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ADVANCED WASTEWATER TREATMENT FACILITY FINAL SAFETY ANALYSIS REPORT

01/27/95

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Advanced Wastewater Treatment Facility

Final Safety Analysis Report

Revision 1

Prepared by

The Fernald Environmental Restoration Management Corporation
Under Contract No. DE-AC05-92OR21972
with the United States Department of Energy

and

PARSONS
Under Subcontract No. 2-21487
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Fernald Environmental
FERMCO
Restoration Management Corporation

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FEMP-2397
Revision 1

Advanced Wastewater Treatment Facility Final Safety Analysis Report

AUTHORIZED BY: _____ 1-27-95
Don Ofte, President Date

FERNALD ENVIRONMENTAL MANAGEMENT PROJECT

Fernald Environmental Restoration Management Corporation
P.O. Box 398704
Cincinnati, Ohio 45239-8704

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Advanced Wastewater Treatment Facility
Final Safety Analysis Report

Approved By:

1-27-95

E.R. Schmidt, FERMCO, Manager, Safety Analysis Department — Date

1/27/95

S.L. Hinnefeld, FERMCO, V.P., Safety and Health — Date

1/27/95

J.R. Hughes, FERMCO, CRU-5, Project Director — Date

1/27/95

D. Paine, FERMCO, V.P., Remediation Support Operations — Date

CONCURRENCE:

1/27/95

R.E. Kline, FERMCO, Independent Safety Review Committee — Date

Advanced Wastewater Treatment Facility
Final Safety Analysis Report

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LIST OF ACRONYMS AND ABBREVIATIONS

ACGIH	American Conference of Governmental Industrial Hygienists
AEDO	Assistant Emergency Duty Officer
AIHA	American Industrial Hygiene Association
ALARA	As Low As Reasonably Achievable
ANSI	American National Standards Institute
ASHRAE	American Association of Heating, Refrigeration, and Air Conditioning Engineers
AWWT	Advanced Wastewater Treatment
BDN	Biodenitrification (facility)
CAT	Construction Acceptance Testing
CEOSHP	Comprehensive Environmental Occupational Safety and Health Program
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFC	Certified for Construction
CFR	Code of Federal Regulations
CMMS	Computerized Maintenance Management System
CPI	Continuous Performance Improvement
CRU	CERCLA/RCRA Unit
DCS	Distributed Control System
D&D	Decontamination and Decommissioning
DOE	United States Department of Energy
EEGL	Emergency Exposure Guideline Limits
EG	Evaluation Guideline
EOC	Emergency Operations Center
EPGA	Estimated Peak Ground Acceleration
ERPG	Emergency Response Preparedness Guidelines
ERT	Emergency Response Team
ES&H	Environmental Safety and Health
ETS	Effluent Treatment System
FEMA	Federal Emergency Management Agency
FEMP	Fernald Environmental Management Project
FERMCO	Fernald Environmental Restoration Management Corporation
FFCA	Federal Facilities Compliance Agreement
FSAR	Final Safety Analysis Report
ft^3	cubic foot (feet)
gal	gallon
gpm	gallons per minute
HAZCOM	Hazards Communication
HAZOP	Hazards and Operability Analysis

LIST OF ACRONYMS AND ABBREVIATIONS (Continued)

HVAC	Heating, Ventilating, and Air Conditioning
I&C	Instrumentation and Control
ICAT	Integrated Construction Acceptance Tests
IDLH	Immediate Danger to Life and Health
IH	Industrial Hygiene
IX	Ion Exchange
lbs	pounds
LOC	Level of Concern
mg/m^3	milligrams per cubic meter
mg/l	milligrams per liter
min	minute
mph	miles per hour
mrem	millirem
MSDS	Material Safety Data Sheets
NAS	National Academy of Sciences
NFPA	National Fire Protection Association
NIOSH	National Institute of Occupational Health and Safety
NPDES	National Pollutant Discharge Elimination System
NPH	Natural Phenomena Hazard
O&M	Operations and Maintenance
OAC	Ohio Administrative Code
OBBC	Ohio Basic Building Code
OSHA	Occupational Safety and Health Administration
OSR	Operational Safety Requirement
P&ID	Piping and Instrumentation Diagram
PEL	Permissible Exposure Limits
PEL-C	Permissible Exposure Limits Ceiling
pH	powers of Hydrolysis
PHA	Preliminary Hazard Assessment
PM	Preventative Maintenance
PPE	Personal Protective Equipment
psf	pounds per square foot
psig	pounds per square inch gage
PSM	Process Safety Management
QA	Quality Assurance
QAP	Quality Assurance Program
QSE	Qualified Safety Evaluator

LIST OF ACRONYMS AND ABBREVIATIONS
(Continued)

RA	Readiness Assessment
RC	Radiological Control
RCRA	Resource Conservation and Recovery Act
REL	Recommended Exposure Limit
RSO	Remedial Support Organization
RWP	Radiation Work Permit
S/RID	Standards/Requirements Identification Document
SAR	Safety Analysis Report
SOP	Standard Operating Procedure
SOT	System Operability Testing
SSC	Structure, System, and Component
STD	Standard (DOE)
STEL	Short-Term Exposure Limit
SWCR	Sitewide Characterization Report
SWRB	Stormwater Retention Basin
TLD	Thermoluminescent Dosimeter
TLV	Threshold Limit Value
TPQ	Threshold Planning Quantity
TQM	Total Quality Management
TR	Technically Responsible
TSR	Technical Safety Requirement
TWA	Time-Weighted Average
UBC	Uniform Building Code
UCRL	University of California Research Laboratories
UF_4	Uranium tetrafluoride
UF_6	Uranium hexafluoride
US DOT	United States Department of Transportation
US EPA	United States Environmental Protection Agency
USQD	Unreviewed Safety Question Determination

EXECUTIVE SUMMARY

E.1 Introduction

This document uses the graded approach to provide the safety basis of the Advanced Wastewater Treatment (AWWT) Facility. United States Department of Energy (DOE) Order 5481.1B, "Safety Analysis and Review System," used for non-nuclear facilities, is the guiding document. Safety Analysis Report (SAR) format guidance is from DOE-STD-3009-94, "Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Safety Analysis Reports;" however, the AWWT is not a nuclear facility.

E.2 Overview of the Facility

The AWWT system is currently under construction in Building 51. It is a continuously controlled treatment process which operates on a 24-hour per day schedule to chemically process Fernald Environmental Management Project (FEMP) site stormwater/groundwater and process wastewater to remove uranium. In this process, small quantities of other trace contaminants are removed. The facility provides pH adjustment, chemical treatment, filtration, carbon adsorption, and ion exchange treatment to the various wastewater streams. Section 2 figures provide diagrams of the AWWT operations and layout. After treatment, the stormwater/groundwater is combined with the process wastewater stream, passed through final filtration, and then discharged to the Great Miami River.

Located in the southwestern corner of the FEMP, the AWWT is considered part of the controlled area. Interfaces between the AWWT and other site facilities are wastewaters and utilities. As part of the FEMP, the AWWT is encompassed by the site boundaries.

Materials in the AWWT system present both radiological and chemical hazards. The groundwater/ stormwater and process wastewater contain trace amounts of uranium and chemicals. Wastewater contaminants are concentrated in the slurry and bound to the ion exchange resin and carbon filters. The typical uranium concentration levels are 0.5 milligrams per liter (mg/l) with a design maximum of 10 mg/l. Risks to the workers are low for the wastewater treatment process system due to low contaminant concentrations. The risk identified as medium is for the receipt and transfer of the concentrated process treatment chemicals (see Section 3 and Appendices B and C). The process treatment chemical--sulfuric acid--is received and stored in a 93 percent concentration. The sodium hydroxide is received at 50 percent, diluted, and stored at 20 percent.

E.3 Facility Hazard Classification

The AWWT facility is classified as a radiological facility with non-nuclear facility documentation per the guidance of DOE-EM-STD-5502-94, "Hazard Baseline Determination," which uses the guideline values of DOE-STD-1027 and United States Environmental Protection Agency (US EPA) reportable quantities for determining facility classification. The potentially releasable treatment chemicals are above the 40 Code of Federal Regulations (CFR) 355 thresholds. Using the classification scheme of DOE-EM-STD-5502-94, DOE Order 5481.1B safety documentation is required. Guidance criteria given in 29 CFR 1910.119, *Process Safety Management of Highly Hazardous Chemicals*, are not applicable because chemicals used in the AWWT facility are not listed.

To determine the hazard category for the AWWT Facility, the highest possible concentration of uranium inventory was considered (see Appendix H). Table 6 of Appendix E, Attachment 1 presents the categorization based on the uranium loading. The total uranium inventory is 17 percent of the allowable threshold limits from DOE-STD-1027-92, Attachment 1 (Ref. 3.5).

Based on the criteria for the impacts associated with hazards as given in Table 1 of WSRC-MS-92-206, Revision 1 (Ref. 3.13), the hazards due to the chemicals present are below those for a low-hazard facility. Owing to the hazards of concentrated sulfuric acid and the caustic, the AWWT is classified as low-hazard.

E.4 Summary of Safety Analysis

The analysis of normal AWWT facility operations (refer to Section 3) identified the principal hazards as radiation and chemical exposure. The primary means for controlling the hazards associated with the processing of wastewater is containment in vessels, tanks, and pipes. The confinement system of sumps, drains, and test wells prevents releases and returns to the treatment system all wastewater, contaminated effluent, and treatment chemicals that may spill or leak from the containment system. The following materials are discharged from the facility: waste slurry to Plant 8 by pipe, drummed solid wastes (spent ion exchange resin and disposable carbon filtration units) to storage other than Building 51, and treated water through Manhole 176B to the Great Miami River. Both the waste slurry and solid wastes represent a radiological hazard due to concentration of the uranium from the waste streams.

The uranium concentrations for the AWWT process streams and vessels contribute negligible levels to external dose rates. During normal operations the wastewater is contained to prevent workers from possible radiation contamination. In the event of an accidental exposure, showers and eyewash stations are available to mitigate any contamination that might occur. Personal Protective Equipment (PPE) is readily available for use as a precaution (i.e., maintenance of potentially contaminated piping/pumps/ equipment) in accordance with AWWT and site procedures.

Due to the presence of uranium in the AWWT Facility, there is a theoretical possibility of an inadvertent criticality event. The AWWT wastewater treatment processes physically limit the uranium in all equipment, save one component, to quantities below safe mass limits. The one component, the clarifier, can only present a criticality hazard through multiple significant operator misoperations and equipment failures (see Appendix G). An administrative control on the enrichment of wastewater permitted to be treated has been established for the clarifier. The enrichment limit is set at 1 percent (see Section 6). In conclusion, the AWWT presents no credible potential for criticality and, therefore, there are no safety-class systems nor criticality alarm systems required to protect against criticality in the facility.

The types, concentrations, and amounts of radioactive and hazardous materials are such that no safety class systems are required for the facility. Any potential exposure of facility workers to hazardous chemicals is due to an accidental release of the stored inventories of sulfuric acid, alum, and caustic (sodium hydroxide). The initiating event for release of these chemicals is by spill, natural phenomena, and inadvertent mixing. Due to a violent reaction and possible worker fatalities if acid and caustic are mixed during offloading, an Operational Safety Requirement is used to prevent such an event. Having controls in place for the acid and caustic material handling limits the potential for exposure of the public or impact to the off-site environment during normal operations of the AWWT facility. The accident analysis presented in Section 3 indicates that no significant off-site exposures result from accidents.

The analysis indicates that the combination of confinement systems, administrative controls including Standard Operating Procedures, and PPE is adequate to control and mitigate the potential facility hazards and their consequences. Using these, normal operations can be conducted with minimal risk to AWWT workers and with no risk to the environment or the general public off site.

A quantitative analysis, presented in Appendix E, demonstrates that the AWWT is below the Hazard Category 3 threshold for radiological inventory. The accident analysis considered natural phenomena hazards and spills of bulk chemicals and wastewater.

Tables 9 and 10 of Appendix E, Attachment 1 show the threshold quantities and concentrations of chemicals released (as milligrams per cubic meter [mg/m^3]) for the natural phenomena hazards, spill and inadvertent mixing, and resultant release of sulfuric acid. The latter accident presents the highest concentration for the release of the sulfuric acid at 45 percent of the allowable threshold. The next highest release, and the only one over 10 percent, is the high wind release of the sodium hydroxide.

Table 11 of Appendix E, Attachment 1 presents the radiological consequences for an accidental release by natural phenomena or spill. The accident resulting in the greatest dose is an earthquake. The 50-year Committed Effective Dose Equivalent is 24 millirem (mrem). This dose is due to the release of the entire AWWT wastewater inventory from all vessels. Uranium concentrations and equipment loadings used are bounding for all cases. Appendix H presents the calculation of the equipment loading.

E.5 Organizations

The AWWT facility is operated by the Fernald Environmental Restoration Management Corporation (FERMCO). The organizations directly responsible are the Remedial Support Organization (RSO), for operation, and the CERCLA/RCRA Unit 5 (CRU-5) engineering staff, for technical oversight and facility design. The CRU-5 Engineering staff functionally reports to the Environmental Engineering and Technology Groups, follows the FERMCO engineering program procedures, and is matrixed to support CRU-5 engineering needs. Prior to FERMCO's assuming the FEMP contract, the managing company was Westinghouse Environmental Management Company of Ohio, and the AWWT architect/engineer was A.M. Kinney. This SAR was developed by FERMCO with assistance from PARSONS and Safety Management, Inc. The responsible group for the SAR is the FERMCO Systems Safety Department. Review by the RSO, CRU-5, and other site organizations (e.g., Radiological Control, Quality Assurance, etc.) helps ensure compliance with the applicable DOE requirements. The SAR is independently reviewed by the Independent Safety Review Committee and is reviewed and approved by the DOE.

FOREWORD

For the purpose of determining the design criteria for the structures, systems, and components (SSCs), the Advanced Wastewater Treatment (AWWT) Facility may be considered a Non-reactor Radioactive Liquid Waste Facility by the definition given in United States Department of Energy (DOE) Order 6430.1A, Section 1323. However, the AWWT Facility does not contain enough radioactive material to be classified as a "Nuclear Facility" per DOE-STD-1027-92, "Hazard Categorization and Accident Analysis Techniques for Compliance with DOE Order 5480.23, Nuclear Safety Analysis Reports," and, as such, DOE Order 5480.23 does not apply to this project (see Section 3). Implementation of the guidance in Figure 1 of DOE-EM-STD-5502-94, "EM Hazard Baseline Documentation Process," results in the AWWT being classified as a radiological facility with non-nuclear facility documentation. Due to the chemical hazards associated with the AWWT Facility, this Final Safety Analysis Report (FSAR) was prepared to meet the requirements of DOE Order 5481.1B, "Safety Analysis and Review System."

To provide a format consistent with other Safety Analysis Reports (SARs) at the Fernald Environmental Management Project (FEMP), this FSAR was prepared in the 17-chapter format recommended in DOE-STD-3009-94, "Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Safety Analysis Reports." Since the AWWT is not a "Nuclear Facility" (for safety analysis purposes), this FSAR does not follow all of the guidance provided in the specific subsections of the proposed DOE standard. In keeping with the DOE graded approach philosophy, this FSAR refers to other site documents.

SECTION 1

SITE CHARACTERISTICS

1.1 Introduction

This section provides a description of the site characteristics that are relevant to the Advanced Wastewater Treatment (AWWT) Facility. The site information is necessary to identify potential external accident initiators and to analyze consequences to the facility.

1.2 Requirements

Based on the analysis in Section 3, the AWWT Facility is a low-hazard chemical facility and does not have a potential for significant consequences to extend beyond the immediate facility site. Requirements for supporting data presented in this section are limited to the level of detail needed to support the analysis.

1.3 Site Description

The Fernald Environmental Management Project (FEMP) is located in rural southwestern Ohio near the unincorporated village of Fernald in Hamilton County. The FEMP is located about 17 miles northwest of downtown Cincinnati, Ohio.

Figure 1-1 identifies the major surrounding roads and site boundaries. The site is generally bounded on the north by State Route 126, on the south by Willey Road, on the west by Paddys Run Road, and on the east by Knollman's Dairy Farm. State Route 128 runs along the southeast side of the FEMP site. Surrounding the production area is a buffer consisting of leased grazing land, reforested land, and unused areas. Paddys Run flows south-southeast along the western edge of the site.

The AWWT Facility is located at the FEMP in the Building 51 area, shown in Figure 1-2. The former production area of the FEMP covers approximately 136 acres in the central portion of the site.

The following data are presented as information to aid the reader in understanding the FEMP and its environs.

The residential population within a 5-mile radius of the FEMP is approximately 23,000. The population density within 5 miles is fairly uniform. Significant localized centers of population within this 5-mile radius of the FEMP are the towns of Ross (east by northeast), Fernald (south), and New Baltimore (south

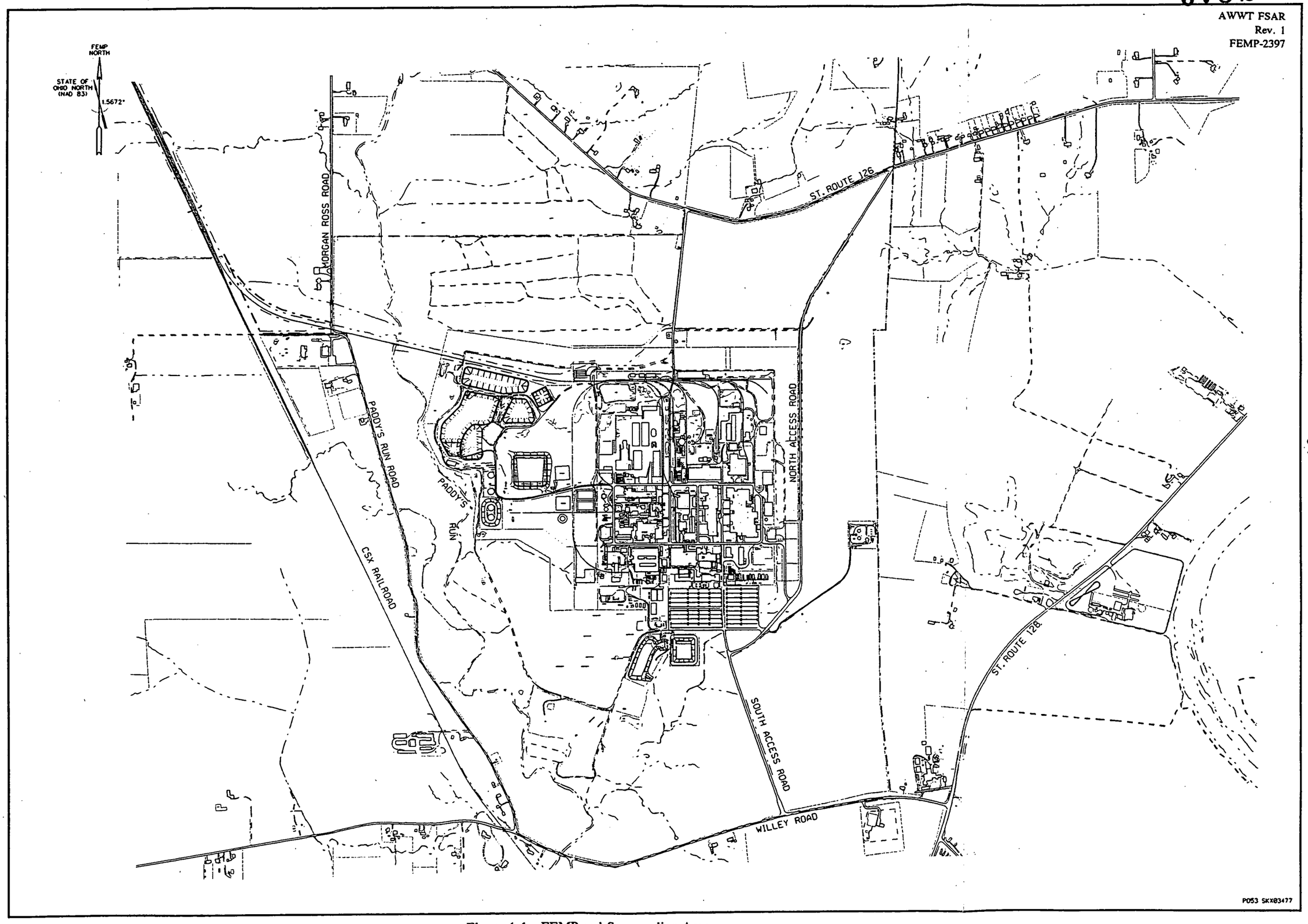

Figure 1-1 - FEMP and Surrounding Area

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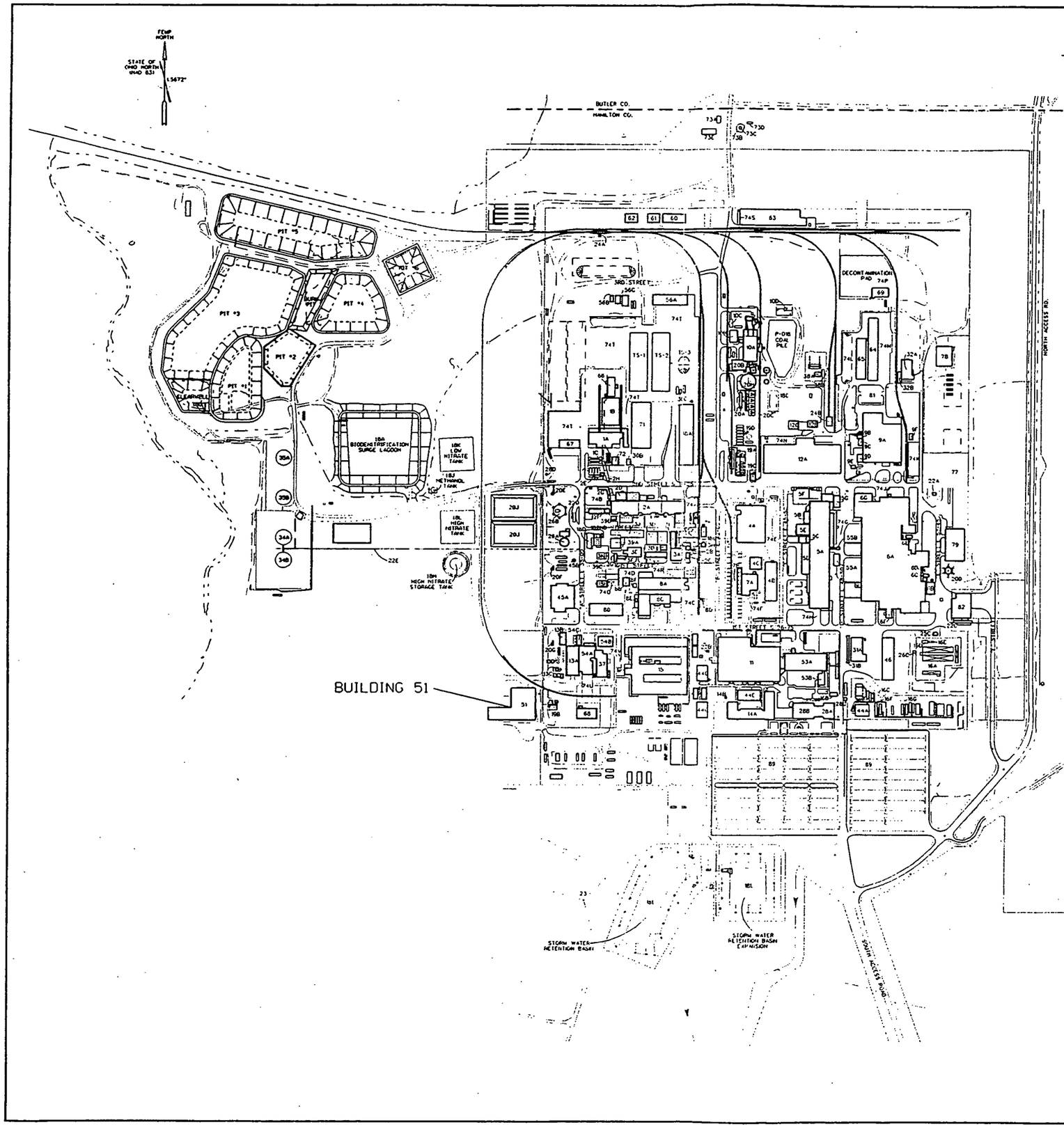

FEMP SITE IDENTIFICATION

TS-1 TENSION SUPPORT STRUCTURE #1
TS-2 TENSION SUPPORT STRUCTURE #2
TS-3 TENSION SUPPORT STRUCTURE #3
TS-4 TENSION SUPPORT STRUCTURE #4
TS-5 TENSION SUPPORT STRUCTURE #5
TS-6 TENSION SUPPORT STRUCTURE #6
1A PREPARATION PLANT
1B PLANT 1 STORAGE BLDG.
1C PLANT 1 ORE SILOS
2A ORE REFINERY PLANT
2B GENERAL/REFINERY SUMP CONTROL BLDG
2C BULK LIME HANDLING BLDG.
2D METAL DISSOLVER BLDG.
2E NFS STORAGE & PUMP HOUSE
2F COLD SIDE ORE CONVEYOR
2G HOT SIDE ORE CONVEYOR
2H CONVEYOR TUNNEL (FROM PLANT 1)
3A MAINTENANCE BLDG.
3B OZONE BLDG.
3C NAR CONTROL HOUSE
3D NAR TOWERS
3E HOT RAFFINATE BLDG.
3F MARSHAW SYSTEM
3G REFRIGERATION BLDG.
3H REFINERY SUMP
3J COMBINED RAFFINATE TANKS
3K OLD COOLING WATER TOWER
3L ELECTRICAL POWER CENTER BLDG.
4A GREEN SALT PLANT
4B PLANT 4 WAREHOUSE
4C PLANT 4 MAINTENANCE BLDG.
5A METALS PRODUCTION PLANT
5B PLANT 5 INGOT PICKLING
5C PLANT 5 ELECTRICAL SUBSTATION
5D WEST DERBY BREAKOUT/SLAG MILLING
5E PLANT 5 FILTER BLDG.
5F PLANT 5 COVERED STORAGE PAD
5G PLANT 5 INGOT STORAGE SHELTER
6A METALS FABRICATION PLANT
6B PLANT 6 COVERED STORAGE AREA
6C PLANT 6 ELECTROSTATIC PRECIPITATOR (SOUTH)
6D PLANT 6 ELECTROSTATIC PRECIPITATOR (CENTRAL)
6E PLANT 6 ELECTROSTATIC PRECIPITATOR (NORTH)
6F PLANT 6 SALT OIL HEAT TREAT BLDG.
6G PLANT 6 SUMP BLDG.
7A PLANT 7
7B PLANT 7 OVERHEAD CRANE
8A RECOVERY PLANT
8B PLANT 8 MAINTENANCE BLDG.
8C ROTARY KILN/DRUM RECONDITIONING
8D PLANT 8 RAILROAD FILTER BLDG.
8E DRUM CONVEYOR SHELTER
8F PLANT 8 OLD DRUM WASHER
9A SPECIAL PRODUCTS PLANT
9B PLANT 9 SUMP TREATMENT FACILITY
9C PLANT 9 DUST COLLECTOR
9D PLANT 9 SUBSTATION
9E PLANT 9 CYLINDER SHED
9F PLANT 9 ELECTROSTATIC PRECIPITATOR
10A BOILER PLANT
10B BOILER PLANT MAINTENANCE BLDG.
10C WET SALT STORAGE BIN
10D CONTAMINATED OIL/GRAPHITE BURN PAD
10E UTILITIES HEAVY EQUIP. BLDG.
11 SERVICE BLDG
12A MAIN MAINTENANCE BLDG.
12B CYLINDER STORAGE BLDG.
12C LUMBER STORAGE BLDG.
12D MAINTENANCE BLDG. WAREHOUSE
13A PILOT PLANT WET SIDE
13B PILOT PLANT MAINTENANCE BLDG.
13C SUMP PUMP HOUSE
13D PILOT PLANT THORIUM TANK FARM
14A ADMINISTRATION BLDG.
14B BLDG. 14 TOC GENERATOR SET
15A LABORATORY
15B LABORATORY CHEMICAL STORAGE BLDG.
16A MAIN ELECTRICAL STATION
16B ELECTRICAL SUBSTATION
16C ELECTRICAL PANELS & TRANSFORMER
16D MAIN ELECTRICAL SWITCH HOUSE
16E MAIN ELECTRICAL TRANSFORMERS
16F TRAILER SUBSTATION #1
16G TRAILER SUBSTATION #2
16H 10 PLEXS NORTH SUBSTATION
16J 10 PLEXS SOUTH SUBSTATION
18A BDN SURGE LAGOON
18B GENERAL SUMP
18C COAL PILE RUNOFF BASIN
18D BIODENITRIFICATION TOWERS
18E STORM WATER RETENTION BASINS
18F PIT #5 SLUICE GATE
18G CLEARWELL PUMP HOUSE
18H BDN EFFLUENT TREATMENT FACILITY
18J METHANOL TANK
18K LOW NITRATE TANK
18L HIGH NITRATE TANK
18M HIGH NITRATE STORAGE TANK
18N WASTE PIT AREA STORM WATER RUNOFF CONTROL
18P DISSOLVED OXYGEN BLDG.
18Q SOUTH PLUME INTERIM TREATMENT BLDG.
18R OUTFALL ONE PIT
19A MAIN TANK FARM
19B PILOT PLANT AMMONIA TANK FARM
19C TANK FARM CONTROL HOUSE
19D OLD NORTH TANK FARM
19E TANK FARM LIME SLITTER BLDG.
20A PUMP STATION & POWER CENTER
20B WATER PLANT
20C COOLING TOWERS
20D ELEVATED POTABLE STORAGE TANK
20E WELL HOUSE #1
20F WELL HOUSE #2
20G WELL HOUSE #3
20H PROCESS WATER STORAGE TANK
20J LIME SLURRY PITS
22A GAS METER BLDG.
22B STORM SEWER LIFT STATION
22C TRUCK SCALE
22D SCALE HOUSE & WEIGH SCALE
22E UTILITY TRENCH TO PIT AREA
23 METEOROLOGICAL TOWER
24A RAILROAD SCALE HOUSE
24B RAILROAD ENGINE HOUSE
25A CHLORINATION BLDG.
25B M.H. #175/EFF. LINE/SAMPLING BLDG.
25C SEWAGE LIFT STATION BLDG.
25D U.V. DISINFECTION BLDG.
25E DIGESTER & CONTROL BLDG.
25F SLUDGE DRYING BEDS
25G PRIMARY SETTLING BASINS
25H TRICKLING FILTERS
25J 10 PLEXS SEWAGE LIFT STATION
26A PUMP HOUSE-HP FIRE PROTECTION
26B ELEVATED WATER STORAGE TANK
26C MAIN ELECTRICAL STRAINER HOUSE
28A SECURITY BLDG.
28B HUMAN RESOURCES BLDG.
28C GUARD POST ON SOUTH END OF "D" STR.
28D GUARD POST ON WEST END OF "2ND" STR.
28E GUARD POST AT T81
28F SKEET RANGE BLDG.
28G GUARD POST SOUTH OF BLDG. 51
30A CHEMICAL WAREHOUSE
30B DRUM STORAGE WAREHOUSE
30C OLD TON TON SCALE
31A ENGINE HOUSE/GARAGE
31B OLD TRUCK SCALE
32A MAGNESIUM STORAGE BLDG.
32B BLDG. 32 COVERED LOADING DOCK
34A K-65 STORAGE TANK (NORTH)
34B K-65 STORAGE TANK (SOUTH)
34C R1S BLDG.
35A METAL OXIDE STORAGE TANK (NORTH)
35B METAL OXIDE STORAGE TANK (SOUTH)
37 PILOT PLANT ANNEX
38A PROPANE STORAGE
38B CYLINDER FILLING STATION
39A INCINERATOR BLDG.
39B WASTE OIL DECANT SHELTER
39C INCINERATOR SPRINKLER RISER HOUSE
39D SEWAGE TREATMENT PLANT INCINERATOR
44A TRAILER COMPLEX (6-PLEX)
44C TRAILER COMPLEX (7-PLEX S.)
44D TRAILER COMPLEX (7-PLEX N.)
44E TRAILER COMPLEX (10 PLEX)
45A CONSTRUCTION DIVISION BLDG.
45B UTILITY SHED EAST OF RUST TRAILERS
46 HEAVY EQUIPMENT BLDG.
51 ADVANCED WASTEWATER TREATMENT FACILITY (AWWT)
53A HEALTH & SAFETY BLDG.
53B IN-VIVO BLDG.
54A SIX TO FOUR REDUCTION FACILITY #1
54B PILOT PLANT WAREHOUSE
54C PILOT PLANT DISSOCIATOR SHELTER
55A SLAG RECYCLING BLDG.
55B SLAG RECYCLING PIT/ELEVATOR
56A CP STORAGE WAREHOUSE
56B STORAGE SHED (WEST)
56C STORAGE SHED (EAST)
60 QUONSET HUT #1
61 QUONSET HUT #2
62 QUONSET HUT #3
63 KC-2 WAREHOUSE
64 THORIUM WAREHOUSE
65 (OLD) PLANT 5 WAREHOUSE
66 DRUM RECONDITIONING BLDG.
67 PLANT 1 THORIUM WAREHOUSE
68 PILOT PLANT WAREHOUSE
69 DECONTAMINATION BLDG.
71 GENERAL IN-PROCESS WAREHOUSE
72 DRUM STORAGE BUILDING
73A FIRE BRIGADE TRAINING CENTER BLDG.
73B FIRE TRAINING POND
73C FIRE TRAINING TANK
73D FIRE TRAINING BURN TROUGH
73E CONFINED SPACE BURN TANK
74A PLANT 2 EAST PAD
74B PLANT 2 WEST PAD
74C PLANT 8 EAST PAD
74D PLANT 8 WEST PAD
74E PLANT 4 PAD
74F PLANT 7 PAD
74G PLANT 5 EAST PAD
74H PLANT 5 SOUTH PAD
74J PLANT 6 PADS
74K PLANT 9 PAD
74L BUILDING 65 WEST PAD
74M BUILDING 64 EAST PAD & R.R. DOCK
74N BUILDING 12 NORTH PAD
74P DECONTAMINATION PAD
74Q PLANT 8 OLD METAL DISSOLVER PAD
74R PLANT 8 NORTH PAD
74S BUILDING 63 WEST PAD
74T PLANT 1 STORAGE PAD
74U PILOT PLANT PAD
74V LABORATORY PAD
74W INCINERATOR BLDG PAD
77 FINISHED PRODUCTS WAREHOUSE (4A)
78 D & D BUILDING
79 PLANT 6 WAREHOUSE
80 PLANT 8 WAREHOUSE
81 PLANT 9 WAREHOUSE
82 RECEIVING/INCOMING MAT'LS. INSP.
88 CLEARWELL LINE
89 PARKING LOTS
T76 INTERIM OFFICE SPACE
T77 INTERIM OFFICE SPACE
T80 INTERIM OFFICE SPACE
T81 INTERIM OFFICE SPACE

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Figure 1-2 - Building 51 Location at the FEMP

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by southeast). The regional population distribution is dominated by the City of Cincinnati and its suburbs to the southeast of the FEMP, beginning about 5 miles away. The urban complex of Hamilton and Fairfield, about 10 to 20 miles to the northeast, and the urban growth along U.S. Highways 27 and 127 greatly influence the population density; however, the population density within 5 miles of the plant is half the state average and is much less than the average of Hamilton and Butler Counties. Therefore, the immediate FEMP area can be characterized as rural. The population growth within a 5-mile radius of the plant is projected to be negligible for the duration of the project.

1.4 Natural Phenomena Threats

Specific natural phenomena threats considered as potential accident initiators are tornadoes, high winds, and earthquakes. Flooding, as discussed in United States Department of Energy (DOE) guidance, is not considered a significant natural phenomena threat because the site location is not near a major waterway. Further concerns with other forms of flooding are detailed in the following discussion.

The floods in the FEMP area are initiated only by rainfall in the form of deluge. Tidal floods and wind-generated floods are not credible for the FEMP site due to inland locations, geography, and climate. Flooding of the FEMP site as the result of Paddys Run and the Great Miami River exceeding the capacity of the river floodplain has not occurred in the recorded historical past.

The FEMP is built on an upland till plain above the Great Miami River floodplain. The approximate 100-year floodplain areas on the FEMP site are determined by the *100- and 500-year Flood Plain Determination Sitewide*, Rev. 0 (Ref. 1.1). The established 100-year floodplain elevation within the Paddys Run watershed is located approximately 1,500 feet due west at an elevation of 554 feet.

The FEMP facility is located in a seismically quiet region that has experienced ground motion principally because of events in adjacent regions. Potential earthquake activity having direct effect on the Fernald reservation has been identified to be a result of the seismic activity in three zones; Anna, Ohio; the New Madrid Fault; and the Appalachian Zone. Thirty-seven earthquakes have been reported in the Anna, Ohio area, approximately 75 miles north of the FEMP facility. This area is located on the northeast flank of the Jessamine Dome. These earthquakes are concentrated in a 40-mile long, northeast to southwest trending zone extending southward from Lima, Ohio. Epicenter distances from the FEMP site range from 50 to 90 miles.

The record of instrumentally monitored seismic events is small. Earthquake history in the area of the FEMP must be supplemented with newspaper accounts and other published references. Since the area has been populated for almost 200 years, any earthquake of consequence has likely been reported. Throughout the nineteenth and twentieth centuries, no damaging earthquakes have been recorded for any areas immediate to the FEMP (Ref. 1.2).

Meteorological conditions at the FEMP site are typical of conditions throughout southwestern Ohio, but wind direction may be influenced by local topography. The facility is situated in a valley oriented from west-southwest to east-northeast, through which the Great Miami River flows to the west-southwest. Gently rolling hills surround the site and larger hills form the boundaries of the aforementioned valley. The closest of these larger, surrounding hills are 0.5 miles to the north and 1.2 miles to the south-southeast.

The Cincinnati, Ohio area, with a nominal elevation of 761 feet above sea level and an approximate latitude of 39 degrees North, has a 99 percent low winter temperature of 8 degrees F and a 99 percent high summer temperature of 94 degrees F (dry bulb). The area average annual wind speed is 7.1 mph, and the normal precipitation is 39.91 inches. The average relative humidity at 7:00 a.m. is 80 percent and at 1:00 p.m. is 57 percent. The average annual number of precipitation days is 132, the average annual number of days below 32 degrees F is 99, and the average annual amount of snowfall is 19.0 inches.

The Greater Cincinnati and Northern Kentucky International Airport and an on-site meteorology tower (installed in August 1986) collect meteorological data for the FEMP area. Meteorological data from the Greater Cincinnati and Northern Kentucky International Airport, approximately 17 miles south of the FEMP site, are comparable to data collected from the FEMP meteorological tower. Short-term and local variations in the data are largely due to differences in local topography. Wind direction and speed monitors on this tower at the 33-foot and 197-foot elevations indicate that most of the local winds are from the west and southwest of G stability class with a wind speed of 0.52 meters per second as the 95 percentile meteorology conditions.

High winds above 70 mph are beyond the Evaluation Criteria as defined in DOE-STD-1020-94.

1.5 External, Man-Made Threats

There are no natural gas lines servicing or near the AWWT Facility. No high explosives are stored, handled, or processed in or near the facility. No design considerations for these hazards have been made.

The waste slurry pipelines transfer the uranium bearing wastewaters to Plant 8 run in the overhead pipe chases to Plant 8. These pipes are not normally susceptible to vehicles crashes in site. A vehicle driving on site would need to have extended boom or crane to impact the pipes. This event would result in a breaking of the pipeline. A review of FEMP site operational history indicate that no such accidents have occurred on site to date. The pipeline is subject to the same natural phenomena hazards as those considered for the AWWT process area.

A more likely vehicle crash event on site would be a tanker truck colliding with the unloading dock of the AWWT facility. The railings and curbing at the chemical unloading dock protect the tanks and east sump from damage from any low-speed collision such as a tanker truck moving into position. No significant impact to the AWWT Facility is expected from any vehicle crashes.

1.6 Nearby Facilities

Currently, the old Pilot Plant, Building 13, and the Stormwater Collection System are the closest facilities. The old Pilot Plant is shut down. Runoff from the production area goes to the Stormwater Collection System, which directs water to one of two cross-connected stormwater retention ponds with a nominal total volume of 1.0 million cubic feet. The Vitrification Pilot Plant is currently starting construction. This facility is located immediately east of the K-65 and metal oxide storage silos, northwest of the AWWT. Operation of this facility should not impact the AWWT. When decommissioning and demolition of the Vitrification Pilot Plant is undertaken, any impacts this may have on the AWWT as a nearby facility will be evaluated.

1.7 References

1.1) PARSONS, September 1993. *100- and 500-Year Flood Plain Determination Sitewide*, Rev. 0.

1.2) DOE, September 1993. *FEMP Sitewide Characterization Report (SWCR), Fernald Environmental Management Project, Fernald, Ohio.* DOE-FN: FEMP-SWCR-3.

SECTION 2

FACILITY DESCRIPTION

2.1 Introduction

This section provides facility and process descriptions and relationships of structures, systems, and components (SSCs) to support assumptions used in the hazard and accident analysis.

2.2 Requirements

Based on the criteria in DOE-EM-STD-5502-94 (Ref. 2.1), the AWWT is a radiological facility requiring a safety analysis under DOE 5481.1B (Ref 2.2).

The following federal regulations have been determined to be applicable to the AWWT:

1) 10 Code of Federal Regulations (CFR) 835, "Occupational Radiation Protection" (Ref. 2.3)

2) 29 CFR 1910, "Occupational Safety and Health Standards, General Industry" (Ref. 2.4)

3) 40 CFR 125, "Criteria and Standards for the NPDES (National Pollutant Discharge Elimination System" (Ref. 2.5)

4) 40 CFR 260, "Hazardous Waste Management System: General" (Ref. 2.6)

5) 40 CFR 270, "US EPA Administered Permit Programs: The Hazardous Waste Permit Program" (Ref. 2.7)

The following DOE Orders have been determined to be applicable to the AWWT:

1) DOE Order 5400.1, "General Environmental Protection Program" (Ref. 2.8)

2) DOE Order 5400.5, "Radiation Protection of the Public and the Environment" (Ref. 2.9)

3) DOE Order 5480.1B, "Environmental, Safety, and Health Program for DOE Operations" (Ref. 2.10)

4) DOE Order 5480.4, "Environmental Protection, Safety, and Health Protection Standards" (Ref. 2.12)

5) DOE Order 5480.7A, "Fire Protection" (Ref. 2.13)

6) DOE Order 5480.10, "Contractor Industrial Hygiene Program" (Ref. 2.14)

7) DOE Order 5480.11, "Radiation Protection for Occupational Workers" (Ref. 2.15)

8) DOE Order 5484.1, "Environmental Protection, Safety, and Health Protection Information Reporting Requirements" (Ref. 2.16)

9) DOE Order 5481.1B, "Safety Analysis and Review System" (Ref. 2.17)

10) DOE Order 5700.6C, "Quality Assurance" (Ref. 2.18)

11) DOE Order 5820.2A, "Radioactive Waste Management" (Ref. 2.19)

The preceding requirements lists are for regulations and DOE Orders. The FERMCO *Management Plan: Policies and Requirements Manual* (Ref. 2.20) includes the Standards/Requirements Identification Documents (S/RIDs) for Engineering Design. This S/RID (No. 2) identifies these requirements for engineering design explicitly or through reference to DOE Order 6430.1A, "General Design Criteria" (Ref. 2.21).

The applicable industry codes and standards that governed the design and installation of the AWWT Facility are listed in Appendix A.

2.3 Facility Overview

The FEMP has four separate systems for collecting, processing, and discharging process liquids, sanitary sewage, and stormwater runoff:

1) The General Sump is designed to contain and treat liquid process waste streams released from storage or holdup tanks throughout the FEMP or currently generated on site. This waste stream is treated to reduce hazardous chemicals and uranium content prior to discharge. The treatment consists of pH adjustment, flocculation, settling, and filtration.

2) The Biodenitrification (BDN)-Effluent Treatment System (ETS) facility processes high-nitrate water from the surge lagoon.

3) The storm sewer system is designed to route plant runoff into the Stormwater Retention Basin (SWRB) prior to discharge to the Great Miami River.

4) The South Plume is a plume of contaminated groundwater which contains dissolved uranium. The South Plume groundwater is pumped to the SWRB valve station. Treatment and subsequent release of some of the South Plume groundwater is currently performed as an interim process until the AWWT is operational.

The source influent to the AWWT may have chemicals of concern for operation. Chemical concentrations are low and reflect current wastes being generated at the FEMP or trace quantities of materials present in the particular wastewater stream. The trace chemicals present in the wastewater stream are characterized and reported yearly in the Annual Site Environmental Monitoring Report.

With the addition of the AWWT facility, the four effluent streams will no longer be discharged after treatment to the Great Miami River but will be diverted to the AWWT Facility for processing through one of two separate treatment streams. One stream will receive the process wastewater effluent from the BDN-ETS and the General Sump, which contains 0.67 milligrams per liter (mg/l) of uranium (Ref 2.22). A range of concentrations from 0.5 mg/l to 10 mg/l for uranium-bearing wastewaters has been used in the design and analysis of the AWWT facility (Ref. 2.23). The other treatment stream will process the stormwater contained in the SWRB or the contaminated groundwater from the South Plume, which may contain up to 0.5 mg/l of uranium (Ref. 2.22). Contaminated waters received from the South Plume are only a part of the total flow. The amount received from the South Plume will vary with the need for make-up water.

Flow rates of 400 gallons per minute (gpm) for the process wastewater and 700 gpm for the stormwater will be provided to optimize equipment capacity relative to the contaminant levels introduced into each treatment system. Each of the two treatment systems will apply current wastewater treatment technology through chemical pretreatment, clarification, filtration, carbon adsorption, and ion exchange. Wastes generated during the treatment processes will be collected in a waste slurry tank for pumping to Plant 8 for disposal. See Figure 2-1 for the Site Wastewater System.

