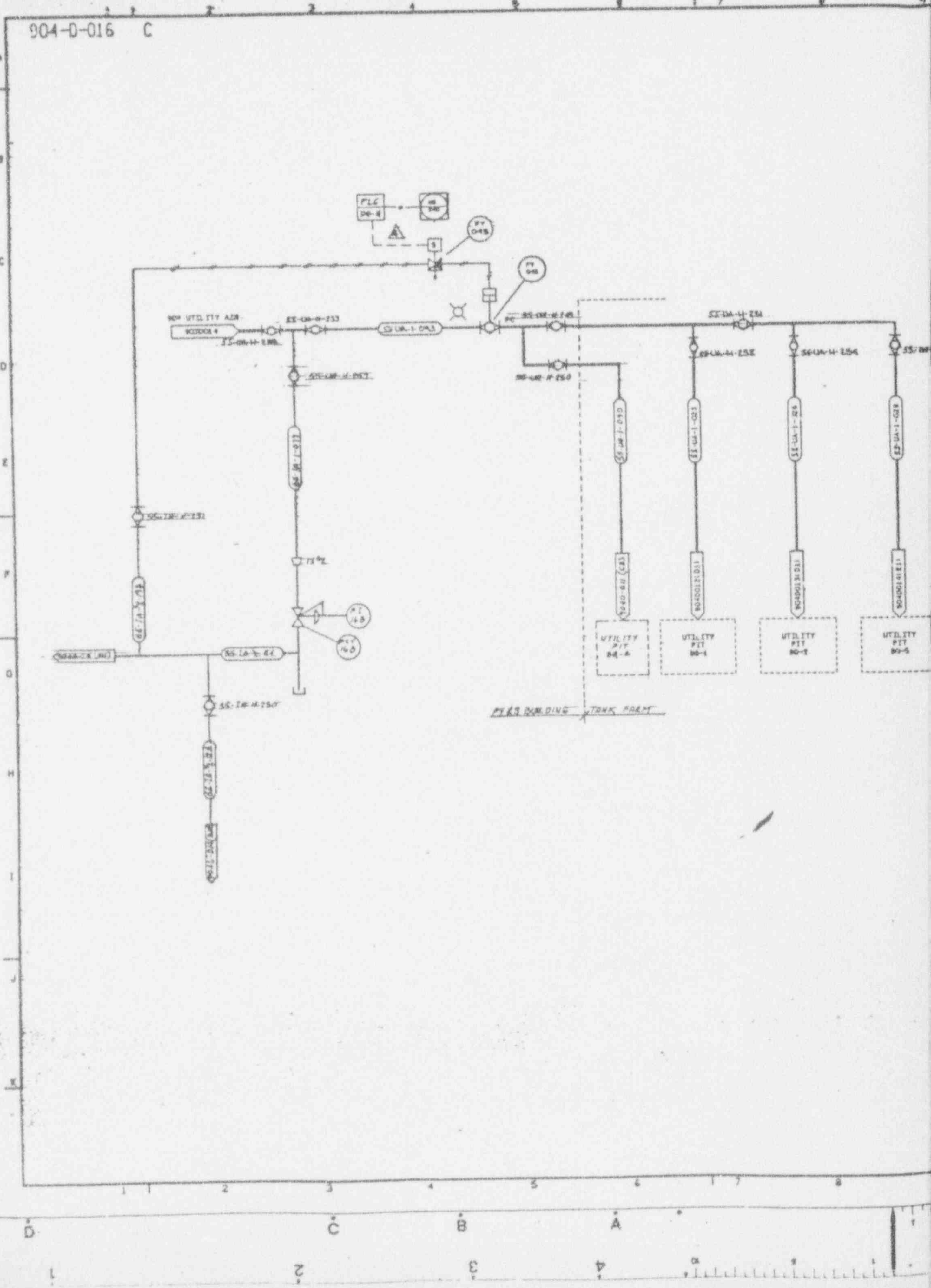
WEST VALLEY DEMONSTRATION PROJECT
P & ID
SLUDGE MOBILIZATION SYSTEM
CHEMICAL, UTILITY WATER & SEAL WATER SYSTEMS

SIZE D — DRAWING NO. 904D-015 — REV. 9

904-D-015 C

9403300133-04

904-D-016 C


UTILITY AIR
PLC
UTILITY PIT
UTILITY PIT
UTILITY PIT
UTILITY PIT
TANK FARM

NO.	DATE	REVISION	DR	CH	APPROVED
A	[illegible]	GENERAL REVISION			
C	2-21-90	GENERAL REVISION			
0	3/12/90	ER 1807			
1	4/18/90	GEN. REV. PER ECN 3570	KAR		
2	12-10-90	GEN. REV. PER ECN 4639			
3	12-13-92	GEN. REV/ECN 5622			
4	12-14-92	REV PER ECN 5685	JH		

ANSTEC APERTURE CARD

Also Available on Aperture Card

NOTES:

1. FOR NOTES SEE DRAWING 904D-011
2. ——— SOFTWARE OR DATA LINK.

REF. DWGS.:

P&ID 5M5 BQ-4 PIT	904D-011
P&ID 5M5 BQ-1 PIT	904D-012
P&ID 5M5 BQ-2 PIT	904D-013
P&ID 5M5 BQ-4 PIT	904D-014

Figure 19

WVNS APPROVAL

COG. MGR.

COG. ENGR.

DRFT SUPR.

Q.A. MGR.

R & S MGR.

PROJ. MGR.

9403300133-05

FOR DRAWING INDEX SEE DRAWING NO.