2.4 Facility Structure

In general, Building 51 has been designed to meet or exceed the DOE requirements in effect at the time the building was built (construction was completed in 1985). The building was designed conservatively for the UF_6 to UF_4 conversion operations. The requirements for wastewater operations are not as

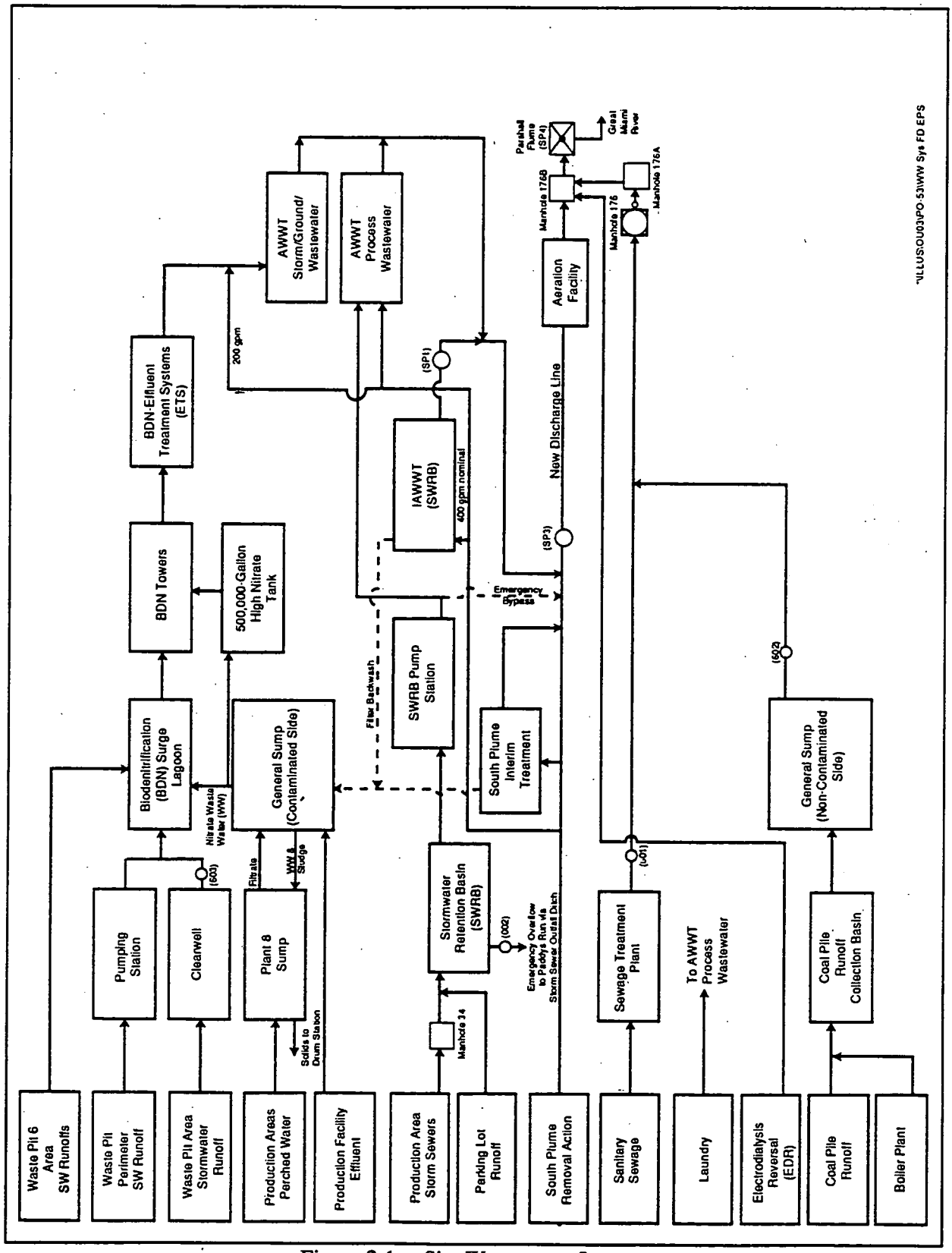

Figure 2-1 - Site Wastewater System

stringent. New structures have also been designed conservatively to meet or surpass DOE requirements. The requirements for process equipment construction are governed by DOE Order 6430.1A (Ref. 2.21).

In 1991, A. M. Kinney, as the Architect Engineer, was tasked to perform a benefits study on the use of Building 51 for the AWWT Facility but was not directed to review the building for conformance to the latest building code. Instructions for the benefits study were to not add to the existing building load; hence, the current design has restricted the new loading to pipe and conduits.

A separate review of the design loads for the existing Building 51, as listed on Sheet 51X-1910-S-00032, dated September 10, 1984, by Sanders and Thomas, was conducted by A.M. Kinney (Ref. 2.24). It was determined that the design loads meet or exceed those required of a building under current design requirements. A comparison of loads and the requirements is as follows:

1) Roof live load at 30 pounds per square foot (psf) - 20 psf is currently required.

2) Snow load of 20 psf - 20 psf is currently required.

3) Wind load of 90 mph - 70 mph is currently required.

4) Seismic load Zone 2 (for 1982 Uniform Building Code [UBC] equates to 0.066W) for current Zone 1.

Building 51 is located in seismic zone 1, according to the Ohio Basic Building Code (OBBC), Paragraph 1113.1 (referenced in Appendix A), and also according to Figure 13 of American National Standards Institute (ANSI) A58.1-1982 (referenced in Appendix A). The building was designed by Sanders and Thomas as if it were in Zone 2, a more stringent requirement, because it was originally intended as a UF_6 to UF_4 Expansion Plant. Therefore, new SSCs of the AWWT Facility designed by A.M. Kinney meet current seismic requirements as defined in DOE-STD-1024-92 (Ref. 2.25) (referencing University of California Research Laboratories [UCRL] 15910) for a low-hazard facility.

The seismic design of Building 51 agrees with Section 0111-2.7.1 of DOE 6430.1A, which states that the design shall be in accordance with the procedures contained in the UBC and UCRL-15910. (The design of the AWWT facility was completed prior to the issue of DOE-STD-1020-94 which incorporates the UCRL-15910 criteria, therefore, the AWWT meets the requirements of DOE-STD-1020-94.) UCRL-53582, Rev. 1, "Natural Phenomena Hazards Modeling Project: Seismic Hazard Models for Department of Energy Sites," November 1984, yields an estimated peak ground acceleration (EPGA) value of 0.1 g and an approximate 550-year return period for the earthquakes at the Fernald site. Based on the very low earthquake occurrence frequency and the fact that the AWWT facility (Building 51) was designed to

withstand loads imposed by a UBC Seismic Zone 2 earthquake, according to the OBBC, paragraph 1113.1, no significant damage is expected for an earthquake of the above EPGA value.

All equipment and access platforms are independently supported. Only the low bay area on the west end (Ion Exchange and Carbon Filters) is receiving additional loading on the sidewalls. However, these sidewalls are being stiffened by new internal liner panels.

According to AWWT specification 02902-3502, section 0100 (Ref. 2.22), all work shall be in accordance with the requirements of the OBBC (Ref. 2.26 and 2.27), the UBC, DOE Order 6430.1A (Ref. 2.21), and the Occupational Safety and Health Administration (OSHA) 1910 (Ref. 2.4). No change is being made to increase floor area or the number of floors. In conclusion, the design is in accordance with applicable building codes.

2.5 Process Description

The AWWT treatment process and equipment are described in this section. The AWWT Facility consists primarily of Building 51, east unloading, and the south containment. Figure 2-2 shows the location of the major components. Figures 2-3 and 2-4 show the treatment processes for process wastewater treatment and groundwater/stormwater treatment, respectively.

The AWWT system will employ the following series of operations to treat FEMP wastewater and stormwater/groundwater.

Clarification

The flow to the AWWT Facility is controlled by flow meters and level controllers. The alum is added to the wastewater in the mix tank. One 85,000-gal clarifier is used for the process wastewater stream. Two clarifiers in parallel are utilized for the stormwater stream.

Clarifiers are sedimentation basins for gravitational separation of suspended solids from liquid. Separation occurs by providing sufficient detention time in the vessel and slowing the velocity of the water to a point at which the solids settle. The settling rate of the particles in liquid suspension varies with temperature gradients, inlet energy dissipation, outlet currents, and other factors; therefore, operational adjustments are necessary for each application. The settling rate can be increased by using the clarifier in conjunction with chemical separation techniques for increasing the particle size. The AWWT treatment processes use both gravitational and chemical sedimentation techniques.

Chemical pretreatment is often required and used in conjunction with the clarification process. Its primary use is to remove finely divided particulate matter which will not settle readily or economically.

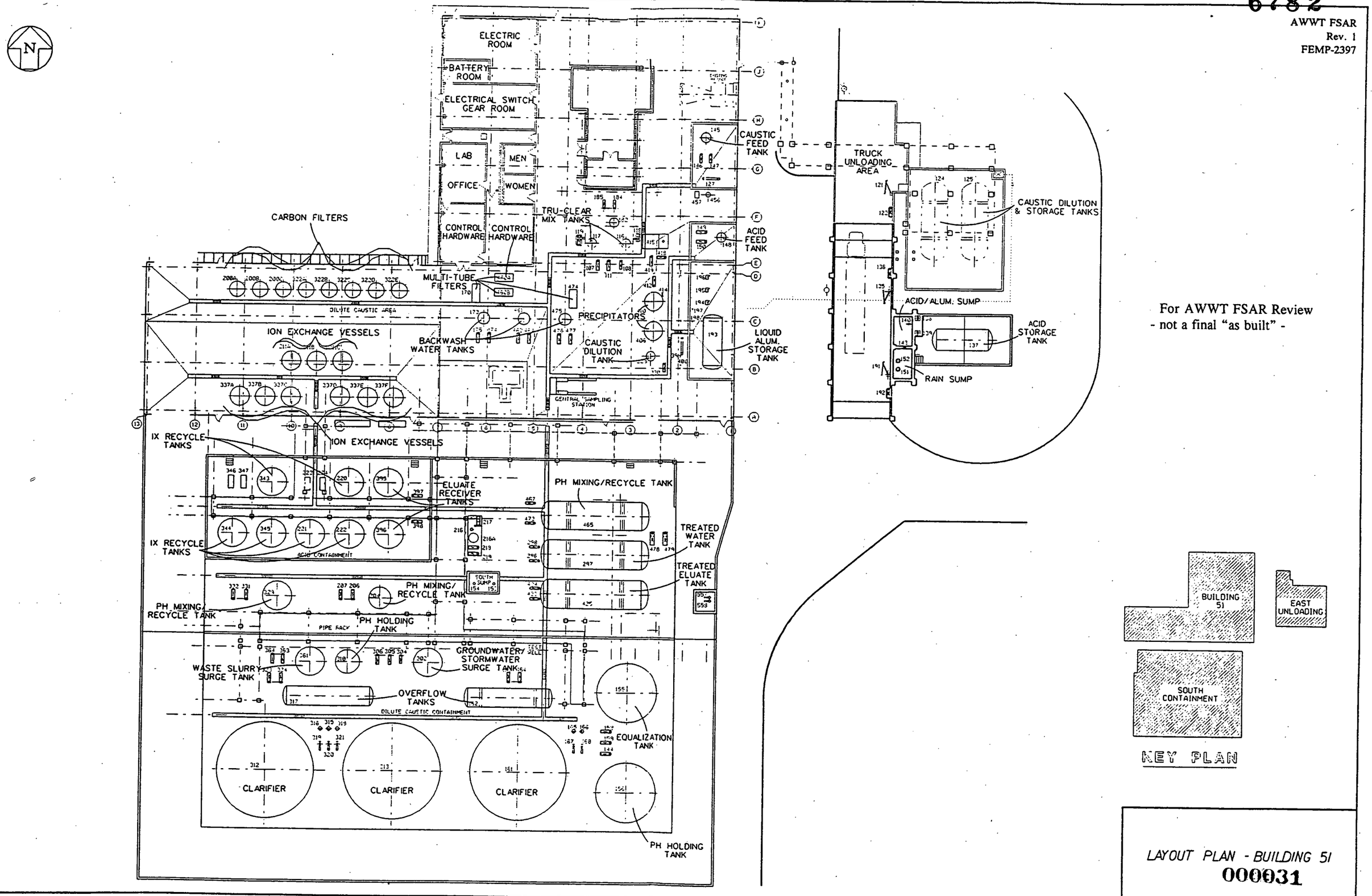

Figure 2-2 - AWWT Layout

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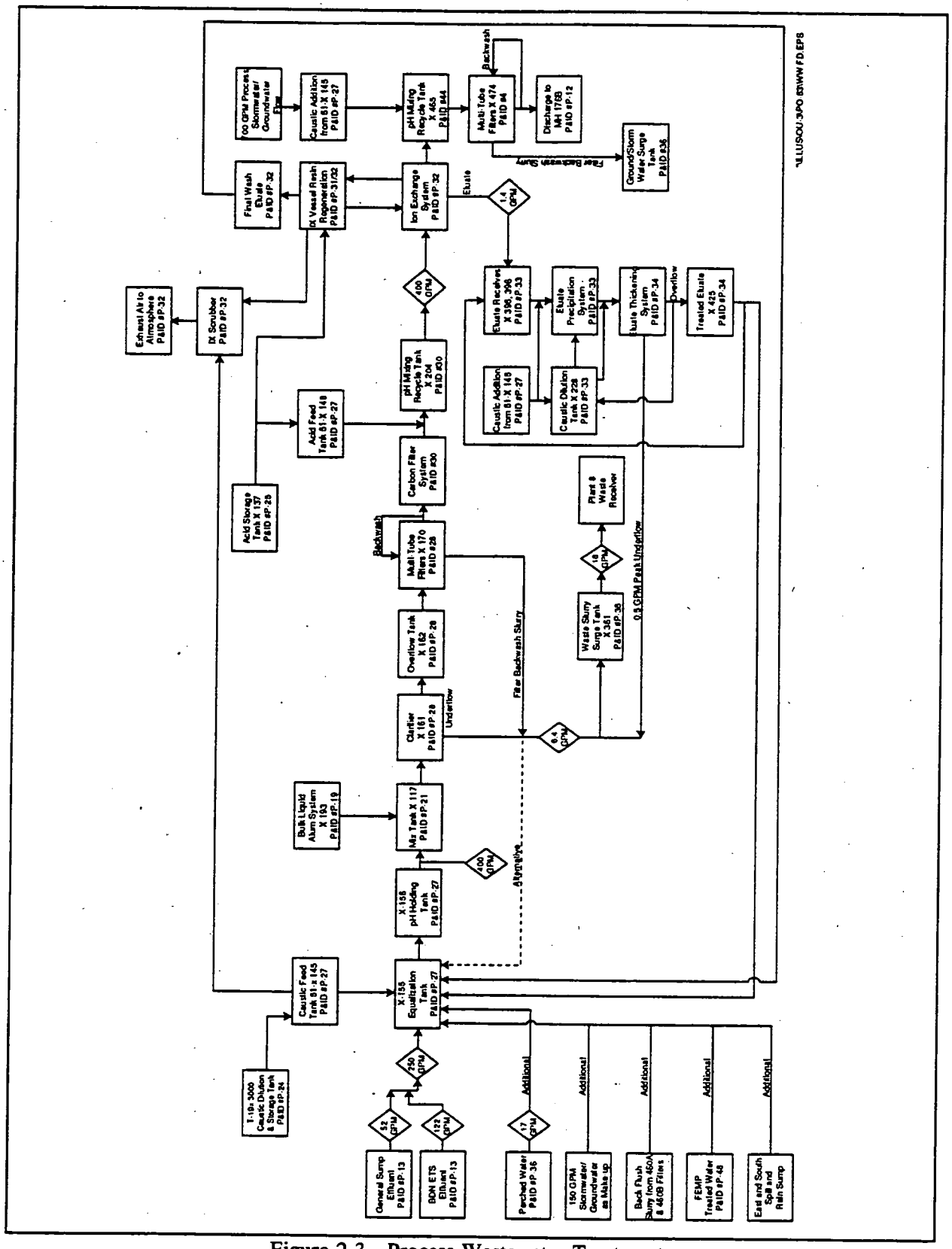

Figure 2-3 - Process Wastewater Treatment

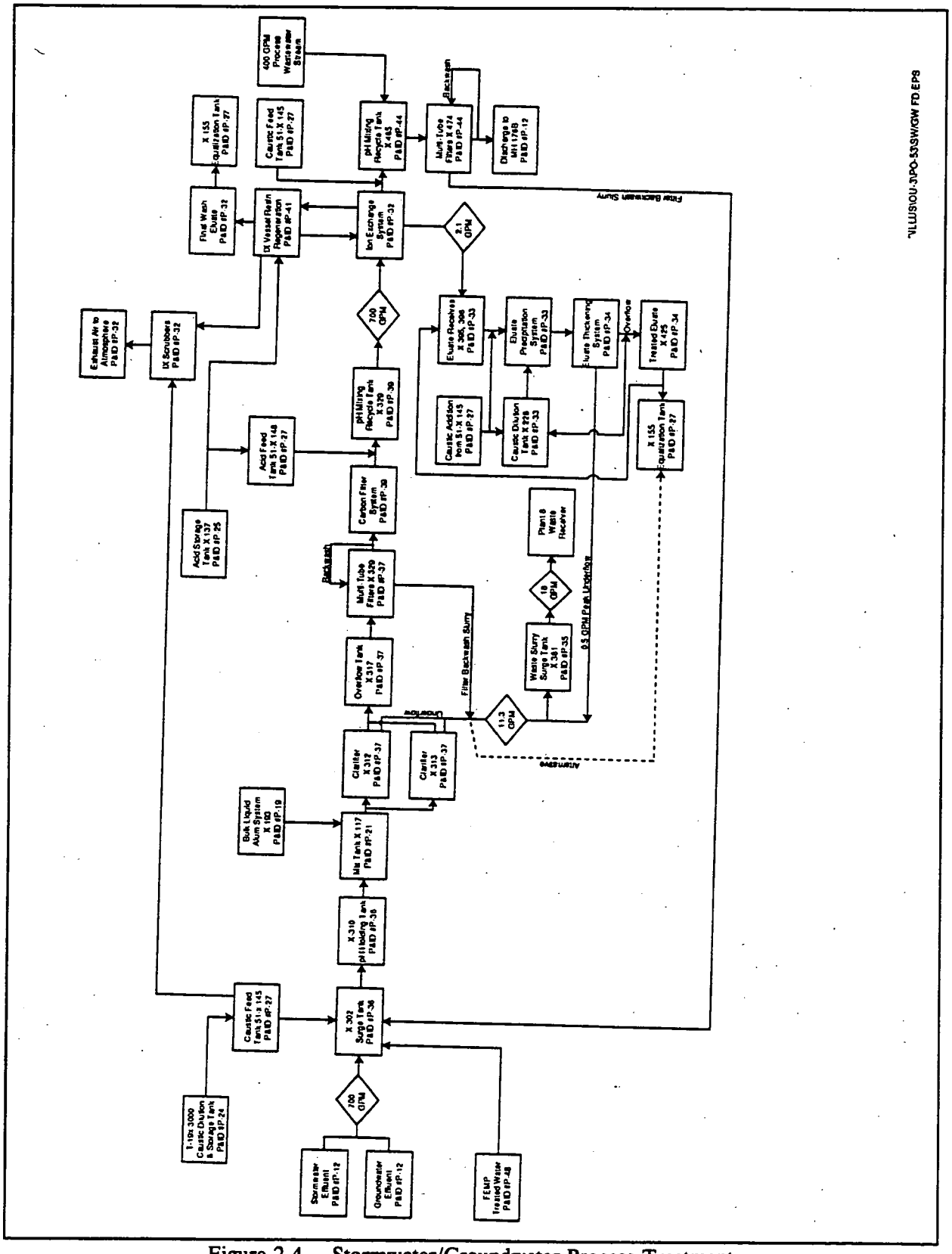

Figure 2-4 - Stormwater/Groundwater Process Treatment

Aggregation of these solids by coagulants and flocculents into larger particles promotes settling.

The wastewater and coagulant then enters the clarifier for settling. The uranium present in the AWWT wastewaters are found in the form of carbonate complexes. These complexes treated with alum to negate the particles' surface charge, the force holding it in solution. At this point the particles can begin to aggregate into larger particles to settle (flocculated). Other metals present behave similarly, flocculate with excess alum and settle. These settled solids are then removed by the underflow. The treated water will flow from the clarifier into an overflow tank, and the sludge, or slurry, will be removed in the underflow and pumped to the waste slurry tank.

Filtration

The overflow from the clarifiers is pumped to the multitube filters. These are 1 micron filters used to further remove suspended solids from the wastewater before the treatment process continues.

Adsorption

After microfiltration, the AWWT wastewater is passed through the carbon filters for adsorption of organics. The carbon filters are loaded with granular carbon. The packed bed of carbon is not regenerated for the AWWT operation due to the presence of uranium. The large volume of carbon initially installed in each of the beds should eliminate the need for frequent replacement with fresh granular carbon. Anticipated replacement frequency is once per year. The levels of organics are anticipated to be very low. The bed volume permits a flow residence time of 10 to 30 minutes at a flow rate of less than 2 gal/min/ft^3.

Ion Exchange

The ion exchange mechanism is both physical and chemical. Simply stated, the undesired ions are transferred from the charged functional group of the compounds found in solution to another functional group on the surface of the ion exchange resin, and the IX resin acts as a filter to remove particulates. The uranium present in the AWWT wastewaters are found in the form of carbonate complexes. These uranium complexes are provide the basis of the strong base anion exchange technology (using DOWEX® 21K).

In the AWWT Facility, the ion exchange units contain the strong-base anion resin DOWEX® 21K. The ion exchange unit consists of three resin bed vessels operated in lead-lag-regenerate configuration. One unit treats the 400-gpm process wastewater, and two units will treat the 700-gpm stormwater. In addition to the resin bed vessels, the units also include influent flow control. Samples of influent and effluent

wastewaters are removed and analyzed for uranium concentration in the laboratory. Operation of the units will also require a resin regeneration system.

The wastewater ion exchange units will have capacity for peak influent flow of 410 gpm. The stormwater/groundwater ion exchange units will have a combined capacity of 720 gpm. The valves for switching the flow sequence and for resin bed regeneration will be automated for remote monitoring and control from the building control room. The ion exchange eluant and regeneration systems are discussed in Subsection 2.5.1.3.

Final Filtration

After ion exchange the wastewater and stormwater/groundwater streams are combined before they enter the filters. These 50-micron filters remove all remaining suspended solids from the treated water before it is pumped to Manhole 176B for discharge to the Great Miami River.

Discharge Streams

The treated water discharged from the AWWT Facility is a combination of water from the process wastewater treatment stream and the stormwater/groundwater treatment stream. The treated water is pumped to Manhole 176B for discharge to the Great Miami River. The various waste streams produced during the treatment process are as follows:

1) Clarifier underflow streams
2) Filter backwashes
3) Eluate thickener sludge

These waste streams are consolidated in the waste slurry tank and then pumped directly to an existing receiving tank in Plant 8 for further treatment.

2.5.1 Auxiliary Process System

The wastewater treatment streams have several auxiliary systems that will enable the system to operate effectively. These are described in detail below. Subsection 2.5.1.5 discusses the transfer and storage of the process chemicals.

2.5.1.1 Coagulant Addition System

Alum is received as a liquid bulk chemical. The additive, alum, is metered into the in-line mixer prior to the stormwater/groundwater entering the clarifier. For the wastewater treatment process the alum is metered into the mix tank.

2.5.1.2 Filtration Backwash Systems

After the clarification step and prior to discharge, filtration removes suspended particles. Each of these systems is supported by a backwash system, generally consisting of a tank and two pumps. These systems flush the solids from the filter to the waste slurry tank. The system uses treated water or eluate saved from a previous rinse.

2.5.1.3 Ion Exchange Eluant and Regeneration System

As part of the ion exchange (IX) package, an eluant system provides for regeneration of the resin. There will be two eluant systems. One system supports the process wastewater IX unit and the other supports the stormwater treatment IX unit. Each eluant system consists of three IX recycle tanks. The regeneration procedure is started manually but will be automatically controlled. During the regeneration cycle, the eluant (sulfuric acid solution) recirculates through the resin vessel and the eluate (the uranium-bearing solution) is sent to the first recycle tank. Compressed air is used to drain the resin vessel between flushings with the eluant. The eluant is again used to flush the resin vessel and the resulting eluate will be sent to the second recycle tank. The eluate pumped to the third recycle tank from the final flushing contains very low levels of uranium. To economize on the regeneration process, the eluate in the second and third recycle tanks, those containing the lowest concentrations of uranium, is reused to regenerate the next ion exchange vessel.

Eluate in the first recycle tank is sent to the eluate treatment system for uranium removal. Fresh sulfuric acid solution is added to the first tank and used for the final flushing in the next cycle of an ion exchange resin vessel.

To precipitate the uranium removed during the ion exchange process, the eluate is processed through an eluate treatment system. The eluate goes into one of two eluate receivers. The eluate is then pumped to a 150 pounds per square inch gage (psig) steam heat exchanger to heat the eluate prior to the addition of caustic to the precipitation steps. From the heat exchanger the eluate goes to an in-line mixer where 20 percent sodium hydroxide will be added. The eluate undergoes a series of dilute caustic additions. The 20 percent sodium hydroxide is mixed at the caustic dilution tank with make-up water from the eluate polishing filter downstream of the caustic addition. The dilute caustic is pumped from this tank to the precipitators by one of two 10-gpm dilute caustic feed pumps. The pH of the eluate inside the tank should be 5.5. From this tank, the eluate goes to the second stage precipitator. At this point, the pH of the eluate should be 6.5. From this tank, the eluate goes to a in-line mixer for the final caustic addition.

Then, eluate goes to the eluate thickener where the solids will settle. The eluate thickener is a lamella-type clarifier - a gravity thickener/settler with inclined parallel plates. The solids are removed from the sludge hopper as underflow by the 2-gpm underflow pump, and go to the waste slurry surge tank.

This underflow is expected to contain an average of 2.9 lbs of uranium per day (Ref. 2.22). The clarified water exits at the top of the tank as the overflow. The 40-gpm overflow pump then pumps the overflow stream through the polishing filter to one of two filtrate recycle tanks. The polishing filter is a multitube filter package unit which operates at 40 gpm. The filter is supported by an automatic filter backwash system. The water used for backflushing comes from the polishing filter filtrate. After use, the backflush water will be pumped back to the eluate receivers for reprocessing through the eluate treatment system. The filtrate receiving tanks collect the remainder of the filtrate from the polishing filters. The filtrate water is pumped back to the equalization tank by one of two 50-gpm filtrate pumps.

2.5.1.4 Waste Collection and Pumping System

The waste products collected during the wastewater treatment processes are collected and slurried before they are pumped to Plant 8. The waste slurry surge tank is a vertical, open-top, carbon steel tank. The tank, located in the south containment area external to Building 51, is 12 feet in diameter, 20 feet high, and holds approximately 17,000 gallons.

Waste is collected in the tank from the clarifier underflow, the filtration backwash systems, and the eluate treatment system. The flow from the clarifier is approximately 2 to 5 gpm from each on a continuous basis. The flow from the various backwash filter systems is 100 gpm of intermittent flow each. Underflow from the eluate thickener will be 2 gpm of continuous flow. One of two slurry pumps transfers the slurry periodically to Plant 8.

2.5.1.5 Material Handling Support Systems

The material handling procedures for the concentrated sulfuric acid are consistent with those in standard industrial practices. The materials, while posing unique handling requirements, are routinely handled and stored for a variety of industrial uses. The shipment, receipt, and storage of the alum, caustic, and sulfuric acid for the AWWT process are commensurate with other wastewater treatment facilities. Industrial practices for storage and handling are presented in Appendix D as part of the Hazards and Operability Analysis (HAZOP). A rigorous review of the handling and storage of the concentrated sulfuric acid was performed due to its hazard.

Engineering controls used for the bulk process chemical receipt and transfer incorporate the HAZOP recommendations. Controls are necessary to ensure that the inadvertent mixing is not a credible event during the unloading of materials.

Installing key locks on each unloading arm and requiring the operations supervisor to be the only person with access to the keys prevents the inadvertent mixing. Installing key locks that the operations shift supervisor must unlock helps ensure the procedure step requiring verification by the operations shift supervisor is implemented. To ensure this, the locks on each swing arm must require different keys. The control of the keys to the locked loading arms is incorporated as a Process Requirement in Section 5.

The use of air pressure to unload a tank truck is common in standard industrial practices. AWWT uses air to offload the bulk chemicals. The AWWT operation will only use the air to assist in unloading of bulk chemicals. In addition, the use of DOT-approved trucks (as specified in the procurement process) requires that pressure relief valves be present. The chemical supplier therefore has pressure relief valves on the truck and the driver is in attendance during unloading (DOT requirement). The air pressure provided by the AWWT is 12 psig with pressure relief at 15 psig. The AWWT air pressure may be modified to 28 psig with pressure relief at 30 psig as recommended in the DuPont Manual. On completing an evaluation of the need for air pressurization during unloading, this practice may be discontinued if unnecessary.

Caustic Delivery and Handling

Concentrated caustic (50 percent NaOH) is unloaded from bulk tank trucks at the truck unloading containment pad at the existing Caustic Unloading area. Plant air or truck supplied air provides a slight head to the tanker truck. The liquid is removed from the tanker through a caustic unloading arm via an unloading pump to an in-line mixer. At the in-line mixer, the 50 percent caustic mixes with treated water pumped from the Treated Water Tank and 20 percent caustic recirculating through a heat exchanger. The existing 20,000-gallon carbon steel tanks east of Building 51 are used for storage of 20 percent caustic. Tank material requirements are acceptable for storing the 20 percent caustic as previously used to store the ammonia. These tanks, previously used for ammonia storage, were cleaned prior to turnover to the AWWT.

During summer months, the heat exchanger is supplied with plant water to cool the dilute caustic from the heat of reaction that occurs during dilution. During winter months, the caustic is recirculated through the heat exchanger supplied with plant steam to keep the storage tank temperature above the minus 13 degrees F freezing point of the caustic. The 20 percent caustic is pumped from the storage tank to the Caustic Feed Tank. The feed tank and the pumps are located beside the heat exchanger in Building 51. The 20 percent caustic is used for ion exchange eluate treatment.

The confinement system is discussed in Subsection 2.6.

Acid Delivery and Handling

Concentrated (93 weight percent) sulfuric acid is unloaded from the tanker truck at the truck unloading pad. Plant air or truck air provides a slight head to the tanker truck to assist in removal of the contents. The unloading pump is connected to the tanker through the swivel-jointed piping hose of the acid unloading arm. The contents of the truck tanker are transferred to the 10,000-gallon Acid Storage Tank, which will be located in the east containment area. The storage tank, a high nickel content steel, Alloy 20, ASME SB463, is insulated and heat traced.

After the acid storage tank is filled from the truck tanker, its contents are transferred to the Strong Acid Feed Tank located in Building 51 or to the Ion Exchange System tie point in the west wing of Building 51. The acid used in the regeneration of the beds is diluted when transferred to the recycle tank.

The east containment and Building 51 confinement systems for acid are discussed in Subsection 2.6.

Alum Delivery and Handling

Alum will be received at Building 51 at the north storage area. Liquid alum, 28 weight percent $Al_2(SO_4)_3$, is pumped out of a tank truck at the East Containment area to a 7,500-gallon Alloy 20 Alum Storage Tank in Building 51. Three metering pumps (one swing) transfer alum to the two Mix Tanks, X-116 and/or X-117, at the rate of 0.05 to 0.4 gallon of liquid alum per 1,000 gallons of water being treated. The Alum Storage Tank and Metering Pumps are in an 8,000 gallon confinement which adjoins the Acid Feed Tank confinement in Building 51.

The alum confinement and recovery system is discussed in Subsection 2.6.

Granular Carbon and Ion Exchange Resin

The Ion Exchange System includes a resin removal and replacement unit, capable of removing spent resin, draining it, and loading it into clamp-top drums. This unit will be capable of hydraulically placing fresh resin in the IX vessels, and will also be capable of removing spent carbon from, and loading fresh carbon into, the carbon bed vessels. The system is designed to contain hazardous chemicals and radioactive materials present in the spent media.

2.6 Confinement Systems

The AWWT Facility has the following confinement system features:

1) Building 51 containment areas, test wells, trench drains
2) East containment areas, test wells, trench drains, and sump
3) South containment areas, test wells, trench drains, and sump

4) Acid scrubber system

The facility confinement system contains, and routes through the treatment processes, the influent wastewater streams as well as any spills or leaks of wastewater or hazardous chemicals onto the process floor areas. Rainwater falling on the south or east containment areas is also processed through the treatment systems. The acid scrubber system confines and neutralizes any H_2SO_4 acid vapors that may be generated.

Spills of chemicals at the loading dock in the facility, or any spills of contaminated wastewater from the AWWT processes, are contained by a system of floor drains and trenches which route flow by gravity to the south sump. Any small leaks developing within the systems, such as at pipe connections, pump seals, valve packing, or drain valves, are confined to the curbed concrete containment or sloped chemical loading dock concrete pad and routed through trench drains to the south sump. All radioactive material or hazardous chemicals collected by the system of containments, trenches, floor drains, and test wells and routed to the last or south sump are pumped to the equalization tank for processing.

Dikes are constructed around all storage tanks and vessels. Each dike is large enough to contain the entire contents of the largest vessel contained within the area. For dikes external to the building, the capacity is sized to accommodate the contents of the largest vessel plus 5 inches of rainfall over the area.

The unloading containment pad area is sloped to collect any spills or rainfall in a test well. The well has two valved drains to control and direct the release of any of the well's contents. One drain routes rainfall to the open trench drain connected to the east sump. The other test well drain routes acid spills to the acid/alum spill sump.

The 10,000-gal acid storage tank and the associated acid transfer pumps are located within a confinement area that drains to a valved test well, which empties to a trench drain connected to the east sump. The test well is valved so that a spill can be directed to the acid/alum spill sump, where it can be pumped through a duplex filter to either the acid storage tank, the alum storage tank, or the east rain sump. A spill recovery and a duplex filter recovery pump are provided for the alum and acid containments.

An acid scrubber is provided for air vented from the IX resin vessels, regeneration work tanks, and eluant receivers. The acid scrubber system is used to limit the release of air and sulfuric acid mist vented from the IX resin vessels, recycle tanks, and eluate receiver tanks. The air and sulfuric acid mist is directed up through a packed tower down which caustic and water are flowing (approximate pH of 7). The air then passes up a bubble cap tray tower down which treated water flows. The air is then exhausted through a vertical stack in Building 51. Spent packed tower scrubwater (2-gpm peak) is discharged to the South Sump.

2.7 Utility Distribution Systems

Support systems are those separate from the direct wastewater treatment process, which supports their operation. These systems include ventilation, electrical power, compressed air, steam, water supply, and sanitary treatment and disposal. Other systems provide safety communications, fire protection, and waste disposal.

2.7.1 Building Ventilation

Due to the nature of the facility, ventilation systems are provided for air exchange and worker comfort. As shown in Section 3, no building ventilation systems are required for radioactive material containment or process performance. The 100 percent Certified for Construction (CFC) design specifies the pressures, flow rates, and system instrumentation and controls, as well as ventilation equipment layout and arrangement drawings.

2.7.2 Electrical Power

Electrical power for operating equipment, lighting, and instrumentation at the AWWT Facility is provided by the FEMP site power distribution system. An equipment room for electrical panels and breakers is provided within the AWWT Facility. Systems and instrumentation shall be provided with adequate grounding. The 100 percent CFC specifications establish the equipment grounding design for power, instrumentation, and control systems.

Lightning protection is currently provided for the existing Building 51. The 100 percent CFC design drawings show the lightning protection of all related buildings, structures, and power and communication services. As shown in Section 3, loss of process control due to a loss of power within the AWWT Facility does not impact personnel health and safety; as such, design considerations do not include a backup generator or an uninterruptible power supply.

2.7.3 Compressed Air and Gases

No provisions for compressed gas storage are included in the design of the AWWT Facility. The steam plant provides plant/instrument air. The 100 percent CFC design establishes the compressed air needs of the facility processes and controls. Valves and control are designed to maintain safe operations with the loss of plant air.

2.7.4 Steam Supply and Distribution

Steam is provided to the AWWT Facility for the building heating system. The 100 percent CFC design contains details of the pipe routings for the AWWT steam supply. Steam for process use is also provided to the NaOH Heat Exchanger. The heat exchanger keeps the Caustic Storage Tank temperature above the -13 degrees F freezing point of 20 percent NaOH. Loss of steam impacts both building heating and process operation, however, no environmental impacts result.

2.7.5 Water Supply

Site utilities supply potable water, fire water, and process water to the AWWT Facility. FEMP process water is required for the following AWWT Facility process systems:

1) Equalization Tank for make-up water

2) Caustic Mixer for diluting 50 percent NaOH to produce 20 percent NaOH (requires 150 gpm for 1 hour)

3) IX units for both the 400- and 700-gpm streams for mixing the eluant for regenerating the IX resins

4) Acid Scrubber to mix with 20 percent NaOH to neutralize acid vapors

5) Hose Stations

These water requirements must be met for the AWWT Facility to remain operational. The 150 gpm required during the unloading of the 50 percent NaOH delivery places an excessive load on the FEMP process water system. To prevent this, the AWWT Facility uses the 25,000-gal Treated Water Tank for storing FEMP process water to be used by the AWWT Facility. The Treated Water Pumps then supply the above process systems within the AWWT Facility without placing an excessive load on the FEMP process water system.

The loss of FEMP process water to the AWWT Facility results in curtailing facility operation if the outage causes depletion of the water in the Treated Water Tank. Loss of the FEMP potable water supply also disables the eyewash stations and safety showers, thereby affecting worker safety.

2.7.6 Cooling Water Systems

The cooling water system is presented in the 100 percent CFC design. System specifications are given for the sizing and routing to meet the cooling requirements. No serious ramifications result from the loss of the AWWT Facility's cooling system, as shown in Section 3. Therefore, no emergency procedures are necessary for abnormal conditions.

2.7.7 Sanitary and Chemical Treatment and Disposal

The existing Building 51 sanitary drain system collects sanitary wastes from the laboratory and lavatories. These wastes flow through the existing 4-inch line to the underground sanitary drain in Building 51. There are no non-radioactive chemical wastes systems designed for the AWWT Facility. Drainage of rainwater from the Building 51 roof collected in downspouts is carried to the storm sewer. As discussed in Subsection 2.6, all rainwater falling on the east and south containment is routed to the equalization tank for processing.

2.7.8 Safety Communications and Alarms

The AWWT Facility is equipped with a control room for monitoring and controlling process operations. Alarms and monitors are in place for malfunctions or out-of-limit conditions.

Abnormal conditions within the facility that could impact the health and safety of personnel are indicated by signals or alarms from the public address system and fire alarm system. Telephone and speaker communication are provided.

2.7.9 Fire Protection System

The 100 percent CFC design specifies the fire protection system including physical arrangement, fire water supply and distribution, and other fire suppression systems. Specification sections 15300, 16770, and 16775 describe the technical features of the detection systems, alarm systems, automatic fire suppression systems, manual fire extinguishing systems, and the fire annunciator warning system. FEMP Site Fire Protection Engineering provides review and approval on all detection and sprinkler system installations. All proposed installations are in accordance with the then-current DOE Order 5480.7, "Fire Protection" (Ref. 2.13), and conform to National Fire Protection Association (NFPA) Standards 13 (Ref. 2.28) and 24 (Ref 2.29).

2.7.10 Radioactive and Hazardous Materials Storage and Handling Systems

No final packaging facilities for waste are part of the AWWT Facility. The filter cake generated at Plant 8 is sampled, characterized, and drummed for on-site disposal or off-site shipment. Spent carbon and spent resin are drummed for transfer to other facilities on site for storage and ultimate disposal. A limited number of drums are accumulated to minimize handling and permit a more efficient waste transfer. The transfer is made in accordance with normal wastewater processing operating procedures currently in use at Plant 8.

2.8 References

2.1) DOE, August 1994. DOE-EM-STD-5502-94, *Hazard Baseline Documentation.*

2.2) DOE, May 1987. DOE Order 5481.1B, "Safety Analysis and Review System."

2.3) DOE, December 14, 1993. 10 CFR 835, "Occupational Radiation Protection."

2.4) OSHA, July 1, 1993. 29 CFR 1910, "Occupational Safety and Health Standards, General Industry."

2.5) United States Environmental Protection Agency (US EPA), July 1, 1933. 40 CFR 125, "Criteria and Standards for the NPDES (National Pollutant Discharge Elimination System)."

2.6) US EPA, July 1, 1993. 40 CFR 260, "Hazardous Waste Management System: General."

2.7) US EPA, July 1, 1993. 40 CFR 270, "US EPA Administered Permit Programs: The Hazardous Waste Permit Program."

2.8) DOE, June 1990. DOE Order 5400.1, "General Environmental Protection Program."

2.9) DOE, January 1993. DOE Order 5400.5, "Radiation Protection of the Public and the Environment."

2.10) DOE, September 1986. DOE Order 5480.1B, "Environmental, Safety, and Health Program for DOE Operations."

2.11) DOE, December 1982. DOE Order 5480.2, "Hazardous and Radioactive Mixed Waste Management."

2.12) DOE, September 1991. DOE Order 5480.4, "Environmental Protection, Safety, and Health Protection Standards."

2.13) DOE, September 1990. DOE Order 5480.7, "Fire Protection."

2.14) DOE, June 1985. DOE Order 5480.10, "Contractor Industrial Hygiene Program."

2.15) DOE, June 1992. DOE Order 5480.11, "Radiation Protection for Occupational Workers."

2.16) DOE, October 1990. DOE Order 5484.1, "Environmental Protection, Safety, and Health Protection Information Reporting Requirements."

2.17) DOE, May 1987. DOE Order 5481.1B, "Safety Analysis and Review System."

2.18) DOE, August 1991. DOE Order 5700.6C, "Quality Assurance."

2.19) DOE, September 1988. DOE Order 5820.2A, "Radioactive Waste Management."

2.20) FERMCO, March 1994. RM-0016, *Management Plan: FERMCO Policies and Requirements Manual.*

2.21) DOE, April 1989. DOE Order 6430.1A, "General Design Criteria."

2.22) Westinghouse Materials Company of Ohio, Inc., July 27, 1989. *Design Criteria for Environmental, Health and Safety Improvements Phases IV, Volume 3. Two Fiscal Year 1990 Subprojects, Part II: Wastewater Treatment Improvements - Plantwide.*

2.23) Westinghouse Materials Company of Ohio, Inc., Quarterly, 1991. Federal Facility Consent Compliance Report.

2.24) A.M. Kinney, September 14, 1994. Letter from J. Yuan to T. Escue. Subject: Existing Building 51 Design Load Review. Letter No. AMK-902-35-110.

2.25) DOE, December 1992. DOE-STD-1024-92, *Guidelines for the Use of Probabilistic Seismic Hazard Curves at Department of Energy Sites.*

2.26) OBBC, 1989. Section 1105.4, "Existing Live Load."

2.27) Ohio Administrative Code (OAC), 1984. Rule 4101:2-1-11, "Building Code BOCA Articles: 1 to 11," 9th Edition.

2.28) NFPA, August 1991. NFPA 13, "Installation of Sprinkler Systems."

2.29) NFPA, February 1992. NFPA 24, "Private Fire Service Mains and Their Appurtenances."

SECTION 3

HAZARD AND ACCIDENT ANALYSIS

3.1 Introduction

This section systematically identifies and evaluates the hazards present in the operation of the AWWT. The graded approach guides the analyst through preliminary qualitative hazard analysis, to qualitative selected accident analysis, and finally to a more selective quantitative accident analysis. This section identifies the requirements that apply to the analysis of hazards, describes the methodology that was used, evaluates the hazards, and compares the results to acceptance criteria. The results are used to provide the basis for subsequent sections in this Final Safety Analysis Report (FSAR) that describe the equipment and programs that will be used to control the identified hazards.

3.2 Requirements

As of the publication of this FSAR, there are no federal rules or regulations that apply to the hazard and accident analysis of this project. The OSHA Process Safety Management (PSM) Rule, 29 CFR 1910.119 (Ref. 3.1), does not apply because the chemicals that are being used on this project are not on the list of applicable chemicals for the rule. However, PSM principles are used because the AWWT has chemical processes. The DOE Safety Analysis Report Rule (i.e., 10 CFR 830.110) (Ref. 3.2) is intended for nuclear facilities, and therefore does not apply.

The requirements to evaluate the hazards associated with the AWWT facility and perform an accident analysis are from DOE Order 5481.1B, "Safety Analysis and Review System" (Ref. 3.3). These requirements are enhanced by DOE-EM-STD-5502-94 (Ref. 3.4). This guidance integrates the DOE regulations and Orders and serves as a road map to these requirements.

Further guidance for determining facility classification is provided in DOE-STD-1027-92, "Hazard Categorization and Accident Analysis Techniques for Compliance with DOE Order 5480.23, Nuclear Safety Analysis Reports" (Ref. 3.5). For accidents involving natural phenomena, additional guidance would be provided in "Natural Phenomena Hazards Design and Evaluation Criteria for Department of Energy Facilities," DOE-STD-1020-94; however, design of the AWWT was completed prior to issue of that order. Therefore, guidance is presented in UCRL 15910 (Ref. 3.6); the "Natural Phenomena Hazards Modeling Project: Extreme Wind/Tornado Hazard Models for DOE Sites," UCRL-53526, Rev. 1 (Ref. 3.7); and the "Natural Phenomena Hazards Modeling Project: Seismic Hazard Models for DOE Sites," UCRL-53582, Rev. 1 (Ref. 3.8).

The principal criterion that is relevant to accident analysis is the selection of the evaluation guidelines (EGs) that are used to assess the severity of the accident consequences. Proposed DOE-STD-3005-YR (Ref. 3.9) established the radiological guidelines and was used to prepare Table 3-5. Quantitative guidelines for the evaluation of exposures to toxic chemicals (i.e., the toxicological classification criteria) are established in WSRC-MS-92-206, Revision 1 (Ref. 3.10). The use of these and the EGs that were selected for this project are discussed in Subsection 3.3.1.

3.3 Hazard Analysis

The hazard analysis (i.e., identification and evaluation) provides a qualitative and quantitative evaluation of the spectrum of risks to the public, workers, and the environment due to accidents involving any of the hazards identified. The Hazard Analysis developed for the AWWT is commensurate with DOE guidance for a simple Hazard Category 3 facility per DOE-STD-3009-94 (Ref. 3.11).

3.3.1 Hazard Analysis Methodology

Analysis of the AWWT hazards was performed by a systematic approach of three analysis methods used in process safety management. The first hazard evaluation procedure was the Preliminary Hazard Analysis (PHA). After identification of the hazards, a What-If based on subsystems was used. This What-If used the hazards identified in the PHA as a guide for selection of those failures impacting the AWWT safety basis. To evaluate identified hazards with a significant impact, the HAZOP was used for the final evaluation. The development, applicability, and use of these methods are presented in the *Guidelines for Hazard Evaluation Procedures* by the American Institute of Chemical Engineers (Ref. 3.12).

The hazard categorization and classification was based on the guidance of DOE-STD-1027-92 (Ref. 3.5) for radioactive materials and Table 1 of WSRC-MS-92-206, Revision 1 (Ref. 3.10) for chemicals. The use of these and other criteria for hazard classification and required documentation is presented in Figure 3-1. The figure is from DOE-EM-STD-5502-94 and presents an approach for the documentation requirements for a facility. By following the logic of Figure 3-1, the hazard categorization for radioactive materials and ensuing hazard classification for chemical hazards is determined.

3.3.1.1 Hazard Identification Methodology

The hazards analysis follows the progression of wastewater from the influent points, to the collection points (equalization tanks for the process wastewater stream and the surge tank for the stormwater stream), and finally through the treatment processes to the points of discharge or waste slurry transfer. At each step of the AWWT processes, hazards were identified.