EBASCO SERVICES INCORPORATED

WEST VALLEY NUCLEAR SERVICES COMPANY, INC
WEST VALLEY, NEW YORK

WEST VALLEY DEMONSTRATION PROJECT

P & ID
SLUDGE MOBILIZATION SYSTEM
UTILITY AIR SYSTEM

SIZE: D
DRAWING NO. 904D-016
REV. 4

SCALE: NONE
904-D-016

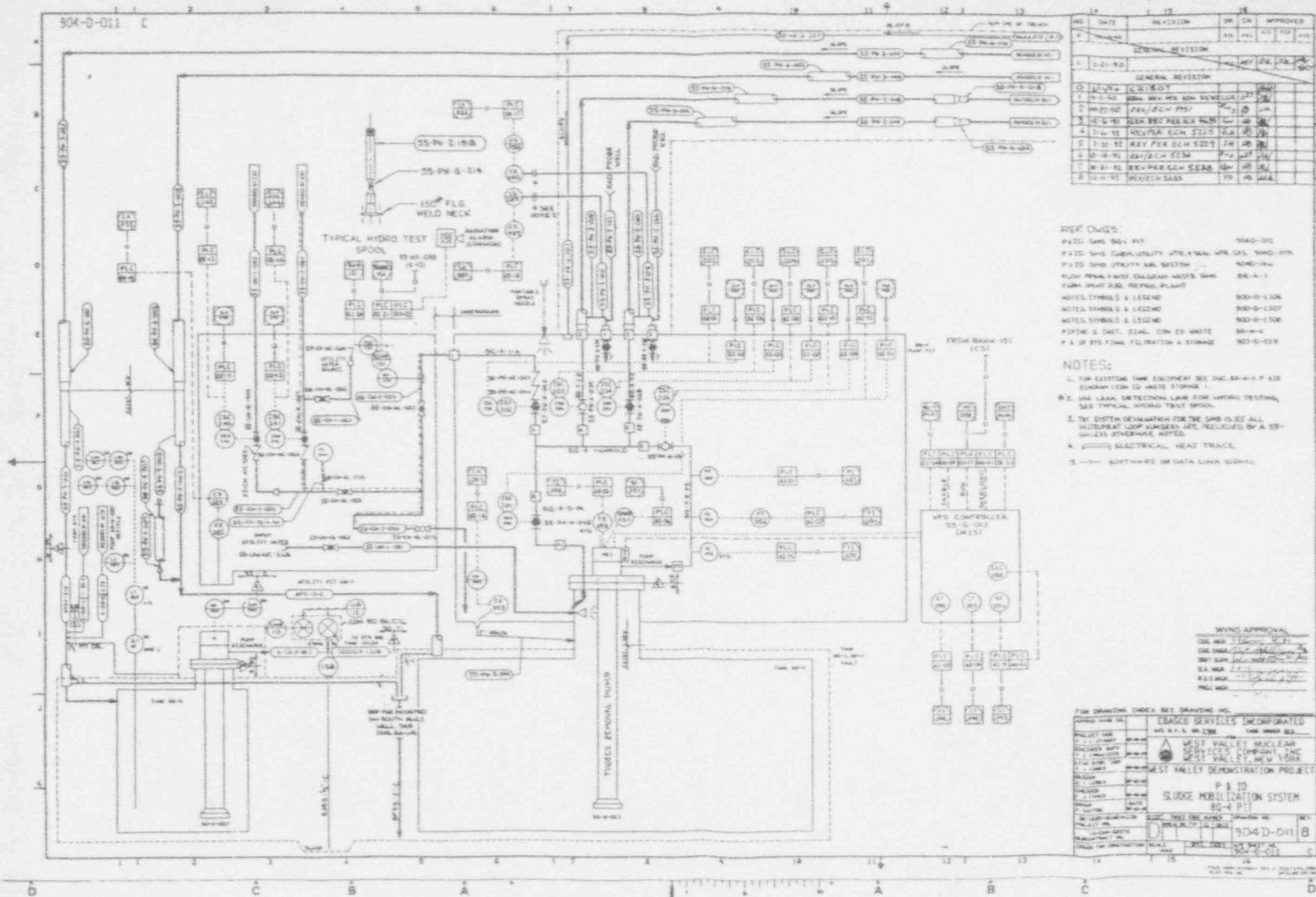

904-D-011 C
55-PH-2-158
55-PH-6-214
150# FLG. WELD NECK
TYPICAL HYDRO TEST SPOOL
VFD CONTROLLER
FROM RAHH-151 (CS)
SLUDGE REMOVAL PUMP
REF DWGS:
NOTES:
4. ELECTRICAL HEAT TRACE
WVNS APPROVAL
EBASCO SERVICES INCORPORATED
WEST VALLEY NUCLEAR SERVICES COMPANY, INC
WEST VALLEY, NEW YORK
WEST VALLEY DEMONSTRATION PROJECT
P & ID
SLUDGE MOBILIZATION SYSTEM
8D-4 PIT
904D-011
8

Figure 15

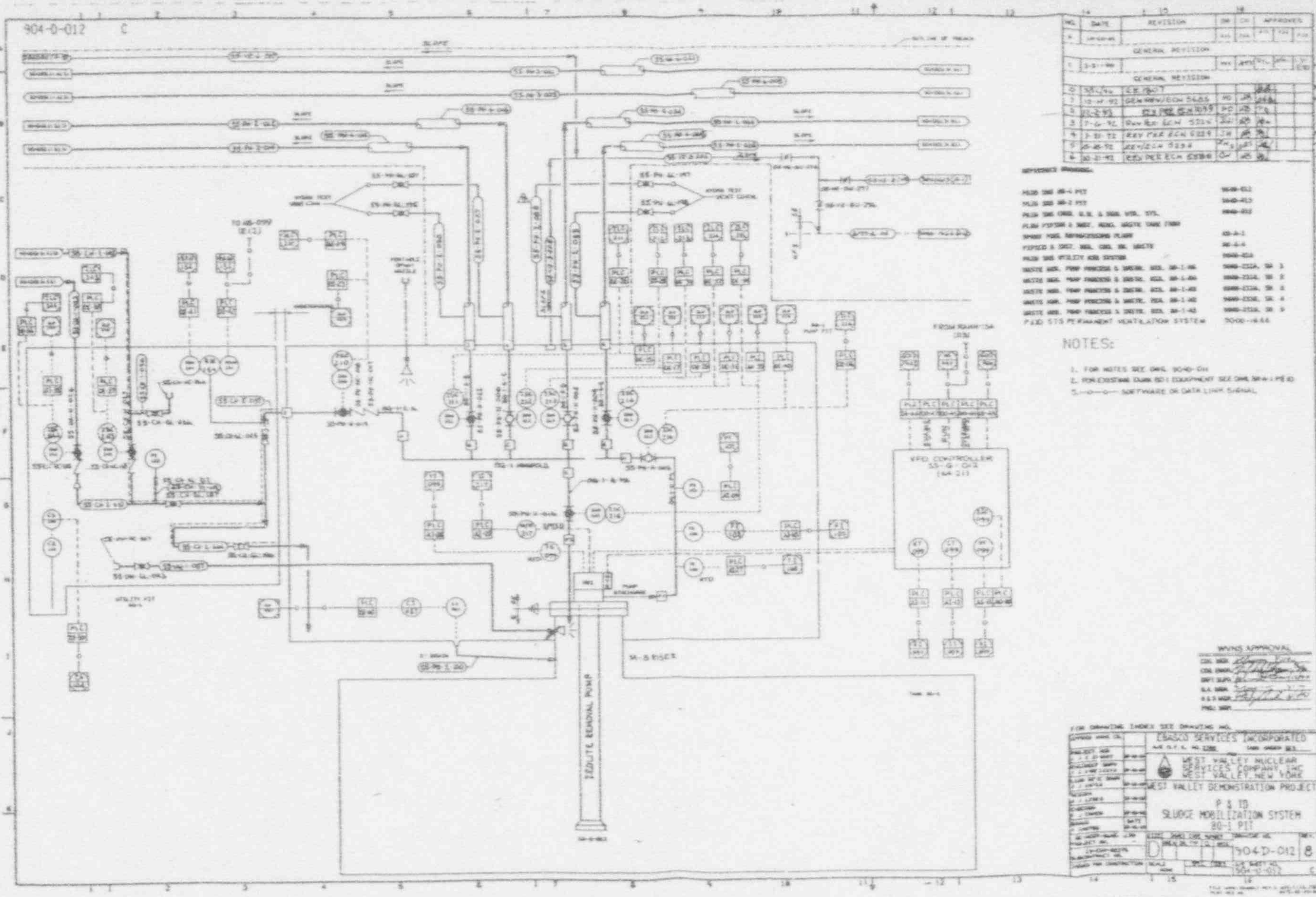

904-D-012
NOTES:
1. FOR NOTES SEE DWG. 904D-011
2. FOR EXISTING TANK 8D-1 EQUIPMENT SEE DWG. 904-1 P&ID
3. —o—o— SOFTWARE OR DATA LINK SIGNAL
VFD CONTROLLER
ZEOLITE REMOVAL PUMP
WVNS APPROVAL
EBASCO SERVICES INCORPORATED
WEST VALLEY NUCLEAR SERVICES COMPANY, INC.
WEST VALLEY, NEW YORK
WEST VALLEY DEMONSTRATION PROJECT
P & ID
SLUDGE MOBILIZATION SYSTEM
8D-1 PIT
904D-012
8