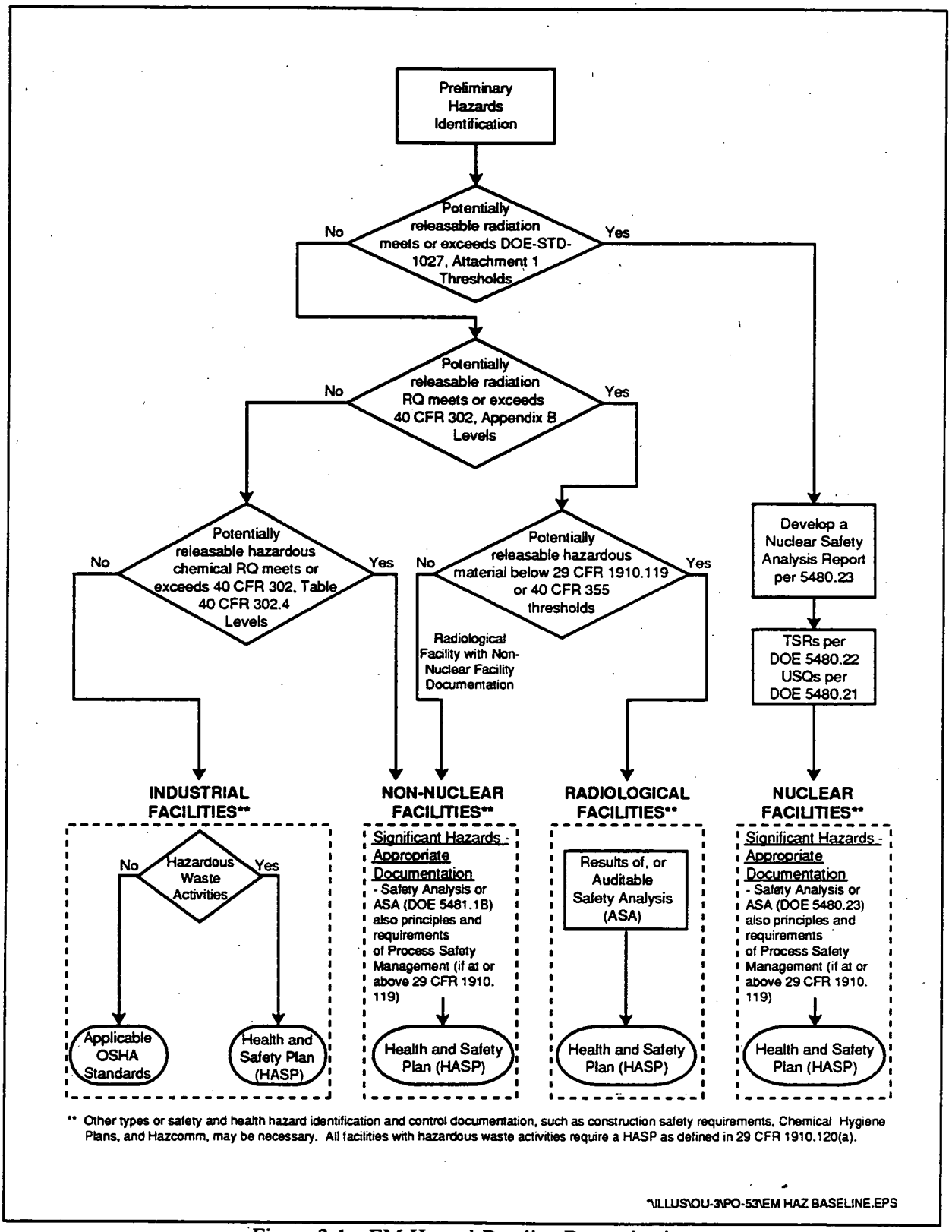

Figure 3-1 - EM Hazard Baseline Determination

For this FSAR, the possibility of workers and/or operators being exposed to radioactive materials and/or hazardous chemicals from contact with either the skin or eyes, inhalation, or ingestion was considered. Two particular routes of exposure to radioactive or hazardous materials included a worker being splashed or sprayed during operations or maintenance, or a worker falling into an open-top tank (such an event is considered most unlikely).

Hazards routinely encountered in industry are covered by OSHA requirements. Analysis of the AWWT hazards recognizes routinely encountered hazards and identifies how they are addressed in the development of a worker safety basis. These hazards are controlled through procedures and the use of appropriate protective equipment, and are discussed in this analysis if identified as an accident initiator to enhance worker safety.

3.3.1.2 Hazard Evaluation Methodology

The AWWT facility is a new facility and system operation data are not yet available to predict operating conditions of the various systems. Possible operating conditions and potential hazards considered in this analysis have been determined using manufacturers' data for the commercially available items.

The Frequency Rating Scale used to identify the likelihood of occurrence of a given accident sequence is presented in Table 3-1. The Hazard Rating and Consequence Definition Scale used to estimate the potential impact to people and the environment is shown in Table 3-2. The Risk Matrix, Figure 3-2, uses the hazard and frequency ratings to establish the ranking mechanism. The rating and ranking mechanisms serve to distinguish lower risk accidents from those that may warrant further analysis. These tables and figure differ from guidance currently in use for a nuclear facility Safety Analysis Report (SAR). This guidance provides more categories (i.e., ranking mechanism) for the hazards and their associated frequency. This approach was used to more clearly distinguish between the hazards and ensure that the risks with greater impact were analyzed. These are adopted from the guidance in DOE Order 5481.1B as referenced from MIL-STD-882 B, "Military Standard System Safety Program Requirements," March 30, 1984.

3.3.1.3 Preliminary Hazard Analysis

The American Institute of Chemical Engineers' *Guidelines for Hazard Evaluation Procedures* (Ref. 3.12) recommends conducting a PHA prior to the start-up of a facility to identify major hazards and accidents, and design or operating guidelines that could reduce or eliminate those hazards. Thus, the PHA was applied to the AWWT's conceptual design as is normally done in industrial applications. The results are presented in Appendix B.

Table 3-1 - Frequency Rating Scale

Frequency Scale	Description	Estimated Frequency of Occurrence (p) (Per Year)
E - Extremely High	Likely to occur one or more times per year.	$p \sim 1.0$
D - High	Likely to occur once every 1 to every 10 years.	$1E\text{-}1 < p < 1E\text{-}0$
C - Medium	Likely to occur once every 10 to 100 years.	$1E\text{-}2 < p < 1E\text{-}1$
B - Low	Likely to occur once every 100 to 1000 years	$1E\text{-}3 < p < 1E\text{-}2$
A - Extremely Low	Occurrence is expected to be less than once every 1000 years.	$p < 1E\text{-}3$

3.3.1.4 What-If Analysis

A hazards analysis employing a modified What-If technique was used to systematically evaluate the ways equipment could fail and the effects of these failures on process safety for the AWWT system. This analysis was performed for specific equipment failures in identified facility locations. It is based on the results of the analysis in Appendix B. The results of the What-If hazards evaluation are presented in Appendix C.

In summary, the analysis followed the progression of wastewater from the influent points, to the collection points, and finally through the treatment processes to the points of discharge or waste slurry transfer.

3.3.1.5 Hazard and Operability Analysis

The PHA identified the receipt and transferring of treatment chemicals as an operation with a potentially significant risk. To more fully determine the risk of an event, a HAZOP of the unloading, storage, and use of sulfuric acid in the AWWT facility was conducted. The analysis focused on the possibility of injuring AWWT workers, other FEMP personnel, or the public with potential acid spills and potential releases of acid aerosol. HAZOP is a qualitative analysis technique that focuses primarily on single failures that can result in consequences of interest. The analysis was performed in team meetings. The

Table 3-2 - Hazard Rating and Consequence Definition

Hazard Level	Maximum Consequence
7 Catastrophic	Extremely serious impact on site and off site for lengthy periods of time. Large geographic areas as well as large population groups affected. Large numbers of fatalities, both on site and off site.
6 Extremely High	Extremely serious impact on site on large numbers of people and to the environment. Many fatalities on site and possible fatalities to the public. Moderate impact beyond the exclusion area.[1]
5 High	Extremely serious impact on site and considerable impact to the environment. Multiple fatalities to operating and other on-site personnel. Moderate health and safety concerns to the public. Minor impact beyond the exclusion area.[1]
4 Medium	Serious on-site impact and significant impact within the exclusion area and the environment. Fatality, severe injury, or severe illness to operating personnel. Significant health concerns to workers at nearby facilities. Few people off site seriously affected.
3 Low	Limited on-site but only minor off-site impact. Moderate injury or creation of moderate health concerns for operating personnel. Minor health and safety concerns for nearby facility workers.
2 Extremely Low	Minor on-site but no off-site impact. Slight injury or illness to operating personnel. Local facility contamination which requires only routine procedures to control or correct. No health and safety concerns for workers at nearby facilities.
1 Negligible	Detectable on-site but no off-site impact. No identifiable safety and health consequences. Negligible contamination of the environment.
Note:	1) Exclusion Area: The area surrounding the facility in which the owner has the authority to determine all activities including exclusion or removal of personnel and property from the area.

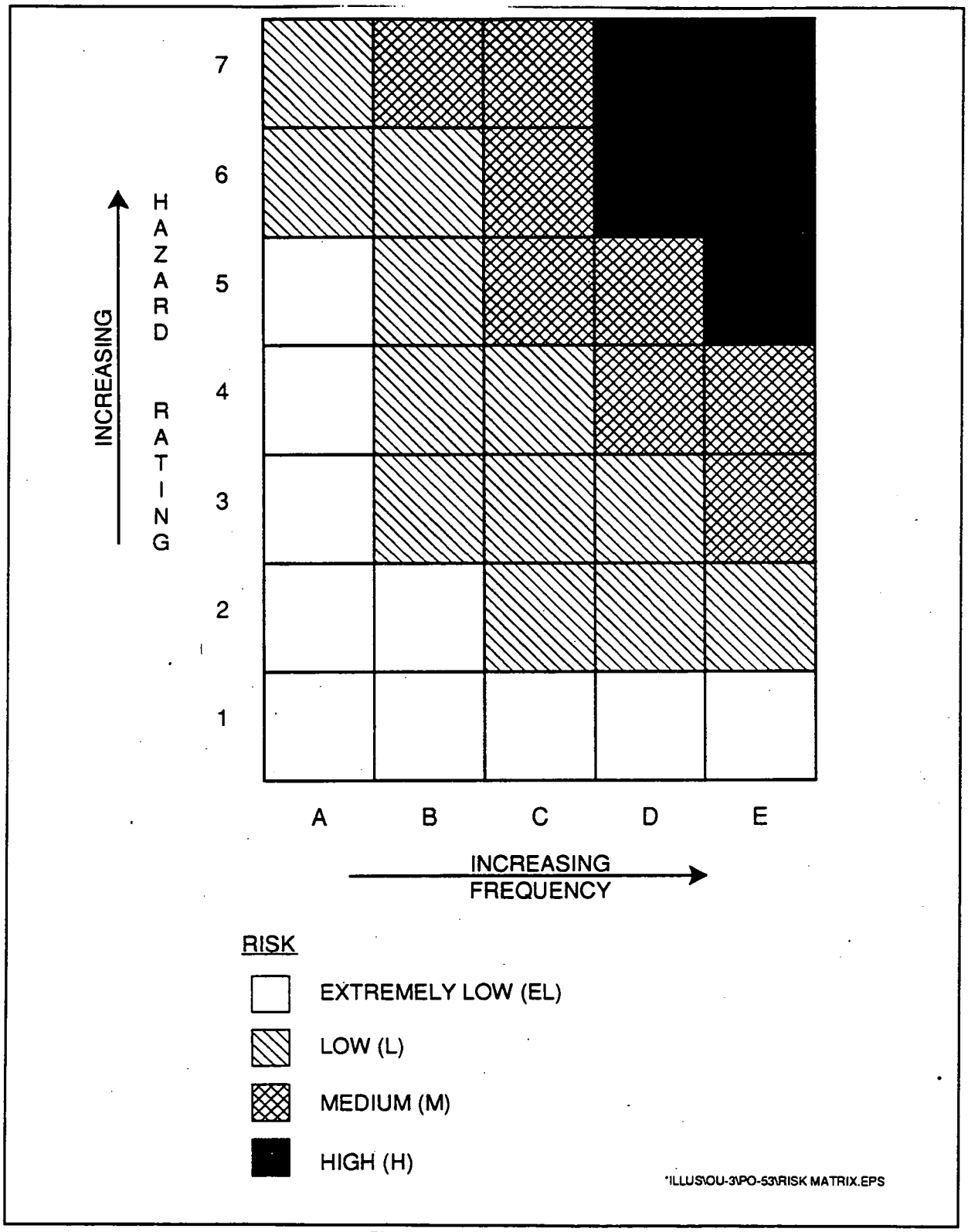

Figure 3-2 - Risk Matrix

piping and instrumentation diagrams (P&IDs) used in the review are referenced in the HAZOP included in Appendix D of this FSAR. The team also reviewed the draft procedures for unloading operations. The analysis considered all AWWT equipment and operations associated with concentrated sulfuric acid (including planned dilution operations) and focused on the potential for uncontrolled dilution or neutralization. The analysis also considered the potential for uncontrolled neutralization of dilute acid solutions; however, no potential accidents of this type were identified.

Only one uncontrolled neutralization reaction is identified in the HAZOP; it is caused by accidentally unloading caustic from a tank truck into the sulfuric acid storage tank. A similar scenario would be accidentally unloading sulfuric acid into the caustic storage tank. Either of these accidents may result in a violent reaction with a steam explosion that would blow off the manway cover and/or rupture the tank.

Similar types of accidents with much less severe consequences would involve accidentally unloading alum into the sulfuric acid storage tank or accidentally unloading sulfuric acid into the alum storage. These accidents could expose workers in the immediate vicinity to risk from acid spills and vapor inhalation, but downwind vapor concentrations should not be significant.

3.3.2 Hazard Analysis Results

Appendix B summarizes the potential hazards. To assure a comprehensive safety basis, worker safety hazards are incorporated by consideration of initiators and not solely consequences. The AWWT hazards in Appendix B identify the hazard, nature of the hazard, location, mitigating facility systems, and special mitigators for personnel.

One hundred two accident initiators were identified and are listed in Appendix C. Of these, 1 is classified as "medium" risk, 66 are classified as "low risk" and 35 are classified as "extremely low risk." Initiators are identified by facility location. Using the facility location provides further insight into potential events and their impact as they relate to each other. The most common concerns associated with the events include exposure of on-site workers to chemicals, mainly from leaks and spills, and direct contact surface contamination from the treated uranium, initiated also from leaks and spills outside the process containment. Risk, probability, and hazard levels were developed from the ranking system previously presented.

3.3.2.1 Hazard Identification

The principal source of hazards present in the AWWT facility are uranium and chemical hazards from heavy metals in the wastewater or from the chemicals that will be used for treatment. After reviewing the materials, equipment, and processes, the primary sources of hazards in the AWWT facility are given

in Appendix B. Tables 3-3 and 3-4 identify the material inventories and serve as the basis for hazard classification.

The results of the uranium inventory loading analysis are presented in Tables 3-3 and 3-4. This table provides information on the uranium present in the process equipment. The loadings presented in the table are total loading or holdup inventories for all of one type of process equipment. As an example, the recycle tanks are given as two sets of three because there is one set for the process wastewater and one set for the stormwater/groundwater streams in the AWWT operations. Eight carbon filter beds are listed. Three are for the process wastewater and five for the stormwater/groundwater. Four multitube filters banks are used for the AWWT. One bank is for the process wastewater, two for the stormwater/groundwater, and one for the combined streams after IX.

3.3.2.2 Hazard Classification

The hazard categorization for uranium and for chemicals of the AWWT are based on the inventory of the materials present in the AWWT. Appendix E develops the chemical inventory. Appendix H develops the uranium hold up inventory. The hazard classification for chemicals present in the AWWT is based on the guidance of Table 1 of WSRC-MS-92-206, Revision 1 (Ref. 3.10). Because the chemical impacts are an immediate hazard to a human life, only the Emergency Response Preparedness Guidelines (ERPGs) are cited. Process chemicals present at the AWWT do not all have ERPG values developed.

To determine the Hazard Category for the AWWT facility, the highest possible concentration of uranium inventory was considered (see Appendix H). Table 6 of Appendix E, Attachment 1 presents the categorization based on the uranium loading. The total uranium inventory is 17 percent of the allowable threshold limits from DOE-STD-1027-92 Attachment 1 (Ref. 3.5). The inventory is, however, greater than that given in 40 CFR 302.4, Appendix B. The guidance in DOE-EM-STD-5502 (see Figure 3-1) indicates the AWWT would be a radiological facility. As indicated in Table 7 of Appendix E, the quantity of sulfuric acid exceeds the 40 CFR 355 threshold and, consequently, based on DOE-EM-STD-5502-94, non-nuclear facility documentation is required.

Based on the criteria for the impacts associated with hazards as given in Table 1 of WSRC-MS-92-206, Revision 1 (Ref. 3.10), the hazards due to the chemicals present are below those for a low-hazard facility (see Appendix E, Tables 9 and 10). However, because of the presence of sulfuric acid and caustic and the potential for an inadvertent mixing release affecting facility workers, the facility is classified as low hazard.

Table 3-3 - Uranium Loading of Process Equipment

Process Equipment	Expected Loading (lbs)	Peak Loading (lbs) (Worst Case)[1]
Clarifier: Process Wastewater Stream (1) (South Containment)	70.2	381
Clarifiers: Stormwater/ Groundwater Stream (1 each) (South Containment)	91.7	275
Multi-Tube Filter Banks[2] (4) (Building 51)	161[3]	329
Ion Exchange Beds (2 sets of 3 each) (Building 51)	90	446
Recycle Tanks (2 sets of 3) (South Containment)	24	119
Receiver Tanks (2 Tanks) (South Containment)	30	149
Carbon Filters (8 beds) (Building 51)	2.5	2.5
Waste Slurry Surge Tank (1) (South Containment)	54	116
Waste Slurry Pipe to Plant 8	6	12
Total	529.4	1829.5

Notes:

1. Peak Loading (Worst Case) is a result of failures and significant misoperation by operator and equipment
2. Design loading of the multitube filter banks is unknown, assumed maximum loading is all uranium.
3. Assumed 50 percent of peak loading

Table 3-4 - Process Equipment Design Loading Inventory

Material	Quantity	Vessel/Location
Sodium Hydroxide (Caustic) 20%	20,000 gal 600 gal 400 gal	T-19X-3000 (East Containment) Tank 145 (Building 51) Tank 228 (Building 51)
Sulfuric Acid (Concentrated 93%)	10,000 gal 420 gal	Tank 137 (East Containment) Tank 148 (Building 51)
Sulfuric Acid (Diluted)		
18% Recycle Tank	5,000 gal	Tank 222 (South Containment)
18% Recycle Tank	5,000 gal	Tank 345 (South Containment)
7% Recycle Tank	7,000 gal	Tank 221 (South Containment)
7% Recycle Tank	7,000 gal	Tank 344 (South Containment)
3% Recycle Tank	16,000 gal	Tank 220 (South Containment)
3% Recycle Tank	16,000 gal	Tank 343 (South Containment)
3% Receiver Tank	16,000 gal	Tank 395 (South Containment)
3% Receiver Tank	16,000 gal	Tank 396 (South Containment)
Liquid Alum 28%	7,500 gal	Tank 193 (Building 51)
DOWEX 21K IX Resin	9 IX Vessels (at 130 ft^3 per vessel)	Building 51
Activated Carbon Beds	8 Vessels (at 200 ft^3 per vessel)	Building 51

Notes:

1. Inventory for the sulfuric acid and sodium hydroxide storage tanks exceed the Hazardous Chemical RQ for 40 CFR 302.
2. The AWWT chemicals listed in 40 CFR 302 for an RQ are sulfuric acid and sodium hydroxide.

3.3.2.3 Hazard Evaluation

To limit hazards, SSCs are characterized as safety-class or safety-significant for the facility and process. There are no AWWT hazards requiring safety-class SSCs. One hazard is identified as safety significant because potential impact to facility workers indicates a possible immediate worker fatality. This hazard is the improper transfer of sulfuric acid or caustic to the wrong tank. A breach of storage tank and potentially violent release of a sulfuric acid mist may result. Procedural and administrative controls are in place to ensure that the inadvertent mixing during offloading is not credible. Sections 4 and 5 discuss the safety-significant SSCs.

Defense in Depth

The equipment and design features provide defense in depth for the AWWT. There are spill, leak, and overflow instrumentation and controls (I&Cs) that oversee normal operations. These I&Cs are implicitly considered for the operation of the AWWT. The design uses proven equipment for wastewater treatment as the first level of safety. The process equipment is compatible with the treatment chemicals at the varying concentrations in use. On a global scale for the AWWT, there is confinement provided for the wastewater streams and chemicals used in the treatment process. Defense in depth is provided for the receipt of the treatment chemicals by having all bulk chemicals sampled for pH and purity prior to transfer.

Summary of Worker Safety Features

Worker safety features provide an additional level of assurance that the facility can operate safely. For the start-up of this project, a Standard Operating Procedure (SOP) is under development to describe off-normal conditions and the expected response to control or mitigate the occurrence. The conditions include response actions for alarms, level indicators, and equipment status checks. Process controls, indicators, and alarms are used to ensure that workers are aware of the conditions of the process system. The controls, indicators, and alarms are located in the control room, enabling the operator to immediately respond to an alarm indication.

3.4 Accident Analysis

This accident analysis qualitatively and quantitatively evaluates the accidents selected by the hazard evaluation above. Each accident scenario that was selected for evaluation focuses on the chemical hazards because the facility is a radiological facility and, hence, below the Hazard Category 3 threshold. Although in very low concentrations, the presence of uranium in process equipment is included in the analysis.

3.4.1 Scenario Development

The various hazards defined in Appendices B and C could result in potential accidents if not properly controlled. The various operations identified were analyzed for failures that could lead to potential accidents. These included failures that could lead to spills or the release of toxic vapors from radioactive or hazardous materials. Appendix F presents accidents binned for common failures and resultant releases. Accidents with common results (e.g., spills) were considered for further development into potential accident sequences.

To establish the bounding cases, worst case or maximum creditable inventories of treatment chemicals and uranium were considered for release by natural phenomena hazards and spills. For the inadvertent mixing of chemicals, both qualitative and quantitative analyses were performed.

Quantitative analysis of the chemical releases indicates that all releases from spills and natural phenomena events are acceptable for the criteria defined in WSRC-MS-92-206, Revision 1 (Ref. 3.10). The analysis of the inadvertent mixing and potential resultant violent reaction and pressure generated must be controlled through the use of engineered and procedural controls. These controls are discussed in Sections 4 and 5.

3.4.2 Source Term Analysis

The source term for the AWWT accident analysis is based on two separate operational equipment loadings. (See Appendix H for uranium loading and Appendix E for analysis.) The first case is the design loading of the AWWT during routine operations. The second case or peak loading (worst case) is the maximum quantity of uranium that process equipment contains when off-normal operations have caused excessive loading (see Table 3-3). The peak loading serves as the inventory for the accident analyses.

The source term for chemicals used in the analysis is based on the total inventory of the particular chemical (See Appendix E).

3.4.3 Consequence Analysis

The accident analysis is based on the frequency and level of consequence for an accident. Given these two factors, the risk level for a selected accident can be determined. Risk levels that are low or extremely low are adequately analyzed for their impact on the AWWT operations. A spill has been selected as an operational accident for quantitative analysis to determine the impact of a chemical release on co-located workers and the off-site public.

Results of the analysis presented in Appendix E indicate that the release of uranium-bearing wastewaters and the process chemicals does not pose an unacceptable risk to on-site workers or personnel at the site boundary. The natural phenomena accident of an earthquake produced the highest consequence that is still below the risk acceptance curve. Therefore, there is no rationale to recommend the implementation of mitigative or preventive features.

Proposed DOE-STD-3005-YR (Ref. 3.9) established the radiological guidelines and was used to prepare Table 3-5. Neither DOE Order 5481.1B nor DOE-STD-1027-92 (Ref. 3.5) provides quantitative guidelines for the evaluation of exposures to toxic chemicals when determining the hazard category of a facility. Therefore, the toxicological risk acceptance criteria established in WSRC-MS-92-206, Revision 1 (Ref. 3.10) has been used for comparison. Guidelines for worker safety and Risk Acceptance Criteria were adopted from DOE-STD-3009-94 (Ref. 3.11). The radiological and toxicological consequences from the selected accident scenarios are compared to the Evaluation Criteria.

Table 3-5 - Risk Acceptance Criteria

Receptor Location		Off-site		On-site and Worker		
Source Reference		DOE-STD-3005-YR	WSRC-MS-92-206, Rev. 1	STD-3005-YR	WSRC-MS-92-206, Rev. 1	STD-3009-94
Frequency (events/year)	Category	Radiological (REM)	Chemical	Radiological (REM)	Chemical	Industrial
> 1E-1	Normal	EPA and Other Legal Limits on Normal Emissions	EPA and Other Legal Limits on Normal Emissions	1 Radiological Control Manual	PEL-TWA 2E-6 ICR	No severe injuries
1E-1 to 1E-2	Anticipated	0.5 (DOE Order 5400.5)	PEL-TWA 2E-6 ICR	5 (5480.11)	ERPG-1 2E-4 ICR	No prompt death Less than 5 severe injuries
1E-2 to 1E-4	Unlikely	5 (10CFR72)	ERPG-1 2E-4 ICR	25	ERPG-2 2E-2 ICR	
1E-4 to 1E-6 (NPH)	Extremely Unlikely	25 (10CFR72)	ERPG-2 2E-2 ICR	100	ERPG-3 2E+0 ICR	NPH No criteria
< 1E-6	Incredible	Does not require analysis.				
NPH is Natural Phenomena Hazards						

Since there was only an ERPG available for sulfuric acid at the time this SAR was written, the hierarchy of references in Table 3-6 was used to select an appropriate concentration when an ERPG was not available. Table 3-6 was adopted from WSRC-MS-92-206, Revision 1 (Ref. 3.10). Implementing the hierarchy in Table 3-6 resulted in the limits for the Risk Acceptance Criteria as shown in Table 3-7.

Table 3-6 - Hierarchy of Alternatives for Risk Acceptance Criteria

Primary Guideline	Hierarchy of Alternative Guidelines	Source of Concentration Parameter
ERPG-3		**AIHA 1991**
	EEGL (30-min)	NAS 1985
	IDLH	NIOSH 1990
ERPG-2		**AIHA 1991**
	EEGL (60-min)	NAS 1985
	LOC	US EPA 1987
	PEL-C	CFR29:1910.1000
	TLV-C	ACGIH 1992
	TLV-TWA * 5	ACGIH 1992
ERPG-1		**AIHA 1991**
	PEL-STEL	CFR 29:1910.1000
	TLV-STEL	ACGIH 1992
	TLV-TWA * 3	ACGIH 1992
PEL-TWA		**CFR 29:1910.1000**
	TLV-TWA	ACGIH 1992
	SPEGL (60-min)	NAS 1985
	CEGL	NAS 1985

Agencies:
ACGIH - American Conference of Governmental Industrial Hygienists
AIHA - American Industrial Hygiene Association
US EPA - Environmental Protection Agency
FEMA - Federal Emergency Management Agency
NAS - National Academy of Sciences
NIOSH - National Institute of Occupational Health and Safety
OSHA - Occupational Safety and Health Administration
US DOT- U.S. Department of Transportation

Table 3-7 - Numerical Chemical Limits Used in Risk Acceptance Criteria

Chemical	ERPG-3		ERPG-2		ERPG-1		PEL-TWA	
	Limit (mg/m^3)	Reference	Limit (mg/m^3)	Reference	Limit (mg/m^3)	Reference	Limit (mg/m^3)	Reference
NaOH	10	IDLH	10	TLV-TWA * 5	6	TLV-TWA * 3	2	PEL
$Al_2(SO_4)_3$	30[1]	IDLH	15	TLV-C	6	TLV-TWA * 3	2	PEL-TWA
H_2SO_4 [2]	30	ERPG-3	10	ERPG-2	2	ERPG-1	1	TLV-TWA

Notes:
1) $Al_2(SO_4)_3$ IDLH is from MSDS reporting a fatality at this level.
2) These values are for the sulfuric acid as a mist (Ref. 3.13).

Credible events that would potentially release large amounts of material that would affect the off-site public or the on-site work force were selected for further evaluation.

Table 11 of Appendix E, Attachment 1 presents the radiological consequences for an accidental release by natural phenomena or spill. The accident resulting in the greatest dose is an earthquake. The 50-year Committed Effective Dose Equivalent is 24 millirem (mrem). This dose is due to the release of the entire AWWT wastewater inventory from all vessels. Uranium concentrations and equipment loadings used are bounding for all cases. Appendix H presents the calculation of the equipment loading.

The consequences based on the chemical releases are all below the risk acceptance criteria curves. Releases of sulfuric acid, caustic (sodium hydroxide), and alum are below the criteria of Table 3-7. See Appendix E, Tables 12 and 13 for the specific results.

Table 14 of Appendix E presents the Incremental Cancer Risk due to uranium. All events are below event criteria.

3.5 References

3.1) OSHA, July 1, 1993. 29 CFR 1910.119, "Process Safety Management of Highly Hazardous Chemicals."

3.2) DOE, December 9, 1991. 10 CFR 830.110, "Nuclear Safety Management," Proposed Rule. Washington D.C.: Federal Register.

3.3) DOE, January 1993. DOE Order 5481.1B, "Safety Analysis and Review System."

3.4) DOE, August 1994. DOE-EM-STD-5502-94, "Hazard Baseline Determination."

3.5) DOE, December 1992. DOE-STD-1027-92, "Hazard Categorization and Accident Analysis Techniques for Compliance with DOE Order 5480.23, Nuclear Safety Analysis Reports."

3.6) University of California Research Laboratory, UCRL-15910, "Design and Evaluation Guidelines for Department of Energy Facilities Subjected to Natural Phenomena Hazards."

3.7) University of California Research Laboratory, UCRL-53526, "Natural Phenomena Hazards Modeling Project: Extreme Wind/Tornado Hazard Models for DOE Sites," Rev. 1.

3.8) University of California Research Laboratory, UCRL-53582, "Natural Phenomena Hazards Modeling Project: Seismic Hazard Models for DOE Sites," Rev. 1.

3.9) DOE, March 1993. DOE-STD-3005-YR, "Evaluation Guidelines for Accident Analysis."

3.10) Westinghouse Savannah River Company, April 1993. WSRC-MS-92-206, "Toxic Chemical Hazard Classification and Risk Acceptance Guidelines for use in DOE Facilities," Rev. 1.

3.11) DOE, July 1994. DOE-STD-3009-94, *Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Safety Analysis Reports.*

3.12) American Institute of Chemical Engineers, September 1992. *Guidelines for Hazard Evaluation Procedures,* Second Edition.

3.13) American Industrial Hygiene Association, 1989. Concepts and Procedures for the Development of Emergency Response Planning Guidelines (ERPGs), Set 7.

SECTION 4

SAFETY STRUCTURES, SYSTEMS, AND COMPONENTS

4.1 Introduction

This section describes those SSCs necessary for the facility to satisfy the Evaluation Guidelines (on site and off site), provide an additional safety margin, or contribute to worker safety. It also presents the worker safety SSCs that are required for defense in depth.

A comprehensive review of the materials, processes, and operations of the AWWT facility was made and the potential hazards were identified using the PHA technique outlined in MIL-STD-882B, "Military Standard System Safety Program Requirements" (Ref. 4.1).

As noted in Subsection 4.3, none of the facility systems will be designated Safety Class; however, some of the SSCs are considered to be safety significant due to worker safety concerns. These systems will be designed to conventional industry standards. These systems will be able to handle the range of normal operations and accidents described in Section 3. Systems and features within the AWWT which will be implemented for safety and which were evaluated using the safety criteria as outlined in DOE Order 6430.1A (Ref. 4.2) are described below.

4.2 Requirements

As required in DOE/TIC-11603 (Ref. 4.3) and DOE Order 6430.1A, Division 13 (Ref. 4.2), applicable codes and standards such as National Electric Code (Ref. 4.4), NFPA, ANSI-Underwriters Laboratories, and American Society of Mechanical Engineers are used as design criteria for fire and vessels and piping, ventilation construction, and other safety criteria.

4.3 Safety-Significant Structures, Systems, and Components

This section describes the safety-significant SSCs for the AWWT operations. As a facility below the Hazard Category 3 level, the AWWT has no safety-class SSCs. To assure the operators' safety, specific existing AWWT SSCs are identified.

4.3.1 Chemical Transfer and Storage

As part of the HAZOP (see Appendix D) operations involving the process treatment chemicals were reviewed. The inadvertent mixing of wastewater treatment chemicals at unloading to the wrong tank

presents a possible fatality hazard. Receipt and unloading of the chemicals, sulfuric acid and caustic, is performed in one central receiving area. There are dedicated individual swing arms and storage vessels for each chemical. The three separate storage tanks each have a swivel jointed swing arm that is secured with a lock to prevent inadvertent transfer and mixing. Each lock is keyed separately from the other two. The transfer system requires the transfer pump be enabled from the control room and started by the attending field operator. A detailed breakdown of the specific operations is in Subsection 5.3 and a separate Operational Safety Requirement document for operation of the AWWT.

4.3.2 Chemical Dilution and Mixing

As part of the HAZOP (see Appendix D) operations involving the process treatment chemicals were reviewed. The operation of mixing and diluting the wastewater treatment chemicals present a hazard to the AWWT worker. Operations are identified in Section 5 that require process controls or administrative controls based on whether the operation is performed automatically or manually. Chemical dilution and/or mixing are processes that require controls to prevent release and resultant worker exposure. A detailed breakdown of the specific operations is in Subsection 5.3 and a separate Process Requirements document for operation of the AWWT.

4.4 Worker Safety-Significant Structures, Systems, and Components

This section identifies SSCs that contribute to worker safety through defense in depth.

4.4.1 Protection by Multiple Confinement Barriers and Systems

The methods of confining the release of radioactive/hazardous materials within the AWWT facility are as follows:

1) Sumps, floor and trench drains, and test wells
2) Diked containment and sloped floors for liquid spill areas
3) Scrubbers for fumes

All radioactive material or hazardous chemicals collected by the system of containments, trenches, floor drains, and test wells and routed to the last or south sump is pumped to the equalization tank for processing. Radiological barriers and control points are determined by Radiological Control, as required. An acid scrubber is provided for air vented from the IX resin vessels, regeneration work tanks, and eluant receivers.

4.4.2 Confinement Barriers and Systems

Standard ventilation for air exchange and employee comfort is provided within the AWWT facility. Process areas are heated for protection from freezing. The A. M. Kinney design (Ref. 4.5) includes no high efficiency particulate air/medium efficiency particulate air filters for chemical off-gas ventilation. A scrubber system is being provided for acid fumes to limit the release of hazardous airborne emissions.

Confinement systems, the scrubber system, and dikes are described in Subsection 2.6.

4.4.3 Special Vessels and Piping

Pressures within the system are maintained at a nominal rate of 15 psig for normal process flow requirements, nominal 50 psig at the ion exchange units, and 70 to 80 psig for pressure vessels to achieve the required flows through the resin beds. No special vessels or piping was specified for this facility because of ambient conditions of temperature and pressure, and standard process chemistry.

Based on the original design criteria identifying the AWWT facility as a nuclear facility, the requirements from DOE Order 6430.1A (Ref. 4.2) called out double walled piping for lines having radioactive liquids outside of the secondary containment. This double-walled piping, separate from the process treatment area, is used for transport of the slurry from the Waste Slurry Surge Tank to a dewatering facility. As noted earlier, the process equipment (i.e., vessels, tanks, and piping) is designed to conventional industry standards based on the requirements of DOE Order 6430.1A (Ref. 4.2), which references various codes and standards (see Section 2).

4.4.4 Ventilation and Off-Gas Systems

The Building 51 ventilation system provides for adequate air circulation and air exchange. The heating and cooling units are designed to meet the requirements in the American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE) *Fundamentals Handbook* (Ref. 4.6) and meet applicable parts of 29 CFR 1910.1000 (Ref. 4.7). The building's main heating, ventilation, and air conditioning (HVAC) system is not designed for contaminant control but for comfort control. A fume hood and local exhaust will be provided in the laboratory.

4.4.5 Fire Protection and Mitigation Systems

As is discussed in Subsection 2.7.9, a wet pipe sprinkler system is installed in the facility. Fire extinguishers will be located in accordance with NFPA 10, "Portable Fire Extinguishers" (Ref. 4.8). A fire hydrant is present due south of the AWWT facility.

4.5 References

4.1) United States Air Force, March 1984. MIL-STD-882B, "Military Standard System Safety Program Requirements."

4.2) DOE, April 1989. DOE Order 6430.1A, "General Design Criteria."

4.3) DOE, September 1986. DOE/TIC 11603, "Non-Reactor Nuclear Facilities: Standards and Criteria Guide," Rev. 1.

4.4) National Fire Protection Association, May 1992. NFPA-70-93, *National Electrical Code*.

4.5) Westinghouse Materials Company of Ohio, Inc., July 27, 1989. *Design Criteria for Environmental, Health and Safety Improvements Phases IV, Volume 3. Two Fiscal Year 1990 Subprojects, Part II: Wastewater Treatment Improvements - Plantwide*.

4.6) American Society of Heating, Refrigerating, and Air Conditioning Engineers. ASHRAE *Fundamentals Handbook*.

4.7) Occupational Safety and Health Administration, July 1, 1993. 29 CFR 1910.1000, "Air Contaminants."

4.8) National Fire Protection Association, August 1994. NFPA-10, "Portable Fire Extinguishers."

SECTION 5

DERIVATION OF OPERATIONAL SAFETY REQUIREMENTS

5.1 Introduction

Formal technical safety requirements (TSRs) are not required for this project. However, specific Operational Safety Requirements (OSRs) must be met. Other support programs are identified that are not specific to the OSR but ensure that the defense-in-depth design and administrative features related to worker safety are maintained. This section identifies design requirements and administrative controls for the use of process chemicals in the AWWT facility.

The analysis presented in this FSAR reflects the need for protective equipment and strict enforcement over operations and maintenance activities. Accomplishing these objectives ensures the safe operation of the facility. Administrative controls are imposed for worker safety and defense in depth through programs and procedures.

5.2 Requirements

DOE Order 5480.22, "Technical Safety Requirements" (Ref. 5.1), would be applicable if the AWWT were a nuclear facility. Instead, FERMCO has developed OSRs to ensure the safe operation of the facility through administrative controls and identification of safety significant SSCs. The OSRs are similar in nature and content to TSRs, developed using a graded approach based on the hazard and accident analysis summarized in Section 3.

5.3 Operational Safety Requirement Derivation

Safety-significant SSCs were identified in Section 3 as features which mitigate serious injury to multiple workers or a single prompt death from non-standard hazards. Identification of these SSCs and derivation of the appropriate controls for these features are developed in the following subsections. In addition, the HAZOP performed on the handling of hazardous chemicals identified several operations, that while not hazardous enough to be classified as safety significant, they should be done with extra administrative controls. Also discussed in Section 6, inadvertent criticality in the AWWT is extremely unlikely even without controls on the uranium content of the water processed. However, to ensure that there is no potential for criticality, certain administrative controls are necessary.

The graded approach to the development of OSRs was based on providing the most stringent and detailed requirements, including both limiting conditions for operation (where appropriate) and administrative

controls, for those situations where an accident would have a potential for worker fatalities while specifying only administrative controls for less hazardous situations without a significant potential for a fatality.

5.3.1 Safety Significant SSC and Controls

One scenario from the HAZOP of AWWT operations required OSR level controls. (See Appendix D for HAZOP results.) This scenario, identified in Appendices B, Operational Accidents, B.2, and C, Hazard Evaluation, is caused by the inadvertent mixing of sulfuric acid and caustic during off-loading. The scenario has a medium risk classification due to the potential for AWWT worker fatalities. The OSR establishes a safety limit for the off-loading and transfer of process chemicals. These are presented in Appendix B, Operational Accidents B.2.

To prevent the inadvertent mixing of the process chemicals at transfer there are separately keyed locks on each of the three chemical transfer arms. The key for each lock is kept by the day shift operations supervisor. On arrival and processing through the FEMP receiving area the tanker truck is escorted to the AWWT facility. A sample of the chemical is taken and analyzed. After confirmation, the field operator requests the day shift operations supervisor to unlock the swing arm. The field operator then requests the control room operator to enable the appropriate transfer pump. The transfer of the chemical from the tanker truck can then be completed with the field operator activating the transfer pump. Checking receiving tank level prior to unloading can also prevent inadvertent mixing under some situations.

From the above and the results of the HAZOP, limiting conditions of operations are included in the OSR to ensure the key locks for the swing arms are in place and that the level gauge is operational. Administrative controls cover the other precautions such as chemical sampling and unloading procedures.

5.3.2 Other Activities

In addition to those for the medium risk scenario identified above, other OSRs have been developed based on the HAZOP and criticality analyses. This document identifies the specific administrative controls that must be in place for the AWWT to safely operate. The HAZOP established requirements for the safe operation of the chemical storage and transfer system. The OSRs specify the controls to ensure that the chemicals are not inadvertently mixed and that releases are minimized. The HAZOP team, analysis results of and HAZOP table are provided in Appendix D. The activities and controls are:

IX Regeneration

Interlocks must be used to prevent/stop feeding acid into an IX recycle tank (51-X222-TNK or 51-X345-TNK) if the water level in the tank is too low, the temperature in the tank is too high, or there is no flow in the recycle (mixing) loop. This operation is also sufficiently controlled if only performed manually.

Filling Caustic Feed Tank

The caustic used in the pH adjustments is automatically diluted when transferred to the storage tank. The HAZOP identified the scenario that single failures in the control systems for this operation could result in overfilling the feed tank and possibly overfilling the dike/sump around the tank. If the tank is to be automatically filled versus manually controlled and monitored, additional interlocks and alarms (such as a high-high feed tank level interlock or a time-out alarm) shall be installed. The additional level interlocks and alarms must be from a level transmitter separate from the one used for the control.

Filling Acid Feed Tank

The HAZOP identified the scenario that single failures in the control systems for this operation could result in overfilling the feed tank (51-X148-TNK) and possibly overfilling the dike/sump around the tank. If the tank is to be automatically filled versus manually controlled, additional interlocks and alarms (such as a high-high feed tank level interlock or a time-delayed alarm) must be installed. The additional level interlocks and alarms must be from level instruments/controls separate from the level transmitter used for the control.

Acid Feed Line Flow Control

From the HAZOP, installation of check valves in the acid lines to the mixers (51-X203-MXR and 51-X328-MXR) is required. If the pressure regulating valve downstream of one of the mixers failed in the closed position, the pressure could be high enough to cause the flow to reverse, sending wastewater to the acid feed tank and resulting in an uncontrolled dilution of the acid in the feed tank. The flow control valve in the acid feed line to the mixer must close and prevent this reverse flow, but a check valve provides an additional safeguard.

Uranium Enrichment

Since the facility is approved as a radiological facility, controls on the uranium enrichment are necessary to provide complete assurance that there is not potential for a nuclear criticality. They are appropriately included in the administrative control section of the OSR.

The AWWT processes identified above are controlled by one OSR. The OSR is a separate stand alone document identifying the limiting conditions for operation, surveillance requirements, and other administrative controls.

5.4 Safety Programs and Procedures

In addition to OSRs, other programs exist and support the AWWT operations. These programs and procedures are not considered appropriate for the OSRs but are commitments identified and implemented for worker safety. The SSCs contributing to worker safety are listed in Table 5-1. A summary table identifies the commitments that are necessary for safe operation of the AWWT.

Table 5-1 - Features Contributing to Significant Defense in Depth

Significant Defense in Depth	Safety Function	Commitment
Level I&C	Prevent overflow	Requires instruments to be operational
Temperature I&C	Prevent high caustic temperature	Requires instruments to be operational
pH I&C	Prevent spill, overflow	Requires instruments to be operational
Locks	Prevent inadvertent mixing	Requires equipment to be operational
Diked area and secondary confinement	Mitigate spill, leak, or overflow	Requires dikes to be functional

5.4.1 Programs

The following programs are required to ensure safe operations during AWWT activities. These programs are required as a result of the hazards identified in the hazard analysis (Section 3) of the FSAR. The resulting administrative controls are presented in Table 5-2.

Table 5-2 - Administrative Controls for FEMP Programs

Program	Control	Reference
Radiation Protection Program	The FEMP is a non-reactor nuclear facility with the potential for radiological contamination in the work areas associated with the AWWT. Section 7 of this SAR discusses the commitments that are made concerning radiation protection for this activity. An administrative control is required to ensure a radiation protection program which contains the commitments is implemented for the AWWT activities.	Section 7
Chemical Hazards Protection Programs	The potential for chemical hazards exists in the AWWT work areas. Section 8 discusses the commitments that are made concerning protection against these hazards. Section 8 also requires a Hazards Communication Program implementing the requirements of 29 CFR 1910.1200 (Ref. 5.2).	Section 9

Program	Control	Reference
Quality Program	An administrative control shall be implemented to ensure that the Quality Program discussed in Section 14 is implemented for the AWWT. The Quality Program includes all the FEMP applicable requirements of DOE Order 5700.6C (Ref. 5.3) as identified in the FERMCO Quality Assurance Program, RM-0012.	Section 14
Fire Protection Program	An administrative control is required to ensure that a fire protection program incorporates the requirements of DOE 5480.7A except those noted in Section 17 (Ref. 5.4).	Section 17
Reviews, Audits and Reporting Requirements	An administrative control is required to ensure that the reviews, audits, and reporting program discussed in the references sections is implemented and maintained.	Sections 7, 8, and 17
Training/ Qualification	An administrative control is required to ensure that the training specified in Section 12 is implemented since it has been credited in the hazard analysis. In particular, training must be conducted on those task-specific procedures controlled in Subsection 12.3.	Section 12
Criticality Control	An administrative control is required to ensure that a verification sampling program is implemented as credited in the hazard analysis. Specifically: that the influent is known to be below 1% enrichment prior to release to the AWWT from the FEMP process area.	Section 6 and Appendix E

5.4.2 Procedures

The types and control of procedures which allow safe operations at the AWWT are presented in Section 12 of this SAR. Several procedures which are necessary to mitigate the hazards identified in Section 3 require administrative controls to ensure their implementation. These administrative requirements are presented in Table 5-3.

Table 5-3 - Administrative Control of Procedures

Procedure	Control	Reference
Initial Testing and Start-up Procedures	1. Development of SOPs in agreement with the specifications to guide AWWT start-up. 2. Prior to execution of a test program, test control procedures are developed for detailed instructions and delineating responsibility.	Section 10 and 12
Approval of Wastewaters for Release to AWWT	1. Development of a clearly written SOP specifying the criteria for evaluating test results and approving receipt of the tested wastewater batch.	
Maintenance Procedures	1. Procedures are developed specifying the components' frequency, interval and requirements for maintenance.	
Process Procedures	1. Development of clearly written SOPs to define specified equipment operating limits. 2. Step-by-step instructions for each operator and supervisor with built in cross-checking of parameters to minimize single failure events. 3. Addressing abnormal conditions and parameters, their implications, and appropriate responses. 4. Training which includes dry runs in PPE and response to events.	
Changeout of IX Resin and Spent Carbon clean-out	Step-by-step instructions for a worker safe operation.	
Acid/Caustic Unloading	Step-by-step instructions for a worker safe operation.	
Service/ Maintenance	1. Appropriate development and use of RWPs for opening process lines for service/maintenance.	
Spill Response	1. Instructions are present for personnel who will respond to leak events. 2. Training and procedures specific to each chemical. 3. Training for potential abnormal operations due to facility failures. 4. Incorporate the AWWT description into the FERMCO Spill Prevention and Countermeasure Plan, PL-2194.	

5.5 Interface with Other Facilities

Current interfaces of the AWWT facility with other facilities are discussed in Section 2. None of these facilities currently have administrative controls or TSRs in place which could affect the AWWT. Note that the testing of waters from the general sump and reporting of results are listed as an administrative control for the AWWT. This reflects the AWWT shift supervisor's responsibility in approving the release of wastewaters to the AWWT.

Process wastewaters are accepted from Plant 8 after a preliminary filtration. The AWWT serves to further concentrate the uranium bearing wastewaters. The slurry wastes are then transferred to Plant 8 for a final filtration. Other activities at Plant 8 use normally dedicated EIMCO rotary filters for sludge treatment. Sludge separation includes both continuous process (sanitary waste and AWWT) and shorter term processes (Uranium Nitrate Hexahydrate solidification, DHF solidification and thorium nitrate solidification). The dedicated equipment, used for sludge removal, including the supply piping from other facilities, is handled as radioactively contaminated.