Figure 16

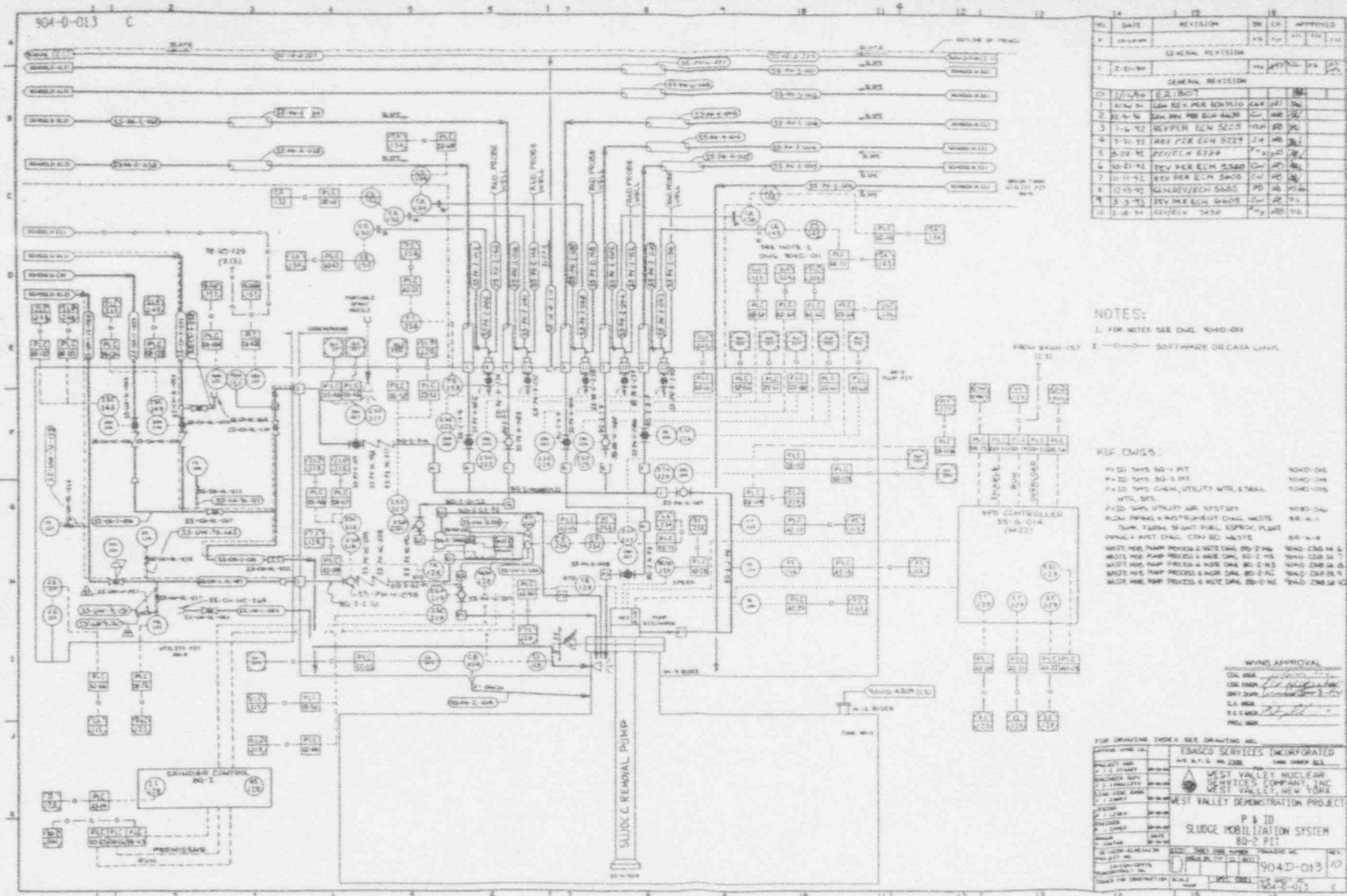

904-D-013 C
SLUDGE REMOVAL PUMP
VFD CONTROLLER
55-G-014
GRINDER CONTROL
NOTES:
1. FOR NOTES SEE DWG. 9040-011
2. SOFTWARE OR DATA LINK
REF DWGS:
GENERAL REVISION
WVNS APPROVAL
FOR DRAWING INDEX SEE DRAWING NO.
EBASCO SERVICES INCORPORATED
WEST VALLEY NUCLEAR SERVICES COMPANY, INC
WEST VALLEY, NEW YORK
WEST VALLEY DEMONSTRATION PROJECT
P & ID
SLUDGE MOBILIZATION SYSTEM
8D-2 PIT
904D-013

Figure 17

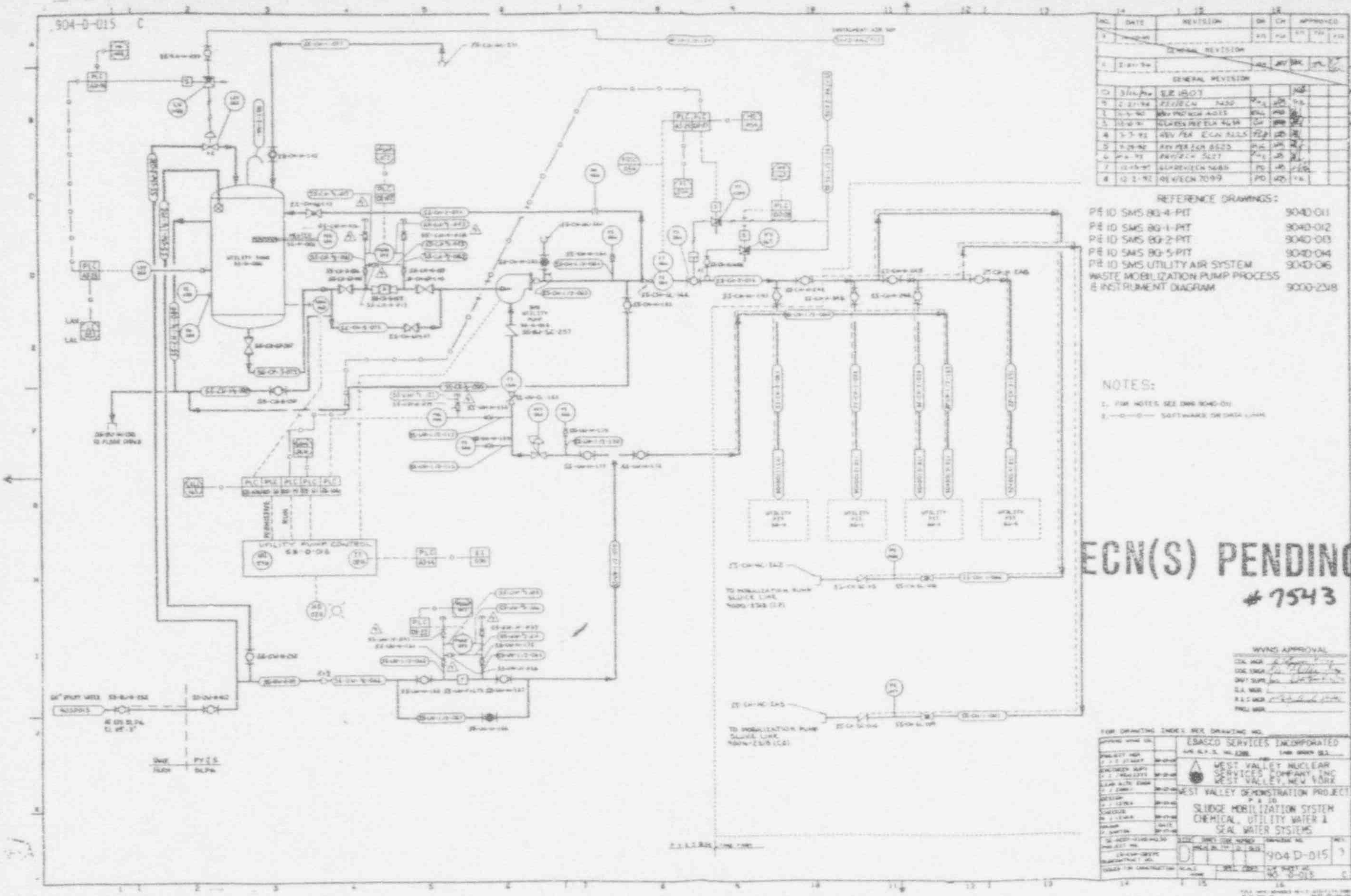

904-D-015 C
UTILITY PUMP CONTROL
REFERENCE DRAWINGS:
P&ID SMS 80-4-PIT 9040-011
P&ID SMS 80-1-PIT 9040-012
P&ID SMS 80-2-PIT 9040-013
P&ID SMS 80-5-PIT 9040-014
P&ID SMS UTILITY AIR SYSTEM 9040-016
WASTE MOBILIZATION PUMP PROCESS & INSTRUMENT DIAGRAM 9000-2318
NOTES:
ECN(S) PENDING
#7543
WVNS APPROVAL
EBASCO SERVICES INCORPORATED
WEST VALLEY NUCLEAR SERVICES COMPANY, INC.
WEST VALLEY, NEW YORK
WEST VALLEY DEMONSTRATION PROJECT
SLUDGE MOBILIZATION SYSTEM
CHEMICAL, UTILITY WATER & SEAL WATER SYSTEMS
904D-015