5.6 References

5.1) DOE, September 1992. DOE Order 5480.22, "Technical Safety Requirements."

5.2) Occupational Safety and Health Administration, July 1, 1993. 29 CFR 1910.1200, "Hazard Communication."

5.3) DOE, August 1991. DOE Order 5700.6C, "Quality Assurance."

5.4) DOE, February 1993. DOE Order 5480.7A, "Fire Protection."

SECTION 6

PREVENTION OF INADVERTENT CRITICALITY

6.1 Introduction

This section identifies the requirements related to inadvertent criticality protection and summarizes the results of the criticality evaluation.

Due to the presence of uranium in the AWWT Facility, there is a theoretical possibility of an inadvertent criticality event. As presented in this section, the physical limitation of the AWWT processes backed up by the administrative control on the water processed by the AWWT leads to the conclusion that there is no credible potential for criticality and, therefore, there are no safety-class systems nor criticality alarm systems required to protect against criticality in the facility. An administrative control has been established to limit the enrichment of uranium released by the AWWT.

6.2 Requirements

The FERMCO *Management Plan: Policies and Requirements Manual* includes the S/RID for Nuclear and Systems Safety. This S/RID (No. 9) identifies the criticality safety requirements for the FEMP per the FERMCO contract with the DOE; Federal, State, and local laws; DOE Orders; and DOE guidance documents.

Compliance with DOE Order 5480.24, "Nuclear Criticality Safety" (Ref. 6.1), is required per FEMP Site Requirement SR-2117, "Nuclear Criticality Safety Requirements" (Ref. 6.2), which identifies the specific requirements from DOE Order 5480.24 that are applicable to this site. However, as will be shown below, the detailed requirements are not applicable to the AWWT because it is concluded that there is no credible potential for a criticality in the AWWT.

6.3 Criticality Evaluation

The FEMP processed uranium up to 2 weight percent U-235. Processing campaigns involving this enrichment were very short in duration. Less than 1 weight percent U-235 enrichment is probably the best number to use to characterize the enrichment of the wastewater streams. For conservatism, 2 weight percent U-235 enrichment was used initially to assess safe mass loadings, or safe concentration limits in the clarifier and in other process equipment for this nuclear criticality assessment.

The AWWT process equipment was screened for criticality based on a safe mass for each piece of equipment. Assuming 2 percent U-235 for conservatism, for the most restrictive concentration, the only piece of process equipment that could conceivably accumulate enough uranium to exceed a safe mass is the clarifier. This critical safety analysis is discussed in greater detail in Appendix G.

Available maximum wastewater slurry uranium concentration data indicate that even with 95 percent of the water removed from the slurry, the concentration would still be an order of magnitude below that required for a criticality event in an infinite, optimally moderated, homogeneous mixture. Nevertheless, administrative controls are being imposed on the transfer of water from the general sump to the AWWT. This prohibits transfer of water that contains uranium of 1 percent or more enrichment to the AWWT without specific criticality safety analysis by the FEMP Nuclear Safety Section. Such approval would be given in limited circumstances where, for example, the total amount of uranium involved is below that required for criticality under peak (worst case) loading conditions and other water being processed and slurry in the AWWT cannot contribute to exceeding limits. This administrative control is established in Section 5, "Derivation of Process Requirements."

6.4 References

6.1) DOE, August 1992. DOE Order 5480.24, "Nuclear Criticality Safety."

6.2) FERMCO, June 1993. SR-2117, "Nuclear Criticality Safety Requirements."

SECTION 7

RADIATION PROTECTION

7.1 Introduction

This section describes the features of the FEMP radiation protection program that are relevant to the safe operation of the AWWT Facility. This section is not intended to provide a detailed discussion of the FEMP radiation protection program.

7.2 Requirements

The *Management Plan: FERMCO Policies and Requirements Manual* (Ref. 7.1) includes the S/RID for Radiological Protection. This S/RID (No. 14) identifies the occupational radiological protection requirements for the FEMP per the FERMCO contract with the DOE; Federal, State, and local laws; DOE Orders; and DOE guidance documents.

10 CFR 835, Occupational Radiation Protection (Ref. 7.2), and DOE Order 5400.5, "Radiation Protection of the Public and the Environment" (Ref. 7.3) are applicable and establish the radiation protection program.

The principal requirements are identified in the DOE *Radiological Control Manual* (Ref. 7.4) and establish the basis for the FEMP radiological protection program.

7.3 Radiation Protection Organization

FEMP management has the responsibilities for the Radiation Protection/As Low as Reasonably Achievable (ALARA) Program. The FEMP management is aware of radiological conditions and alert to potential radiological problems. Employees are trained, monitored for exposure, notified periodically of occupational radiation dose history, and provided the necessary equipment and procedures to safely control radiological conditions.

The Radiological Control (RC) Department has the overall program responsibility. Radiological assessment, engineering, compliance, and dosimetry are essential elements of the RC Department.

Both the Remedial Support Organization (RSO), as operators of the AWWT, and CERCLA/RCRA Unit 5 (CRU-5) Engineering shall interface with the RC Department to identify operational requirements and assure worker training.

All AWWT operational workers are trained as Radiological Workers II per the DOE Radiological Control Manual. Therefore, all workers will be cognizant of the rules for radiation protection and in the use of ALARA principles to minimize exposure.

7.4 External Radiation Exposure Control

External radiation exposure is of limited concern for the AWWT facility because of the low energy levels associated with the radioactive decay of uranium. The uranium is only present in the groundwater and FEMP process wastewaters being treated in closed systems.

7.5 External Dosimetry

All personnel entering the FEMP are responsible for wearing Thermoluminescent Dosimeters (TLDs) in accordance with FEMP procedures. As part of the controlled area, AWWT workers are required to wear TLDs. Radiological Dosimetry is presented in the Comprehensive Environmental Occupational Safety and Health Program (CEOSHP) (Ref. 7.5). The use of extremity and/or direct reading dosimeters is not anticipated for routine AWWT operations.

7.6 Internal Radiation Exposure Control

Surface contamination is expected to be minimal for the AWWT facility. Areas that become contaminated are cleaned or the contamination is fixed. Process equipment in Building 51 and outside areas is enclosed or adequately sized to contain wastewaters in process. Measures employed to minimize the spread of surface contamination from the controlled areas are inherent in the wastewater treatment process (i.e., the systems are closed and not routinely accessible). Workplace surfaces or areas are posted if contaminated and accessible. For routine operations, protective clothing for workers is not required. Workers wear protective clothing to minimize the spread of contamination when working in a posted contamination area. Personnel and equipment are monitored to decrease the possibility of contamination leaving its bounded zone.

The AWWT operations preclude the possibility of airborne contamination. Spills will be collected and returned to the process equipment to prevent surface contamination. If operations are identified that may generate airborne contamination, the RC Department will be notified and establish monitoring to

determine if a hazard exists. Respiratory protection will be required based on monitoring results or when likely to exceed administrative control levels.

7.7 Internal Dosimetry

The RC Department defines the internal radiation monitoring program for all personnel at the FEMP. All AWWT workers are responsible for obeying requirements of the internal dosimetry program. Internal radiation monitoring for the AWWT workers will be in compliance with the FEMP internal radiation monitoring program. Radiological workers who are likely to receive a committed effective dose equivalent of 100 mrem or more per year, or if any organ or tissue dose equivalent could exceed 5 rem annual dose equivalent, are required to participate in the internal dosimetry program. Further information on the internal dosimetry program can be found in the Radiological Dosimetry section of the CEOSHP.

7.8 Radiological Protection Instrumentation

Personnel contamination monitors for the AWWT operations shall be used to determine if contamination is present and if it has been spread. In particular, all personnel shall survey themselves and materials prior to entering the breakroom. Tool and waste monitoring equipment will be used to survey these prior to release or waste relocation for storage. Instrumentation for radiological monitoring of the AWWT Facility shall be prescribed and maintained by the RC Department. RC procedures are maintained for the use and calibration of instruments. The laboratory will employ effluent monitors and sampling equipment to determine the concentration of the AWWT effluent released.

7.9 Respiratory Protection Program

Respiratory protection for AWWT workers will be used whenever potential respiratory hazards are present at concentrations that could present a health concern, or as dictated by good health physics practices. The RC Department will make a determination for the use of respirators for radiological purposes.

The Respiratory Protection Program specifies the types of respirators approved for use at the FEMP and describes procedures for conducting respirator storage audits and the performance of medical evaluation for respirator use. All respirator users at the FEMP must be fitted and trained as part of this program. The FEMP Respiratory Requirements Manual, RM-0007, discusses respirators and their use in more detail.

7.10 Air Monitoring

The RC Department will perform air monitoring for radioactivity to characterize ambient conditions during routine operations of the facility. Subsequent monitoring will be required if the potential exists to exceed 2 percent of the Annual Limit of Intake as required by 10 CFR 835.

7.11 Radiological Monitoring and Contamination Control

Radiation and contamination surveys will be performed on a routine basis by the RC Department according to survey schedules identified in Environmental Safety and Health (ES&H) Division procedures. Action levels and requirements are identified by ES&H procedures. Task-specific monitoring will be specified by permit for any breach of system piping or containments. The RC Department will also be notified and survey for any spill or loss of containment.

7.12 Radiological Protection Recordkeeping

Radiological records for the AWWT workers and associated maintenance personnel are kept in accordance with site requirements which meet those of the DOE *Radiological Control Manual* (Ref. 7.4). The RC Department maintains records of radiological monitoring, workplace monitoring, and personnel exposure.

Records of surveys, data sheets, maps, Radiation Work Permits (RWPs), health physics calculations, investigations, air sample results, worksheets, and any other documentation directly related to workplace monitoring are filed by the RC Department and maintained indefinitely. Documentation of work conditions affecting the results of work area monitoring are listed on the appropriate record with sufficient detail to allow understanding at an undefined future date.

7.13 Radiological Area Boundaries, Posting, and Controls

The AWWT Facility will be maintained as a radiologically controlled area to protect people from exposure to radioactive materials. The controlled area will be defined by a physical barrier (i.e, fence or building wall), and will be posted according to DOE radiological control standards. The posting requirements, definitions, and methods presented per the DOE *Radiological Control Manual* (Ref. 7.4) are followed by the RC Department and implemented in accordance with FEMP requirements for posting. Specific DOE requirements are given in Articles 233 through 237 of the DOE *Radiological Control Manual* (Ref. 7.4).

7.14 Entry and Exit Control Program

Access to the radiologically controlled area is controlled by the RC Department to ensure that only those individuals meeting site training requirements are granted unescorted access to the site. Site Standard Operating Procedure SSOP-1079, Access to the FEMP, defines requirements for the various areas and personnel, including visitors, to enter the FEMP.

7.15 References

7.1) FERMCO, March 1994. RM-0016, *Management Plan: FERMCO Policies and Requirements Manual.*

7.2) DOE, December 1993. 10 CFR 835, Occupational Radiation Protection.

7.3) DOE, January 1993. DOE Order 5400.5, "Radiation Protection of the Public and the Environment."

7.4) DOE, April 1994. DOE/EH-0256T, *Radiological Control Manual*, Rev. 1.

7.5) FERMCO, February 1993. ESH-1-1000, *Comprehensive Environmental Occupational Safety and Health Program,* latest revision.

SECTION 8

HAZARDOUS MATERIAL PROTECTION

8.1 Introduction

This section describes the hazardous material protection provisions. It also summarizes the hazardous material concerns from the hazard analysis in Section 3 where these sections contain the requested information. The SAR is not intended to be the vehicle for review and approval of this program. It is intended to describe the salient features of the program as it relates to this facility.

8.2 Requirements

The *Management Plan: FERMCO Policies and Requirements Manual* includes the S/RID for Occupational Safety and Health. This S/RID (No. 10) identifies the protection requirements for the FEMP per the FERMCO contract with the DOE; Federal, State, and local laws; DOE Orders; and DOE guidance documents.

The applicable rules, regulations, and DOE Orders are as established in 40 CFR 262, 264, 265, 268 for Resource Conservation and Recovery Act (RCRA) (Ref. 8.1 through 8.4); 29 CFR 1910.1200, "Hazard Communication" (Ref. 8.5); 29 CFR 1910.146, "Permit-Required Confined Spaces" (Ref. 8.6); 29 CFR 1910.147, "The Control of Hazardous Energy (Lockout/Tagout)" (Ref. 8.7); Ohio Solid and Hazardous Waste Act as established in Ohio Administrative Code 3745-52 et. seq. (Ref. 8.8); and DOE Order 5820.2A, "Radioactive Waste Management" (Ref. 8.9).

The principal criteria for the AWWT facility are the OSHA guidelines for limiting worker exposure.

8.3 Industrial Hygiene Organization

FEMP management and employee responsibilities are given in the Site Safety Analysis Reference Report. For the AWWT, Industrial Hygiene (IH) interfaces with Utilities Services as operators of AWWT and CRU-5 as the lead technical group for testing, start-up, and equipment design. The IH group serves to review the SOPs and Standing Orders used in the operation of the AWWT.

8.4 Hazardous Material Identification Program

As part of the AWWT hazardous material program, the identification compatibility of hazardous materials is reviewed (refer to Table 8-1 for a discussion of the hazardous materials present in the AWWT). For the hazardous materials identified, the violent reactivity of the concentrated sulfuric acid with the caustic must be noted. The reactive nature of the sulfuric acid with water and the alum must be noted, though it only results in the potential generation of an acid mist.

8.5 Occupational Exposure Assessments

Employee exposure to chemical/physical agents (i.e., process chemicals, wastewater contaminants, noise, biological and other nuisance materials) associated with the AWWT operations described in Section 2 will be evaluated during initial start-up and once facility process conditions stabilize. As part of the initial startup plan a baseline survey will be conducted. The IH group will determine the need for and frequency of further evaluations. A baseline survey will be performed at start-up. Periodic monitoring may be performed to ensure that AWWT operations are conducted with proper exposure controls; to ensure potential IH hazards are identified for which no monitoring data are available to produce an adequate exposure estimate; to ensure routinely performed activities continue to be properly controlled; and to follow up on elevated routine monitoring results, medical findings, requests by the Manager, IH, or employee complaints.

The assessment program is conducted to maintain compliance with DOE Orders. For air contaminants, the current ACGIH TLVs, NIOSH Recommended Exposure Limits (RELs), or OSHA PELs establish an acceptable worker exposure. If sample results exceed half of an applicable exposure limit, engineering and/or administrative controls and the use of personal protective equipment is implemented.

IH monitors for various chemical/physical agents using various direct reading devices, along with sampling and lab analysis. Generally, IH compares sample data to OSHA or ACGIH occupational exposure limits.

8.6 Hazard Communication Program

DOE Order 5480.10 (Ref. 8.10) and OSHA 29 CFR 1910.1200 (Ref. 8.5) require that health hazards be identified and that affected employees and others entering the AWWT be notified of hazards. The methods used for compliance with these requirements are contained in the FEMP "Hazard Communication Program," RM-2086 (Ref. 8.11). The purpose of HAZCOM is to ensure that the hazards of all chemical materials in AWWT operations are evaluated so that proper controls can be maintained, and to ensure that information concerning the hazards is transmitted to affected employees

and others as appropriate. The process chemicals and the wastewater are clearly identified to all operations personnel.

Table 8-1 - Hazardous Material Handling

Chemical	Hazard
Sodium Hydroxide ($NaOH$)	Sodium hydroxide will be used as a caustic agent to adjust the pH of the wastewater at various steps in the treatment process. NaOH will be delivered by tank truck as a 50% solution and then diluted to 20%. NaOH is a toxic substance, a severe eye hazard, and in solid or concentrated solution destroys tissue on contact. As a solid, sodium hydroxide is a colorless, odorless material which has a high or severe toxicity. Sodium hydroxide has an OSHA PEL-TWA, an ACGIH TLV-TWA, and a NIOSH REL-TWA for an 8-hour exposure limit of 2 mg/m^3. The IDLH value is 10 mg/m^3. Contact with NaOH can be avoided by wearing protective clothing during unloading. Safety showers and an eye wash station will be available in the event of an exposure. Spills should be neutralized and washed to the trench drain.
Sulfuric Acid (H_2SO_4)	Sulfuric acid will be used as an acidifying agent to adjust the pH of the wastewater at various steps in the treatment process. The acid will be delivered by tank truck in concentrations as high as 93%. H_2SO_4 is a toxic substance. Contact with the body can cause rapid destruction of tissue similar to damage resulting from a severe burn. In concentrated form, it acts as a powerful caustic to the skin, destroying the epidermis and penetrating into the subcutaneous tissue, where it causes necrosis. Mists of this material cause coughing and irritation of the mucous membranes of the eyes and upper respiratory tract. Severe exposure to the vapors may cause a chemical pneumonitis. The current OSHA PEL-TWA, ACGIH TLV-TWA, and NIOSH REL-TWA for an 8-hour exposure to H_2SO_4 is 1 mg/m^3. The IDLH value is 80 mg/m^3. Contact with H_2SO_4 can be avoided by use of appropriate protective clothing worn during unloading. In the event of worker exposure, safety showers and eye wash basins are provided.
Uranium	Uranium will be present as a contaminant in the wastewater and stormwater/groundwater being treated. The ACGIH TLV-TWA for soluble and insoluble uranium compounds is 0.2 mg/m^3. The OSHA PEL for soluble and insoluble uranium is 50 micrograms/m^3. The DOE *Radiological Control Manual* (Ref. 8.10) provides limits for exposure of personnel to uranium. These limits range from solubility class "D" (the most soluble forms of uranium), which is 6 E-10 microCi/ml in air, to solubility class "Y" (the least soluble forms of uranium), which is 2E-11 microCi/ml in air.
Wastewater	In addition to uranium, the process wastewater will also contain low concentrations of hazardous materials, such as heavy metals. These materials will be concentrated in effluent side-streams during the treatment process. Therefore, personnel exposure to these materials becomes a greater concern in relation to their concentration in the effluent streams. For normal operations, no direct contact with wastewater should occur. In the event of a leak or spill, concentrations should be well below hazardous levels. The possibility exists for workers to be exposed to hazardous materials such as heavy metals (including uranium compounds) during maintenance activities. Appropriate precautions and administrative controls should be applied.
Aluminum Sulfate	Alum ($AL_2(SO)_4$. 14 H_2O) is used in the treatment processes as a coagulant. The alum will arrive in bulk tank truck delivery. The material is a skin and eye irritant. The ACGIH TLV-TWA and NIOSH REL-TWA for alum is 2.0 mg/m^3. Contact can be avoided by using protective clothing during handling. In the event of worker exposure, safety showers and eye wash stations will be provided.

OSHA 29 CFR 1910.1200 (Ref. 8.5) is implemented at the FEMP for all personnel and establishes responsibilities for hazard communication. Requirements are included to cover the following HAZCOM or Right-to-Know aspects:

1) Communicating hazard information
2) Controlling the purchase of chemicals
3) Determining potential health hazards
4) Material safety data sheets
5) Container labels
6) Training
7) Information on non-routine work

The Utilities Service/Landlord is responsible for ensuring that all personnel are trained and cognizant of facility hazards.

8.7 Hazardous Material Training

The operations personnel are trained for all hazardous substances used in the AWWT wastewater processing per OSHA 1910.120. Hazards of materials, their uses, and incompatibilities are presented to all AWWT operations personnel. Process chemicals (i.e., sulfuric acid and caustic [sodium hydroxide]) are emphasized for their violent reactivity when mixed. The training consists of formal classroom presentation, demonstrations, and testing to assess the level of training. The chemicals presented in Table 8-1 are incorporated into the training for normal use in handling, the equipment process, and responses to take in the event of chemical release.

8.8 Confined Space Entry

The FERMCO Permit-Required Confined Space Program lists the requirements for protecting employees in a permit-required confined space from hazards such as hazardous atmospheres and hazardous materials. All spaces in the AWWT facility which meet the definition of a confined space (per 29 CFR 1910.146) are identified and have labels affixed to the exterior of the space. All personnel entry to the confined space is governed by the Confined Space Evaluation/Permit form described in SPR 5-13 of the CEOSHP. The completed permit must be posted near the confined space entry point. Other requirements for conducting work in a confined space are identified in SPR 5-13. All personnel who enter a confined space must receive training (per SPR 5-13) before being assigned for a permit space entry.

8.9 Lockout/Tagout

FERMCO procedure SSOP-0719, "FERMCO Lockout/Tagout (Hazardous Material and Energy Control) Procedure" identifies the requirements for servicing and maintaining machines and equipment in which unexpected startup could cause injury to employees. This procedure must be utilized whenever employees are servicing and maintaining AWWT facility equipment that involves the potential for release of hazardous material. Adherence to this procedure minimizes the potential for personnel injury.

8.10 Respiratory Protection Program

Employee exposure monitoring will be performed by IH to determine if respirators are necessary. The operations that may require respirator use are changeout of the IX columns and carbon filters. Entry into a vessel must meet radiological and confined space entry requirements, if applicable. The AWWT respiratory protection program is overseen by IH. All operators are trained and responsible for the correct use of respirators. The Utilities Service/Landlord Supervisor is responsible for implementation of a respiratory program as required by IH. The requirements of RM-0007, "FEMP Respiratory Protection Requirements Manual," is followed for respirator use.

8.11 Occupational Medical Programs

The FEMP Occupational Health Program conforms to DOE Order 5480.8A, "Contractor Occupational Medical Program" (Reference 8.13). The purpose of this program is protection of the employee against health hazards in the work environment. This conforms to 29 CFR 1910.120, "Hazardous Waste Operations and Emergency Response" (Ref. 8.14), as required by DOE policy. The examining physician has the responsibility to determine if there are any detected medical conditions that would place the employee at an increased risk of health impairment from work in hazardous waste operations or emergency response, or from respirator use.

The physician's examination under 29 CFR 1910.120 (Ref. 8.5) is initiated by either a significant employee exposure or the potential for such exposure (i.e., a potential employee exposure that is either at or near the action level, or at or near the PEL). The Medical Services Section is generally notified by IH.

8.12 Hazardous Material Protection Recordkeeping

A series of records are maintained on an employee by the Medical Department and the Safety Engineering Department as specified in Emergency and Medical Services Execution of the *FERMCO CEOSHP Manual*

(Ref. 8.15). A Supervisor's Report of Injury Form and a copy of the Notification of Visit to Medical Services are used to document that an occupational illness or injury may have occurred and that medical aid was administered. These two forms provide the recordkeeping basis for exposure to hazardous materials while used for all occupational injuries and illnesses reports.

8.13 References

8.1) US EPA, July 1, 1994. 40 CFR 262, "EPA Regulations for Hazardous Waste Generators."

8.2) US EPA, July 1, 1994. 40 CFR 264, "EPA Regulations for Owners and Operators of Permitted Hazardous Waste Facilities."

8.3) US EPA, July 1, 1994. 40 CFR 265, "EPA Interim Status Standards for Owners and Operators of Hazardous Waste Facilities."

8.4) US EPA, July 1, 1994. 40 CFR 268, "EPA Regulations on Land Disposal Restrictions."

8.5) Occupational Safety and Health Administration, July 1, 1994. 29 CFR 1910.1200, "Hazard Communication."

8.6) Occupational Safety and Health Administration, July 1, 1994. 29 CFR 1910.146, "Permit - Required Confined Spaces."

8.7) Occupational Safety and Health Administration, July 1, 1994. 29 CFR 1910.147, "The Control of Hazardous Energy (Lockout/Tagout)."

8.8) Ohio Administrative Code, April 1993. OAC 3745-52, "Generators of Hazardous Waste."

8.9) DOE, September 1988. DOE Order 5820.2A, "Radioactive Waste Management."

8.10) DOE, June 1985. DOE Order 5480.10, "Contractor Industrial Hygiene Program."

8.11) FERMCO, July 1992. FEMP RM-2086, "Chemical Hazard Communication Program."

8.12) DOE, April 1994. DOE-EH-0256T, Rev. 1, *Radiological Control Manual.*

8.13) DOE, October 1992. DOE Order 5480.8A, "Contractor Occupational Medical Program."

8.14) Occupational Safety and Health Administration, July 1, 1993. 29 CFR 1910.120, "Hazardous Waste Operations and Emergency Response."

8.15) FERMCO, February 1993. ESH-1-1000, *Comprehensive Environmental Occupational Safety and Health Program*, latest revision.

SECTION 9

RADIOACTIVE AND HAZARDOUS WASTE MANAGEMENT

9.1 Introduction

This section provides information relating to radioactive and hazardous waste management for the facility. It is intended to describe the salient features of the program as it relates to this facility.

9.2 Requirements

The FERMCO *Management Plan: Policies and Requirements Manual* (Ref 9.1) includes the S/RIDs for Packaging and Transportation and for Environmental Restoration and Waste Management. The Packaging and Transportation S/RID (No.12) identifies the administration requirements for the on-site/off-site transportation of hazardous and radioactive materials and waste for the FEMP per the FERMCO contract with the DOE; Federal, State, and local laws; DOE Orders; and DOE guidance documents. The Environmental Restoration and Waste Management S/RID (No.17) identifies the requirements for the elements and programmatic controls necessary to manage hazardous, radioactive, and solid waste compliance at the FEMP.

The applicable rules, regulations, and DOE Orders for waste generated and collected at the AWWT facility are consistent with DOE Order 5480.1B, "Environmental Protection, Safety, and Health Program for DOE Operations" (Ref. 9.2); DOE Order 5484.1, "Environmental Protection, Safety, and Health Protection Information Reporting Requirements" (Ref. 9.3); DOE Order 5820.2A, "Radioactive Waste Management" (Ref. 9.4); 49 CFR 100-179 (Ref. 9.5) for packaging and transportation; and 40 CFR 261 (Ref. 9.6) for waste operations.

9.3 Radioactive and Hazardous Waste Management Organization

Waste operations for the AWWT is under the RSO. Waste management practices are developed by CRU-5 engineering and the site waste management organization. The organizational structure which manages the AWWT is presented in Section 17. Procedures and training for the AWWT operations involving radiological and hazardous wastes are presented in Section 12.

9.4 Radioactive and Hazardous Waste Streams or Sources

The mission of the AWWT facility is the treatment of waste streams containing uranium and other potential contaminants. A description of the influents is provided in Section 2. Waste handling processes are structured to assure the waste is properly managed according to its classification (i.e., radioactive, mixed, or hazardous). Liquid and solid wastes are not permanently stored within the AWWT facility.

9.4.1 Waste Management Process

The waste generated during the AWWT operations consists of both radiological and nonradiological liquids and solids. The wastes are segregated by the nature of the contamination as part of waste minimization. Wastes that are not hazardous or radioactive are segregated to prevent contamination of the wastes and the AWWT facility. Operational and administrative controls are implemented by operating procedures.

Within the AWWT facility, radiological waste, primarily in the form of waste slurry, generated from the clarifier underflow, multi-tube filter backwash, and eluate thickening system is pumped to a Waste Slurry Surge Tank. The collected slurry is then pumped to Plant 8 through double-walled pipe.

Other radiological wastes are spent ion exchange resin and the spent carbon from the carbon filters. These solid radiological wastes are evaluated and classified for contamination levels and hazardous materials in accordance with site procedures based on the requirements given in Subsection 9.2.

9.4.2 Waste Sources and Characteristics

This section identifies the wastes generated by operation of the AWWT.

9.4.2.1 Radiological Wastes

Radiological wastes produced by this facility are limited to sludge from the clarifier, filter backwash systems, and eluate precipitation. Residual uranium is also present on spent active carbon and ion exchange resin. Table 9-1 lists the type of radiological wastes generated.

Table 9-1 - Radiological Waste Sources

Types of Waste	Containment	Confinement for Release	Disposal
1. Process waste slurry from clarifiers	piping, tanks, valves	curbed concrete dike	waste slurry/ Plant 8
2. IX spent resin	IX vessels, portable removal equipment	curbed concrete dike	drum
3. Spent active carbon	carbon filter beds	curbed concrete dike	drum
4. Filter backwash water	piping, tanks, valves	curbed concrete dike	waste slurry/ Plant 8
5. Process waste slurry from eluate treatment	piping, valves, pumps, tanks	curbed concrete dike	waste slurry/ Plant 8

For radiological consideration, the estimated rates of uranium removal are summarized as follows:

1) 400 gpm Wastewater Flow

(1) Clarifier underflow and multi-tube filter backwash are expected to contain about 2.2 pounds of uranium daily which is directed to the Waste Slurry Surge Tank.

(2) IX vessels are expected to contain less than 15 pounds of uranium per vessel from normal operations. One IX Vessel is regenerated per month. The eluant from regeneration is expected to contain approximately 1.5 pounds of uranium daily. The eluate with the highest uranium concentration is pumped to a receiver into the eluate treatment system. The thickener underflow from this treatment system is expected to contain an average of 2.9 pounds of uranium daily. This underflow is directed to the Waste Slurry Surge Tank.

2) 700 gpm Wastewater Flow

(1) Clarifier underflow and multi-tube filter backwash are expected to contain about 2.9 pounds of uranium daily which is directed to the Waste Slurry Surge Tank.

(2) The eluant from regeneration is expected to contain an average of 1.4 pounds of uranium daily. Refer to item 2 above from the 400 gpm flow.

3) Waste Slurry Surge Tank to Plant 8

(1) Waste slurry collected in the Waste Slurry Surge Tank and pumped to Plant 8 is expected to contain 8 pounds of uranium daily.

The rate of uranium removal at different points within the process can be estimated based on an average stream concentration of 0.67 mg/l and 0.50 mg/l uranium for the Process Wastewater stream and the Stormwater/Groundwater, respectively, and estimations of the uranium removal efficiency for each major treatment group. The total stream flow into the AWWT facility at peak treatment of the wastewater is 1,100 gpm (700 + 400). The total uranium removed then is a calculated maximum of 8 lbs per day. Storage capacity of the Waste Slurry Surge Tank is 17,000 gallons (16,000 operational volume) which is less than its average flow rate input per day of 25,536 gallons.

9.4.2.2 Nonradiological Wastes

One nonradiological waste stream consists of spent scrub water from the Packed Tower in the Ion Exchange Scrubbing system.

Nonradiological wastes are generated as a spill of the process chemicals or a vapor/dust release. In general, these wastes are collected and introduced into the process systems for treatment with the wastewater. Any emissions of treated nonradiological waste to the environment are governed by Ohio Environmental Protection Agency Permit No. 1I000004*B. The non-radiological wastes are listed in Table 9-2.

Table 9-2 identifies the various nonradiological materials within the facility which are waste effluent generated during operations. In the event of a spill or leak, the liquid chemicals or the wastewater would be released into the facility. If a release occurs, the curbed containment and sumps collect the liquid material and pump it into the process stream for treatment.

Table 9-2 - Nonradiological Waste Sources

Types of Waste	Confinement	Containment for Release	Disposal
1. Liquid chemicals - as spill or leak	piping, tanks, valves, pumps	curbed concrete dike	sump/reentry to wastewater
2. Acid vapors - small amounts as aerosols	piping, tanks, safety valve, scrubber	N/A	acid scrubber/ atmosphere exhaust

9.4.3 Waste-Handling or Treatment System Functions

Spent pH 7 scrub water from the Packed Tower (2 gpm peak) in the Acid Scrubbing system is discharged into a trench drain to the South Sump. South Sump wastewater is pumped into the X155 Equalization Tank for processing in the wastewater stream. Radiological solid waste consists of spent resin from the IX units and spent carbon from the activated carbon filters. Both of these waste streams are collected via a handling unit, de-watered, and drummed.

Two types of solid wastes are produced within the AWWT during normal operation. These are the wastes contained in the disposable carbon filtration units and in the IX spent resins. Periodically the carbon filters will require changing. However, these units are sized so that the activity is performed approximately once per year. These filters are primarily for the removal of organics in the treatment. Removal of the spent carbon and IX resin is completed using the Resin Handling Unit.

Only low levels of radioactive and hazardous materials are present. During the operating cycle of the IX units, the resins within each of the IX vessels undergo regeneration with an acid eluant to remove the waste contaminants. The waste contaminants are collected as an eluate and handled as a liquid waste. Because regeneration effectiveness diminishes as a function of bed volumes of treated water, the resin in each IX bed must be periodically replaced with new resin. Prior to removal, the spent resin goes through an eluting process to remove uranium captured by the bed. Some residue of uranium remains with the spent resin, which requires packaging as a contaminated waste.

The resin is removed and drummed by portable equipment. Labeling includes identification of contents, contamination level, and disposal instructions. If the resin is unloaded without being eluted (uranium removed) and packaged for disposal, the contamination level of the unloaded resin is considerably higher than spent resin and the packaged weight is also higher. Once removed for disposal, resin is not permanently stored within the AWWT facility.

Since the waste slurry produced by normal operations is pumped to Plant 8 for processing, no permanent storage of sealed drums of solid or liquid wastes in the AWWT facility is needed. The spent resin from the IX units and the spent carbon from the carbon beds contain some radioactive and hazardous material for disposal. This material is transferred to 55-gal drums using portable hydraulic units. Temporary storage of these drums within the AWWT facility, prior to transfer to another FEMP facility for processing, is subject to the administrative controls defined by FEMP procedures. The maximum amount of uranium in the spent resin is less than 75 lbs. For the spent carbon, the maximum amount of uranium is less than 3 lbs (see Appendix H).

9.5 References

9.1) FERMCO, December 1993. RM-0016, *Management Plan: Policies and Requirements Manual*. Rev. 0.

9.2) DOE, May 1993. DOE Order 5480.1B, "Environment, Safety, and Health Program for DOE Operations."

9.3) DOE, October 1990. DOE Order 5484.1, "Environmental Protection, Safety, and Health Protection Information Reporting Requirements."

9.4) DOE, September 1988. DOE Order 5820.2A, "Radioactive Waste Management."

9.5) United States Department of Transportation, October 1, 1993. 49 CFR 100-179, "Chapter 1 - Research and Special Programs Administration."

9.6) United States Environmental Protection Agency, July 1, 1993. 40 CFR 261, "Identification and Listing of Hazardous Waste."

SECTION 10

INITIAL TESTING, IN-SERVICE SURVEILLANCE, AND MAINTENANCE

10.1 Introduction

This section demonstrates that a programmatic commitment to initial testing, surveillance, and maintenance programs exists and is an integral part of safety assurance. It is intended to describe the salient features of the programs for the AWWT.

10.2 Requirements

The FERMCO *Management Plan: Policies and Requirements Manual* includes the S/RIDs for Maintenance and for Operations. The Maintenance S/RID (No. 7) identifies the requirements for establishing the equipment and systems maintenance methods and practices, providing equipment calibrations, and establishing preventative or routine maintenance for the FEMP. The Operations S/RID (No. 11) identifies the requirements for executing and monitoring operational activities; operating methodologies and procedures; lockout and tagout; abnormal events investigation; and equipment or process labeling.

The "FERMCO Operational Readiness Manual," SM-0005 (Ref. 10.1) requires a review program for the initial start-up or start-up after a prolonged shutdown. The operational readiness program is graded in accordance with the importance and complexity of the item. The procedure establishes a graded level of approval and readiness review criteria. FEMP Engineering Procedure ENG-12-6003, "Start-Up and System Operability Test Procedure" (Ref. 10.2), establishes the guidelines for determining when a test is to be performed, its preparation, execution, and closeout.

10.3 Initial Testing Program

An initial testing program has been developed for the AWWT. This program focuses on the individual systems within the process area. For the purposes of prioritizing and managing construction acceptance and turnover, the AWWT project is separated into subsystems. The construction acceptance and turnover has been divided into the following subsystems:

1) East Rain and South Sumps
2) SWRB and Transfer Pump Station
3) Perched Water Sump

4) 700 gpm Equalization
5) 700 gpm Coagulant Mix Tank
6) 700 gpm Clarification and Filter
7) 700 gpm Carbon Filter
8) 8,400 gpm Equalization
9) 400 gpm Coagulant Mix Tank
10) 400 gpm Clarification and Filter
11) 400 gpm Carbon Filter
12) 700/400 gpm Ion Exchange Systems
13) Effluent pH Adjustment
14) Effluent Filter
15) Central Sampling System
16) Safety Showers
17) Waste Slurry Collection and Discharge to Plant 8
18) Alum Storage and Metering Pumps
19) Treated Water
20) Caustic Dilution, Storage, and Transfer Pumps
21) Steam and Condensate
22) Sulfuric Acid Storage and Transfer Pumps
23) Eluate Precipitation
24) Eluate Thickening and Transfer Pumps
25) Vent (acid) Scrubber
26) Compressed Air
27) Other support systems and installations

Testing of AWWT components, subsystems, and design features for safety is performed according to written and approved plans and procedures. One Readiness Assessment (RA) is performed to review the AWWT for the 27 subsystems' testing procedures, scheduling, and test results to ensure that a new system or process is tested and its design function verified as specified in the 100 percent CFC design package. The AWWT Project is listed in the FEMP Start-up Notification Report as Readiness Report #94-15, Hazard Category: 4, and Type: Readiness Assessment.

As described in SM-0005, "FERMCO Operational Readiness Manual" (Ref. 10.1), CRU-5 has been designated as the Performing Organization for the initial start-up of the AWWT Facility. The AWWT RA Team Leader has been appointed by a recommendation from RSO Management Programs, based on a satisfactory review of his qualifications. The RA Team Leader selects and trains the RA Team members, prepares and coordinates the RA Implementation Plan, prepares the RA Final Report and/or Closure Report, and recommends start-up to the Approval Authority.

The CRU-5 Engineering Project Manager has been assigned the responsibility for RA Approval Authority. The CRU-5 Engineering Start-Up Manager is the primary contact with the RA Team and performs the responsibilities of the Performing Organization. The AWWT Project Engineer and the RSO AWWT Facility Supervisor (Utilities Services) support as secondary contacts.

The RA Team's Implementation Plan is a phased execution of the RA process - (I) Readiness to Test/Operate with Chemicals and Contaminated Influents and (II) Readiness for Sustained Operation. The presence of chemicals and, to a much lesser degree, radioactive contaminants requires that applicable readiness items have been satisfactorily assessed before chemicals and contaminated influents are introduced into the AWWT process, even for System Operability Testing. Hence, the initial phase of the RA allows operational testing to proceed under the direction of qualified CRU-5 Engineering personnel as overall operational readiness is completed for sustained AWWT operation beyond the initial start-up. System Operability Testing using groundwater from the South Plume may proceed prior to readiness assessment.

Systems and features identified in the Section 3 Hazard Analysis and appendices are identified because they have a direct bearing on the safety and operability of the process. Responsibility for ensuring the completion of initial testing as required in ENG-12-6003 prior to operations is presented in Section 17.

Each test procedure contains a checklist and sign-off to document the successful completion of each step of the test. The test program also documents any deviations and the actions taken to correct them. An explanation of any uncorrected deviations must be provided in the test procedure or system performance/ functional requirements. Acceptance criteria for systems test(s) are specified in the test procedures. The acceptance criteria are based on AWWT design parameters. The individual resolution of noncompliance items requires the evaluation of test or retest requirements. This initial testing program documents that the systems are properly tested to assure safe operation.

10.3.1 Construction Acceptance Testing

The construction contractors shall be responsible for preparation of Construction Acceptance Testing (CAT) procedures, performing the CATs, and submitting CAT reports to FERMCO Construction. CAT includes, but is not limited to, the following:

1) Continuity and operation of lighting, receptacles, power, and control circuits
2) Electrical insulation resistance
3) Ground connections
4) Electrical overload elements
5) Piping pressure (leak) testing and cleaning/flushing
6) Equipment lubrication, rotation, alignment, vibration, and operation

7) Air Handling Systems tests and adjustments
8) Instrument calibration, loop checks, and Distributed Control System (DCS) testing

The general plan for execution of CAT is outlined below:

1) Prepare CAT procedure (Contractor)
2) Review and approve CAT procedure (FERMCO Construction)
3) Inspect/punch list construction completion (Contractor/FERMCO Construction)
4) Complete punch list items required for CAT (Contractor)
5) Verify acceptable punch list completion (FERMCO Construction)
6) Manage facility energy controls (lockout and tagging) (FERMCO Construction)
7) Attach green tags to identify system CAT boundaries (Contractor)
8) Perform CAT and associated documentation (Contractor)
9) Witness CAT (FERMCO Quality Assurance [QA] and Construction)
10) Correct deficiencies, retest, and document (Contractor)
11) Remove green tags (Contractor)
12) Complete post-CAT punch list items (Contractor)

10.3.2 Integrated Construction Acceptance Testing

The construction specifications require the contractors, after each primary system has been constructed, tested, and adjusted, to operate the system to demonstrate satisfactory performance. The AWWT Start-up Team has CRU-5 Engineering prepare test procedures to conduct these operational tests. These tests have been named "Integrated Construction Acceptance Tests" (ICATs) as the tests are performed by the construction contractors and witnessed/supervised by the AWWT Start-up Team. These operational tests are more comprehensive than the typical construction acceptance tests, but do not provide the overall performance-level testing that is accomplished by the following System Operability Testing. The primary intent of the ICATs is to demonstrate satisfactory operation of the integrated subsystem control interlocks, pump capacities, etc. to the extent possible without treatment chemicals (alum, sulfuric acid, and caustic soda). Fine tuning of some subsystems, particularly the chemical feed systems, is accomplished during System Operability Testing.

The ICATs are performed on subsystems as listed above. First run of the ICATs is performed with non-uranium-contaminated water and without treatment chemicals. Following satisfactory completion of subsystem testing, the appropriate subsystems are grouped to provide primary systems for System Operability Testing. This testing is performed by FERMCO, with contaminated influent wastewater and treatment chemicals.

The general plan for execution of ICATs is outlined below:

1) Notify FERMCO that subsystem is ready for ICAT (Contractor)

2) Provide necessary subsystem documentation and instrumentation operating manuals (Contractor)

3) Walkdown/Inspect/Generate subsystem punch list (Contractor/FERMCO Construction and Start-Up team)

4) Complete punch list items required for ICAT (Contractor)

5) Verify acceptable punch list completion (FERMCO Construction and Start-Up team)

6) Manage facility energy controls (lockout and tagging) (FERMCO Construction)

7) Attach blue tags to identify system ICAT boundaries (Contractor)

8) Perform ICAT and associated documentation (Contractor/FERMCO Start-Up team)

9) Correct deficiencies, retest, and document (Contractor/FERMCO Start-Up team)

10) Remove blue tags (Contractor)

11) Complete post-ICAT punch list items (Contractor)

10.3.3 Turnover to FERMCO

After satisfactory completion of ICAT, the tested subsystem is turned over to the FERMCO start-up team (CRU-5 Engineering and RSO) per FERMCO Construction Procedure 3.6.1, "Punchlist/Construction Turnover/Final Acceptance." If no open punch list items exist, a "final" turnover is documented; otherwise, the turnover is "conditional." In either event, Facility Owner responsibilities, including lockout and tagging, are transferred to RSO. Orange tagging shall be attached to identify the "turned over" system boundaries. Any open punch list work by the construction contractor must be coordinated with the designated RSO facility owner or alternate facility owner(s).

10.3.4 System Operability Testing

Following ICAT of AWWT subsystems, the subsystems are grouped into primary systems, started up, and operated using the RSO department SOPs. During this System Operability Testing (SOT) phase, final operating adjustments (e.g., control loop tuning) and verification of the SOPs are made. CRU-5 Engineering directs and performs the SOT effort with assistance from RSO. RSO Utilities Services manages the Facility Owner responsibilities during the SOT phase. The groupings of subsystems into primary systems are identified as Utility and Support Systems, Bulk Chemical Systems, AWWT DCS and Ion Exchange Control Systems, Sumps and Spill Containment, Groundwater/Stormwater Treatment (700 gpm) and FEMP Process Wastewater Treatment (400 gpm) Systems, Ion Exchange Regeneration and Changeout Systems, and Eluate Precipitation and Thickening Systems.

SOT operations are initiated with groundwater from the South Groundwater Contamination Plume, which has a uranium concentration below current drinking water limitations. Treatment of South Plume groundwater, without treatment chemicals, in each AWWT phase (700 gpm and 400 gpm) is operationally tested before contaminated stormwater or wastewater is introduced. SOT operations with FEMP wastewater and stormwater and with treatment chemicals are initiated after the appropriate Operational Readiness Assessment phase is completed.

As the SOTs are conducted, system deficiencies shall be corrected by either Construction or Maintenance, as determined on a case-by-case basis depending on the nature of the deficiency. Identified deficiencies in SOPs shall be addressed by SOP revision or Temporary Change Notice. Following satisfactory completion of System Operability Testing, the AWWT facility is considered ready to operate, subject to completion of other operational readiness items.

10.4 In-Service Surveillance Program

Surveillance testing proves that the safety design function of a system or component can be fulfilled when required. From the results of the hazard analysis, in-service surveillance testing is required for labeling and operation of the swing arm for transfer of the acid and caustic and process equipment controls contributing to worker safety.

The requirements for confirming the readiness of safety-significant systems and components have been identified during preparation of the safety analysis. Administrative Controls mandate the corresponding surveillance testing and/or in-service inspection requirements. The capability of components, instruments, and systems to fulfill their design functions by specifying tests, calibrations, and inspections is ensured by Administrative Controls and their subsequent implementation. After identification of the Administrative

Controls, the operating organization prepares the procedures. Site Service schedules, tests, and ensures that testing has a minimum impact. While surveillance testing normally ensures the operational readiness of components and systems to fulfill their active design functions, in-service inspection ensures passive features are ready when required.

In-service inspection for the AWWT process equipment confirms that an aspect of a system or component continues to be satisfactory (e.g., pressure integrity). Maintenance refers to the refurbishment, calibration, repair, or overhaul of a component.

For safety significant systems identified in Section 5, controls have been identified for operations dealing with the process chemical transfer, storage and dilution and for criticality control. The criticality control will not require any in service surveillance because it is an administrative control. The locking arms and locks require surveillance to assure they are not broken or have been defeated. Filling both the acid and caustic feed tanks must have the process controls under an in-service surveillance, which may be implemented as part of the operators logging of activities and the maintenance program. The regeneration of the IX columns must have interlocks and the acid feed line a check valve for flow control. Note, all operations may be performed manually in which case the controls do not have to be active.

10.5 Maintenance Program

FERMCO RSO Maintenance provides maintenance of the AWWT Facility, systems, and components following turnover of the facility from the construction contractor. Maintenance activities include corrective maintenance and routine preventative maintenance.

By performing routine checks and inspections of the AWWT Facility, systems, and components, operators identify corrective maintenance items. The operators' supervisor submits maintenance work orders, with the appropriate priority level, to the Maintenance department. Maintenance then performs the maintenance work using Maintenance Work Instructions and applicable site procedures.

Preventative Maintenance (PM), including periodically scheduled instrument calibrations, is implemented using a Computerized Maintenance Management System (CMMS). The CMMS contains maintenance information - PM schedule, maintenance and/or calibration instructions, spare parts required, etc. - on each facility component. The CMMS automatically issues a maintenance work order when preventative maintenance or calibration is due for a component. Although the information loaded into the CMMS is the primary responsibility of Maintenance, Engineering, and RSO Utilities Services (operating supervision and operators) provide input to ensure that the planned maintenance activities are technically and operationally acceptable.

10.6 References

10.1) FERMCO, December 1993. SM-0005, "FERMCO Operational Readiness Manual."

10.2) FERMCO, 1994. ENG-12-6003, "Start-Up and System Operability Test Procedure."

SECTION 11

OPERATIONAL SAFETY

11.1 Introduction

The section describes the bases for programs, plans, and procedures used to ensure that operation of the facility is managed, organized, and controlled in a safe manner in accordance with the requirements of DOE 5480.19 (Ref. 11.1) and other applicable DOE directives.