Figure 18

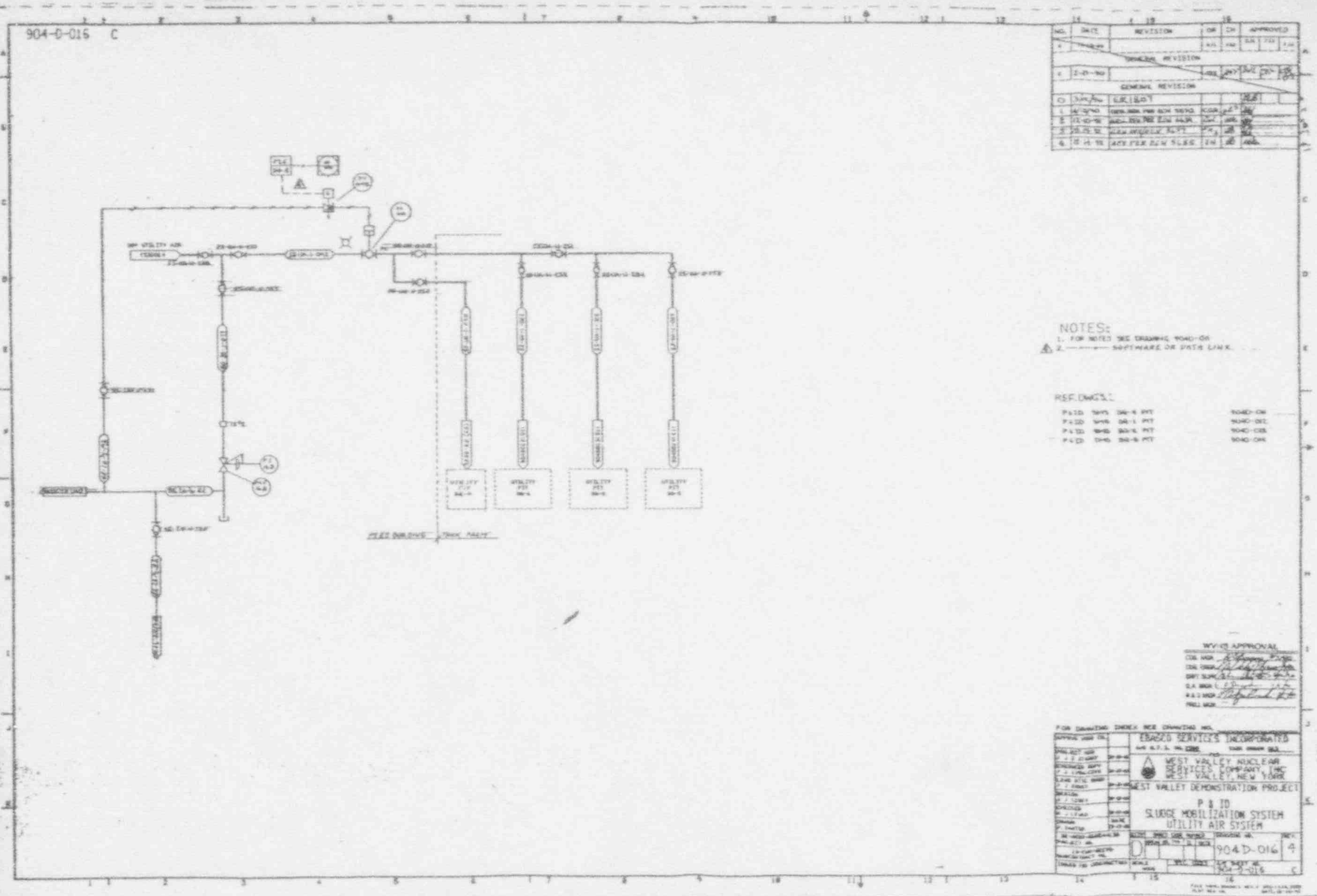

904-D-016 C
GENERAL REVISION
NOTES:
1. FOR NOTES SEE DRAWING
2. SOFTWARE OR DATA LINK
REF. DWGS.:
WV-I3 APPROVAL
EBASCO SERVICES INCORPORATED
WEST VALLEY NUCLEAR SERVICES COMPANY, INC
WEST VALLEY, NEW YORK
WEST VALLEY DEMONSTRATION PROJECT
P & ID
SLUDGE MOBILIZATION SYSTEM
UTILITY AIR SYSTEM
D
904D-016
4

Figure 19

Safety Review Screen

USE BLACK INK OR TYPE — Page 1 of

I. Responsibility — A. Date: 3/17/94

B.1 Title of Proposed Change or Discovery:
HIGH-LEVEL WASTE TRANSFER SYSTEM SAFETY EVALUATION (REV. 1)

B.2 Reference Document (affected document - e.g. work order no. " ")
WVNS-SAR-004 - SUPERNATANT TREATMENT SYSTEM

C. Cognizant Department: DESIGN ENGINEERING

D. Cognizant Manager (Typed/Printed): C. J. WINKLER

E. Prepared by (Typed/Printed): T. W. SHEARER

II. Safety Exclusion Screen (Complete either A or B, not both)

A. Discovery Process (Occurrence Reports, Non Conformance Reports, and RCA's only)

1. Does the facility configuration or operation differ from that described in the approved safety analysis or authorization basis? ☐ No ☐ Yes ☐ Mayb

2. Is there an error, omission, or inadequacy in the safety analysis which could reduce margin of safety in the SAR or an OSR/TSR? ☐ No ☐ Yes ☐ Mayb

B. Change Process:

1. Will the proposed change be a change in a facility described in an approved safety analysis? ☐ No ☒ Yes ☐ May

2. Will the proposed change make changes in procedures described in the approved safety analysis? ☐ No ☒ Yes ☐ May

3. Will the proposed change involve tests or experiments affecting a facility or operation described in the approved safety analysis? ☒ No ☐ Yes ☐ May

If any of the questions in A or B above were answered with "Yes" or "Maybe" then complete the remainder of the Safety Review Screen.