11.2 Requirements

The FERMCO *Management Plan: Policies and Requirements Manual* (Ref. 11.2) includes the S/RID for Operations. The Operations S/RID (No. 11) identifies the requirements for executing and monitoring operational activities, operating methodologies and procedures, lockout and tagout, abnormal events investigation, and equipment or process labeling.

11.3 Conduct of Operations

In the preparation of a SAR, the conduct of operations should demonstrate compliance with DOE Order 5480.19, "Conduct of Operations Requirements for DOE Facilities." Conduct of Operation requirements are recognized and implemented by the use of the RSO Division Conduct of Operations Manual, SOPs and Standing Orders specific for AWWT Operations. Reference is made to other sections of this FSAR for topics that may considered part Conduct of Operations (e.g., training, management organization). The following considerations are addressed in the following subsections:

1) Operating Procedures
2) Shift Routines and Operating Practices
3) Control Area Activities
4) Communications Within the Facility
5) Control of On-Shift Training
6) Notification and Reporting Practices
7) Investigation of Abnormal Events
8) Control of Equipment and Systems Status
9) Control of Hazardous Materials and Fire Protection
10) Independent Verification Practices
11) Operations Turnover Practices
12) Control of Operations Procedures

11.3.1 Operating Procedures

The AWWT facility is subject to the previous list of features of the conduct of operations program. Implementation of these features is recognized in this FSAR to demonstrate a commitment to providing a safe work environment. The requirements for lockout/tagout and confined space entry are presented in Section 8.

Procedures are developed for both operation of the process wastewater and stormwater/groundwater waste streams. These include start-up, shutdown, normal operations, waste slurry transfer, routine checks, and sampling. Procedures are also developed for the various supply systems associated with AWWT operations. These include the dry and liquid coagulant, caustic, and acid supply systems. Utilities for AWWT (electrical, steam, air, and water) are addressed by separate procedures. Spill response procedures, as required by 40 CFR 125.104 (Ref. 11.3), are provided along with sump operation procedures. Specific procedures are discussed Subsection 12.3.

Standing Orders are in place for the AWWT operations to supplement the SOPs. These Standing Orders are documented in AWWT operations manuals and impart from the Facility Services Supervisor the more detailed information. This does not imply that SOPs require supporting Standing Orders for detail or for specific responses to given situations. Standing Orders are used for shift-specific activities that may change (e.g., turnover practices).

11.3.2 Shift Routines and Operating Practices

AWWT personnel are expected to conduct their duties to maintain high standards of performance and to use safety procedures and personnel protective equipment based on DOE, OSHA, NFPA, and other standards that apply to the water treatment processes and related chemicals. The shift supervisor is responsible for first-line management in maintaining the performance standards for the shift operations.

All operational activities, such as materials handling, which include transferring and storing incoming chemicals as well as periodically removing and disposing of spent carbon from the activated carbon filters and spent resin from the IX system, are performed under the direction of the shift supervisor and in accordance with the established SOPs for each operation. Maintenance requirements and spare parts for the water treatment system are identified and approved for use by the site maintenance program, CMMS.

RSO Procedure D10-20-002, "Shift Routines and Operating Practices" (Ref. 11.4), prescribes the standards of professional conduct expected of operations personnel. Guidance is provided for both normal and off-normal operating conditions, emphasizing operational safety, procedural compliance, positive control of equipment and plant configuration, and monitoring and recording of plant conditions.

For the AWWT shift operations, all shifts staff the control room for oversight of operations, provide a field operator to visually verify control changes, where possible, made by the control room operator, and perform facility inspections. Each operator logs their respective shift position duties and the field operator uses a prepared log form for all inspections. The day shift is responsible for receipt and transfer of the bulk chemicals. This is required because the tanker trucks are required to first go to the FEMP central receiving area and then be escorted to the AWWT facility.

11.3.3 Control Area Activities

The AWWT facility utilizes state-of-the-art control and instrumentation in conjunction with standard piping and equipment typically used in water treatment processes. The system operates on a 24-hour schedule with trained and certified wastewater plant operators stationed in the facility control room on a shift basis. A computer network monitors status information to provide a continuous update of process data for display at the operator's console. The process data are also logged by the computer system for later analysis. The operator's console includes a graphics panel to status alarm functions and discrete controls which allow the operator to intervene.

11.3.4 Communications Within the Facility

By using formal communications techniques, an individual can reliably transmit and receive work instructions, feedback or results of work, and results of data, emergency or safety warnings, and instructions. Both written and verbal communications must be clear, concise, and correct. The AWWT facility implementing RSO Procedure is D10-20-004, "Communications" (Ref. 11.5).

Field operators have outside telephones in place throughout the AWWT for communications. In addition, radios are used by all field, control room, and shift supervisors for maintaining communications during facility operations.

11.3.5 Control of On-Shift Training

RSO Procedure D10-20-005, "Control of On-Shift Training" (Reference 11.6), describes the relationship between the qualified operator and assigned trainees. Operators are responsible for the actions of trainees, and are required to maintain visual contact with trainees and direct control over their actions. Trainees are prohibited from acting independently. The AWWT control room is always staffed and under the direct supervision of a qualified operator when trainees are present.

11.3.6 Notifications and Reporting Practices

RSO Procedure D10-20-007, "Notifications" (Reference 11.7), provides instructions to operating personnel for prompt reporting of emergencies and non-routine events. Operators are directed to take immediate actions to ensure their own safety and to warn others who may be affected. As soon as possible thereafter, the Shift Supervisor is notified. The Shift Supervisor in turn notifies the Assistant Emergency Duty Officer (AEDO) by the fastest means. The AEDO is responsible for activating and coordinating site wide response based on the nature of the emergency or non-routine situation. The notifications and reports are developed as Standing Orders because a leak, rupture, or release is not limited to a specific SOP for routine work activities.

Specific non-routine events and emergencies that are considered and have a developed response action for the AWWT are the release of chemicals and wastewater. Prior to performing any preventive or mitigative actions the operator is to notify the shift supervisor. The notifications and reports are documented according to guidance of the procedure above.

11.3.7 Investigation of Abnormal Events

The investigation of abnormal events program identifies events requiring investigation, assigns responsibility, defines the qualifications for those conducting the investigation, lists the necessary information that must be examined, outlines the steps for the investigation, and establishes guidelines for assigning and completing corrective actions. The responsible person for each shift is the shift supervisor, and the shift supervisors report to the Wastewater Facilities Supervisor. Event investigation is tracked, reported to the AEDO, and implemented to prevent degradation of the safety or operation of the AWWT in accordance with RSO Procedure D10-20-006, "Investigation of Abnormal Events" (Ref.11.8).

11.3.8 Control of Equipment and Systems Status

The shift supervisor is responsible for maintaining proper configuration and shall authorize status changes to major equipment and systems. The supervisor, as the senior operating person on shift, is tasked with maintaining a broad overview of facility operations. The supervisor's perspective of status must necessarily be the focal point of shift operations.

The operators must be aware of equipment and system status; the supervisor shall ensure that all changes in status are communicated to these persons. The AWWT control room operator may be the supervisor or in the line-of-information flow to and from the supervisor.

Changes in the status of wastewater treatment and ancillary systems are monitored by the control room and by operators on inspection tours. Changes in status observed by the operators are reported to other AWWT workers by radio or telephone in that work area. Changes in status of safety-related equipment and systems shall be authorized by the supervisor and reported to the control room for logging.

Locks and tags for the AWWT are used on those components that require special administrative control for worker safety or other reasons. Locks and tags provide security that a system or component is operated only by authorized facility personnel performing required evolutions in a controlled fashion. Additionally, locks and tags alert the operator of the importance of the component and are a reminder that special controls over repositioning are to be maintained. Tags and locks are controlled by the "FERMCO Lockout/Tagout (Hazardous Energy and Material Control) Procedure," SSOP-0719 (Ref. 11.9).

11.3.9 Control of Hazardous Material and Fire Protection

In summary, fire protection is not required in most areas of the AWWT due to the nature of the facility - wastewater treatment. The majority of the process operations do not require shelter and are located outside, thereby not requiring for protection. Building 51 has fire protection for the control room and operator support areas. A confinement system is in place to contain and divert any firewater to the treatment processes, if necessary. More information on the hazardous material uses and storage are described in Sections 2 and 8 of this SAR.

11.3.10 Independent Verification Practice

Independent verification is required only for those operations involving the process chemicals. RSO Procedure PO-D-020, "Independent Verification" (Ref. 11.10), provides independent verification procedures and requires their use for critical and safety related systems. Standard Operating Procedure 43-C-341, "Advanced Wastewater Treatment Baseline Valve Line-Up" (Ref. 11.11), defines AWWT systems and components containing acid, caustic, or alum as critical systems requiring independent verification. Additionally, this procedure requires the Wastewater Facilities Supervisor to designate process chemical systems and components for verification prior to resumption of operations following significant maintenance, testing, or prolonged shutdown.

The independent verification is in place for valve line-ups and for start-ups initiated by the control room operator. For the start-up of a pump, the control room operator sees the flow rate or level in the tank on the screen and records the value. The field operator observes the local gauge pressure to confirm the activity for the control room operator and records the value.

11.3.11 Operations Turnover Practices

RSO Procedure D10-20-012, "Shift Turnover" (Reference 11.12), defines the actions to be taken by both the Shift Supervisor and operators at shift relief. These actions include pre-shift briefings, review of plant operating logs, and discussion of plant conditions and unexecuted orders. The Standing Orders for AWWT Operations include a turnover checklist to promote a consistent and complete shift relief.

The checklists are developed to support the determination of status for routine operations and indicating any off-normal events. The number of readings necessary for wastewater or bulk chemical transfers or current source of wastewaters, quantities, and status of process equipment are representative of items for the checklist.

11.4 References

11.1) DOE, May 1992. DOE Order 5480.19, "Conduct of Operations Requirements for DOE Facilities."

11.2) FERMCO, September 1994. RM-0016, *Management Plan: FERMCO Policies and Requirements Manual*. Rev. 1.

11.3) US EPA, July 1, 1993. 40 CFR 125.104, "Criteria and Standards for the National Pollutant Discharge Elimination System (Best Management Practices Programs)."

11.4) FERMCO, December 1994. D10-20-002, "Shift Routines and Operating Practices."

11.5) FERMCO, December 1994. D10-20-004, "Communications."

11.6) FERMCO, December 1994. D10-20-005, "Control of On-Shift Training."

11.7) FERMCO, December 1994. D10-20-007, "Notifications."

11.8) FERMCO, December 1994. D10-20-006, "Investigation of Abnormal Events."

11.9) FERMCO, February 1994. SSOP-0719, "FERMCO Lockout/Tagout (Hazardous Energy and Material Control) Procedure," Rev. 1.

11.10) FERMCO, December 1994. D10-20-010, "Independent Verification."

11.11) FERMCO, December 1994. 43-C-341, "Advanced Wastewater Treatment Baseline Valve Line-Up."

11.12) FERMCO, December 1994. D10-20-012, "Shift Turnover."

SECTION 12

PROCEDURES AND TRAINING

12.1 Introduction

This section describes the AWWT-specific and FEMP developmental features for procedures and training programs that are relevant to safe operation. It is not intended to provide a detailed discussion of all procedures and training used at the FEMP.

12.2 Requirements

The FERMCO *Management Plan: Policies and Requirements Manual* (Ref. 12.1) includes the S/RIDs for Training and Qualification. This S/RID (No. 16) identifies the requirements for training and qualifying personnel and developing accreditable programs for the FEMP per the FERMCO contract with the DOE; Federal, State, and local laws; DOE Orders; and DOE guidance documents.

The principal requirements for this section are 10 CFR 835, Occupational Radiation Protection (Ref. 12.2) and DOE Order 5480.19, "Conduct of Operations for DOE Facilities" (Ref. 12.3).

12.3 Procedures

AWWT Management ensures that procedures written for the AWWT meet the criteria contained in this subsection. The AWWT facility cannot start up until the required procedures are approved and personnel are trained as required by DOE Orders, FERMCO policies and procedures, and this FSAR.

The *Conducts of Operations Manual* (Ref. 12.4) establishes a set of standards and procedures for achieving excellence in operation of FEMP facilities and activities. The procedure provides instructions to ensure that procedure development, content, changes and revisions, approval, review, availability, and use are appropriately addressed and support safe operation of the facility. In addition, the manual requires that operators be capable of performing the immediate action steps of emergency procedures without reference to the procedure. In addition, the emergency procedure is to be reviewed after the actions are performed, verifying that all required actions have been taken.

12.3.1 AWWT Procedures

Eight AWWT-specific procedures are currently under development. These standard operating procedures state training, staffing, and health and safety requirements for workers in addition to the methods for operations. The eight are:

1) Baseline Valve Line-Up - includes manual, instrument isolation and air valves.

2) Process Wastewater and Stormwater/Groundwater Treatment Operations - includes pre-operation, start-up, shutdown and routine checks and operations of clarification, filtration, waste slurry, and ion exchange.

3) Control Room Operations - includes general instructions, data collection, reporting, and alarms and responses.

4) Ion Exchange Resin Regeneration and Changeout - includes operation of process equipment handling equipment and packaging of spent resins for on-site transportation.

5) Chemical Receiving Systems - includes transfer and storage of the liquid coagulant, caustic, and sulfuric acid. Chemicals spilled during transfer will not be pumped back to storage tanks. These materials will be added to the wastewaters in the treatment process. Implementing the following procedural controls, identified in the HAZOP, prevents an inadvertent mixing by unloading the wrong material into the sulfuric acid, caustic, or alum storage tanks:
   (1) Incorporate steps to the unloading procedures to require the outside operator to check the bill of lading for the delivery to ensure the right amount of the right material is to be unloaded.
   (2) Require sampling of all deliveries and testing for material and purity before connecting unloading arm to tank truck.
   (3) Require verification by the operations supervisor that the truck is at the right unloading station before connecting the unloading arm to the truck.
   (4) Add steps to the unloading procedures to require the outside operator to check the local level gauge on the storage tank, thus helping to ensure the storage tank can accommodate the amount of material to be unloaded.
   (5) Incorporate steps to the unloading procedures to require the unloading arms, pumps, and storage tank fill lines to be emptied and blown down with air at the completion of each unloading operation.

These features in the AWWT procedure, along with the existing controls and the engineering controls presented in Subsection 2.5.1.5, ensure that inadvertent mixing is not a credible event.

6) Utilities Systems Operations - includes HVAC, air, steam, and water.

7) Sumps Operation and Response to Chemical Spills - includes isolation of spills and valve line-ups for transfer from sump to process storage tank.

From the HAZOP, review all procedures involving transfers to or from sumps. Require an independent check of all valve line-ups and a verification that no contaminants are in any line to be used for the planned transfer. The sump and spill pump arrangements allow a lot of flexibility, but with this flexibility comes the potential for line-up errors that could cause uncontrolled dilution of acid.

8) Eluate Precipitation and Thickening - includes the eluate thickening and precipitation from the recycle tanks.

12.3.2 Maintenance of Procedures

For the AWWT operations, procedure changes and revisions are necessary to ensure that procedures reflect current operating practices and requirements. The review and approval process for each procedure change or revision is documented using a Procedure Change Request Form.

New and revised procedures are approved prior to use. Operating procedures are approved by the RSO facility Utilities Supervisor. Procedures that affect safety equipment and emergency procedures are reviewed by the facility safety review committee or by another appropriate review mechanism.

Changes that alter the intent of a procedure receive the same approval as a new or revised procedure. Changes in operations procedures that do not affect the intent of the procedure may be approved by a qualified operator and a member of facility management.

New and revised operations procedures are reviewed at least every 2 years to ensure that the information and instructions are technically accurate and that appropriate human-factor considerations are included.

Applicable procedures are reviewed after an unusual incident (such as an accident, an unexpected transient, significant operator error, or equipment malfunction). During reviews, procedures are compared to source documents to verify their accuracy.

A controlled copy of all operations procedures is maintained in the control area and at specific work locations. Procedures are open and followed step-by-step when:

1) A trainee is conducting activities under the supervision of a qualified individual.

2) The operation being conducted is non-routine, complicated in nature, or infrequently performed.

3) There is evidence that a general weakness in procedural knowledge exists.

4) The procedure contains sign-offs.

5) An error in performance could cause significant adverse impact.

The Standing Orders are identified and implemented by the Facility Utilities Supervisor to ensure that the appropriate safety measures for the AWWT are in place. The Standing Orders are based on the current status and condition of the AWWT and its equipment, and the operations being preformed. The Standing Orders are reviewed for applicability at each change in phases of AWWT operations.

12.4 Training

It is FERMCO policy to ensure that training is provided for all individuals to perform their work. Training for the AWWT is currently under development. Prior to operation, the training is reviewed for adequacy and compliance with the FERMCO "Training Department Program Manual," Rev. 0, RM-0002 (Ref. 12.5).

As a new facility, the training for start-up and operations of the AWWT is accomplished in three phases. Each phase represents the training and responsible training group for the that phase. The three phases of training are:

1) Contractor Training
2) Technical and SOP Training
3) Operator-specific training on Standing Orders, data sheets, etc.

For each phase, Centralized Training and RSO Training coordinate the training requirements for the AWWT project. An AWWT-specific training plan and associated lesson plans are prepared for all phases of training. The construction contractors provide Operating and Maintenance training on the DCS and other AWWT equipment and systems as detailed below. CRU-5 Engineering assists RSO in providing technical and SOP training. RSO supervision provides training on standing orders and other "operations-specific" requirements. Maintenance supervision identifies any additional training requirements beyond those listed below.

The Engineering/RSO-provided training encompasses:

1) Orientation
2) Utilities and Support Systems
3) Baseline Valve Line-ups
4) Phase I and Phase II Operations
5) Control Room Operations and Alarm Responses
6) Chemical Systems
7) Sumps Operations and Response to Chemical Spills
8) Ion Exchange Resin Regeneration and Changeout
9) Eluate Precipitation and Thickening
10) AWWT Standing Orders
11) Health and Safety

AWWT operational training shall focus on the training requirements specific to the operation of the facility. Personnel are trained and certified as wastewater treatment facility operators. A key element of the training is the operators' training to identify the controls, alarms, and limiting switches to ensure safe operation and responses. Maintenance personnel receive separate task-specific training for opening or potentially breaking seals of contaminated lines, vessels, or pumps. Project-specific training that assures safety for the AWWT operations is provided in part by the vendor. Specification No. 02902-3501 is for the IX equipment. The vendor's obligations are described in Section 15990 of the specification. Some of the major support includes:

1) Testing of all valves and switches
2) Preliminary equipment operation
3) Regeneration flow testing
4) Resin loading and unloading using the vendor supplied resin handling unit
5) Ten working days of personnel training

Specification No. 02902-3502 is for the other AWWT systems. Specification 15990 requires general personnel instruction in the primary systems (10 days for process and instrumentation and 3 days for HVAC and electrical). Section 15946 calls out DCS system training specifically (3 days on site for three work shifts of operators and 4 to 6 weeks off site for engineers and maintenance personnel). Section 11225 specifies start-up and training on the clarifiers (5 days training and 5 additional days start-up). Section 14570 describes start-up and training on the loss-in-weight feeders (2 days training and 3 additional days start-up).

Specific contractor-provided training consists of:

1) DCS Engineering and Maintenance
2) DCS Operation
3) Clarifier Operations and Maintenance (O&M)
4) Carbon Filters O&M
5) Tests and Adjustments - Process
6) Tests and Adjustments - Instrumentation
7) Tests and Adjustments - Electrical
8) Tests and Adjustments - HVAC
9) Automatic Temperature Controls O&M
10) Evacuation Alarm System O&M

The RSO Utilities Services Manager is responsible for identifying the operations under his/her responsibility which comply with mandatory training requirements and which need trained, qualified, or certified employees. Additionally, the Utilities Services Manager is responsible for ensuring that visitors, subcontractors, vendors, and temporary employees under their cognizance receive the training necessary for their protection and in accordance with DOE and FERMCO requirements. The Utilities Services Manager may select and request that personnel be trained and qualified as Technical Instructors. The Utilities Services Manager is responsible for the conduct and execution of training and for the documentation of Subject Matter Experts.

12.5 References

12.1) FERMCO, December 1993. RM-0016, *Management Plan: Policies and Requirements Manual.*

12.2) DOE, December 1993. 10 CFR 835, Occupational Radiation Protection.

12.3) DOE, May 1992. DOE Order 5480.19, "Conduct of Operations for DOE Facilities."

12.4) FERMCO, *Conducts of Operations Manual*, Draft.

12.5) FERMCO, January 1994. RM-0002, "Training Department Program Manual," Rev. 0.

SECTION 13

HUMAN FACTORS

13.1 Introduction

This section provides assurance that human factors considerations have been applied in the operation of processing systems (safety-class, safety-significant, etc.).

This section demonstrates that human factors concepts are considered in the operation of the facility, where humans (e.g., operators, maintainers) are relied upon to take mitigating actions that prevent or mitigate localized incidents. No incident capable of producing more than localized effects has been identified. There are no safety-class SSCs. Safety-significant SSCs are identified in Sections 3 and 4. The objective of this section, therefore, is to briefly summarize human factor considerations in design and human-machine interface.

13.2 Requirements

DOE Order 6430.1A, "General Design Criteria" (Ref. 13.1), establishes the guidelines for human factors. Section 1300-12 of DOE Order 6430.1A, "General Design Criteria," is a detailed description of Human Factors considerations which includes the following:

1) Planning for Human Factors appropriate to the level of importance
2) Analyses requirements
3) Process design interfaces
4) Test and evaluation
5) Human dimensions
6) Environmental considerations (temperature, humidity, lighting, noise, vibration)
7) Component arrangement
8) Protective equipment
9) Display devices
10) System and component controls
11) Warning and annunciators
12) Communications
13) Maintainability
14) Labels

13.3 Human Factors Process

The objective during the AWWT design phase was to design a system that was not complex and that required minimal operator interaction. System controls are centrally located and provide operating personnel full indication of the process system. Hazard Analysis results of the conceptual design were fed back and reflected in the 50 percent design. Further analyses and reviews were fed back and reflected in the 100 percent CFC design. A HAZOP was performed from the 100 percent CFC on the transfer and use of the process treatment chemicals.

As a new project, AWWT uses Standing Orders to identify hazards of the operation and communicate the hazards to personnel. All procedures for the AWWT process wastewater and groundwater/stormwater treatment are reviewed, hazards identified, and the standing orders prepared. These identified hazards are incorporated into Standing Orders and training prior to performing the task specified in the SOPs that govern operations for the AWWT.

13.4 Identification of Human-Machine Interface

There is one identified human-machine interface considered as a safety-significant SSC. The transfer of the bulk chemicals could lead to an inadvertent mixing that would lead to a release of sulfuric acid mist. The adherence to procedures and incorporation of multiple safety measures makes the inadvertent mixing an incredible event. Section 2 presents the equipment controls to prevent the improper transfer.

Subsection 13.5 presents a general discussion of the human-machine interface for control operations. To ensure worker safety, the training given by the vendors covers operational controls and equipment use. Specific areas of training are given in Subsection 12.4.

13.5 Design Optimization of Human-Machine Interface

AWWT human factor concerns recognize the magnitude of the risk and importance of humans in fulfilling a safety function. The AWWT facility is equipped with a DCS in the Control Room of Building 51 (Ref. 13.2). The starting and stopping of motors and the opening and closing of valves are handled by the DCS through automatic control or manual control via keyboard-available software switches. To clearly identify the process equipment status, the DCS has its own graphics package to handle any alarms or graphics display requirements. The graphics package provides the status of operations and indicates by alarm any operation not within defined operating ranges.

The DCS receives a "motor running" signal for each motor in the project. This discrete signal input comes from each motor's auxiliary contact, located at the Motor Control Center. The DCS receives an

"open" or "full closed" signal from each solenoid-operated, two-position control valve. These discrete signals come from limit switches on the valve.

Refer to Appendix E of Specification 02902-3502, Control Logic Data Tables for more information. A Porter Fisher DCS has been installed. The CFC drawings provided by Dublin Technical Systems provide the control room layout.

13.6 References

13.1) DOE, April 1989. DOE Order 6430.1A, "General Design Criteria."

13.2) Westinghouse Materials Company of Ohio, Inc., July 27, 1989. *Design Criteria for Environmental, Health and Safety Improvements Phases IV, Volume 3. Two Fiscal Year 1990 Subprojects, Part II: Wastewater Treatment Improvements - Plantwide.*

SECTION 14

QUALITY ASSURANCE

14.1 Introduction

This section describes management programs in place that achieve and assure safety and environmental protection in a DOE-approved QA program. This FSAR is intended to describe the salient features of the program as it relates to this facility; it is not intended to be a vehicle for review and approval of the program.

The AWWT facility is a radiological facility and has no safety-class SSCs. However, there are safety-significant SSCs; therefore, this section discusses the FEMP QA program in support of worker safety. Administrative controls are identified for QA in support of AWWT operations.

14.2 Requirements

The FERMCO *Management Plan: Policies and Requirements Manual* (Ref. 14.1) includes the S/RIDs for Quality Assurance. This S/RID (No. 13) identifies the requirements for identifying the integral elements of the QA Program and ensuring corrective action and tracking of non-compliance for the FEMP.

The FERMCO QA Program is developed in accordance with criteria specified in DOE Order 5700.6C, "Quality Assurance" (Ref. 14.2); 4700.1, "Program Management System" (Ref.14.3); and 5400.1, "General Environmental Protection Program Requirements" (Ref. 14.4). The "Quality Assurance Program" (QAP), RM-0012, Rev. 3 (Ref. 14.5) is based on the requirements above and uses other references to enhance and tailor the QA Program to meet the needs of the facility.

14.3 Quality Assurance Program

This section presents an overview of the QA policy and programs for the AWWT.

14.3.1 Program

AWWT QA is implemented through the existing FEMP site program and procedures. The QAP discusses compliance with the requirements and lists the corresponding site procedures. The QAP divides the FERMCO QA program into the following 10 topics:

1) Program
2) Personnel Training and Qualification
3) Quality Improvement
4) Documents and Records
5) Work Process
6) Design
7) Procurement
8) Inspection and Acceptance Testing
9) Management Assessment
10) Independent Assessment

Criterion 1 describes the requirements to develop, implement, and maintain a documented program. It describes the organizational structure, functional responsibilities, levels of authority, and interfaces for FERMCO divisions in managing, performing, and assessing the adequacy of work. The documented system for the AWWT is based on the FEMP guidance.

14.3.2 Personnel Qualification and Training

Criterion 2 describes the FERMCO requirements for personnel to be trained and qualified to ensure they are capable of performing their assigned work. AWWT Project Management is responsible for ensuring training encompasses all relevant duties. Personnel shall be provided continuing training to ensure that job proficiency is maintained. The AWWT-specific training for the operators, encompassing wastewater operations, bulk chemical receipt, and operation controls, is verified by QA. The training procedures are reviewed against the job descriptions to ensure that all duties are incorporated into the training. The measure of the training is documented by results of testing and by demonstrating the appropriate actions for a particular job task. Training and qualification of personnel are presented in Sections 12 and 17, respectively. Further guidance for training requirements is addressed in RM-0002, "Training Department Program Manual" (Ref. 14.6). Sections 2, 7, 8, 15, and 17 of this FSAR address these requirements.

14.3.3 Quality Improvement

Criterion 3 of the QAP describes the requirements and responsibilities for establishing and implementing processes to detect, control, correct, and prevent quality problems and to promote quality improvement. The FERMCO Total Quality Management/Continuous Performance Improvement (TQM/CPI) process is implemented for AWWT operations to meet this criterion. Section 17 of the FSAR addresses this requirement.

14.3.4 Documents and Records

Criterion 4 of the QAP describes the requirements and responsibilities for establishing and implementing a system for the control of documents and the handling, collection, storage, and control of quality assurance records generated by the FEMP. Sections 7, 8, 12, and 17 present the requirements of this criterion.

14.4 Quality Assurance Performance

The design features of the FEMP QA Program are derived from the basic requirements and supplements of DOE Order 5700.6C (Ref. 14.2). For the quality program to operate, graded levels of QA must be established based on the importance of the activity to safety and reliability.

The determination of quality levels is based on the results of the Risk Assessment Report, which analyzed the modified facility in accordance with SM-0001, "Risk Assessment and Management System Manual" (Ref. 14.7). From the Risk Analysis Report worksheets, 138 items were designated Quality Level 3, 150 were Quality Level 4, 105 were Quality Level 2, and no Quality Level 1 items were designated. Refer to the Risk Management Plan RMP-92-0015-A-0 (Ref. 14.8).

14.4.1 Work Processes

Criterion 5 describes the requirements and responsibilities for the control of processes affecting work performance. The purpose of work process control is to ensure that standard processes and special processes are accomplished under controlled conditions. Work process control also includes the control of measuring and test equipment used by FERMCO for determining acceptability of characteristics, or which influence critical parameters of facility operations or standard and special processes.

The requirements of QAMS-005/80 (Ref. 14.9) and DOE Order 5400.1 (Ref. 14.4) apply to all environmental monitoring and measurement efforts mandated by the US EPA. The Amended Consent Agreement requires that an approved Quality Assurance Project Plan be established in accordance with US EPA requirements for QA plans to address data generation activities. FD-1000, *Sitewide CERCLA Quality Assurance Project Plan* (Ref.14.10), has been developed to cover the US EPA requirements for environmental sampling and analysis. AWWT Operations will make a determination as to the applicability of this guidance for the AWWT process monitoring.

14.4.2 Design

Criterion 6 describes the requirements and responsibilities for the implementation of a formal design control process. It is FERMCO's policy to design items and processes using sound engineering/ scientific principles and appropriate standards. The requirements of this criterion apply to all organizations that perform design, or are responsible for design performed by contractors or subcontractors. The AWWT design criteria are discussed in Subsection 2.2.

14.4.3 Procurement

Criterion 7 describes the requirements and responsibilities for the preparation, review, and control of procurement documents. It also specifies the requirements and responsibilities for the control of purchased material, equipment, and services. All procurement contracts for the AWWT follow the requirements of the QAP. The procurement process plays an integral part in assuring the safe operations for the AWWT in receipt and storage of the bulk process chemicals. The supplier must follow U.S. Department of Transportation requirements for shipping and transferring the process chemicals.

Initial procurement requirements for the AWWT are presented in Subsection 14.4. Ongoing procurement of materials is covered by RSO divisional procedures and site procedures already established to implement these requirements.

14.4.4 Inspection and Testing for Acceptance

Criterion 8 describes requirements and responsibilities for performing inspection and acceptance testing. It is FERMCO's policy to perform inspection and acceptance testing of specified items and processes using established acceptance and performance criteria, and to require calibration and maintenance of equipment used for inspections and tests.

Specification 02902-3502 (Ref. 14.11) lists applicable QA requirements for each technical specification. These QA requirements involve installation and checkout of equipment followed by acceptance (sign-off) by the FERMCO QA representative and the Construction Manager.

14.4.5 Management Assessment

Criterion 9 describes the requirements and responsibilities for regularly assessing and documenting the adequacy and effectiveness of the QA (or management) program in providing the framework for the project to achieve its mission and objectives. It is FERMCO policy for management at all levels to periodically assess the integrated QA Program and its performance, and to identify and correct problems

that hinder the organization from achieving its quality objectives. This criterion is addressed in Section 17.

14.4.6 Independent Assessment

Criterion 10 describes the requirements and responsibilities for the implementation of an independent assessment program. The FERMCO independent assessment program evaluates the adequacy and effectiveness of activities for compliance with applicable requirements.

QA provides an independent assessment of the AWWT for start-up, testing, and operations of the process equipment. The activities of the facility operators are evaluated against the developed procedures and their requirements.

The AWWT Independent Assessment program will be coordinated between the FERMCO Quality Assurance Division and the AWWT Utilities Services Manager. The AWWT Utilities Services Manager will determine the areas to be assessed and their relative priorities within the project. Then a schedule will be determined with the Manager of Quality Systems and Audits for audits, and with the Manager of Quality Engineering for surveillances.

14.5 References

14.1) FERMCO, September 1994. RM-0016, Revision 1. *Management Plan: Policies and Requirements Manual.*

14.2) DOE, August 1991. DOE Order 5700.6C, "Quality Assurance."

14.3) DOE, June 1992. DOE Order 4700.1, "Program Management System."

14.4) DOE, June 1990. DOE Order 5400.1, "General Environmental Protection Program Requirements."

14.5) FERMCO, November 1994. RM-0012, "Quality Assurance Program," Rev. 3.

14.6) FERMCO, January 1994. RM-0002, "Training Department Program Manual."

14.7) FERMCO, January 1992. SM-0001, "Risk Assessment and Management (RAM) System Manual."

14.8) FERMCO, June 1992. RMP-92-0015-A-0, "Risk Management Plan for AWWT Facility."

14.9) US EPA, 1983. QAMS-005/80, *Interim Guidelines and Specifications for Preparing Quality Assurance Plans*.

14.10) FERMCO, April 1993. FD-1000, *Sitewide CERCLA Quality Assurance Project Plan*, Rev. 1.

14.11) Westinghouse Materials Company of Ohio, Inc., July 27, 1989. *Design Criteria for Environmental, Health and Safety Improvements Phases IV, Volume 3. Two Fiscal Year 1990 Subprojects, Part II: Wastewater Treatment Improvements - Plantwide.*

SECTION 15

EMERGENCY PREPAREDNESS PROGRAM

15.1 Introduction

This section is intended to describe how emergencies at the AWWT Facility will be handled through the site program, and to identify any unique aspects of the AWWT Facility as they relate to emergency preparedness.

The postulated accidents identified in Subsection 3.4 for the AWWT affect only the facility personnel and as such the need for complex and extensive emergency response actions is limited. The "FERMCO Emergency Plan," PL-3020 (Ref. 15.1) describes the approach for emergency preparedness at the FEMP and identifies the responsible organizations.

15.2 Requirements

The FERMCO *Management Plan: Policies and Requirements Manual* includes the S/RIDs for Emergency Preparedness and Management. This S/RID (No. 3) identifies the requirements for emergency preparedness planning and hazards identification; emergency response; and emergency reporting for the FEMP per the FERMCO contract with the DOE; Federal, State, and local laws; DOE Orders; and DOE guidance documents.

For the emergency preparedness program, the applicable rules, regulations, and orders are DOE Orders 5000.3B, 5480.11, and the 5500 series (Ref. 15.2, 15.3, and 15.4); *Title III of the Superfund Amendment and Reauthorization Act of 1986, Emergency Planning and Community Right-To-Know Act*, specifically section 303(c) (Ref. 15.5); NRT 1-A, *Criteria of Review of Hazardous Material Emergency Plans* (Ref. 15.6); the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980 as amended by Public Law 96-510, December 1980, specifically sections 120(c) and 103(a) (Ref. 15.7); and Ohio emergency planning laws and regulations.

The above requirements are implemented by the following FEMP procedures:

1) SSOP-0089, "Personnel Accountability" (Ref. 15.8)

2) SSOP-1018, "Event Categorization/Classification Procedure" (Ref. 15.9)

3) ED-0001, "Event Notification and Occurrence Reporting Procedure" (Ref. 15.10)

4) PL-2194, "FERMCO Spill Prevention Control and Countermeasure Plan" (Ref. 15.11)

The principal criteria for the AWWT facility are the guidelines for limiting worker exposure. These are presented in Subsection 8.2 for the materials in process.

15.3 Scope of Emergency Preparedness

The responses to potential events are based on their consequences. The AWWT events are limited in impact to the facility and neighboring trailers. For this reason, the only event classified as Alert is a release of a sulfuric acid mist. Other emergencies do not invoke a site alert. Emergency response is based on the actual consequence, not the type. However, with a cursory review of Appendix E, Attachment 1, Table 7, one concludes that Emergency Response Personnel should be aware that the following two events have potential worker safety consequence:

1) Generation of a sulfuric acid mist
2) Mixing of incompatible chemicals (i.e., acid with caustic, caustic with alum) during unloading

The inventory of sulfuric acid present in the storage tank (51-X137-TNK), capacity of 10,000 gallons exceeds the Threshold Planning Quantity (TPQ) listed in 40 CFR 355 Appendix A Exceeding the TPQ requires that the AWWT facility meet the FEMP notification requirements.

15.4 Emergency Preparedness Planning

Facility planning is divided into the seven subsections below. There are no unique operational hazards associated with the AWWT operations. The primary hazards are the chemical hazards and the uranium which are the same hazards generally associated with activities at the FEMP. The only accident scenarios which could release a quantity capable of causing a significant (though acceptable) dose are severe natural phenomena events. In the event of severe phenomena, the consequences would be localized to the AWWT facility. The AWWT facility is located away from other FEMP facilities and has limited inventories of radioactive and hazardous materials.

15.4.1 Emergency Response Organization

Off-site emergency response organizations are not presented because no off-site impacts are associated with the AWWT facility. The "FERMCO Emergency Plan," PL-3020 (Ref. 15.1) identifies the responsible organizations.

15.4.2 Assessment Actions

Initially the AEDO assesses the event impacts in the following manner:

1) Data Gathering - obtain information about the incident and its potential impact
2) Evaluate Critical Factors - determine how and where initial efforts must be concentrated
3) Tactical Attack Plan Development - formulate a structure plan to respond to the event

Within 40 minutes of notification the FEMP Emergency Operations Center (EOC), composed of senior advisory personnel, is operational and the Emergency Response Team (ERT) is assembled. Dispersion conditions, atmospheric, and other factors may be evaluated based on the nature of the event. The AEDO categorizes the event. A discussion of the consequence assessment is given in PL-3020, "FERMCO Emergency Plan" (Ref. 15.1).

15.4.3 Notification

Initial notification of the emergency response organizations is summarized in ED-0001, "Event Notification and Occurrence Reporting" (Ref. 15.10), which outlines the initial notification requirements and details the actions required to prepare, track, and maintain the status for reportable events.

15.4.4 Emergency Facilities

The emergency facilities and equipment are designed for emergency response, emergency communications, and public information communications. Associated equipment supports the rescue, spill prevention, and fire control. Spill kits are placed near the tanker truck loading area. Spill kits are available in the Spill Response vehicle No. 328.

The AWWT facility has no unique medical requirements. Medical vehicles for emergency use include two fully-equipped ambulance vehicles designed to Federal standards and staffed by a minimum of two medical technicians whenever responding to a medical event. There are also various pieces of diagnostic equipment, two hospital wards, an in vivo whole body counter, and other equipment.

15.4.5 Protective Actions

A General Emergency as defined by DOE requires protective action recommendations be issued by the FEMP when an event will have an off-site impact. The sulfuric acid release is not considered to result in a General Emergency by itself. (See Section 3 and Appendix E for analysis.) Therefore, no specific

AWWT events cause a General Emergency. Protective actions, such as evacuation or sheltering, will be taken for personnel during on-site emergencies at the FEMP.

Emergency Response does categorize events for the Building 51 facility. The personnel in the parking lot trailers nearby are considered a separate facility. The personnel would not be aware of AWWT emergency actions; therefore, a sulfuric acid release scenario requires an "Alert."

Responses to events resulting in releases, hence the need for emergency actions, are governed by:

1) EA-FEMP-004, "Protective Action Procedure" (Ref. 15.12)

2) IM-7006, "Incident Building Evacuation Procedure" (Ref. 15.13)

3) SSOP-0077, "Building Emergency Procedure" (indicated use of Rally Point 2 for Building 51 personnel) (Ref. 15.14)

15.4.6 Training and Exercises

Personnel involved in Emergency Preparedness are provided classroom training, practical training, and frequent drills and exercises. The training is defined, documented, and auditable. Radiation Safety, the ERT, and Industrial Hygiene separately conduct their own respective training classes.

Various departments provide a formal training program for the instruction and qualification of all personnel involved in the emergency response organization. This program provides the initial and annual retraining of both primary and alternate response personnel. The program is composed of classroom and practical training, and includes frequent drills and exercises.

EOC staff qualification is and tracked individually. The emergency drill and exercise program provides members of the Emergency Response Organization at least one opportunity annually to practice their skills and be evaluated. Further description, the conduct of training, record keeping, and evaluation of training effectiveness for emergency response are given in PL-3020, "FERMCO Emergency Plan" (Ref. 15.1).

15.4.7 Recovery and Re-Entry

The primary responsibility for event termination and recovery planning rests with the Deputy Emergency Director with compliance from DOE-Headquarters and the State of Ohio. Upon termination of an emergency, the EOC is deactivated. The recovery plan should include a description of damage and those

actions necessary to restore the facility and immediate vicinity to a safe condition. The recovery procedure, EA-EMF-003, "Recovery and Re-Entry Procedure" (Ref. 15.15) is used for the AWWT.

15.5 References

15.1) FERMCO, June 1994. PL-3020, "FERMCO Emergency Plan."

15.2) DOE, January 1993. DOE Order 5000.3B, "Occurrence Reporting and Processing of Operations Information."

15.3) DOE, June 1992. DOE Order 5480.11, "Radiological Protection for Occupational Workers."

15.4) DOE, DOE Orders, 5500 Series.

15.5) Enacted by Public Law 99-499, October 17, 1986. *Title III of the Superfund Amendment and Reauthorization Act (SARA) of 1986, Emergency Planning and Community Right-To-Know Act.* 42 USC 11000 et. seq.

15.6) United States Nuclear Regulatory Commission, May 1988. NRT 1-A, *Criteria of Review of Hazardous Materials Emergency Plans.*

15.7) Enacted by Public Law 96-510, December 11, 1980. *Comprehensive Environmental Response, Compensation, and Liability Act of 1980.* 42 USC 9601 et. seq.

15.8) FERMCO, February 1994. SSOP-0089, "Personnel Accountability."

15.9) FERMCO, June 1994. SSOP-1018, "Event Categorization/Classification Procedure."

15.10) FERMCO, June 1994. ED-0001, "Event Notification and Occurrence Reporting Procedure."

15.11) FERMCO, April 1993. PL-2194, "FERMCO Spill Prevention Control and Countermeasure (SPCC) Plan."

15.12) FERMCO, September 1994. EA-FEMP-0004, "Protective Action Procedure."

15.13) FERMCO, September 1994. IM-7006, "Incident Building Evacuation Manual."

15.14) FERMCO, September 1994. SSOP-0077, "Building Emergency Procedure."

15.15) FERMCO, 1994. EA-EMF-003, "Recovery and Re-entry Procedure."

SECTION 16

PROVISIONS FOR DECONTAMINATION AND DECOMMISSIONING

16.1 Introduction

This section provides information relating to decontamination and decommissioning (D&D). The expected life cycle of the AWWT facility is 30 to 35 years and provisions for D&D may be impacted by changes in operations. The facility only treats liquid effluent for the removal of uranium. D&D of the AWWT facility should be straightforward for the facility and process equipment therein.

16.2 Requirements

The DOE and US EPA jointly signed a Federal Facilities Compliance Agreement (FFCA) in July 1986 (Ref. 16.1). A Consent Agreement was entered in June 1990 and amended in September 1991 (Ref. 16.2 and 16.3). The FERMCO *Management Plan: Policies and Requirements Manual* (Ref. 16.4) includes the S/RIDs for Environmental Restoration and Waste Management that encompasses D&D activities. This S/RID (No. 17) identifies the requirements for ensuring that environmental impacts associated with past and present activities are thoroughly investigated. As a result of the investigation, appropriate environmental response actions can be formulated, assessed, and implemented. As part of these response actions the impacts during the D&D must be assessed and the eventual D&D for release of facilities.

16.3 Description of Conceptual Plans

Upon completion of wastewater treatment, the D&D of the equipment used may begin. This equipment includes the AWWT facility and the associated miscellaneous material and utility services for the remediation facilities. Due to the anticipated length of the project D&D has not been considered in the design of the AWWT.

Inventories of wastewater and any residual process materials and low level radioactive or hazardous wastes must be disposed of, treated, or removed to appropriate storage facilities. Stormwater and sump flows must be routed to other facilities for appropriate disposition. All process equipment, piping systems, and associated utilities, as appropriate, should be locked and tagged out of service in accordance with existing procedures. The fire protection systems should be converted to dry systems, but lighting and fire alarms should be maintained.

An equipment inventory and radiological characterization are completed to determine the decontamination techniques and final disposition for each piece of equipment and structure. A complete history of the facility's condition including construction, equipment, contamination levels, and operating history are evaluated to establish the clean-up levels and final disposition on the equipment. Final disposition may include:

1) Free release

2) Packaging for disposal in an on-site disposal facility

3) Packaged, non-reusable items (rubble, miscellaneous concrete, building materials, etc.)

4) Reusable items by others on site (certain utilities, power station, forklifts, other equipment, melter, and associated components)

The final step is to establish health physics and operating procedures to comply with the radiological conditions of the facility as well as the regulatory requirements for the D&D of the facility. The health physics and pertinent operating procedures include area monitoring requirements, surface contamination area control, radiation area control, and airborne radioactivity area control. With these systems operational, identification and disposal of the surplus materials and equipment in the facility can be accomplished.

16.4 References

16.1) 102nd Congress of the United States of America, January 3, 1992. *Federal Facilities Compliance Act as Amended by House Resolution 2194.*

16.2) United States Environmental Protection Agency, Region V, 1990. *US Department of Energy, Feed Materials Production Center, Fernald, Ohio, Consent Agreement.*

16.3) United States Environmental Protection Agency, Region V, 1991. *US Department of Energy, Feed Materials Production Center, Fernald, Ohio (OH6 890 008 976), Consent Agreement as Amended Under CERCLA Sections 120 and 106(a).* Administrative Docket Number: V-W-90-C-057.

16.4) FERMCO, September 1994. RM-0016, Revision 1. *Management Plan: Policies and Requirements Manual.*

SECTION 17

MANAGEMENT, ORGANIZATION, AND INSTITUTIONAL SAFETY PROVISIONS

17.1 Introduction

The management, organization, and institutional safety structures employed to ensure safe operation of the AWWT facility are described in the following sections. The sections discuss safety programs that promote safety consciousness and morale, including safety culture, safety performance assessment, configuration and document control, occurrence reporting, and staffing and qualification.

17.2 Requirements

The applicable requirements for this section are in DOE Order 4700.1, "Project Management" (Ref. 17.1) and the FERMCO *Management Plan: Policies and Requirements Manual.*

17.3 Organizational Structure, Responsibilities, and Interfaces

The AWWT organization is shown in Figure 17-1 and described in the following subsections.

The AWWT is organized within the RSO Operations Division under the RSO Department. CRU-Engineering, functionally reporting to the Environmental Engineering and Technology Group, is matrixed to support the AWWT during start-up. RSO is responsible for the safe operation and maintenance of the AWWT. The Utilities Services Manager reports to the Manager of RSO who is responsible for facility operations at the FEMP. The Utilities Services Manager is responsible for interfacing with the Safety and Regulatory Departments and CRU-5 Engineering on site. CRU-5 Engineering has technical responsibility for the design and facility engineering.

Overall AWWT programmatic and project direction (design, construction, start-up, and long-term operation) is the responsibility of the CRU-5 Project Director. Implementation of the AWWT project is managed by the organizations matrixed to support CRU-5 - primarily Construction, Engineering, and RSO.

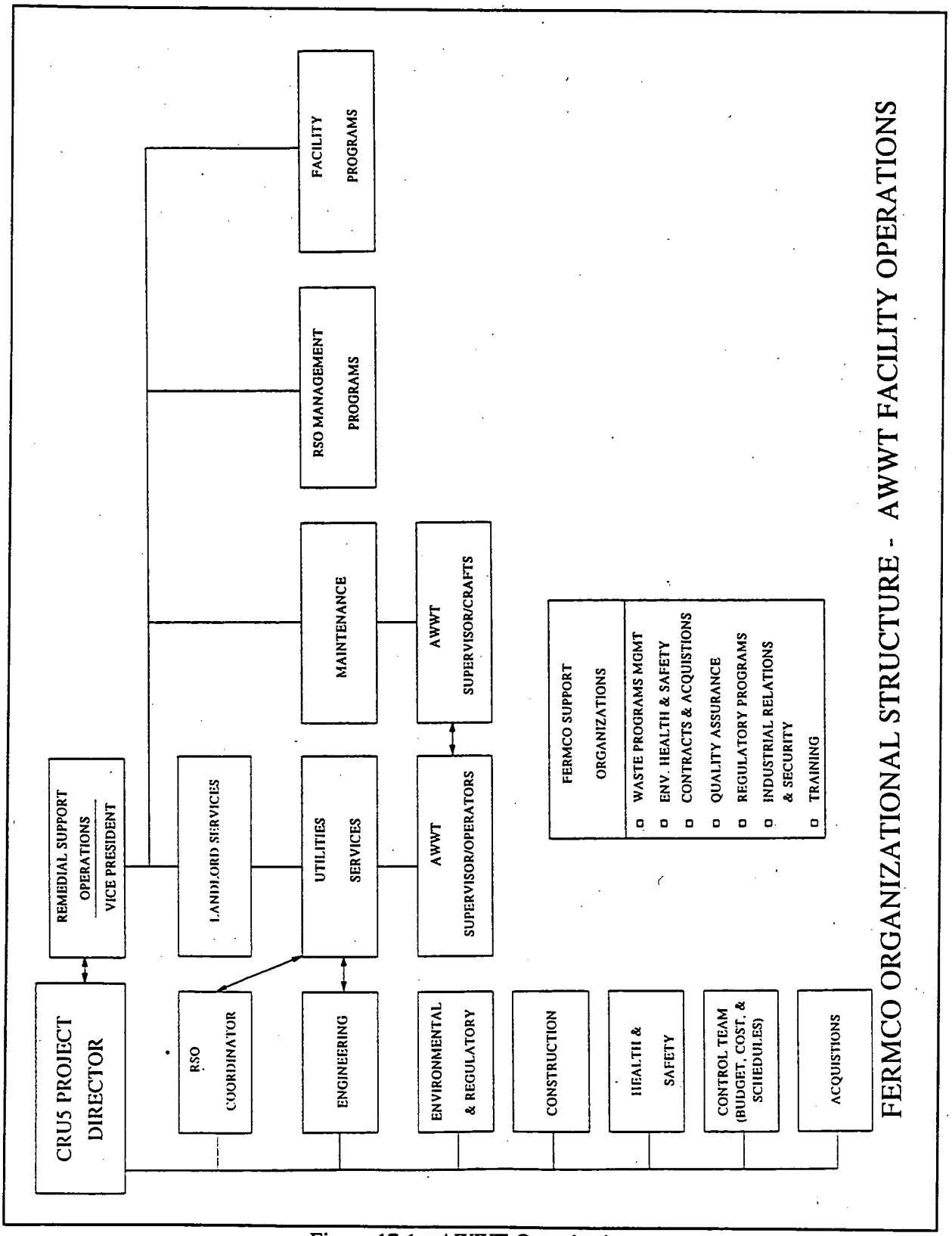

Figure 17-1 - AWWT Organization

An awareness of safety considerations is provided to all involved functional groups and operations personnel. The discovery of safety issues by operators or other support personnel are reported to their supervisor and resolved, with the RSO Utilities Services Manager being responsible and CRU-5 providing technical direction with other site organizations.

17.3.1 Construction

Construction is responsible for managing the AWWT prime construction contractors - Danis Havy Construction Company and Hydro-pure Systems Company. Construction is responsible for ensuring that the contractors satisfactorily complete construction, plan and perform construction acceptance testing, and perform integrated construction acceptance testing in accordance with the project design and construction specifications. Construction is primarily responsible for punch list resolution and turnover of the AWWT from the construction contractors to FERMCO.

Construction will manage Facility Owner responsibilities, including lockout and tagging, during construction, construction acceptance testing, and integrated construction acceptance testing. This responsibility will be transferred to RSO upon "turnover" following integrated construction testing and acceptance of AWWT subsystems.

17.3.2 Engineering

Engineering is responsible for project management, technical direction, and management of the AWWT design (by A. M. Kinney, Inc.). Engineering has also provided project and technical engineering during construction. A. M. Kinney, managed by Engineering, has provided Title III engineering services. Engineering has the primary responsibility to coordinate the start-up of the AWWT. Engineering is responsible for the preparation of:

1) The AWWT Start-Up Plan
2) ICAT procedures
3) SOT procedures
4) SOPs
5) AWWT Technical Manual
6) Technical training lessons
7) As-built drawings and other related technical documentation.

Engineering provides technical direction for the ICATs performed by the construction contractors. Engineering performs SOTs with assistance from RSO Utilities Services. Engineering provides technical

training and direction to RSO during start-up and subsequent long-term operations. Engineering and RSO provide the primary interface with the Operational Readiness Assessment team.

17.3.3 Remediation Support Operations

RSO Landlord Services/Utilities Services and Maintenance have the primary responsibility for operating and maintaining the AWWT following start-up. RSO provides supervisors, operators, and maintenance crafts personnel during start-up for training and start-up assistance.

The RSO Work Coordination Center, supported by RSO Facility Programs/Near-term Verification, is responsible for ensuring that RSO responsibilities for start-up support and operational/maintenance readiness are identified and accomplished. These RSO responsibilities include staffing, conduct of operations (standing orders, operator/crafts qualification, operating aids, operating records management, facility labeling/tagging, adequate SOPs, etc.), Plant 8 readiness, waste management, operating health and safety, radiological controls, emergency preparedness, etc. These groups will also ensure that construction and engineering responsibilities, as well as other support organization responsibilities, are satisfactorily completed prior to acceptance.

RSO Utilities Services will manage Facility Owner responsibilities following integrated construction acceptance testing and subsequent "turnover" from Construction. Engineering will provide overall technical and operational direction during start-up until RSO attains satisfactory operational readiness.

17.3.4 Staffing and Qualifications

The AWWT Utilities Services Manager assures that minimum staffing requirements are met for safe and reliable operations. AWWT operations are 24 hours a day so all shifts are fully staffed. Staffing is based on maintaining a safe productive work environment. The staffing is such that operators are available to respond to operational needs but also maintain a safe work place and notify FEMP response teams.

An Operations Shift Supervisor is responsible to the Day Shift Supervisor and ultimately the Utilities Services Manager. This reporting chain ensures that all operations are conducted in accordance with formal approved instructions and procedures and that equipment is operated properly within the specified operating limits and by qualified personnel. In addition, the day-to-day operations are planned and reviewed by the chain of supervisors.

The operations of the AWWT require three shifts of four operations personnel per shift. One is a shift supervisor trained and certified in wastewater treatment operations. The other three operators consist of a control room operator to oversee the operations and two field operators to monitor plant conditions and

perform routine inspections. Manual operations of the field operators are overseen by the control room operator and both are overseen by the shift supervisor.

The qualification process includes formal and informal training, demonstration of ability, personnel interview, and final approval by the Utilities Services Manager. The Utilities Services Manager has determined the minimum staffing levels and staff qualification required to perform each activity associated with the wastewater processing in accordance with DOE 5480.19, "Conduct of Operations Requirements for DOE Facilities" (Ref. 17.2). Operator briefings will be given at the beginning of each shift to keep worker knowledge level current and ensure the workers are aware of the system configuration prior to beginning the shift. Free forum discussions and a questioning attitude toward safety issues are encouraged.

17.4 Safety Management Policies and Programs

A brief discussion of the programs and procedures used to enhance facility safety follows. Safety Management Policies and Programs as developed for the FEMP and drawn on by the AWWT facility are discussed in the following subsections.

17.4.1 Safety Review and Performance Assessment

The Independent Safety Review Committee evaluates safety basis documentation. The Committee ensures consistency among safety analyses, associated safety documentation, and existing AWWT operating conditions. Independent safety reviews are conducted as required by SSOP-1080. *Establishing an Independent Safety Review Committee and Conducting Independent Safety Reviews* (Ref. 17.3) provides specifications for an ad hoc ISR Committee appointment, responsibilities, operational scope, membership, and reporting requirements.

"FEMP Unreviewed Safety Question and Safety Evaluation System," SSOP-1035 (Ref. 17.4), establishes the program for implementing the Unreviewed Safety Question Determination (USQD) process, as outlined in DOE Order 5480.21. The purpose of the USQD process is to determine if a change to a facility or activity can be made without prior safety review and approval by the original approving body. The FEMP USQD System training is divided into two levels of qualification, the Technically Responsible (TR) Individual and the Qualified Safety Evaluator (QSE). The TR qualification is a prerequisite to the QSE qualification. TRs screen changes/activities to limit the number of items put through the USQ process. QSEs perform all USQD/SEs in accordance with the provisions and requirements of SSOP-1035. The AWWT Facility will have an adequate number of TRs qualified and available to support the review of all document, drawing, training, and design changes for potential USQs.

17.4.2 Configuration and Document Control

The AWWT Utilities and Services Supervisor is responsible for maintaining the established baseline configuration for the facility and any changes to such configuration. The required configuration control is described in baseline documentation procedures which detail Design Features for safety and Safety Systems. Approved management procedures provide the mechanism for maintaining the approved facility configuration.

The AWWT is currently under construction and the 100 percent CFC specifications establish the current safe design for operation. "As Built " drawings are to be issued and used in the operation of the facility once construction is completed. If operational changes are necessary from design changes or through initial start-up, these are then to be reviewed and incorporated into the safety documentation.

To preserve the safety basis as defined in the SAR, drawings, records, documents, design, and the configuration of the AWWT facility documentation must be maintained. RSO Utilities Facilities/Services has the responsibility of maintaining project documentation and ensuring its integrity, such as the SOPs. These documents important to the safety basis will be controlled by the RSO Division's document control system, the issuing organization's document control system, or the site's document control system. The CRU-5 Engineering maintains the technical drawings and operation specifications. AWWT facility project drawings, controlled by CRU-5 Engineering, ensure that only approved, up-to-date drawings are used by project personnel.

Design Control and Configuration Management are performed in accordance with Engineering Division Procedures. The primary governing procedures are:

1) 12-4004, "Design Package"
2) 12-4006, "Specifications Preparation and Issue"
3) 12-4013, "Engineering Change Notices"
4) 12-5001, "Engineering Document Control"
5) 12-5004, "Configuration Management"

The original design package for the AWWT predates issuance of these Engineering Division Standards.

17.4.3 Occurrence Reporting

FERMCO documents all unusual events at the FEMP. The categorization and reporting of the event is based on DOE Order 5000.3B, "Occurrence Reporting and Processing of Operations Information" (Ref. 17.5). Guidance for initial event notification and reporting requirements is found in procedure ED-0001,

"Event Notification and Occurrence Reporting Procedure" (Ref. 17.6). The Self-Assessment Group is responsible for conducting deficiency trend analyses, root cause analyses, incorporating lessons learned, and communicating results and trends throughout the FEMP.

FERMCO provides for information selection and analysis by identification of root and contributory causes, and by deficiency trend analyses. The causes, corrective actions, lessons learned and impact are incorporated into the Occurrence Report. A DOE facility representative reviews and evaluates the Occurrence Report.

The information gained from an evaluation based on experience is dependent upon a complete description of the occurrence and identification of the root cause. FERMCO's determination of root cause provides insight on how to prevent or mitigate the effects of the event. An event is classified by its effect on the overall restoration program. Root cause analysis provides the identification of the primary cause and contributory causes.

Corrective action is taken to prevent recurrence of an event at the FEMP. The impact of the event may be on the program or project, on the environment, safety and health, or any combination.

17.4.4 Safety Culture

The site has various policies and programs for personnel in facility safety. The policies and programs shown on Table 17-1 promote a positive attitude toward safety-related activities and encourage personal safety. The key to this positive attitude is an understanding of the work environment and the potential risks. These are representative of the extensive safety culture present at the FEMP.

The FERMCO TQM/CPI process is implemented for the AWWT operations. Developing, implementing, and evaluating organizational development goals, implementation strategies, and performance measures are part of TQM/CPI. Further goals of TQM/CPI are development of a strong operator commitment to continuous improvement in performance and safety and incorporating this process in the workplace.

17.4.4.1 Safety First Initiative

In a new cooperative step forward, a mixed group of FERMCO management and operations representatives are currently working to improve the safety culture at the site focussing on the areas of management commitment, employee involvement, rewards and recognition, communications, and training. The work group safety concept is part of this initiative. As part of the Safety First initiative, pilot work groups have been established to involve workers and supervisors in the identification and resolution of safety concerns. Concerns are addressed at this level or taken to management for resolution.

Table 17-1 - Programs That Emphasize the FEMP Safety Culture

Safety	Brief Description
Walk your space	Employees are trained and required to "walk their space" in each area where they work. "Walking their space" includes an inspection of the floor, equipment, and general safety conditions of their immediate environment. The emphasis on such safety forming habits contributes to a safe working environment.
Stop work	Any equipment or activity under review for actual or suspected unsafe conditions is shut down by line supervisors and/or managers until either a determination is made that the equipment or activity is safe, or the unsafe condition is remedied. The Safety Engineering and Fire Services representative reassess the correction, equipment, or activity to assure that it is in a safe condition before being restarted.
Hours since lost work time injury	The number of hours since the last lost work time injury is tracked and posted at the entrances and exits to the FEMP. This serves as a daily reminder to personnel of the importance of safety.
Safety notes	As required by FERMCO policy, each meeting must begin with a "safety note." A safety note is a brief discussion of a specific hazard and the relevant practices which ensure safe performance.
Open door policy	In the event that an employee has a safety concern, they may utilize the FERMCO open door policy to ensure that safety concerns are given the highest priority.

17.4.4.2 Employee Bill of Rights

FERMCO management strongly supports the rights of all workers to work safely and in a safe environment. The Employee Bill of Rights provides workers the written commitment from management that they have the authority to exercise these rights. Included in these rights is the right to refuse, without reprisal or loss of regular pay, work that an individual feels is unsafe (Ref. 17.7).

17.5 References

17.1) DOE, June 1992. DOE Order 4700.1, "Project Management."

17.2) DOE, May 1992. DOE Order 5480.19, "Conduct of Operations Requirements for DOE Facilities."

17.3) FERMCO, August 1994. SSOP-1080, Rev. 0. "Establishing an Independent Safety Review Committee and Conducting Independent Safety Reviews."

17.4) FERMCO, August 1994. "Unreviewed Safety Question (USQ) Determination and Safety Evaluation System." Rev. 0.

17.5) DOE, January 1993. DOE Order 5000.3B, "Occurrence Reporting and Processing of Operations Information."

17.6) FERMCO, June 1994. ED-0001, Revision 3. "Event Notification and Occurrence Reporting Procedure."

17.7) FERMCO, February 1990. FMPC-0122, Rev. 1. "Open Communication of Employee Concerns."

APPENDIX A

DESIGN CODES AND STANDARDS

DESIGN CODES AND STANDARDS

During the design of the AWWT facility, the guidance for determining if a facility was considered a nuclear facility was through the definitions given in DOE Order 6430.1A, "General Design Criteria," and DOE Order 5480.5, "Safety of Nuclear Facilities." Based on these definitions, the AWWT was classified as a radioactive liquid waste facility and a non-reactor nuclear facility. Since then guidance has been issued which uses the radioactive material inventory as criteria. Under this current guidance, DOE-EM-STD-5502-94, *Hazard Baseline Determination*, the AWWT, owing to a limited quantity of radioactive and chemicals, is no longer subject to all the criteria listed below for a nuclear facility. Where specific issues or revision dates are not given the last applicable issue is for the date of 100 percent CFC design, 1992.

The applicable sections of the latest issue of the following codes, standards, and specifications governed the design and installation of the AWWT facility:

1) ACI - American Concrete Institute
   (1) ACI 315, Manual of Standard Practice for Detailing Reinforced Concrete.
   (2) ACI 318, Building Code Requirements for Reinforced Concrete.

2) ACGIH - American Conference of Governmental Industrial Hygienist
   (1) Threshold Limit Value and Biological Exposure Indices for 1990-1991. Guidelines only.
   (2) Guidelines for Industrial Ventilation, 1992.

3) AICHE - American Institute of Chemical Engineers
   (1) Guidelines for Hazardous Evaluation Procedures, 1985. Guidelines only.

4) AISC - American Institute of Steel Construction
   (1) AISC S326, Specification for the Design, Fabrication and Erection of Structural Steel for Buildings (included in AISC Manual of Steel Construction).

5) ASME - American Society of Mechanical Engineers
   (1) ASME NQA-1 - Quality Assurance Program Requirements for Nuclear Facilities.

6) ANSI - American National Standards Institute
   (1) ANSI A58.1-1982, Building Code Requirements for Minimum Design Loads in Buildings and Other Structures.
   (2) ANSI N16.1, Safety Standards for Operations with Fissionable Materials.
   (3) ANSI/ANS - 8.1-1983; Nuclear Criticality Safety in Operations with Fissionable Materials Outside Reactors.

7) ASHRAE - American Society of Heating, Refrigeration and Air-Conditioning Engineers
   (1) Standard 55, Thermal Environmental Conditions for Human Occupancy.
   (2) Standard 62, Ventilation for Acceptable Indoor Air Quality.
   (3) Standard 100, Energy Conservation In Existing Buildings.

8) ASTM - American Society for Testing and Materials
   (1) ASTM A36, Standard Specification for Structural Steel.
   (2) ASTM A123, Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
   (3) ASTM A325, Standard Specification for High-Strength Bolts for Structural Steel Joints.
   (4) ASTM A500, Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes.

9) AWS - American Welding Society
   (1) AWS D1.1, Structural Welding Code - Steel.
   (2) AWS D5.2, Standard for Welded Steel, Elevated Tanks, Standpipes, and Reservoirs for Water Storage.

10) AWWA - American Water Works Association
   (1) AWWA D100, Welded Steel Tanks for Water Storage.

11) BOCA - Building Officials and Code Administrators International, Inc.
   (1) OBBC, Ohio Basic Building Code.
   (2) OBMC, Ohio Basic Mechanical Code.

12) US EPA - United States Environmental Protection Agency
   (1) EPA 625/1-80-012, Design Manual: On-Site Wastewater Treatment and Disposal Systems.
   (2) EPA, Radiation Protection Guidance to the Federal Agencies for Occupational Exposure, Federal Register,Vol. 52, No. 17, 1987.
   (3) EPA 540/G-89-004, Guidance for Conducting Remedial and Feasibility Studies Under CERCLA.

13) Occupational Safety and Health Administration
   (1) OSHA 1910 Occupational Safety and Health Standards, General Industry
   (2) OSHA 1926 Occupational Safety and Health Standards, Construction Standards

14) FEMP - Fernald Environmental Management Project
   (1) ESH-1000, Comprehensive Environmental Occupational Safety and Health Program, Revision 0, February 1993.

15) LANL - Los Alamos National Laboratory
   (1) LA-10294-MS, A Guide to Radiological Accident Considerations for Siting and Design of Nonreactor Nuclear Facilities.

16) LLNL - Lawrence Livermore National Laboratory
   (1) UCRL - 15910, June 1990, Design and Evaluation Guidelines for DOE Facilities Subjected to Natural Phenomena Hazards.
   (2) UCRL - 53526, Natural Phenomena Hazards Modeling Project: Extreme Wind/Tornado Hazard Models for Department of Energy Sites.

17) NFPA - National Fire Protection Association
   (1) NFPA 13, Installation of Sprinkler Systems.
   (2) NFPA 14, Installation of Standpipe and Hose Systems.
   (3) NFPA 43A, Storage of Liquids and Solid Oxidizing Material.
   (4) NFPA 45, Fire Protection for Laboratories Using Chemicals.
   (5) NFPA 49, Hazardous Chemical Data.
   (6) NFPA 491M, Manual of Hazardous Chemical Reaction.
   (7) NFPA 70, National Electrical Code (NEC).
   (8) NFPA 78, Lightning Protection Code.
   (9) NFPA 101, Life Safety Code.
   (10)) NFPA 704, Identification of the Fire Hazards of Materials, 1989.

18) PCA - Portland Cement Association
   (1) Surface Treatment for Concrete Floors.

19) SMACNA - Sheet Metal and Air Conditioning Contractors National Association
   (1) HVAC, Duct Construction Standards-Metal and Flexible.
   (2) HVAC, Duct Design Standard.

20) UL - Underwriters Laboratories
   (1) UL 508, Industrial Control Equipment.

APPENDIX B

PRELIMINARY HAZARDS ANALYSIS AND OPERATIONAL ACCIDENTS

The AWWT Hazards identified in these tables are further developed in Appendix C, Hazard Evaluation. Initiators corresponding to these hazards are separated by hazard types and facility location. At the end of this appendix operational accidents are evaluated based on hazards identified in Table B-1.

Table B-1 - AWWT Hazards

Hazard	Description of the Nature of the Hazard	Location	Facility Systems to Mitigate	Special Mitigators (Personnel)
I. PROCESS SPILL COMPONENTS				
Process Spills: (from operations at the FEMP) • Diesel Fuel #2 • Hydrogen Fluoride • Kerosene • Methanol • Nitric Acid • Potassium Carbonate • Sodium Hydroxide • Sulfuric Acid • Tri-Butyl Phosphate • Unleaded Gasoline • Uranyl Nitrate • 1,1,1-Trichloroethane • Tetrachloroethylene • Trichloroethylene	Process spill is routed to the equalization tanks instead of General Sump due to multiple valve alignment errors. Hazard could result from: A. Spill of the material outside of AWWT containment B. Spill of the material inside AWWT containment	Equalization tanks (From MH 34 low flow dam) Overflow to SWRB	Equalization tanks and pumps, valves, piping aligned to route spill volume collected in equalization tanks back to General Sump for treatment or removal.	• Showers and eyewash stations • Administrative Controls
Note: Multiple failures required for this to be a concern, i.e., two valve misalignments to empty to the site wastewater lines and valve misalignment to direct to AWWT.				

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Table B-1 - AWWT Hazards (Continued)

Hazard	Description of the Nature of the Hazard	Location	Facility Systems to Mitigate	Special Mitigators (Personnel)
II. WASTEWATER TREATMENT STREAM COMPONENTS (Process Wastewater and Stormwater/Groundwater)				
Radioactive material in wastewater (uranium compounds as heavy metals: oxides and complexed carbonates) (Radioactive material and Toxic Chemical in wastewater and slurry form)	A. Spill of wastewater outside containment B. Spill of wastewater inside of containment	• Influent filters • Clarifiers (overflow) • Carbon filter beds • Ion exchange units • IX eluate thickener (overflow) • Polishing Filter • Tanks • Drains/sumps • Pumps/valves/piping	• Confinement system components	• Showers and eyewash stations • Administrative Controls
Other contaminants in wastewater: • Ammonia • Cyanide • Copper • Chlorine • Chromium (total) • Chromium (Hexavalent) • Fluoride • Iron • Lead • Nickel • Silver	A. Spill of wastewater outside containment B. Spill of wastewater inside of containment	• Influent filters • Carbon filter beds • Clarifiers (overflow) • Ion exchange units • Polishing filter • IX Eluate thickener (overflow) • Tanks • Drains/sumps • Pumps/valves/piping	• Confinement system components	• Showers and eyewash stations • Administrative Controls

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Table B-1 - AWWT Hazards (Continued)

Hazard	Description of the Nature of the Hazard	Location	Facility Systems to Mitigate	Special Mitigators (Personnel)
III. WASTEWATER TREATMENT CHEMICALS				
Sulfuric Acid H_2SO_4 (Corrosive Liquid)	Spill of strong acid inside of containment	• Acid unloading system • Acid unloading pump • Acid transfer pump • Acid feed tank • Acid pump • Piping/valves	• Acid unloading test well • Acid spill containment sump • Acid spill tank curbed concrete containment • Acid sump pump hose connection • Acid storage tank test well • Trench to east sump • East pump • Piping/valves • Treated water hose stations • Acid transfer pumps • In-line mixer to eluant tank apparatus as required by site procedures	• Showers and eyewash stations • Administrative Controls
Dilute Acid H_2SO_4 (Corrosive Liquid)	Spill of dilute acid inside of containment	• Eluant tank • Eluant pumps • Eluant tank recycle valves • Piping/valves	• Eluant tank test well • Dilute acid (low pH) containment • Trench drain to south sump • South sump • Treated water hose stations	• Showers and eyewash stations • Administrative Controls

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Table B-1 - AWWT Hazards (Continued)

Hazard	Description of the Nature of the Hazard	Location	Facility Systems to Mitigate	Special Mitigators (Personnel)
Sodium Hydroxide (50% NaOH) (Corrosive Liquid)	Spill of caustic inside of containment	• Caustic unloading system • Caustic unloading pump • Caustic storage tank • Caustic transfer pump • Piping/ Valves	• Caustic unloading station test well • Caustic storage tank test well • Trench drain to east sump • East sump • Piping/valves • Treated water hose stations	• Showers and eyewash stations • Administrative Controls
Sodium Hydroxide (20% NaOH) (Corrosive Liquid)	Spill of caustic inside of containment	• Caustic dilution tank • 20% caustic pumps • Mixer • Piping/ valves • Caustic dilution tank mixer • Caustic feed tank • 20% caustic piping/valves for pH adjustment	• Treated water hose stations • Dilute caustic pump test well • Trench to east sump • East sump • Piping/valves	• Showers and eyewash stations • Administrative Controls
Aluminum Sulfate (Alum) (Al_2 SO_4) (Corrosive Liquid)	Spills of alum (wet) in: • unloading area • storage area coagulation additive system (backup)	• Equipment for mixing and injecting alum into clarifiers • Alum receiving, handling, storing, and loading into supply tank	• Bldg 51 floor drains • South sump • Treated water hose stations • Alum addition ventilation system	• Showers and eyewash stations • Administrative Controls

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Table B-1 - AWWT Hazards (Continued)

Hazard	Description of the Nature of the Hazard	Location	Facility Systems to Mitigate	Special Mitigators (Personnel)
IV. CONCENTRATED RADIOACTIVE MATERIAL AND HAZARDOUS CHEMICALS				
Concentrated Radioactive and Hazardous Wastes (Uranium compounds as heavy metals: oxides and complexed carbonates)	Spill of waste slurry inside of containment	• Stormwater influent clarifiers (underflow) • Process wastewater influent clarifier (underflow) • Stormwater influent filter (backflush) • Process wastewater influent filter (backflush) • IX eluate thickener (underflow) • Polishing filter (backflush) • Slurry neutralization • Waste slurry pumps • Waste slurry tanks • Piping/valves, tanks	• Treated water hose stations • Bldg. 51 trench drains • South sump • South sump pumps • Piping/valves	• Showers and eyewash stations • Administrative Controls
Spent Resin (Contains uranium compounds)	Spill of spent resin inside of containment	• Ion exchange units in process wastewater stream • Ion exchange units in stormwater/groundwater stream • Portable hydraulic unit for unloading spent resin • Piping, hoses, valves, drums used to unload spent resin	• Treated water hose stations • Bldg. 51 trench drains • Dilute acid containment • Neutral containment trench drain • South sump • South sump pumps • Piping/valves	• Showers and eyewash stations • Administrative Controls

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Table B-1 - AWWT Hazards (Continued)

Hazard	Description of the Nature of the Hazard	Location	Facility Systems to Mitigate	Special Mitigators (Personnel)
Spent Carbon (Contains uranium compounds)	Spill of spent carbon inside of containment	• Active carbon bed filters in process wastewater stream • Active carbon filters in stormwater/groundwater stream • Portable hydraulic unit for unloading spent carbon • Piping, hoses, valves, drums used to unload spent carbon	• Treated water hose stations • Bldg. 51 trench drains • Neutral containment trench drain • South sump • South sump pumps • Piping/valves	• Showers and eyewash stations • Administrative Controls

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Table B-1 - AWWT Hazards (Continued)

Hazard	Description of the Nature of the Hazard	Location	Facility Systems to Mitigate	Special Mitigators (Personnel)
V. RADIOACTIVE MATERIAL AND HAZARDOUS CHEMICALS IN TEST WELLS/DRAINS/SUMPS				
• Concentrated Radioactive Material Waste Slurry: uranium as oxides and complexed carbonates (Radioactive Material) • Sulfuric Acid (Corrosive Liquid) • Aluminum Sulfate (Corrosive Liquid) • Sodium Hydroxide (Corrosive Liquid)	Excessive accumulation of radionuclides or hazardous chemicals	• Building 51 Areas - Floor drains and trench drains - Acid containment testwell - Caustic containment test well • South Containment Areas - Dilute caustic containment test well - Dilute acid containment test well - Neutral containment trench drain - Neutral sump - Trench drains • East Containment test well - Trench drains Areas - Acid Containment test well - Caustic	• Treated water hose stations	• Showers and eyewash stations • Administrative Controls • Equipment for cleaning drains, wells, sumps

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Table B-1 - AWWT Hazards (Continued)

Hazard	Description of the Nature of the Hazard	Location	Facility Systems to Mitigate	Special Mitigators (Personnel)
VI. ACID VAPOR				
Acid Vapor (H_2SO_4) (Corrosive Liquid)	Airborne acid vapors	• Acid spill containment sump • Acid storage tank • Acid feed tank • Piping/Valves • Mix Tank • Ion Exchange Vessels • Eluate Receiver Tanks • Regeneration Work Tanks	• Acid Scrubber system • Pressure/ Vacuum Conservation Vent Valve on Storage Tank	• Showers and eyewash stations • Administrative Controls

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OPERATIONAL ACCIDENTS

B.1 High Temperature Caustic Storage Tank

The accident analysis determines the consequences of the failure of Heat Exchanger X127 to cool heat of dilution for 50 percent caustic during unloading operation. The potential result is high temperature in the caustic storage tank. The cause is the loss of cooling plant water supply to heat exchanger.

Preventive Measures

1) Design - none determined.
2) Administrative - operator training and SOPs.

Method of Detection - Operator detects high temp (TI685) on caustic return line to storage tank or high temp (TIX) in caustic storage tank. Operator detects high temp (TI687) on feed line to heat exchanger.

Mitigative Features

1) Design - thermal relief pressure relief valve PSV-686 on caustic return line exiting heat exchanger. Three-inch vent on caustic storage tank.

2) Administrative - none determined.

Potential Impact - Assuming no cooling, the heat of dilution from one 25 ton delivery (50,000 pounds) 50 percent NaOH to 20 percent NaOH will result in a temperature increase of the solution in the storage tank of approximately 20 degrees F. This corresponds well with the design calculations provided by A.M. Kinney.

A 20 degree F increase from ambient temperature will not result in excessive vapor/mist generation (net increase in vapor pressure) or pressure in the tank. This accident poses no impact to the immediate worker and the on-site population.

Risk Determination

Frequency Level - C, Medium
Consequence Level - 1, Negligible
Risk Level - Extremely Low

B.2 Mixing of Chemicals in Offloading

During offloading of caustic, acid, or alum, the chemical is inadvertently pumped to the wrong storage tank resulting in an uncontrolled chemical reaction in the receiving tank. The cause is not sampling and analyzing shipment prior to transfer, incorrect placement of delivery truck, failure of supervisor to independently identify chemical to transfer, and hookup to incorrect unloading arm. The incorrect unloading pump is enabled by control room operator. (Initiator is failure of OSR)

Preventive Measures

1) Design - There are three separate unloading stations, one for each chemical physically spaced from each other. Unloading arms and pumps to be marked according to OSHA requirements on labeling.

2) Administrative - Operational Safety Requirement, Operator training and SOPs (identifying and implementing the OSR).

Method of Detection - Operator observation of excessive venting (misting). High temp (TIX) in caustic storage tank. No temperature to indicate if a reaction is occurring on strong acid storage tank or alum storage tank.

Mitigative Features

1) Design - Three-inch vent, 3-inch overflow on caustic storage tank located in outside containment. A rupture disk on acid storage tank located in outside containment. Four-inch vent and 8-inch overflow on alum tank located in Building 51 east side acid containment.

2) Administrative - Employee training and SOPs.

Potential Impact - Acid to caustic, caustic to acid, and caustic to alum will result in strong exothermic reaction, violent - potentially explosive for acid/caustic reactions, with a resulting potential fatal injury to personnel in immediate area.

Risk Determination

Frequency Level - C, Medium
Consequence Level - 5, High
Risk Level - Medium

B.3 Water Mixing with Acid

Water accumulation in the acid containment area is pumped into the Acid Storage Tank instead of East Rain Sump.

Causes of Accident - During heavy rainfall, the 4-inch butterfly valve at the Test Well which directs rain water to the East Sump was closed and the 4-inch butterfly valve from the Test Well to the Acid/Alum Spill Sump was open. Rain water accumulation in the Acid Spill Sump is pumped to the Acid Storage Tank via Spill Pumps X140 or X143 instead of the East Rain Sump. A two valve (plug valve) misalignment is required on the line leading to the Acid Storage Tank.

Preventive Measures

1) Design - None.

2) Administrative - Operator training and SOPs. Two independent valve alignments required.

Method of Detection - Operator observation of excessive venting (misting) from Acid Demister or emergency vent (Rupture Disc PSE 693) is discharging.

Mitigative Features

1) Design - Pressure vacuum vent valve with demister and pressure relief rupture disc on acid storage tank located in outside containment.

2) Administrative - Operator training and SOPs.

Potential Impact - Water mixed with concentrated acid will yield a strong exothermic reaction resulting in heavy mist being discharged through the demister on the acid storage tank and possible actuation of the emergency vent PSE 693. Potential injury to personnel in immediate area from chemical burns or inhalation of heavy mists.

Risk Determination

Frequency Level - C, Medium
Consequence Level - 3, Low
Risk Level - Low

APPENDIX C

HAZARD EVALUATION

Table C-1 - Hazard Evaluation

Facility Location : 1 - Process Spills into Storm Sewer					
ID #	Accident Initiator	Concern	Analysis		
			Prob. Rating[1]	Haz. Rating[2]	Risk[3]
1.1	Process Spill - Diesel Fuel #2	Fire Hazard	C	1	EL
1.2	Process Spill - Hydrogen Fluoride (dilute)	Acid Spill Chemical Reaction	C	1	EL
1.3	Process Spill - Kerosene (dilute)	Fire Hazard	C	1	EL
1.4	Process Spill - Methanol (dilute)	Fire Hazard	C	1	EL
1.5	Process Spill - Nitric Acid (dilute)	Fire Hazard Chemical Reaction	C	1	EL
1.6	Process Spill - Potassium Carbonate (dilute)	Chemical Reaction	C	1	EL
1.7	Process Spill - Sodium Hydroxide (dilute)	Corrosive Base Chemical Reaction	C	1	EL
1.8	Process Spill - Sulfuric Acid (dilute)	Chemical Reaction Toxic Vapors	C	1	EL
1.9	Process Spill - Tri-butyl Phosphate	Toxic Exposure	C	1	EL
1.10	Process Spill - Unleaded Gasoline	Fire Hazard Toxic Vapors	C	1	EL
1.11	Process Spill - Uranyl Nitrate (solution)	Toxic Vapors (very low level)	C	1	EL

Note: 1) Refer to Table 3-1
2) Refer to Figure 3-1
3) Refer to Figure 3-2
4) This accident summary is based on an accident scenario requiring multiple event failures. For example, a spill occurs somewhere on the process side involving one of the above chemicals. The spill is not contained by its own containment and enters the process side storm sewer system. During spill control, the spill is inadvertently routed to the AWWT Equalization Tank. This requires two independent failures in valve alignments. The overall risk is assumed to be extremely low.
5) The assumption used was that large spills caused by the complete break of a line have a frequency level of D, while those caused by the rupture of a tank/vessel have a frequency level of C. Minor spills caused by a leaking pipe fitting, valve packing, pump seal, or gasket failure were assumed to have a frequency level of E.

Table C-1 - Hazard Evaluation (Continued)

Facility Location: 2 - Process Wastewater Treatment Stream					
ID #	Accident Initiator	Concern	Analysis		
			Prob. Rating[1]	Haz. Rating[2]	Risk[3]
2.1	Equalization Tank Inlet Line Break	BDN/ GEN. Sump and/or perched groundwater spill or backflush slurry.	D	1	EL
2.2	First Equalization Tank Rupture	75,000 gal. wastewater spill	C	1	EL
2.3	pH Holding Tank Rupture	75,000 gal. High pH wastewater spill	C	2	L
2.4	Inter-tank Line Break	Large spill of radioactive/ hazardous chemicals	D	2	L
2.5	Equalization Tank pH Control Failure	Excessive radionuclides in clarifier overflow	E	1	EL
2.6	Influent Clarifier Rupture	Large spill of high pH radioactive/hazardous chemicals	C	2	L
2.7	Influent Clarifier Inlet Line Break	Large spill of high pH radioactive/hazardous chemicals	D	2	L
2.8	Influent Clarifier Underflow Line Break	Large spill of high pH radioactive/hazardous chemicals	D	2	L
2.9	Influent Clarifier Overflow Line Break	Large spill of high pH radioactive/hazardous chemicals	D	2	L
2.10	Influent Filter Rupture	Large spill of high pH radioactive/hazardous chemicals	C	2	L
2.11	Influent Filter Inlet Line Break	Large spill of high pH radioactive/hazardous chemicals	D	2	L
2.12	Influent Filter Outlet Line Break	Large spill of high pH radioactive/hazardous chemicals	D	2	L
2.13	Influent Filter Backwash Line Break	Large spill of high pH radioactive/hazardous chemicals	D	2	L

Table C-1 - Hazard Evaluation (Continued)

Facility Location: 2 - Process Wastewater Treatment Stream					
ID #	Accident Initiator	Concern	Analysis		
			Prob. Rating[1]	Haz. Rating[2]	Risk[3]
2.14	Active Carbon Filter Bed (Plugged, Saturated, or other Failure)	Higher level of organics in wastewater - potential spill of high pH radioactive/hazardous chemicals	D	1	EL
2.15	Active Carbon Filter Bed Inlet Line Break	Large spill of high pH radioactive/ hazardous chemicals	D	2	L
2.16	Active Carbon Filter Bed Outlet Break Line	Large spill of high pH radioactive/ hazardous chemicals	D	2	L
2.17	pH Adjustment Failure	High pH in IX unit	E	1	EL
2.18	pH Adjustment Inlet Line Break	Large spill of high pH hazardous chemicals	D	2	L
2.19	pH Adjustment Outlet Line Break	Large spill of high pH hazardous chemicals	D	2	L
2.20	IX System Rupture	Large spill of hazardous chemicals	C	2	L
2.21	IX Inlet Line Break	Large spill of hazardous chemicals	D	2	L
2.22	IX Outlet Line Break	Large spill of treated wastewater	D	1	EL
2.23	IX Regeneration Unit Failure	Higher level of hazardous chemicals in effluent	D	1	EL
2.24	Coagulant Addition Failure	Higher level of radionuclide in clarifier overflow	D	1	EL
2.25	Coagulant Addition Inlet Line Break	Large spill of high pH radioactive/ hazardous chemicals	D	2	L
2.26	Coagulant Addition Outlet Line Break	Large spill of high pH radioactive/ hazardous chemicals	D	2	L

Table C-1 - Hazard Evaluation (Continued)

Facility Location: 3 - Stormwater/Groundwater Treatment Stream					
ID #	Accident Initiator	Concern	Analysis		
			Prob. Rating[1]	Haz. Rating[2]	Risk[3]
3.1	pH Adjustment Failure	Excessive radionuclides in clarifier overflow	E	1	EL
3.2	pH Adjustment Inlet Line Break	Large spill of high pH radioactive wastewater	D	2	L
3.3	pH Adjustment Outlet Line Break	Large spill of high pH radioactive wastewater	D	2	L
3.4	Surge Tank Rupture	Large spill of high pH radioactive wastewater	C	2	L
3.5	Surge Tank Inlet Line Break	Large spill of high pH radioactive wastewater	D	2	L
3.6	Surge Tank Outlet Line Break	Large spill of high pH radioactive wastewater	D	2	L
3.7	Coagulant Addition Failure	Higher level of radionuclides in clarifier overflow	D	2	L
3.8	Coagulant Addition Inlet Line Break	Large spill of high pH radioactive wastewater	D	2	L
3.9	Coagulant Addition Outlet Line Break	Large spill of high pH radioactive wastewater	D	2	L
3.10	Influent Clarifier Rupture	Large spill of high pH radioactive wastewater	D	2	L
3.11	Influent Clarifier Inlet Line Break	Large spill of high pH radioactive wastewater	C	2	L
3.12	Influent Clarifier Underflow Line Break	Large spill of high pH radioactive wastewater	D	2	L
3.13	Influent Clarifier Overflow Line Break	Large spill of high pH radioactive wastewater	D	2	L
3.14	Influent Filter Outlet Line Break	Large spill of high pH radioactive wastewater	D	2	L
3.15	Influent Filter Inlet Line Break	Large spill of high pH radioactive wastewater	D	2	L

Table C-1 - Hazard Evaluation (Continued)

Facility Location: 3 - Stormwater/Groundwater Treatment Stream					
ID #	Accident Initiator	Concern	Analysis		
			Prob. Rating[1]	Haz. Rating[2]	Risk[3]
3.16	Influent Filter Backwash Line Break	Large spill of high pH radioactive wastewater	D	2	L
3.17	Active Carbon Filter Bed (Plugged, Saturated. or other Failure)	Large spill of high pH radioactive wastewater	D	1	EL
3.18	Active Carbon Filter Bed Inlet Line Break	Large spill of high pH radioactive wastewater	D	2	L
3.19	Active Carbon Filter Bed Outlet Line Break	Large spill of high pH radioactive wastewater	D	2	L
3.20	pH Adjustment Failure	High pH in IX unit	E	1	EL
3.21	pH Adjustment Inlet Line Break	Large spill of high pH radioactive wastewater	D	2	L
3.22	pH Adjustment Outlet Line Break	Large spill of treated wastewater	D	1	EL
3.23	IX System Rupture	Large spill of treated wastewater	C	1	EL
3.24	IX Inlet Line Break	Large spill of treated wastewater	D	1	EL
3.25	IX Outlet Line Break	Large spill of treated wastewater	D	1	EL
3.26	IX Regeneration Unit Failure	Uranium leak through	D	1	EL

Table C-1 - Hazard Evaluation (Continued)

Facility Location: 4 - Process Wastewater and Stormwater/Stormwater Treatment Chemicals					
ID#	Accident Initiator	Concern	Analysis		
			Prob. Rating[1]	Haz. Rating[2]	Risk[3]
4.1	Coagulant Supply System Failure	High level of radionuclides in clarifier overflow	D	2	L
4.2	50% Sodium Hydroxide Supply Tank Rupture	Large spill of high pH caustic	C	3	L
4.3	50% Sodium Hydroxide Supply Line Break	Spill of high pH caustic	D	2	L
4.4	20% Sodium Hydroxide Tank Rupture	Large caustic spill	C	3	L
4.5	20% Sodium Hydroxide Supply Line Break	Caustic spill	D	2	L
4.6	93% Sulfuric Acid Supply Tank Rupture	Large acid spill	C	3	L
4.7	93% Sulfuric Acid Supply Line Break	Acid spill	D	2	L
4.8	Failure of Heat Exchanger X127 to cool heat of dilution for 50% caustic during unloading operations.	High temperature caustic, excessive vapor/mist generation from storage tank.	D	1	EL
4.9	During offloading, a chemical is inadvertently pumped to the wrong storage tank.	Uncontrolled chemical reaction in receiving tank.	C	5	M
4.10	Water accumulation in the acid/alum containment area is pumped into the concentrated acid storage tank instead of East Rain Sump.	Water to strong acid chemical reaction, heavy misting from storage tank.	D	3	L
4.11	Excessive steam delivery to Heat Exchanger X127	Excessive heating of caustic	D	1	EL

Table C-1 - Hazard Evaluation (Continued)

Facility Location: 5 - Concentrated Process Wastewater and Stormwater/Groundwater Effluent					
ID#	Accident Initiator	Concern	Analysis		
			Prob. Rating[1]	Haz. Rating[2]	Risk[3]
5.1	Influent Clarifier Underflow Line Break	Large spill of high pH wastewater with radioactive/ chemical material	D	2	L
5.2	Influent Filter Waste Slurry Line Break	Large spill of high pH wastewater with hazardous chemicals	D	2	L
5.3	Process Wastewater IX Eluate Line Break	Large spill of wastewater with hazardous chemicals	D	2	L
5.4	Eluate Treatment System Rupture	Large spill of wastewater with hazardous chemicals	C	2	L
5.5	Eluate Thickener System Rupture Break	Large spill of wastewater with hazardous chemicals	C	2	L
5.6	Eluate Thickener Outlet Line Break Rupture	Large spill of wastewater with hazardous chemicals	D	2	L
5.7	Waste Slurry Transport Line Break	Large spill of wastewater with radioactive/hazardous chemicals	D	2	L
5.8	Waste Slurry Tank Rupture	Large spill of wastewater with radioactive/hazardous chemicals	C	2	L
5.9	Waste Slurry Pumps Failure	Overflow of waste slurry (spill of radioactive/hazardous chemicals)	D	2	L
5.10	Waste Slurry Line to Plant 8 Break	Large spill of radioactive/ hazardous chemicals	D	2	L
5.11	Polishing Filter Rupture	Large spill of radioactive/ hazardous chemicals	C	2	L
5.12	Polishing Filter Waste Slurry Line Break	Large spill of radioactive/ hazardous chemicals	D	2	L
5.13	Failure in Hydraulic Unit Unloading Spent Resin from an Ion Exchange Unit	Large spill of radioactive/hazardous material	D	2	L

Table C-1 - Hazard Evaluation (Continued)

Facility Location: 5 - Concentrated Process Wastewater and Stormwater/Groundwater Effluent					
ID#	Accident Initiator	Concern	Analysis		
			Prob. Rating[1]	Haz. Rating[2]	Risk[3]
5.14	Failure in Hydraulic Unit Unloading Spent Carbon from an Active Carbon Bed Vessel	Large spill of radioactive/hazardous material	D	1	EL
5.15	Excessive uranium accumulation in Building 51 processing equipment allowing IX columns to load up.	Determine if category 3 low hazard threshold uranium amount is exceeded.	B	1	EL
5.16	Excessive uranium in solution results in high uranium hold-up quantities in AWWT process equipment.	Determine criticality potential.	Incredible	4	EL

Table C-1 - Hazard Evaluation (Continued)

Facility Location: 6 - Building 51 Drains, South Containment and Sump					
ID#	Accident Initiator	Concern	Analysis		
			Prob. Rating[1]	Haz. Rating[2]	Risk[3]
6.1	Building 51 Floor Drain Plugged	Backup of major radioactive/ chemical spill	D	2	L
6.2	South Containment Overflow - Rainfall Plus Worst Spill	Spill onto ground and into storm sewer	C	2	L
6.3	South Sump Material Build-up Undetected	Chemical reaction	D	2	L
6.4	South Sump Pumps Failure	Unavailable for spill event	D	1	EL
6.5	South Sump Line to Equalization Tank Break	Radioactive/chemical spill	D	2	L

Facility Location: 7 - East Containment and Sump					
ID#	Accident Initiator	Concern	Analysis		
			Prob. Rating[1]	Haz. Rating[2]	Risk[3]
7.1	East Containment Floor Drain Plugged	Backup of major chemical spill	D	2	L
7.2	East Containment Overflow - Rainfall Plus Worst Spill	Spill onto ground and into storm sewer	C	2	L
7.3	East Sump Material Build-up Undetected	Chemical reaction	D	2	L
7.4	East Sump Pumps Failure	Unavailable for spill event	D	1	EL
7.5	East Sump Line to Equalization Tank Break	Chemical spill	D	2	L

Table C-1 - Hazard Evaluation (Continued)

Facility Location: 8 - Acid Scrubber Serving IX Columns, Regeneration Tanks and Eluate Receiving Tanks					
ID#	Accident Initiator	Concern	Analysis		
			Prob. Rating[1]	Haz. Rating[2]	Risk[3]
8.1	Tank Rupture	Acid vapor/mist release into work area.	C	3	L
8.2	Break of Inlet Lines	Acid vapor/mist release into work area.	C	3	L

APPENDIX D

HAZARD AND OPERABILITY ANALYSIS

This appendix presents the results of a hazard analysis of the unloading, storage, and use of sulfuric acid in the AWWT Plant at the FEMP. The hazard analysis focused on the possibility of injuring AWWT workers, other FEMP personnel, or the public with potential acid spills and potential releases of acid aerosol. AWWT workers can be injured by contact with liquid acid or by exposure to acid aerosol.