If all of the questions in A or B above were answered "No" then provide the basis in Section V, sign the form where indicated, and attach this copy with the change or discovery documentation per the governing procedure (see WV-914, Att. B).

III. Safety Research and Conclusions (attach additional pages if needed):

SEE ATTACHED PAGES

SAFETY REVIEW SCREEN

IV. Safety Questions:

A. Will the probability of an accident previously evaluated in approved safety analyses be increased? ☒ No ☐ Yes ☐ Maybe

B. Will the consequences of an accident previously evaluated in the approved safety analyses be increased? ☒ No ☐ Yes ☐ Maybe

C. Will the probability of a malfunction of equipment important to safety be increased? ☒ No ☐ Yes ☐ Maybe

D. Will the consequences of a malfunction of equipment important to safety be increased? ☒ No ☐ Yes ☐ Maybe

E. Will the possibility of an accident of a different type than any previously evaluated in approved safety analyses be created? ☒ No ☐ Yes ☐ Maybe

F. Will the possibility of a malfunction of a different type than any previously evaluated in the approved safety analyses be created? ☒ No ☐ Yes ☐ Maybe

G. Will the margin of safety as defined in the basis for any technical specification or safety analysis report be reduced? ☒ No ☐ Yes ☐ Maybe

H. Name (Typed/Printed) and Signature:

1. [signature] 3/17/94
Safety Reviewer TODD W SHEARER Date

2. R Joe Johnson 3/17/94
Independent Reviewer R. Joe Johnson Date

V. Basis (attach additional pages as needed):

VI. Manager Recommendation and Signoff

A. Recommendation (Either 1, 2, or 3 shall be answered "Yes"):

1. It is recommended that the change or discovery is not a potential USQ. [X] Yes

2. It is recommended that the change or discovery is a potential USQ to be transmitted to the Radiation and Safety Committee for further review. [ ] Yes

3. Terminate the proposed change activity. [ ] Yes

B. Signoff:

1. [signature] for CJW 3/16/94
Cognizant Manager C.J. WINKLER Date

VII. Radiation and Safety Committee Recommendation:

Recommendation (circle choice): Not USQ Probable USQ

Chairman, R&SC Date

Attachment to the Safety Review Screen for the High Level Waste Transfer System Safety Evaluation (Rev. 1)

III Safety Research and Conclusions:

A: Will the probability of an accident previously evaluated in approved safety analyses be increased?

Transferring of the wastes stored in tanks 8D-1 and 8D-4 to tank 8D-2 does not increase the probability of an accident previously analyzed in WVNS-SAR-004, Safety Analysis Report for Supernatant Treatment System (STS), which includes tank to tank transfers of waste. Accidents analyzed in Section 4.0 of the safety evaluation include tank, vault, and transfer pipe failure. These accidents are considered incredible based on the annual probability of exceedance and duration (< 6 months) of the proposed activities. Tank, vault, and pipe failures analyzed in WVNS-SAR-004 are also considered incredible. The HLWTS also meets or exceeds the design, material, and constructions standards specified in Section D.5.0 of WVNS-SAR-004. Section 2.0 of the safety evaluation specifies the standards associated with the HLWTS. Instrumentation used in the HLWTS has been subjected to the same quality and safety standards as the instrumentation used in the STS. Thus, the same reliability, accuracies and response characteristics are expected from the HLWTS instrumentation as those used in the STS. Therefore the probability of occurrence of accidents previously analyzed in Section D.9.0 of WVNS-SAR-004 is not increased.

B: Will the consequences of an accident previously evaluated in the approved safety analyses be increased?

Accidents analyzed in WVNS-SAR-004, include tank 8D-2 roof collapse, pipe rupture, ion exchange column over-pressurization, and HEPA filter fire. The maximum total effective dose equivalent (TEDE) to an off-site individual from these accidents was estimated to be less than 8.0E-01 rem. Accidents associated with the High-Level Waste Transfer System (HLWTS) include tank 8D-4 and 8D-2 roof collapse, and a pipe rupture. These analyses showed that the bounding accident for the HLWTS is a rupture of the THOREX transfer pipe. The consequence (i.e., TEDE) to an off-site individual for this accident was estimated to be less than 5.0E-1 rem.

Therefore, accidents that could occur during the HLWTS are bounded by the accidents analyzed in WVNS-SAR-004, such that no increase in radiological consequence will result. For additional information on the analyses performed for the HLWTS see Section 4.0 of the safety evaluation. For additional information on the accidents analyzed in the STS SAR see Section D.9.0 of WVNS-SAR-004.

C: Will the probability of a malfunction of equipment important to safety be increased?

The HLWTS will not increase the probability of a malfunction of equipment important to safety, previously analyzed in WVNS-SAR-004. The equipment specified in WVNS-SAR-004, and the proposed HLWTS equipment is not considered important to safety. Equipment important to safety is defined as any equipment or design feature that is required to remain functional to mitigate the consequence of an accident to an acceptable risk. In the accidents analyzed for both the STS and HLWTS all equipment is assumed to fail under accident conditions (i.e., probability of one) and no credit was taken for mitigating features. Thus, there is no equipment important to safety associated with the HLWTS. It is therefore concluded that the probability of a malfunction of equipment important to safety will not be increased.

D: Will the consequences of a malfunction of equipment important to safety be increased?