Because the vapor pressure of concentrated sulfuric acid is low (the concentrated acid is 93.19 percent H_2SO_4 having a vapor pressure less than 0.3 mm Hg at 77 degrees F), the boiling point is high (535 degrees F), and there are no significant external heat sources associated with the concentrated sulfuric acid equipment, the only postulated mechanisms for releasing significant quantities of acid to the atmosphere are uncontrolled dilution of the acid with water and uncontrolled neutralization of the acid. The dilution and neutralization reactions are both exothermic, and both are capable of producing steam that can entrain acid droplets. Dilute acid solutions (less than 50 percent H_2SO_4) will not produce enough heat to boil the solution when further diluted.

With the above considerations in mind, the analysis considered all AWWT equipment and operations associated with concentrated sulfuric acid (including planned dilution operations), focusing on the potential for uncontrolled dilution or neutralization. The analysis also considered the potential for uncontrolled neutralization of dilute acid solutions; however, no potential accidents of this type were identified.

The operations reviewed consisted of receipt, transfer to storage, storage, and transfer to process and dilution for the 93 percent sulfuric acid. The same material handling operations were reviewed for the 50 percent caustic. AWWT operations and materials of construction were reviewed and compared to industrial standards for applicability and appropriateness to ensure the safety of the workers and public, and enhance operations. Table D-1 is a comparison of AWWT operations to what are considered industrial standards for a manufacturer and distributor of many forms of sulfuric acid. The HAZOP team members, their affiliations, and their responsibilities are:

Mike Barringer	PARSONS	Safety Analysis
Ron Bartos	FERMCO	Systems Safety
Doug Beers	A.M. Kinney, Inc.	Design Engineer
David Campbell	Safety Management, Inc.	Safety Analysis
Tom Escue	FERMCO	AWWT Construction Project Engineer
Mike Griffin	FERMCO	CRU5 Process Engineering Manager
Jim Leslie	FERMCO	Operations Supervisor

Table D-1 - Comparison of AWWT Practices with DuPont Recommended Practices

DuPont Recommended Practice	AWWT Practice
Personnel protective equipment - Have available and wear as appropriate for conditions: chemical splash goggles; full length shield; acid-proof gauntlet gloves, apron, and boots; long-sleeve wool, acrylic, or polyester clothing acid-proof suit and hood; and approved respiratory protection	Recommended personnel protective equipment is available and worn according to the instructions of the operations supervisor
Safety showers, water hydrant and hose, and eye-wash fountains	Safety showers, emergency showers and eye-wash fountains installed
Spill containment and provisions for neutralization and disposal	Spill containment and provisions for re-use
Fire fighting - Dry chemical or carbon dioxide extinguishing methods	This was not checked during the HAZOP. On follow up fire extinguishers are dry chemical
Consider location of storage tank relative to other chemicals and working areas; storage should be in the open or in a well-ventilated area	Storage tank is outside, away from other work areas
Acid should never stand in a completely sealed line or pressure will build up	Lines are teflon lines; (on follow up transfer lines are plastic) acid reaction with metal to produce gas pressure will not occur
Exterior piping that carries grades subject to freezing should be heat traced and insulated	Exterior lines and tank are heat traced and insulated even though the acid used freezes at -31°F
Storage tanks should be thickness tested every 2 years	Storage tank is made of alloy 20, acid is concentrated; corrosion is not expected
Pump unloading is preferred over air unloading	Provision to unload by AWWT pump, truck pump, or air; AWWT pump is preferred method
Air connections must include a pressure regulator and relief valve	Air connections include a pressure regulator and a relief valve
Tank truck must meet DOT regulations	See recommendation 4
Tank truck must have pressure relief and vent valves	See recommendation 1

Table D-1 - Comparison of AWWT Practices with DuPont Recommended Practices (Continued)

DuPont Recommended Practice	AWWT Practice
Personnel should verify that the delivery is the correct material and amount	Procedures address this requirement; see recommendation 2
Personnel should be sure the tank can take the entire delivery	Procedures address this requirement; see recommendation 6
Be sure the unloading connections are labeled specifically for the product to be received	Unloading connections are to be clearly labeled; inside operator must open correct valve and start correct pump
Be sure the storage tank vent is open	Tank equipment with vent and vacuum relief valve that opens at $\pm$ 2 oz.; no valves in relief or vent lines
Unloading must be attended	Driver and operator will be present during unloading
Storage tank fill line should extend below the liquid level near the bottom of the tank; it should have four 3/8-inch vent holes near the top of the tank to prevent siphoning	Fill line extends to near the bottom of the tank, but has only 1/8-inch vent hole
Numerous equipment and material specifications	Materials of construction appear to meet or exceed all recommendations

The piping and instrumentation diagrams (P&IDs) used in the review are referenced in the HAZOP table included as an attachment to this report. The team also reviewed the draft procedures for unloading operations.

The HAZOP table developed during the team meetings is included as an attachment to this report. The consequences of interest in the HAZOP table are acid spills, uncontrolled dilution reactions, and uncontrolled neutralization reactions. In addition to the drawings and procedures, the HAZOP team used the comprehensive recommended practice guidelines for unloading, storage, and use of sulfuric acid available as issued by DuPont.

The following 11 recommendations were developed as a result of the HAZOP of the sulfuric acid unloading, storage, and handling operations. Implementing these recommendations should reduce the probability of uncontrolled neutralization reactions to less than 10^{-6} per year, and make the other accidents with consequences of interest significantly unlikely to be acceptable. These recommendations are incorporated into the discussion of the AWWT procedures, Section 12, and facility description, Section 2.

1) Consider specifying in the contracts for sulfuric acid, caustic, and alum purchases that the tank trucks be equipped with pressure relief valves, vacuum relief valves, and sample connections.

2) Consider implementing the following procedural controls to help prevent unloading the wrong material into the sulfuric acid, caustic, or alum storage tanks:
   (1) Add steps to the unloading procedures to require the outside operator to check the bill of lading for the delivery to ensure the right amount of the right material is to be unloaded.
   (2) Require sampling of all deliveries and testing for material and purity before connecting unloading arm to tank truck.
   (3) Require verification by the operations supervisor that the truck is at the right unloading station before connecting the unloading arm to the truck.

   These controls, along with the controls already in place and the engineering controls in the following recommendation, should make unloading into the wrong storage tank incredible.

3) Consider implementing the following engineering control to help prevent unloading the wrong material into the sulfuric acid, caustic, or alum storage tanks. Install key locks on each unloading arm and require the operations supervisor to be the only person with access to the keys.

   Installing different types of connectors on the unloading arms is effective only if the truck does not have a variety of connectors on board. Installing key locks that the operations supervisor must unlock will help ensure the procedure step requiring verification by the operations supervisor (recommendation 2) is implemented.

4) Consider specifying in the contracts for sulfuric acid, caustic, and alum purchases that the tank trucks must meet all United States Department of Transportation requirements applicable to the shipments and unloading operations.

5) Review the possibility of water or alum being in the acid/alum spill sump or in the lines from this sump to the acid storage tank when acid is transferred to/from the sump. Consider implementing procedures to completely empty the sump and blow down the lines before any acid is transferred to the sump. (This recommendation is based on materials being transferred from the sump to the tank. This possible operation will not be done. Locks and tags will be implemented to prevent this operation.)

6) Consider adding steps to the unloading procedures to require the outside operator to check the local level gauge on the storage tank, thus helping to ensure the storage tank can accommodate the amount of material to be unloaded.

7) Consider adding steps to the unloading procedures to require the unloading arms, pumps, and storage tank fill lines to be emptied and blown down with air at the completion of each unloading operation.

8) Review the plans to automatically fill the acid feed tank (51-X148-TNK) from the acid storage tank (51-X137-TNK). Single failures in the control systems for this operation could result in overfilling the feed tank and possibly overfilling the dike/sump around the tank. If the tank is to be automatically filled, consider installing additional interlocks and alarms (such as a high-high feed tank level interlock or a time-out alarm). Any additional level interlocks and alarms should be from a level transmitter separate from the one used for the control. This same recommendation applies to automatically filling the caustic feed tank.

9) Consider installing check valves in the acid lines to the mixers (51-X203-MXR and 51-X328-MXR). If the pressure regulating valve downstream of one of the mixers failed in the closed position, the pressure could be high enough to cause the flow to reverse, sending wastewater to the acid feed tank and resulting in an uncontrolled dilution of the acid in the feed tank. The flow control valve in the acid feed line to the mixer should close and prevent this reverse flow, but a check valve would provide an additional safeguard.

10) Consider installing interlocks to prevent/stop feeding acid into an ion exchange recycle tank (51-X222-TNK or 51-X345-TNK) if the level in the tank is too low, the temperature in the tank is too high, or there is no flow in the recycle (mixing) loop.

11) Review all procedures involving transfers to or from sumps. Consider requiring an independent check of all valve line-ups and a verification that no contaminants are in any line to be used for the planned transfer. The sump and spill pump arrangements allow a lot of flexibility, but with this flexibility comes the potential for line-up errors that could cause uncontrolled dilution of acid.

HAZOP Table for AWWT Sulfuric Acid Operations

Item Number	Deviation	Causes	Consequences	Safeguards	Actions
		1.0 Vessel - Acid delivery tank truck (dwg: 51D-4445-P-00579, P-25, Rev. 1/2)			
1.1	High level	No credible cause identified		The elevation of the top of the tank truck is nearly as high as the elevation of the top of the acid storage tank. Overflowing the tank truck would require siphoning acid from the storage tank with the storage tank full. Siphoning acid from the storage tank is unlikely, as is trying to unload a tank truck into a full storage tank.	
1.2	Low level		No consequence of interest		
1.3	High temperature	No credible cause identified			
1.4	Low temperature		No consequence of interest--material freezes at -31F		
1.5	High pressure	No credible cause of a safety consequence identified		Pressure relief valve on tank truck	1 4
1.6	Low pressure	No credible cause of a safety consequence identified		Tank truck vented	1 4

HAZOP Table for AWWT Sulfuric Acid Operations (continued)

Item Number	Deviation	Causes	Consequences	Safeguards	Actions
		1.0 Vessel - Acid delivery tank truck (continued)			
1.7	High concentration of contaminants	Wrong material in tank truck Wrong truck (caustic or alum) connected to acid unloading arm	Possible explosive reaction with acid and caustic vapor release	Truck contents sampled before unloading DCS operator has to enable pump and block valve Signs to mark unloading areas Outside operator assists in connecting to and unloading tank truck Unloading arms separated from each other	2 3
1.8	Leak	Gasket, packing leak Metal failure (corrosion)	Acid spill in diked area	Vendor inspection and maintenance	4
1.9	Rupture	Gasket, packing blowout Metal failure (corrosion)	High level in the Acid unloading dike/sump (Item 3.1)	Vendor inspection and maintenance	4
		2.0 Line - Plant air line to acid delivery tank truck (dwg: 51D-4445-P-00579, P-25, Rev. 1/2)			
2.1	High flow		See high pressure		
2.2	Low/no flow		No consequence of interest		
2.3	Reverse/misdirected flow	No credible cause identified		Check valve in air line Air line terminates at top of tank dome Plant air pressure normally on line	

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HAZOP Table for AWWT Sulfuric Acid Operations (continued)

Item Number	Deviation	Causes	Consequences	Safeguards	Actions
		2.0 Line - Plant air line to acid delivery tank truck (continued)			
2.4	High temperature		No consequence of interest		
2.5	Low temperature		No consequence of interest		
2.6	High pressure	No credible cause of a safety consequence identified		Pressure regulated by PCV 163 PSV 161 opens at 15 psig	1
2.7	Low pressure		No consequence of interest		
2.8	High concentration of contaminants	Water or oil in plant air could react in tank truck--no safety consequence expected--tank should contain acid and reaction products			
2.9	Leak		No consequence of interest		
2.10	Rupture		No consequence of interest		

HAZOP Table for AWWT Sulfuric Acid Operations (continued)

Item Number	Deviation	Causes	Consequences	Safeguards	Actions
		3.0 Dike/sump - Acid unloading dike/sump (dwg: 51D-4445-P-00579, P-25, Rev. 1/2)			
3.1	High level	Rupture in the Acid delivery tank truck (Item 1.9) Rupture in the Acid unloading arm/piping from acid delivery tank truck to acid unloading pump (Item 6.10) Rupture in the Acid unloading pump bypass line (Item 8.10) Rupture in the Acid unloading pump (51-X136-PMP) (Item 7.2) Rupture in the Line from acid unloading pump to acid storage tank (Item 9.10)	Acid pumped to alum/acid spill sump for disposal (Item 29.1) Possibility for water and acid mixing--see high concentration of contaminants	Water drained from sump	5
3.2	Low level		No consequence of interest		
3.3	High temperature	Water and acid mixing (Item 3.5)	Acid vapor release	Water drained from sump before unloading	
3.4	Low temperature		No consequence of interest		
3.5	High concentration of contaminants	Rainwater in sump when acid spilled into sump (see high level) Rain fall while acid in sump following spill	High temperature (Item 3.3)	Water drained from sump before unloading	

HAZOP Table for AWWT Sulfuric Acid Operations (continued)

Item Number	Deviation	Causes	Consequences	Safeguards	Actions
4.0 Line - Line from acid unloading sump to East rain sump (dwg: 51D-4445-P-00579, P-25, Rev. 1/2 and 51D-4445-P-00580, P-27, Rev. 1/2)					
4.1	High flow	Block valve left open, acid spilled into sump (see high level in sump)	Acid to East rain sump, possible release of acid vapor	Operator training and procedures	
4.2	Low/no flow		No consequence of interest		
4.3	Reverse/misdirected flow	No credible cause identified			
4.4	High temperature		No consequence of interest		
4.5	Low temperature		No consequence of interest		
4.6	High pressure		No consequence of interest		
4.7	Low pressure		No consequence of interest		
4.8	High concentration of contaminants		See high flow		
4.9	Leak		No consequence of interest		
4.10	Rupture		No consequence of interest		

HAZOP Table for AWWT Sulfuric Acid Operations (continued)

Item Number	Deviation	Causes	Consequences	Safeguards	Actions
		5.0 Line - Line from acid unloading sump to acid/alum spill sump (dwg: 51D-4445-P-00579, P-25, Rev. 1/2)			
5.1	High flow	Block valve left open, acid spilled into sump (see high level in sump)	Unplanned transfer of acid to acid\alum sump, release of acid vapor if water or alum present in sump (Item 29.1)	Operator training and procedures	
5.2	Low/no flow		No consequence of interest		
5.3	Reverse/misdirected flow	No credible cause identified			
5.4	High temperature		No consequence of interest		
5.5	Low temperature		No consequence of interest		
5.6	High pressure		No consequence of interest		
5.7	Low pressure		No consequence of interest		
5.8	High concentration of contaminants		See high flow		
5.9	Leak		No consequence of interest	Gravity flow line, assumed empty	
5.10	Rupture		No consequence of interest	Gravity flow line, assumed empty	

HAZOP Table for AWWT Sulfuric Acid Operations (continued)

Item Number	Deviation	Causes	Consequences	Safeguards	Actions
	6.0 Line - Acid unloading arm/piping from acid delivery tank truck to acid unloading pump (dwg: 51D-4445-P-00579, P-25, Rev. 1/2)				
6.1	High flow		See high level in acid storage tank		
6.2	Low/no flow		No consequence of interest		
6.3	Reverse/misdirected flow	No credible cause identified			
6.4	High temperature	No credible cause identified		Acid normally cleared from line at end of unloading	7
6.5	Low temperature		No consequence of interest	Line insulated and heat traced	
6.6	High pressure	No credible cause identified		Acid normally cleared from line at end of unloading	7
6.7	Low pressure		No consequence of interest		
6.8	High concentration of contaminants		See high concentration of contaminants in tank truck		
6.9	Leak	Gasket, packing leak Metal failure (corrosion)	Acid spill in diked area	Inspection Diked containment Hydrotesting Operator present during unloading	

HAZOP Table for AWWT Sulfuric Acid Operations (continued)

Item Number	Deviation	Causes	Consequences	Safeguards	Actions
		6.0 Line - Acid unloading arm/piping from acid delivery tank truck to acid unloading pump (continued)			
6.10	Rupture	Gasket, packing blowout Metal failure (corrosion)	High level in the Acid unloading dike/sump (Item 3.1)	Inspection Diked containment Hydrotesting Operator present during unloading	
		7.0 Pump - Acid unloading pump (51-X136-PMP) (dwg: 51D-4445-P-00579, P-25, Rev. 1/2)			
7.1	Leak	Seal,gasket, packing leak Metal failure (corrosion) Low/no flow in the Line from acid unloading pump to acid storage tank (Item 9.2)	Acid spill in diked area	Inspection Diked containment Hydrotesting Operator present during unloading	
7.2	Rupture	Gasket, packing blowout Metal failure (corrosion)	High level in the Acid unloading dike/sump (Item 3.1)	Inspection Diked containment Hydrotesting Operator present during unloading	

HAZOP Table for AWWT Sulfuric Acid Operations (continued)

Item Number	Deviation	Causes	Consequences	Safeguards	Actions
		8.0 Line - Acid unloading pump bypass line (dwg: 51D-4445-P-00579, P-25, Rev. 1/2)			
8.1	High flow		See high level in acid storage tank		
8.2	Low/no flow		No consequence of interest		
8.3	Reverse/misdirected flow		No consequence of interest		
8.4	High temperature	No credible cause identified		Acid normally cleared from line at end of unloading	7
8.5	Low temperature		No consequence of interest	Line insulated and heat traced	
8.6	High pressure	No credible cause identified		Acid normally cleared from line at end of unloading	7
8.7	Low pressure		No consequence of interest		
8.8	High concentration of contaminants		See high concentration of contaminants in tank truck		
8.9	Leak	Gasket, packing leak Metal failure (corrosion)	Acid spill in diked area	Inspection Diked containment Hydrotesting Operator present during unloading	

HAZOP Table for AWWT Sulfuric Acid Operations (continued)

Item Number	Deviation	Causes	Consequences	Safeguards	Actions
		8.0 Line - Acid unloading pump bypass line (continued)			
8.10	Rupture	Gasket, packing blowout Metal failure (corrosion)	High level in the Acid unloading dike/sump (Item 3.1)	Inspection Diked containment Hydrotesting Operator present during unloading	
		9.0 Line - Line from acid unloading pump to acid storage tank (dwg: 51D-4445-P-00579, P-25, Rev. 1/2)			
9.1	High flow		See high level in acid storage tank		
9.2	Low/no flow	FV 907 closed while pump running	Leak in the Acid unloading pump (51-X136-PMP) (Item 7.1)	Operator present during unloading	
9.3	Reverse/misdirected flow	No credible cause identified			
9.4	High temperature	No credible cause identified		Acid normally cleared from line at end of unloading	7
9.5	Low temperature		No consequence of interest	Line insulated and heat traced	
9.6	High pressure	No credible cause identified		Acid normally cleared from line at end of unloading	7
9.7	Low pressure		No consequence of interest		
9.8	High concentration of contaminants		See high concentration of contaminants in tank truck		

HAZOP Table for AWWT Sulfuric Acid Operations (continued)

Item Number	Deviation	Causes	Consequences	Safeguards	Actions
		9.0 Line - Line from acid unloading pump to acid storage tank (continued)			
9.9	Leak	Gasket, packing leak Metal failure (corrosion)	Acid spill in diked area	Inspection Diked containment Hydrotesting Operator present during unloading	
9.10	Rupture	Gasket, packing blowout Metal failure (corrosion)	High level in the Acid unloading dike/sump (Item 3.1) High level in the Acid storage tank dike/sump (Item 12.1)	Inspection Diked containment Hydrotesting Operator present during unloading	
		10.0 Vessel - Acid storage tank (51-X137-TNK) (dwg: 51D-4445-P-00579, P-25, Rev. 1/2)			
10.1	High level	LI 169 failure LIT 169 failure Too much acid on truck	Acid spill through vent line to diked area (Item 12.1)	Operator present during unloading Acid use monitored	6
10.2	Low level		No consequence of interest		
10.3	High temperature	See high concentration of contaminants in tank truck High concentration of contaminants (Item 10.7)	Release of acid vapor		
10.4	Low temperature		No consequence of interest		

HAZOP Table for AWWT Sulfuric Acid Operations (continued)

Item Number	Deviation	Causes	Consequences	Safeguards	Actions
		10.0 Vessel - Acid storage tank (51-X137-TNK) (continued)			
10.5	High pressure		See high concentration of contaminants in acid delivery tank truck	Vent line through PVVV 168 Rupture disk (PSE 693)	
10.6	Low pressure		No consequence of interest	Tank rated for full vacuum	6
10.7	High concentration of contaminants	See high concentration of contaminants in delivery truck Reverse/misdirected flow in the Spill pump discharge line to East rain sump (Item 32.3) Reverse/misdirected flow in the Backflush line to East rain sump (Item 33.3) Reverse/misdirected flow in the Line for transfering contents of acid/alum spill sump to alum storage tank (Item 34.3) High concentration of contaminants in the Line for transfering contents of acid/alum spill sump to acid storage tank (Item 35.8)	High temperature (Item 10.3)		
10.8	Leak	Gasket, packing leak Metal failure (corrosion)	Acid spill in diked area	Inspection Diked containment Hydrotesting	

HAZOP Table for AWWT Sulfuric Acid Operations (continued)

Item Number	Deviation	Causes	Consequences	Safeguards	Actions
		10.0 Vessel - Acid storage tank (51-X137-TNK) (continued)			
10.9	Rupture	Gasket, packing blowout Metal failure (corrosion)	High level in the Acid storage tank dike/sump (Item 12.1)	Inspection Diked containment Hydrotesting	
		11.0 Line - Acid storage tank vent line/demister (dwg: 51D-4445-P-00579, P-25, Rev. 1/2)			
11.1	High flow		See high level in the storage tank		
11.2	Low/no flow		No consequence of interest	Tank rated for full vacuum Rupture disk on tank (PSE 693)	6
11.3	Reverse/misdirected flow		No consequence of interest		
11.4	High temperature		No consequence of interest		
11.5	Low temperature		No consequence of interest		
11.6	High pressure		No consequence of interest		
11.7	Low pressure		No consequence of interest		
11.8	High concentration of contaminants		No consequence of interest		
11.9	Leak		No consequence of interest		
11.10	Rupture		No consequence of interest		

HAZOP Table for AWWT Sulfuric Acid Operations (continued)

Item Number	Deviation	Causes	Consequences	Safeguards	Actions
		12.0 Dike/sump - Acid storage tank dike/sump (dwg: 51D-4445-P-00579, P-25, Rev. 1/2)			
12.1	High level	Rupture in the Line from acid unloading pump to acid storage tank (Item 9.10) High level in the Acid storage tank (51-X137-TNK) (Item 10.1) Rupture in the Acid storage tank (51-X137-TNK) (Item 10.9)	Acid pumped to alum/acid spill sump for disposal (Item 29.1) Possibility for water and acid mixing--see high concentration of contaminants	Water drained from sump	5
12.2	Low level		No consequence of interest		
12.3	High temperature	Water and acid mixing (Item 12.5)	Acid vapor release	Water drained from sump	
12.4	Low temperature		No consequence of interest		
12.5	High concentration of contaminants	Rainwater in sump when acid spilled into sump (see high level) Rain fall while acid in sump following spill	High temperature (Item 12.3)	Water drained from sump	

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HAZOP Table for AWWT Sulfuric Acid Operations (continued)

Item Number	Deviation	Causes	Consequences	Safeguards	Actions
13.0 Line - Line from acid storage tank sump to East rain sump (dwg: 51D-4445-P-00579, P-25, Rev. 1/2 and 51D-4445-P-00580, P-27, Rev. 1/2)					
13.1	High flow	Block valve left open, acid spilled into sump (see high level in sump)	Acid to East rain sump, possible release of acid vapor	Operator training and procedures	
13.2	Low/no flow		No consequence of interest		
13.3	Reverse/misdirected flow	No credible cause identified			
13.4	High temperature		No consequence of interest		
13.5	Low temperature		No consequence of interest		
13.6	High pressure		No consequence of interest		
13.7	Low pressure		No consequence of interest		
13.8	High concentration of contaminants		See high flow		
13.9	Leak		No consequence of interest		
13.10	Rupture		No consequence of interest		

HAZOP Table for AWWT Sulfuric Acid Operations (continued)

Item Number	Deviation	Causes	Consequences	Safeguards	Actions
14.0	Line - Line from acid storage tank sump to acid/alum spill sump (dwg: 51D-4445-P-00579, P-25, Rev. 1/2)				
14.1	High flow	Block valve left open, acid spilled into sump (see high level in sump)	Unplanned transfer of acid to acid\alum sump, release of acid vapor if water or alum present in sump (Item 29.1)	Operator training and procedures	
14.2	Low/no flow		No consequence of interest		
14.3	Reverse/misdirected flow	No credible cause identified			
14.4	High temperature		No consequence of interest		
14.5	Low temperature		No consequence of interest		
14.6	High pressure		No consequence of interest		
14.7	Low pressure		No consequence of interest		
14.8	High concentration of contaminants		See high flow		
14.9	Leak		No consequence of interest	Gravity flow line, assumed empty	
14.10	Rupture		No consequence of interest	Gravity flow line, assumed empty	

HAZOP Table for AWWT Sulfuric Acid Operations (continued)

Item Number	Deviation	Causes	Consequences	Safeguards	Actions
		15.0 Line - Line from acid storage tank to acid transfer pumps (dwg: 51D-4445-P-00579, P-25, Rev. 1/2)			
15.1	High flow		See high flow downstream		
15.2	Low/no flow		No consequence of interest		
15.3	Reverse/misdirected flow	No credible cause identified		Check valves Diaphragm pumps	
15.4	High temperature		No consequence of interest	Pump suction and discharge valves will normally be open	
15.5	Low temperature		No consequence of interest		
15.6	High pressure	No credible cause identified		Pump suction and discharge valves will normally be open	
15.7	Low pressure		No consequence of interest		
15.8	High concentration of contaminants		No consequence of interest		
15.9	Leak	Gasket, packing leak Metal failure (corrosion)	Acid spill in diked area	Inspection Diked containment Hydrotesting	
15.10	Rupture	Gasket, packing blowout Metal failure (corrosion)	Acid spill in diked area	Inspection Diked containment Hydrotesting Check valves on pump discharges	

HAZOP Table for AWWT Sulfuric Acid Operations (continued)

Item Number	Deviation	Causes	Consequences	Safeguards	Actions
		16.0 Pump - Acid transfer pumps (51-X138-PMP and 51-X139-PMP) (dwg: 51D-4445-P-00579, P-25, Rev. 1/2)			
16.1	Leak	Seal,gasket, packing leak Metal failure (corrosion)	Acid spill in diked area	Inspection Diked containment Hydrotesting	
16.2	Rupture	Gasket, packing blowout Metal failure (corrosion)	Acid spill in diked area	Inspection Diked containment Hydrotesting Check valves on pump discharges	
		17.0 Line - Discharge line from acid transfer pumps to acid feed tank (dwg: 51D-4445-P-00579, P-25, Rev. 1/2 and 51D-4445-P-00580, P-27, Rev. 1/2)			
17.1	High flow	LI 192 failure LIT 192 failure FV 173 control failure	High level in the Acid feed tank (54-X148-TNK) (Item 18.1)	High level alarm on LI 192 (may be defeated) Low level alarm on LI 192 alerts operator to transfer in progress (may be defeated)	8
17.2	Low/no flow		No consequence of interest		
17.3	Reverse/misdirected flow		See high flow to ion exchange system		
17.4	High temperature		No consequence of interest		
17.5	Low temperature		No consequence of interest		
17.6	High pressure	No credible cause identified			

HAZOP Table for AWWT Sulfuric Acid Operations (continued)

Item Number	Deviation	Causes	Consequences	Safeguards	Actions
		17.0 Line - Discharge line from acid transfer pumps to acid feed tank (continued)			
17.7	Low pressure		No consequence of interest		
17.8	High concentration of contaminants		No consequence of interest		
17.9	Leak	Gasket, packing leak Metal failure (corrosion)	Acid spill in diked area, on ground, or in building	Inspection Diked containment for part of the line Hydrotesting	
17.10	Rupture	Gasket, packing blowout Metal failure (corrosion)	Acid spill in diked area, on ground, or in building	Inspection Diked containment for part of the line Hydrotesting	
		18.0 Vessel - Acid feed tank (54-X148-TNK) (dwg: 51D-4445-P-00580, P-27, Rev. 1/2)			
18.1	High level	High flow in the Discharge line from acid transfer pumps to acid feed tank (Item 17.1)	Acid spill through overflow line to diked area (Item 20.1)	High level alarm on LI 192 (may be defeated) Low level alarm on LI 192 alerts operator to transfer in progress (may be defeated)	8
18.2	Low level		No consequence of interest		
18.3	High temperature	High concentration of contaminants (Item 18.7)	Release of acid vapor from tank vent	FV 295 and FV 695 close on low flow in the associated wastewater lines	9
18.4	Low temperature		No consequence of interest		

HAZOP Table for AWWT Sulfuric Acid Operations (continued)

Item Number	Deviation	Causes	Consequences	Safeguards	Actions
		18.0 Vessel - Acid feed tank (54-X148-TNK) (continued)			
18.5	High pressure		See high temperature		
18.6	Low pressure	No credible cause identified		4-inch vent line with no valves	
18.7	High concentration of contaminants	Reverse/misdirected flow in the Line from acid feed tank, through and including acid pumps (51-X149-PMP and 51-X150-PMP), to acid mixers (Item 23.3)	High temperature (Item 18.3)	FV 295 and FV 695 close on low flow in the associated wastewater lines	9
18.8	Leak	Gasket, packing leak Metal failure (corrosion)	Acid spill in diked area	Inspection Diked containment Hydrotesting	
18.9	Rupture	Gasket, packing blowout Metal failure (corrosion)	High level in the Acid feed tank dike/sump (Item 20.1)	Inspection Diked containment Hydrotesting	

HAZOP Table for AWWT Sulfuric Acid Operations (continued)

Item Number	Deviation	Causes	Consequences	Safeguards	Actions
19.0 Line - Vent line from acid feed tank to acid/alum spill sump (dwg: 51D-4445-P-00580, P-27, Rev. 1/2 and 51D-4445-P-00579, P-25, Rev. 1/2)					
19.1	High flow		See high temperature in the acid feed tank		
19.2	Low/no flow		No consequence of interest		
19.3	Reverse/misdirected flow		No consequence of interest		
19.4	High temperature		No consequence of interest		
19.5	Low temperature		No consequence of interest		
19.6	High pressure		No consequence of interest		
19.7	Low pressure		No consequence of interest		
19.8	High concentration of contaminants		No consequence of interest		
19.9	Leak	Gasket, packing leak Metal failure (corrosion)	Possible acid vapor release in building	Inspection Hydrotesting	
19.10	Rupture	Gasket, packing blowout Metal failure (corrosion)	Possible acid vapor release in building	Inspection Hydrotesting	

HAZOP Table for AWWT Sulfuric Acid Operations (continued)

Item Number	Deviation	Causes	Consequences	Safeguards	Actions
		20.0 Dike/sump - Acid feed tank dike/sump (dwg: 51D-4445-P-00580, P-27, Rev. 1/2)			
20.1	High level	Rupture in the Acid feed tank (54-X148-TNK) (Item 18.9) High level in the Acid feed tank (54-X148-TNK) (Item 18.1)	No significant consequence expected since the dike/sump is inside and no water should be present		
20.2	Low level		No consequence of interest		
20.3	High temperature	No credible cause identified			
20.4	Low temperature		No consequence of interest		
20.5	High concentration of contaminants	No credible cause identified			
		21.0 Line - Line from acid feed tank sump to trench drain in building 51 (dwg: 51D-4445-P-00580, P-27, Rev. 1/2)			
21.1	High flow	Block valve left open, acid spilled into sump (see high level in sump)	Acid to trench drain inside building 51, possible release of acid vapor	Operator training and procedures	
21.2	Low/no flow		No consequence of interest		
21.3	Reverse/misdirected flow	No credible cause identified			
21.4	High temperature		No consequence of interest		
21.5	Low temperature		No consequence of interest		
21.6	High pressure		No consequence of interest		

HAZOP Table for AWWT Sulfuric Acid Operations (continued)

Item Number	Deviation	Causes	Consequences	Safeguards	Actions
		21.0 Line - Line from acid feed tank sump to trench drain in building 51 (continued)			
21.7	Low pressure		No consequence of interest		
21.8	High concentration of contaminants		See high flow		
21.9	Leak		No consequence of interest		
21.10	Rupture		No consequence of interest		
22.0 Line/pump - Line from acid feed tank sump, through and including spill pump (51-X197-PMP) and duplex filter, to acid feed tank feed line (dwg: 51D-4445-P-00580, P-27, Rev. 1/2 and 51D-4445-P-00574, P-19, Rev. 1/2)					
22.1	High flow		No consequence of interest		
22.2	Low/no flow		No consequence of interest		
22.3	Reverse/misdirected flow	Valve misalignment	Acid to alum storage tank, possible release of acid vapor	Operator training and procedures	11
22.4	High temperature		No consequence of interest		
22.5	Low temperature		No consequence of interest		
22.6	High pressure		No consequence of interest		
22.7	Low pressure		No consequence of interest		
22.8	High concentration of contaminants		Water or alum in lines could result in local high temperature, but no safety consequence is expected		11

HAZOP Table for AWWT Sulfuric Acid Operations (continued)

Item Number	Deviation	Causes	Consequences	Safeguards	Actions
22.0 Line/pump - Line from acid feed tank sump, through and including spill pump (51-X197-PMP) and duplex filter, to acid feed tank feed line (continued)					
22.9	Leak	Gasket, packing leak Metal failure (corrosion)	Acid spill in diked area, on ground, or in building	Inspection Diked containment for part of the line Hydrotesting	
22.10	Rupture	Gasket, packing blowout Metal failure (corrosion)	Acid spill in diked area, on ground, or in building	Inspection Diked containment Hydrotesting	
23.0 Line/pump - Line from acid feed tank, through and including acid pumps (51-X149-PMP and 51-X150-PMP), to acid mixers (dwg: 51D-4445-P-00580, 582, and 589, P-27, P-30, and P-39, Rev. 1/2)					
23.1	High flow	FV 295 or FV 695 sticks open FIC 295 or FIC 695 failure	Possible release of acid vapor from pH mixing/recycle tank if allowed to continue too long	pH override on proportional flow controller pH alarm Flow indication in DCS	
23.2	Low/no flow		See high pressure		
23.3	Reverse/misdirected flow	PCV 310 or PCV 330 sticks closed	High concentration of contaminants in the Acid feed tank (54-X148-TNK) (Item 18.7)	FV 295 and FV 695 close on low flow in the associated wastewater lines	9
23.4	High temperature		See reverse flow		
23.5	Low temperature		No consequence of interest		

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HAZOP Table for AWWT Sulfuric Acid Operations (continued)

Item Number	Deviation	Causes	Consequences	Safeguards	Actions
23.0 Line/pump - Line from acid feed tank, through and including acid pumps (51-X149-PMP and 51-X150-PMP), to acid mixers (continued)					
23.6	High pressure	Line blocked and low/no flow in the Acid pump discharge pressure relief line/valve (Item 25.2)	Leak (Item 23.9) See reverse flow		
23.7	Low pressure		No consequence of interest		
23.8	High concentration of contaminants		See reverse flow		
23.9	Leak	Gasket, packing leak Metal failure (corrosion) High pressure (Item 23.6)	Acid spill in building	Inspection Diked containment for part of the line Hydrotesting	
23.10	Rupture	Gasket, packing blowout Metal failure (corrosion)	Acid spill in building	Inspection Diked containment Hydrotesting	
24.0 Line - Wastewater lines through acid mixers (51-X203-MXR and 51-X328-MXR) (dwg: 51D-4445-P-00582, P-30, Rev. 1/2 and 51D-4445-P-00589, P-30, Rev. 1/2)					
24.1	High flow		No consequence of interest		
24.2	Low/no flow	Loss of wastewater flow	Possible release of acid vapor from pH mixing/recycle tank if acid flow is not shut off for too long--see high flow in the acid lines See reverse flow in the acid lines to the mixers	pH override on proportional flow controller pH alarm Flow indication in DCS Proportional flow controller should shut off acid flow	

HAZOP Table for AWWT Sulfuric Acid Operations (continued)

Item Number	Deviation	Causes	Consequences	Safeguards	Actions
		24.0 Line - Wastewater lines through acid mixers (51-X203-MXR and 51-X328-MXR) (continued)			
24.3	Reverse/misdirected flow		See reverse flow in the acid lines to the mixers		
24.4	High temperature		See high acid flow		
24.5	Low temperature		No consequence of interest		
24.6	High pressure		See high acid flow		
24.7	Low pressure		No consequence of interest		
24.8	High concentration of contaminants		See high acid flow		
24.9	Leak		No safety consequence expected		
24.10	Rupture		No safety consequence expected		
		25.0 Line - Acid pump discharge pressure relief line/valve (dwg: 51D-4445-P-00580, P-27, Rev. 1/2)			
25.1	High flow		See reverse flow from mixers		
25.2	Low/no flow	PCV 194 sticks closed	High pressure in the Line from acid feed tank, through and including acid pumps (51-X149-PMP and 51-X150-PMP), to acid mixers (Item 23.6)		
25.3	Reverse/misdirected flow	No credible cause identified			
25.4	High temperature		No consequence of interest		

HAZOP Table for AWWT Sulfuric Acid Operations (continued)

Item Number	Deviation	Causes	Consequences	Safeguards	Actions
		25.0 Line - Acid pump discharge pressure relief line/valve (continued)			
25.5	Low temperature		No consequence of interest		
25.6	High pressure		See high pressure in pump discharge line		
25.7	Low pressure		No consequence of interest		
25.8	High concentration of contaminants		See high flow		
25.9	Leak	Gasket, packing leak Metal failure (corrosion)	Acid spill in building	Inspection Diked containment for part of the line Hydrotesting	
25.10	Rupture	Gasket, packing blowout Metal failure (corrosion)	Acid spill in building	Inspection Diked containment Hydrotesting	

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HAZOP Table for AWWT Sulfuric Acid Operations (continued)

Item Number	Deviation	Causes	Consequences	Safeguards	Actions
	26.0 Line - Line from acid tanks to mix tanks (dwg: 51D-4445-P-00580, P-27, Rev. 1/2 and 51D-4445-P-00576, P-21, Rev. 1)				
26.1	High flow	No credible cause identified		Line used infrequently to acid wash the mix tanks Valve locks controlled by supervisor Operator training and procedures	11
26.2	Low/no flow		No consequence of interest		
26.3	Reverse/misdirected flow		See high flow		
26.4	High temperature		No consequence of interest		
26.5	Low temperature		No consequence of interest		
26.6	High pressure		See high pressure in line to mixers		
26.7	Low pressure		No consequence of interest		
26.8	High concentration of contaminants		No consequence of interest		
26.9	Leak		See leak in line to mixers		
26.10	Rupture		See rupture in line to mixers		

HAZOP Table for AWWT Sulfuric Acid Operations (continued)

Item Number	Deviation	Causes	Consequences	Safeguards	Actions
27.0	Line - Line from acid transfer pumps to ion exchange recycle tanks (dwg: 51D-4445-P-00579, 583, P-25, P-32, Rev. 1/2 and 51D-5500-P-00811, 812, Rev. F)				
27.1	High flow	Flow started with low level in recycle tank	High temperature, possible acid vapor release from tank	Operator training and procedures Temperature alarms on tank recycle lines	10 11
27.2	Low/no flow		No consequence of interest		
27.3	Reverse/misdirected flow	No credible cause identified		Acid lines end at tops of tanks Tanks have overflow lines Tanks are not pressurized	
27.4	High temperature		No consequence of interest		
27.5	Low temperature		No consequence of interest		
27.6	High pressure		No consequence of interest		
27.7	Low pressure		No consequence of interest		
27.8	High concentration of contaminants		No consequence of interest		
27.9	Leak	Gasket, packing leak Metal failure (corrosion)	Acid spill on ground or in building	Inspection Hydrotesting	
27.10	Rupture	Gasket, packing blowout Metal failure (corrosion)	Acid spill on ground or in building	Inspection Hydrotesting	

HAZOP Table for AWWT Sulfuric Acid Operations (continued)

Item Number	Deviation	Causes	Consequences	Safeguards	Actions
		28.0 Line - Line from acid storage tank sump to spill pumps (dwg: 51D-4445-P-00579, P-25, Rev. 1/2)			
28.1	High flow		No consequence of interest		
28.2	Low/no flow		No consequence of interest		
28.3	Reverse/misdirected flow	No credible cause identified			
28.4	High temperature		No consequence of interest		
28.5	Low temperature		No consequence of interest		
28.6	High pressure		No consequence of interest		
28.7	Low pressure		No consequence of interest		
28.8	High concentration of contaminants		See high concentration of contaminants downstream of pumps		
28.9	Leak		No consequence of interest	Air would leak in when line in use	
28.10	Rupture		No consequence of interest	Air inleakge would prevent transfer	

HAZOP Table for AWWT Sulfuric Acid Operations (continued)

Item Number	Deviation	Causes	Consequences	Safeguards	Actions
		29.0 Sump - Acid/alum spill sump (dwg: 51D-4445-P-00579, P-25, Rev. 1/2)			
29.1	High level	High level in the Acid unloading dike/sump (Item 3.1) High flow in the Line from acid unloading sump to acid/alum spill sump (Item 5.1) High level in the Acid storage tank dike/sump (Item 12.1) High flow in the Line from acid storage tank sump to acid/alum spill sump (Item 14.1)	Acid to be transferred to storage tank, see misdirected flow downstream of spill pumps		
29.2	Low level		No consequence of interest		
29.3	High temperature	Acid introduced into sump with water present Reverse/misdirected flow in the Line from acid/alum spill sump to spill pumps (Item 30.3)	Possible release of acid vapor	Operator training and procedures	5 11
29.4	Low temperature		No consequence of interest		
29.5	High concentration of contaminants		See high temperature		

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HAZOP Table for AWWT Sulfuric Acid Operations (continued)

Item Number	Deviation	Causes	Consequences	Safeguards	Actions
		30.0 Line - Line from acid/alum spill sump to spill pumps (dwg: 51D-4445-P-00579, P-25, Rev. 1/2)			
30.1	High flow		No consequence of interest		
30.2	Low/no flow		No consequence of interest		
30.3	Reverse/misdirected flow	Valve misalignment when transferring acid from storage tank sump	High temperature in the Acid/alum spill sump (Item 29.3)	Operator training and procedures	5 11
30.4	High temperature		No consequence of interest		
30.5	Low temperature		No consequence of interest		
30.6	High pressure		No consequence of interest		
30.7	Low pressure		No consequence of interest		
30.8	High concentration of contaminants		See high concentration of contaminants downstream of pumps		
30.9	Leak		No consequence of interest	Air would leak in when line in use	
30.10	Rupture		No consequence of interest	Air inleakge would prevent transfer	

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HAZOP Table for AWWT Sulfuric Acid Operations (continued)

Item Number	Deviation	Causes	Consequences	Safeguards	Actions
		31.0 Pump - Spill pumps (51-X140-PMP and 51-X143-PMP) (dwg: 51D-4445-P-00579, P-25, Rev. 1/2)			
31.1	Leak	Seal,gasket, packing leak Metal failure (corrosion)	Acid spill on ground	Inspection Hydrotesting	
31.2	Rupture	Gasket, packing blowout Metal failure (corrosion)	Acid spill on ground	Inspection Hydrotesting Check valves on pump discharges	
		32.0 Line - Spill pump discharge line to East rain sump (dwg: 51D-4445-P-00579, P-25, Rev. 1/2 and 51D-4445-P-00580, P-27, Rev. 1/2)			
32.1	High flow		No consequence of interest		
32.2	Low/no flow		No consequence of interest		
32.3	Reverse/misdirected flow	Valve misalignment	High concentration of contaminants in the Acid storage tank (51-X137-TNK) (Item 10.7)	Operator training and procedures	11
32.4	High temperature		No consequence of interest		
32.5	Low temperature		No consequence of interest		
32.6	High pressure		No consequence of interest		
32.7	Low pressure		No consequence of interest		
32.8	High concentration of contaminants	Valve misalignment	Acid pumped to east rain sump, possible release of acid vapor	Operator training and procedures	11

HAZOP Table for AWWT Sulfuric Acid Operations (continued)

Item Number	Deviation	Causes	Consequences	Safeguards	Actions
		32.0 Line - Spill pump discharge line to East rain sump (continued)			
32.9	Leak		No consequence of interest		
32.10	Rupture		No consequence of interest		
		33.0 Line - Backflush line to East rain sump (dwg: 51D-4445-P-00579, P-25, Rev. 1/2 and 51D-4445-P-00580, P-27, Rev. 1/2)			
33.1	High flow		No consequence of interest		
33.2	Low/no flow		No consequence of interest		
33.3	Reverse/misdirected flow	Valve misalignment	High concentration of contaminants in the Acid storage tank (51-X137-TNK) (Item 10.7)	Operator training and procedures	11
33.4	High temperature		No consequence of interest		
33.5	Low temperature		No consequence of interest		
33.6	High pressure		No consequence of interest		
33.7	Low pressure		No consequence of interest		
33.8	High concentration of contaminants	Valve misalignment	Acid pumped to east rain sump, possible release of acid vapor	Operator training and procedures	11
33.9	Leak		No consequence of interest		
33.10	Rupture		No consequence of interest		

HAZOP Table for AWWT Sulfuric Acid Operations (continued)

Item Number	Deviation	Causes	Consequences	Safeguards	Actions
34.0 Line - Line for transfering contents of acid/alum spill sump to alum storage tank (dwg: 51D-4445-P-00579, P-25, Rev. 1/2 and 51D-4445-P-00574, P-19, Rev. 1/2)					
34.1	High flow		No consequence of interest		
34.2	Low/no flow		No consequence of interest		
34.3	Reverse/misdirected flow	Valve misalignment	High concentration of contaminants in the Acid storage tank (51-X137-TNK) (Item 10.7)	Operator training and procedures	11
34.4	High temperature		No consequence of interest		
34.5	Low temperature		No consequence of interest		
34.6	High pressure		No consequence of interest		
34.7	Low pressure		No consequence of interest		
34.8	High concentration of contaminants	Valve misalignment	Acid pumped to alum storage tank, possible release of acid vapor	Operator training and procedures	11
34.9	Leak		No safety consequence expected		
34.10	Rupture		No safety consequence expected		

HAZOP Table for AWWT Sulfuric Acid Operations (continued)

Item Number	Deviation	Causes	Consequences	Safeguards	Actions
35.0 Line - Line for transfering contents of acid/alum spill sump to acid storage tank (dwg: 51D-4445-P-00579, P-25, Rev. 1/2)					
35.1	High flow		No consequence of interest		
35.2	Low/no flow		No consequence of interest		
35.3	Reverse/misdirected flow	Valve misalignment	Acid pumped to east rain sump, possible release of acid vapor Acid pumped to alum storage tank, possible release of acid vapor	Operator training and procedures	11
35.4	High temperature		No consequence of interest		
35.5	Low temperature	Failure of heat tracing during cold weather	Freezing, rupture of line if water in line (Item 35.10)		
35.6	High pressure		No consequence of interest		
35.7	Low pressure		No consequence of interest		
35.8	High concentration of contaminants	Valve misalignment	High concentration of contaminants in the Acid storage tank (51-X137-TNK) (Item 10.7)	Operator training and procedures	11
35.9	Leak	Gasket, packing leak Metal failure (corrosion)	Acid spill in diked area or on ground	Inspection Diked containment for part of the line Hydrotesting	

HAZOP Table for AWWT Sulfuric Acid Operations (continued)

Item Number	Deviation	Causes	Consequences	Safeguards	Actions
		35.0 Line - Line for transfering contents of acid/alum spill sump to acid storage tank (continued)			
35.10	Rupture	Low temperature (Item 35.5) Gasket, packing blowout Metal failure (corrosion)	Acid spill in diked area or on ground	Inspection Diked containment for part of the line Hydrotesting	

APPENDIX E

HAZARD CLASSIFICATION AND CONSEQUENCE ANALYSIS

E.1 Objectives

The objective of this appendix is to determine the hazard categorization, hazard classification, and consequences of accidents for the process chemicals and uranium present in the Advance Wastewater Treatment (AWWT) facility.