The HLWTS will not increase the consequence of a malfunction of equipment important to safety, previously evaluated in WVNS-SAR-004. Since there is no equipment important to safety connected to the HLWTS or the STS, the malfunction of equipment important to safety is impossible and the consequence from the malfunction of equipment important to safety cannot be increased.

E: Will the possibility of an accident of a different type than any previously evaluated in approved safety analyses be created?

The HLWTS does not create the possibility of an accident which is of a different type than previously analyzed in WVNS-SAR-004. The types of accidents analyzed in WVNS-SAR-004 include vault failure, tank failure, pipe rupture, ion exchange column over-pressurization, and HEPA filter fire. The accidents affiliated with the HLWTS include vault failure, tank failure, and pipe rupture and have consequences of the same order of magnitude or less than those analyzed in WVNS-SAR-004. Therefore the proposed activity does not create an accident of a different type than those previously analyzed in WVNS-SAR-004. For further information on the types of accidents analyzed in the STS SAR see Section D.9.0 of WVNS-SAR-004. For information on the types of accidents analyzed for the HLWTS see Section 4.0 of the safety evaluation.

F: Will the possibility of a malfunction of equipment important to safety of a different type than any previously evaluated in the approved safety analyses be created?

The HLWTS will not create the possibility of a malfunction of equipment important to safety of a different type. The original design, intent, and performance criteria of the STS equipment will continue to be met for all HLWTS equipment. Since there is no equipment important to safety connected to the HLWTS or the STS, the malfunction of HLWTS equipment important to safety is impossible. Thus it is concluded that a malfunction of equipment important to safety of a different type is not created.

G: Will the margin of safety as defined in the basis for any technical specification or safety analysis report be reduced?

The HLWTS will not decrease the margin of safety as defined in the Operational Safety Requirements (OSRs). All facility systems which will be relied upon during the high-level waste transfer are identified in WVNS-SAR-004 and are governed by the OSRs described in Volume VI of the SAR. The evaluation of the effect on the pH of the contents in tank 8D-2 from the proposed addition of acidic THOREX waste has verified that the safety margin of 10 % excess caustic for the contents of 8D-2 will remain valid. As such there is no reduction in the margin of safety as defined in the basis for any OSR. For further description of the evaluation on the effects of the addition of THOREX to tank 8D-2, see section 3.0 of the safety evaluation.

WVNS-SAR-003, Rev 2

"Vitrification System Operations and High Level Waste Interim Storage"

Scope: Vitrification Radioactive Operations, including Waste Transfer from Tank Farm, Vitrification, and High Level Waste Interim Storage

FIGURE A-3: RADIOLOGICAL PUBLIC CRITERIA

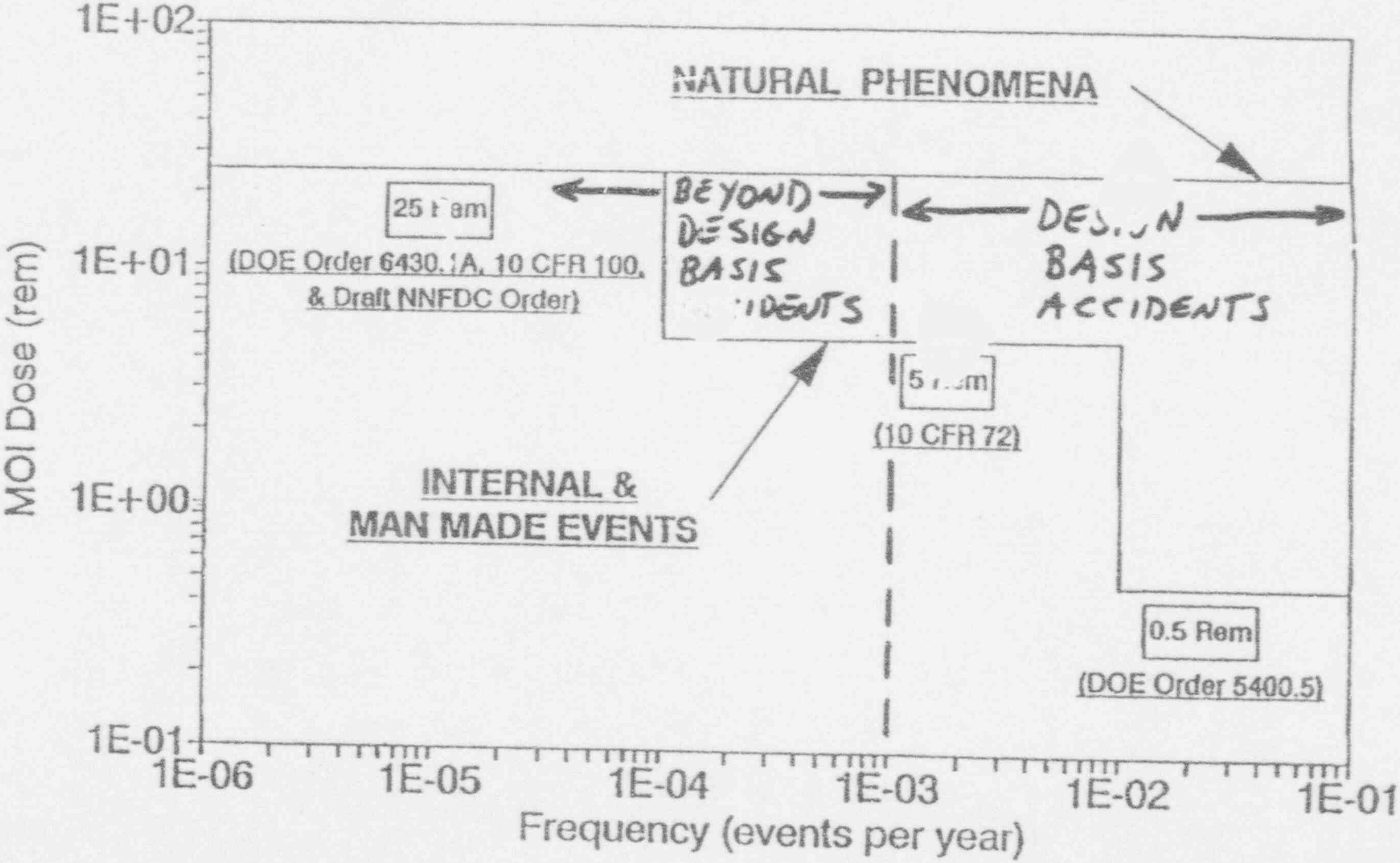


Table C.2.4-1

Evaluation Basis Accidents

SAR Section	Event	Bases for Accident	Dose		REMARKS
			On-Site	Off-Site	
C.9.4.1	CFMT Slurry Release	It is assumed that CFMT HLW slurry is released at its maximum inventory/ concentration/temperature.	1.7E-01 mrem	7.0E-02 mrem	Maximum concentration occurs 10% of time, reducing probability of this event.
C.9.4.2	CFMT Steam and Slurry Release	A break occurs in the CFMT heating coil when the CFMT slurry is at maximum concentration, "atomizing" slurry with steam.	1.0E+01 mrem	4.2E+00 mrem	All normal systems operate.
C.9.4.3	CFMT Loss of Vent Condenser	Boil-up from the CFMT continues for 10 minutes after steam starts escaping to Vitrification Cell.	8.1E-02 mrem	3.4E-02 mrem	Alarms cause operator to shut off steam after 10 min.
C.9.4.4	SFCM Off-Gas Jumper Failure	On failure, normal feed continues for one half hour, after which the off-gas rate decreases over the next 5 hours.	1.3E-01 mrem	4.6E-02 mrem	Cell ventilation HEPAs operate normally.
C.9.4.5	SFCM Molten Glass Spill	A rupture of the SFCM dumps total melter inventory.	3.9E-02 mrem	1.4E-02 mrem	This event bounds all other less significant molten glass spills.
C.9.4.6	SFCM Steam Explosion	Steam explosion in SFCM ruptures vessel and dumps the glass.	3.9E-02 mrem	1.4E-02 mrem	Steam explosion could cause some additional fraction to be airborne, but more likely result would be a drip from a crack.
C.9.4.7	HLW Canister Drop	A 10-m drop of a canister causes canister rupture and some release of fine glass particulates.	4.6E-03 mrem	1.9E-03 mrem	10% of bare glass release is assumed to account for canister containment.

Table C.2.4-1 (cont.)

Evaluation Basis Accidents

SAR Section	Event	Bases for Accident	Dose		REMARKS
			On-Site	Off-Site	
C.9.4.8	Vit Cell HEPA Filter Blow-out	Rupture/blowout of HEPAs having a loading of 10 rem at 1 ft.	NA 5.5E+02 mrem	4.3E-01 mrem 2.3E+02 mrem	Process vent system HEPA failure. Cell HEPA failure.
C.9.4.9	Vit Cell Loss of Coolers	Failure of coolers or cooling water supply.	----	----	No release if coolers are only failure and vent system continues to operate.
C.9.4.10	Vit Facility Loss of Power	All power, including for back-up ventilation systems, is lost.	6.6E+01 mrem	2.8E+01 mrem	Loss of all back-up power systems is an unlikely low probability event.
C.9.4.11	Tornado	DB Tornado missile penetrates containment barrier (note: BDB Tornado may cause ventilation system failure).	----	----	Dose is equivalent to two days normal operation; probability less than 10^{-6}/yr.
C.9.4.12	Nuclear Criticality	Nuclear criticality in the vitrification cell and HLWISF is incredible.	----	----	Concentration of fissile isotopes in vitrification feed and product is insufficient to support criticality.
C.9.5.1	Nitric Acid Day Tank	Failure of Day Tank	0.38 ppm	0.17 ppm	Bounding nitric acid release; will be mitigated by excess flow valves.
C.9.5.2	Oxides of Nitrogen	Failure of selective catalytic reactor.	0.015 ppm	0.023	NO_x concentrations too low for any consequences.

Table C.9.6-1

Beyond Design Basis Events

Ref/SAR	Scenario	Bases for Accident	Dose		REMARKS
			On-Site	Off-Site	
C.9.6.1	BDB Tornado	Not Analyzed	N/A	N/A	Frequency < 5E-10/year
C.9.6.2	BDB Earthquake, Power loss	Direct path out-leakage	270 mrem	110 mrem	Jumper failure and no HEPA filter
	BDB Earthquake, SFCM and CFMT Dump	Cell Vent stops at time zero	3.8 rem	1.6 rem	Vent system failure
	BDB Earthquake, SFCM and CFMT Dump	Cell Vent continues after HEPA failure	50 rem	21 rem	Instrument logic keeps vent system operating after HEPA failure
C.9.6.3	BDB Earthquake, CPC roof collapse	CPC roof falls onto 396 HLW canisters	----	----	No canister failure; roof collapse energy approximately 1/2 that of 7-meter canister drop
	BDB Earthquake Upper Crane Falls	Crane falls to rupture 4 canisters	13.6 mR	5.7 mR	Crane falls in optimum pattern for canister rupture

Table C.9.7-1

Nonradiological Beyond Design Basis Events

Ref/SAR	Scenario	Bases for Accident	Dose		REMARKS
			On-Site	Off-Site	
C.9.7.1.1	BDB Ammonia Tank Failure	Not Analyzed	N/A	N/A	Failure from overpressurization
C.9.7.1.2	BDB Ammonia Accident Failure	Failure of loading hose and excess flow valves fail to actuate	3,400 ppm	1,400 ppm	5.2E-06/yr frequency, 50 gpm continuous release
C.9.7.1.3	BDB Ammonia Tank Truck Accident	Not analyzed	N/A	N/A	1.0E-05/yr frequency
C.9.7.2	BDB Nitric Acid Tank Truck Accident	Significant (>10% cargo loss) from truck accident	20 ppm	10 ppm	2.1E-05/yr frequency, evaporation from liquid pool