E.2 Background and Approach

In the AWWT facility wastewaters are treated to remove the uranium contamination. Treatment processes include pH adjustment, chemical treatment, filtration, carbon adsorption, and ion exchange treatment. The chemicals and uranium contaminated wastewaters present the material hazards.

The primary concern with the AWWT facility is the inventory itself. To determine the hazard baseline documentation needed DOE-EM-STD-5502 (Ref E6.1) was used. The hazard categorization is based on a uranium inventory comparison with DOE-STD-1027-92 (Ref. E6.2). Hazard classification, performed once the facility's radiological hazard category is determined, is based on the guidance of WSRC-MS-92-206 (Ref E6.3). The accident analysis examines the consequences of one or all process equipment vessels or storage tanks being released due to accident conditions. The accidents are selected to provide bounding consequences for both chemical and radiological releases.

E.2.1 Earthquake

The earthquake scenario is based on an earthquake at the FEMP which results in the release of the entire AWWT inventory. All project related facilities are assumes to fail. The tanks release their contents from a height of 3 meters. From DOE-STD-1020-94, the lower end of a severe earthquake for a hazard category 3 (Performance Category 2) facility is $0.13g_a$ with an exceedance frequency of 1E-3 earthquakes/year. However, the UCRL-15910, Rev 1 earthquake frequency of 1.8E-3 was conservatively used in the analysis.

E.2.2 High Winds and Tornado

High Winds and Tornado are assumed to affect the entire site. Therefore, they are assumed to cause a common mode failure of all AWWT tanks. All tanks are overturned, or ruptured, and spill their entire contents. The High Winds disperse the waste water. All project related facilities are assumed to fail.

<u>High Winds</u>

Based on DOE-STD-1020-94, a High Wind event is 70 miles per hour. The meteorology for the high wind event is Pasquill Stability Class A at 31 m/s (70 mph) for High Winds based on Reference E.7.4.

The 70 mph high winds exceedance frequency shown on page 3-4 of DOE-STD-1020-94 is 2.0E-2. However, the UCRL-15910, Rev 1. earthquake frequency of 2.5E-2 was conservatively used in the analysis.

Tornado

Note that DOE-STD-1020-94 does not require an evaluation of tornados. The meteorology for the Tornado event is Pasquill Stability Class A at 62 m/s (139 mph) for Tornado based on Reference E.7.4. UCRL-15910, Rev 1 earthquake frequency of 7.6E-4 was conservatively used in the analysis.

E 2.3 AWWT Spill

The AWWT spill scenario is based on a variety of initiators including:

1) a blockage in transfer lines
2) improper valve alignments
3) failure of a valve
4) failure of multiple engineered controls
5) leakage/pipe break around pump discharge and flanged connections

The frequency of this accident is qualitatively evaluated to be "Unlikely" and uses a point estimate of 1.0E-3 events per year.

E.3 Assumptions

E3.1 Uranium concentrations for specific influent wastewaters, i.e., process wastewater and stormwater/groundwater, are assumed. The values assumed are greater than the observed U concentration used in the jar testing for optimization of clarifier operation. Therefore, assumed values were used in the design of the AWWT for process equipment loading.

E3.2 The entire inventory is assumed to be at risk in the earthquake and high wind accidents. All other accidents assume the tank with the greatest inventory of uranium or chemical, i.e., bounding event, is released.

E3.3 Dilution Factors for the hazard categorization are based on the conditions presented in Reference E6.2. No credit is taken for plume meander or building wake effects in the hazards analysis. (Ref.E6.2)

E3.4 The enrichment of uranium present in the AWWT is assumed to be 1 percent by weight.

E3.5 All releases are modeled with a ground level release height.

E3.6 The wind direction is conservatively assumed to not waver for accident durations shorter than 8 hours.

E.4 Calculations

There are three separate calculations - determination of Hazard Category (4.1), Hazard Classification (4.2), and Accident Consequences (4.3). An inventory was developed for the uranium and chemical hazards. (See Appendix H.) The inventory is then used to determine a concentration or dose that is compared to the appropriate criteria. Refer to the individual calculation sections below for the appropriate criteria. The Airborne Release Fraction (ARF) is used for both calculations 4.2 and 4.3. A summary of release parameters for the hazard classification scenarios reviewed are listed below.

Table E-1 - Summary of Release Parameters

Scenario	Chemical	Percent Released (RM)	Airborne Release Fraction (ARF)	Respirable Fraction (RF)	Source
Earthquake	NaOH	100	2.19E-06	1	Note 1
	H2SO4	100	1.98E-07	1	Note 1
	Alum	100	3.90E-06	1	Note 1
High wind	NaOH	100	1.00E-02	1	Note 2
	H2SO4	100	1.00E-03	1	Note 3
	Alum	100	1.00E-02	1	Note 2
Tornado	NaOH	100	1.00E-02	1	Note 2
	H2SO4	100	1.00E-03	1	Note 3
	Alum	100	1.00E-02	1	Note 2
Spill	NaOH	100	1.00E-06	1	Note 1
	H2SO4	100	9.95E-08	1	Note 1
	Alum	100	1.96E-06	1	Note 1

Notes
1. Due to the differing physical properties of the chemicals, used equation 4.59 for liquid spills, from section 4.4.2.2 of NUREG-1320 (Ref. E6.4)
2. SP-A-01-013 (Ref. E6.5)
3. Due to the high viscosity of concentrated H2SO4 it is less dispersible (Ref. E6.4)

E.4.1 Determination of Hazard Category

The inventories of uranium (see Attachment 1 Table 2) at risk are based on Appendix H. The inventories are summed for the process equipment and compared in Table 6 to criteria in DOE-STD-1027-92 Attachment 1 (Ref. E6.2).

E.4.2 Determination of Hazard Classification

The inventories of chemicals (see Attachment 1 Table 5) at risk are given in Appendix H.

The basic formula to determine the concentration of chemicals is:

Concentration (mg/m^3) = [Inventory (mg) * χ/Q (s/m^3) * RM*RF*ARF/ RD]

Where:
- ARF = Airborne Release Fraction
- RD = Release Duration (time weighted over 15 minutes or 900 seconds)
- RM = Percent of total chemical released
- RF = Respirable Fraction
- χ/Q = Dispersion Coefficient

The downwind concentration of chemicals is determined through the application of a gaussian plume model (from Refs. E6.6 and E6.7). The dilution factor for each hazard is assumed for all chemical hazard classifications except the tornado/high wind, using a Pasquill Class D stability category with a wind speed of 4.5 m/s. The tornado scenario uses Pasquill Class A with a wind speed of 62 m/s. A high wind scenario assumes a Pasquill Class A with a wind speed of 31 m/s (Ref. E6.8).

The dilution factors for chemical hazard classification are presented in Table E-2.

Table E-2 - Hazard Classification Dilution Factors (χ/Q)

Scenario	100 m Distance (s/m3)
Earthquake	1.80E-3
Spill	1.80E-3
Tornado	4.11E-6
High Wind	8.22E-6

E.4.3 Determination of Accident Consequences

The inventories of uranium and chemicals at risk are based on Appendix H and identified in Tables 2 and 5 of the Attachment.

The calculation uses the following formula for radionuclides:

CEDE (mrem) = [Inventory (pCi) * χ/Q (s/m^3) * RM*RF*ARF / RD (s)] * DCF (mrem/pCi) * BR (m3/s) * ED (s)

Where: ARF = Airborne Release Fraction
RD = Release Duration
DCF = Dose Conversion Factor (Reference E6.9)
BR = Breathing Rate (Reference E6.10)
ED = Exposure Duration (equal to release duration)
RM = Percent of total uranium released
RF = Respirable Fraction
χ/Q = Dispersion Coefficient

and the basic formula for chemicals is:

Concentration (mg/m^3) = [Inventory (mg) * χ/Q (s/m^3) * RM*RF*ARF/ RD] with the same variables as above.

The dilution factor is determined through the application of a gaussian plume model (Ref.s E6.6 and E6.7) to the release estimate. The dilution factor for each accident assumed a Pasquill Class G stability category with a wind speed of 0.5 m/s is used (Ref. E6.11). The tornado scenario uses Pasquill Class A with a wind speed of 62 m/s (Ref. E6.8). A high wind scenario uses a Pasquill Class A with a wind speed of 31 m/s (Ref. E6.8). The earthquake frequency is based on UCRL-53582 (Ref E6.12).

The dilution factors for the accident analysis are presented below:

Table E-3 - Accident Analysis Dilution Factors (χ/Q)

Scenario	**On Site (at 100 m) (s/m3)**	**Off Site (at 680 m) (s/m3)**
Earthquake	1.52E-01	5.38E-3
Spill	1.52E-01	5.38E-3
Tornado	4.11E-6	2.38E-8
High Wind	8.22E-6	4.77E-8

The frequency of accidents for the various scenarios is listed in Table E-4 below:

Table E-4 - Event Frequency

Event	Frequency
Earthquake	1.82E-03
High Wind	2.5E-02
Tornado	7.60E-04
Spill	1.00E-03
Note: Spill frequency is based on the human factors	

E.5 Summary

For the hazard categorization, the AWWT radiological inventory (see Attachment, Table 6) is below the threshold category for a Hazard Category 3 facility per DOE-STD-1027-92 Attachment 1 (Ref. E6.1). The AWWT exceeds the radiological facility threshold. (See Attachment, Table 6) established by 40 CFR 302 Appendix B.

The AWWT chemical inventory is above the threshold quantities identified in 40 CFR 355. (See Attachment, Table 7.)

The accident consequences are below the risk acceptance criteria without requiring any mitigators. (See Attachment, Tables 11, 12 and 13.)

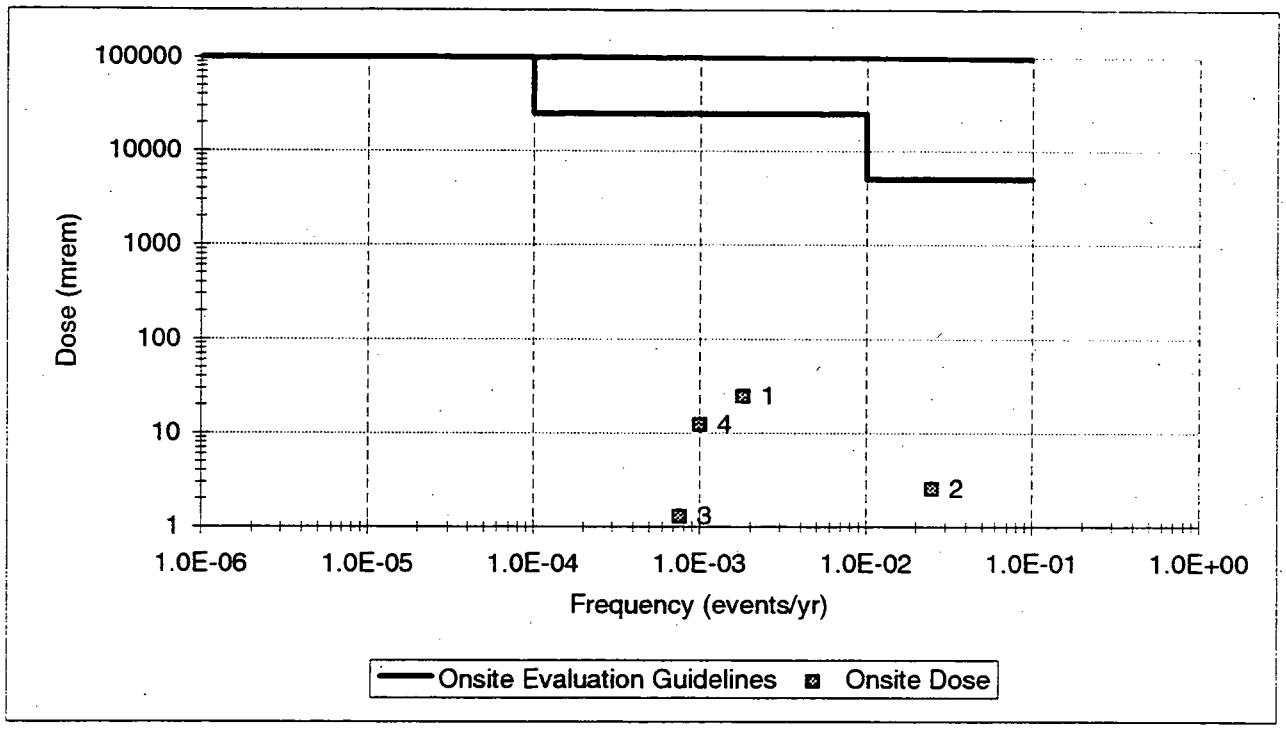

Figure E-1 - On-Site Radiological Risk Acceptance Criteria
KEY: 1 = Earthquake, 2 = High Wind, 3 = Tornado, 4 = Spill

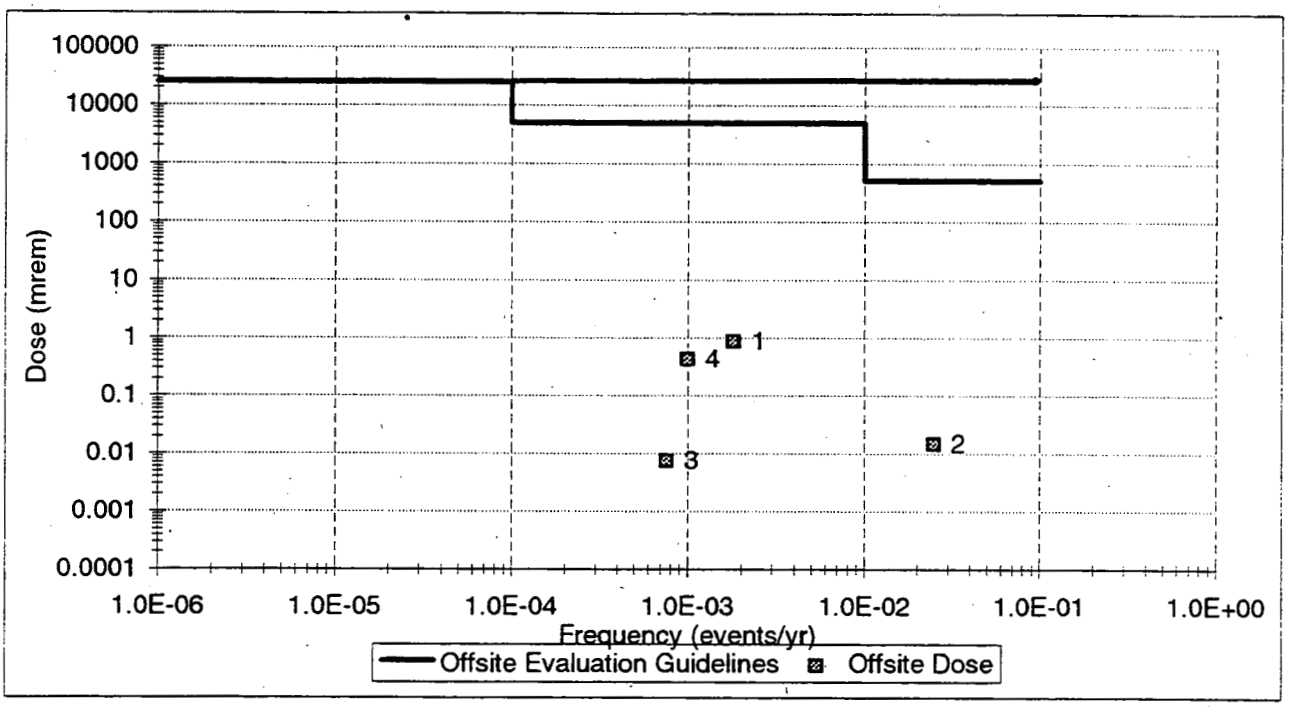

Figure E-2 - Off-Site Radiological Risk Acceptance Criteria
KEY: 1 = Earthquake, 2 = High Wind, 3 = Tornado, 4 = Spill

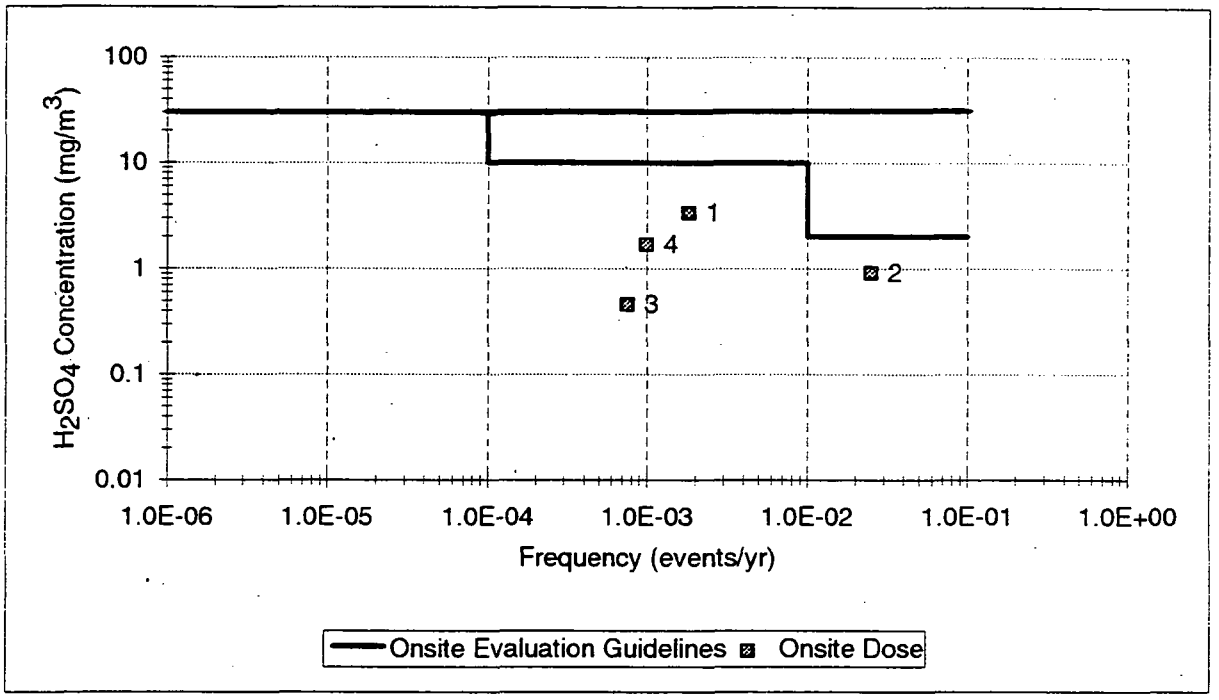

Figure E-3 - On-Site Sulfuric Acid Risk Acceptance Criteria
KEY: 1 = Earthquake, 2 = High Wind, 3 = Tornado, 4 = Spill

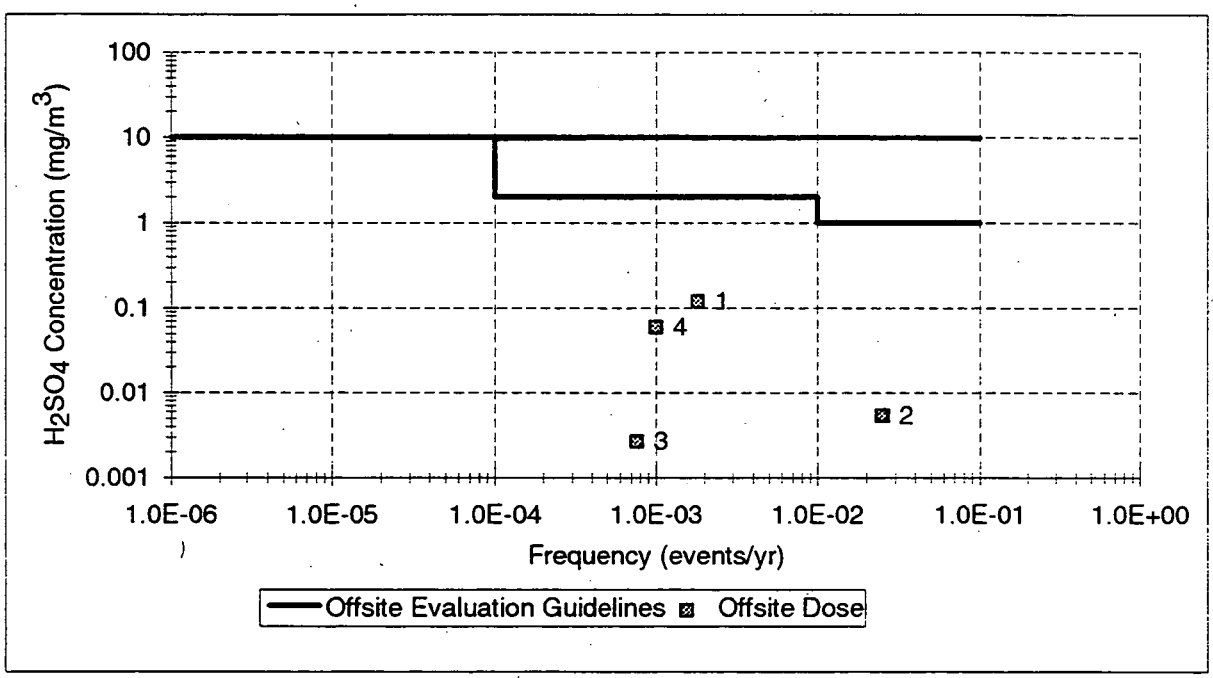

Figure E-4 - Off-Site Sulfuric Acid Risk Acceptance Criteria
KEY: 1 = Earthquake, 2 = High Wind, 3 = Tornado, 4 = Spill

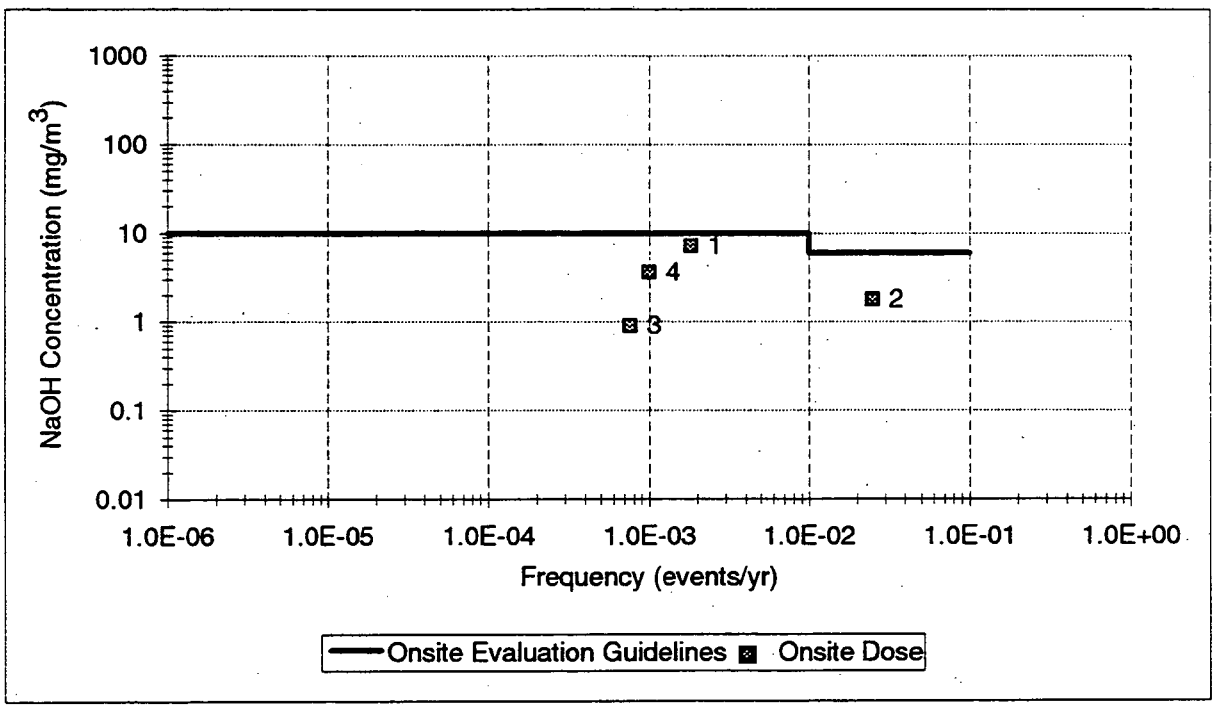

Figure E-5 - On-Site NaOH Risk Acceptance Criteria
KEY: 1 = Earthquake, 2 = High Wind, 3 = Tornado, 4 = Spill

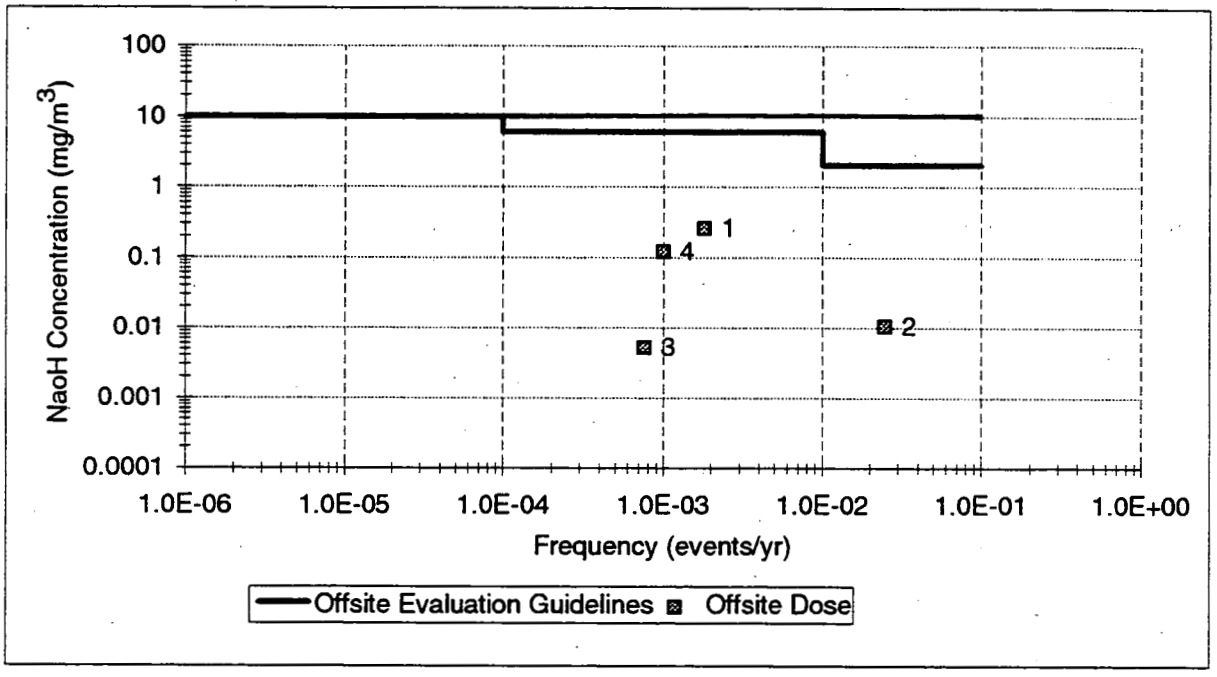

Figure E-6 - Off-Site NaOH Risk Acceptance Criteria
KEY: 1 = Earthquake, 2 = High Wind, 3 = Tornado, 4 = Spill

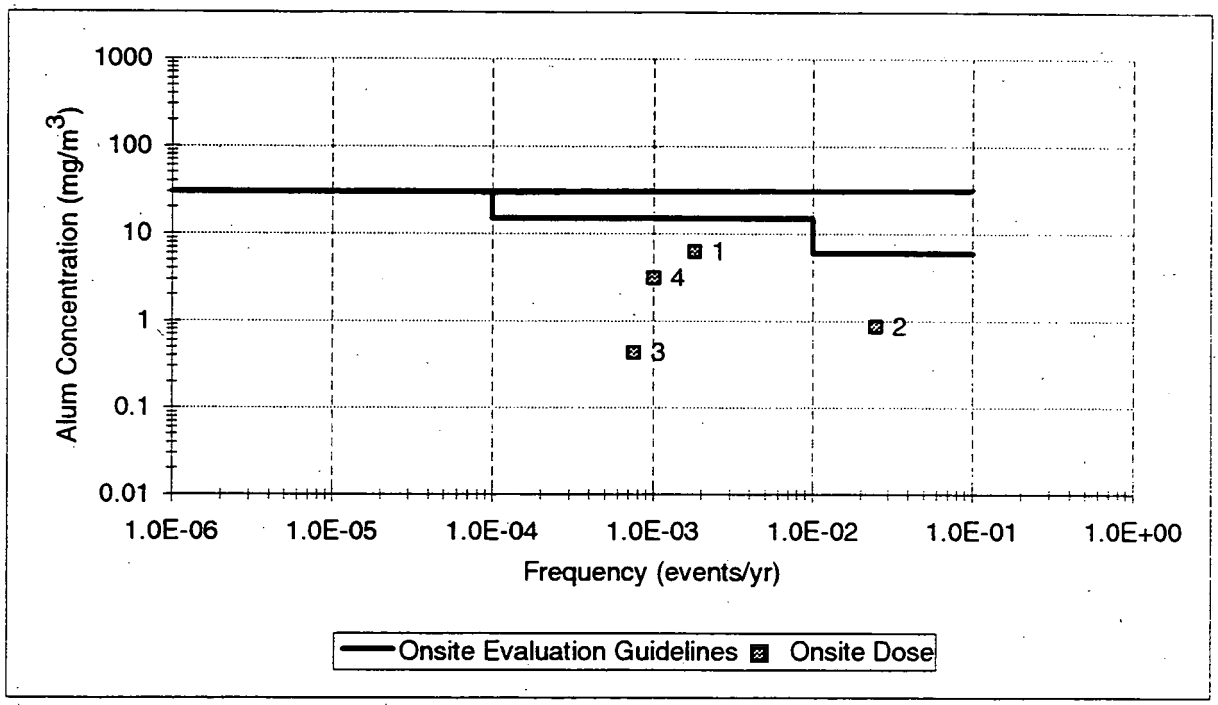

Figure E-7 - On-Site Alum Risk Acceptance Criteria
KEY: 1 = Earthquake, 2 = High Wind, 3 = Tornado, 4 = Spill

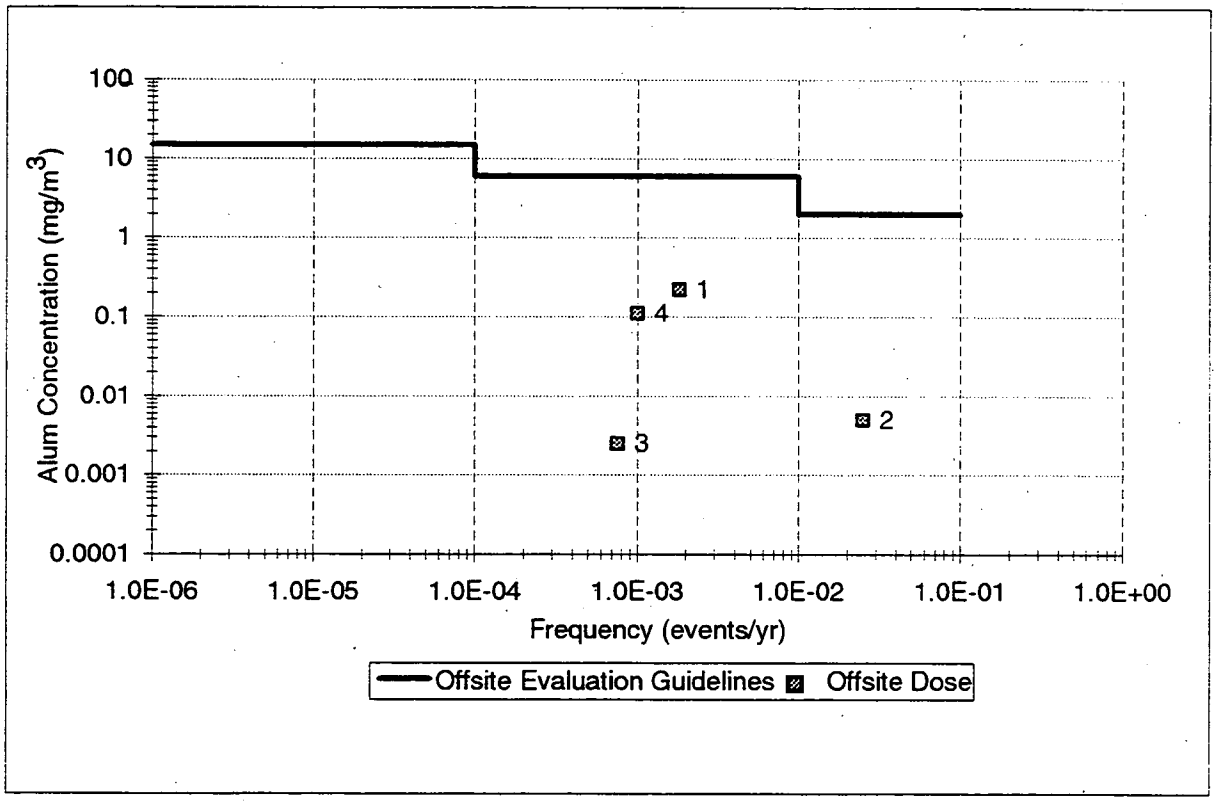

Figure E-8 - Off-Site Alum Risk Acceptance Criteria
KEY: 1 = Earthquake, 2 = High Wind, 3 = Tornado, 4 = Spill

ATTACHMENT E1

Constants	
3.33E-04	Breathing Rate
6.02E+23	Avagadro's number
0.2642	liters->Gallons
980	Gravity Con cm/sec^2
454	lbs->grams
1000	cm^3/liter
3.70E+10	dps/Ci

Table 1

Event	Freq
Earthquake	1.82E-03
High Wind	2.50E-02
Tornado	7.60E-04
Spill	1.00E-03

Table 2 - AWWT Uranium Inventory for Hazard and Accident Analysis

Location	U (Lbs)	MASS U (grams)	Enrich %U-235	%U-234	%U-238	U-235 (grams)	U-234 (grams)	U-238 (grams)
Clarifier: process wastewater	3.81E+02	1.73E+05	1.000%	8.53E-05	9.90E-01	1.73E+03	1.48E+01	1.71E+05
Clarifiers(2): stormwater/ groundwater	2.75E+02	1.25E+05	1.000%	8.53E-05	9.90E-01	1.25E+03	1.06E+01	1.24E+05
Multi-tube filter banks	3.29E+02	1.49E+05	1.000%	8.53E-05	9.90E-01	1.49E+03	1.27E+01	1.48E+05
Ion exchange resin bed (2 sets of 3)	4.46E+02	2.02E+05	1.000%	8.53E-05	9.90E-01	2.02E+03	1.73E+01	2.00E+05
Recycle tanks (2 sets of 3)	1.19E+02	5.40E+04	1.000%	8.53E-05	9.90E-01	5.40E+02	4.61E+00	5.35E+04
Receiver tanks (2 tanks)	1.49E+02	6.76E+04	1.000%	8.53E-05	9.90E-01	6.76E+02	5.77E+00	6.70E+04
Carbon filters (8 beds)	2.50E+00	1.14E+03	1.000%	8.53E-05	9.90E-01	1.14E+01	9.68E-02	1.12E+03
Waste slurry surge tank	1.16E+02	5.27E+04	1.000%	8.53E-05	9.90E-01	5.27E+02	4.49E+00	5.21E+04
Slurry Piping to Plant 8	1.13E+01	5.13E+03	1.000%	8.53E-05	9.90E-01	5.13E+01	4.38E-01	5.08E+03
Totals		**8.30E+05**	**0.01**			**8.30E+03**	**7.08E+01**	**8.22E+05**

Table 3 - NUREG-1320 Hand Calculation for Earthquake

Liquid	Release Fraction	Archimedes number ARCH	Solution density (g/cm3)	Air density (g/cm3)	Drop Height (cm)	Grav Constant (cm/s2)	Viscosity (poise)	Froude number Fr	Impact velocity (cm/s)	Solution volume (ml)	Liquid drop Radius
Wastewater	5.19E-06	2.646E+14	1	0.001205	300	980	0.01	0.36	767	1.89E+09	1646
NaOH	2.19E-06	3.08884E+13	1.23	0.001205	300	980	0.036	1.79	767	1.59E+07	335
H2SO4	1.98E-07	1.44706E+12	1.834	0.001205	300	980	0.248	1.19	767	5.45E+07	504
Alum	3.90E-06	7.61217E+13	1.18	0.001205	300	980	0.022	2.26	767	7.95E+06	266

Table 4 - NUREG-1320 Hand Calculation for Spill

Wastewater	2.60E-06	7.84E+13	1	0.001205	200	980	0.01	0.24	626	1.89E+09	1646
NaOH	1.10E-06	9.15211E+12	1.23	0.001205	200	980	0.036	1.20	626	1.59E+07	335
H2SO4	9.95E-08	4.28757E+11	1.834	0.001205	200	980	0.248	0.79	626	5.45E+07	504
Alum	1.96E-06	2.25546E+13	1.18	0.001205	200	980	0.022	1.51	626	7.95E+06	266

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Table 5 - NaOH, H2SO4 and Alum Inventories for Hazard and Accident Analysis

Tank	Chemical	Vol (gallons)	Specific Gravity	Mass (grams)	(%)	(grams)	Total (grams)
T-19X-3000	NaOH	20000	1.23	9.31E+07	20%	1.86E+07	
145		600	1.23	2.79E+06	20%	5.59E+05	
228		400	1.23	1.86E+06	20%	3.72E+05	1.96E+07
137	H2SO4	10000	1.834	6.94E+07	93%	6.46E+07	
148		420	1.834	2.92E+06	93%	2.71E+06	
222		5000	1.834	3.47E+07	18%	6.25E+06	
345		5000	1.834	3.47E+07	18%	6.25E+06	
221		7000	1.834	4.86E+07	7%	3.40E+06	
344		7000	1.834	4.86E+07	7%	3.40E+06	
220		16000	1.834	1.11E+08	3%	3.33E+06	
343		16000	1.834	1.11E+08	3%	3.33E+06	
395		16000	1.834	1.11E+08	3%	3.33E+06	
396		16000	1.834	1.11E+08	3%	3.33E+06	9.99E+07
193	Alum	7500	1.18	3.35E+07	28%	9.38E+06	9.38E+06

Table 6 - Radiological Hazard Categorization (from Criteria of DOE-EM-STD-5502)

Isotope	Mass (grams)	Category 3 (Based on DOE-1027) (grams)	result percent	Radiological Facility (Based on 40 CFR 302 App B) (grams)	result percent
U-235	8.30E+03	1.9E+06	4.37E-03	4.7E+04	1.78E+01
U-234	7.08E+01	6.7E+02	1.06E-01	1.6E+01	4.43E+02
U-238	8.22E+05	1.3E+07	6.32E-02	3.0E+05	2.75E+02
Total			1.73E-01		7.36E+02

Table 7 - Chemical Hazard Classification per 40 CFR 355 (from Criteria of DOE-EM-STD-5502)

Chemical	Mass (grams)	Threshold Category (grams)	result
NaOH	1.96E+07	Not Listed	NA
H2SO4	9.99E+07	4.54E+05	22000%
Alum	9.38E+06	Not Listed	NA

Attachment 1

Table 8 - Inventory Development - (grams -> mrem) Comversion

Total AWWT Inventory								
Isotope	mass (g)	(g/mole)	Lamda (1/sec)	(# atoms)	(d/s)	(pCi)	DCF (mrem/ pCi)	(mrem)
U-235	8.30E+03	2.35E+02	3.10E-17	2.13E+25	6.60E+08	1.78E+10	1.20E-01	2.14E+09
U-234	7.08E+01	2.34E+02	8.97E-14	1.82E+23	1.64E+10	4.42E+11	1.30E-01	5.75E+10
U-238	8.22E+05	2.38E+02	4.92E-18	2.08E+27	1.02E+10	2.77E+11	1.20E-01	3.32E+10
							per gram	1.12E+05

Table 9 - AWWT Chemical Hazard Classification per WSRC-MS-92-206 guidance

ONSITE AWWT Events	Location	Release Duration (sec)	Chemical	Inventory (grams)	ARF	Dispersion (X/Q) (s/m3)	Material Conc. (mg/m3)	Threshold Quantity (mg/m3)	Result Percent
Earthquake	100	900	NaOH	1.96E+07	2.19E-06	1.80E-03	8.55E-02	1.00E+01	8.55E-03
	100	900	H2SO4	9.99E+07	1.98E-07	1.80E-03	3.96E-02	1.00E+01	3.96E-03
	100	900	Alum	9.38E+06	3.90E-06	1.80E-03	7.31E-02	1.50E+01	4.87E-03
High Wind	100	900	NaOH	1.96E+07	1.00E-02	8.22E-06	1.79E+00	1.00E+01	1.79E-01
	100	900	H2SO4	9.99E+07	1.00E-03	8.22E-06	9.12E-01	1.00E+01	9.12E-02
	100	900	Alum	9.38E+06	1.00E-02	8.22E-06	8.57E-01	1.50E+01	5.71E-02
Tornado	100	900	NaOH	1.96E+07	1.00E-02	4.11E-06	8.93E-01	1.00E+01	8.93E-02
	100	900	H2SO4	9.99E+07	1.00E-03	4.11E-06	4.56E-01	1.00E+01	4.56E-02
	100	900	Alum	9.38E+06	1.00E-02	4.11E-06	4.28E-01	1.50E+01	2.86E-02
Spill	100	900	NaOH	1.96E+07	1.10E-06	1.80E-03	4.29E-02	1.00E+01	4.29E-03
	100	900	H2SO4	9.99E+07	9.95E-08	1.80E-03	1.99E-02	1.00E+01	1.99E-03
	100	900	Alum	9.38E+06	1.96E-06	1.80E-03	3.67E-02	1.50E+01	2.45E-03

Notes:
"mg per gram" is shown in inventory data.
Dispersion calculated using Reg Guide 1.145 model, 100 meters onsite.
Release height is ground level.
Pasquill Stability Class A for High Wind (@ 31 m/s windspeed), Tornado (@ 62 m/s).
Pasquill Stability Class D @ 4.5 m/s windspeed for earthquake and spill.
Threshold Quantity from WSRC-MS-92-906 is ERPG-2.

Attachment 1

Table 10 - AWWT Chemical Hazard Classification per WSRC-MS-92-206 guidance

OFFSITE AWWT Events	Release Location	Release Duration (sec)	Inventory Chemical	Inventory (grams)	ARF	Dispersion (X/Q) (s/m3)	Material Conc. (mg/m3)	Threshold Quantity (mg/m3)	Result Percent
Earthquake	680	900	NaOH	1.96E+07	2.19E-06	6.41E-05	3.04E-03	6.00E+00	5.07E-04
	680	900	H2SO4	9.99E+07	1.98E-07	6.41E-05	1.41E-03	2.00E+00	7.05E-04
	680	900	Alum	9.38E+06	3.90E-06	6.41E-05	2.60E-03	6.00E+00	4.34E-04
High Wind	680	900	NaOH	1.96E+07	1.00E-02	8.22E-06	1.79E+00	6.00E+00	2.98E-01
	680	900	H2SO4	9.99E+07	1.00E-03	8.22E-06	9.12E-01	2.00E+00	4.56E-01
	680	900	Alum	9.38E+06	1.00E-02	8.22E-06	8.57E-01	6.00E+00	1.43E-01
Tornado	680	900	NaOH	1.96E+07	1.00E-02	4.11E-06	8.93E-01	6.00E+00	1.49E-01
	680	900	H2SO4	9.99E+07	1.00E-03	4.11E-06	4.56E-01	2.00E+00	2.28E-01
	680	900	Alum	9.38E+06	1.00E-02	4.11E-06	4.28E-01	6.00E+00	7.14E-02
Spill	680	900	NaOH	1.96E+07	1.10E-06	6.41E-05	1.53E-03	6.00E+00	2.55E-04
	680	900	H2SO4	9.99E+07	9.95E-08	6.41E-05	7.08E-04	2.00E+00	3.54E-04
	680	900	Alum	9.38E+06	1.96E-06	6.41E-05	1.31E-03	6.00E+00	2.18E-04

Notes:
"mg per gram" is shown in inventory data.
Dispersion calculated using Reg Guide 1.145 model, 100 meters onsite.
Release height is ground level.
Pasquill Stability Class A for High Wind (@ 31 m/s windspeed), Tornado (@ 62 m/s).
Pasquill Stability Class D @ 4.5 m/s windspeed for earthquake and spill.
Threshold Quantity from WSRC-MS-92-906 is ERPG-2.

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Table 11 - AWWT Radiological Consequences for Accident Analysis

AWWT Events	Location	Release Duration (sec)	Number of (grams)	Inventory (mrem per gram)	ARF	Dispersion (X/Q) (s/m3)	50 year CEDE (mrem)	Hazard Category	mg Inhaled
Earthquake	Onsite	900	8.30E+05	1.12E+05	5.19E-06	1.52E-01	2.44E+01	4	2.18E-07
	Offsite	900	8.30E+05	1.12E+05	5.19E-06	5.38E-03	8.63E-01	4	7.72E-09
High Wind	Onsite	900	8.30E+05	1.12E+05	1.00E-02	8.22E-06	2.54E+00	4	2.27E-08
	Offsite	900	8.30E+05	1.12E+05	1.00E-02	4.77E-08	1.48E-02	4	1.32E-10
Tornado	Onsite	900	8.30E+05	1.12E+05	1.00E-02	4.11E-06	1.27E+00	4	1.14E-08
	Offsite	900	8.30E+05	1.12E+05	1.00E-02	2.38E-08	7.36E-03	4	6.59E-11
Spill	Onsite	900	8.30E+05	1.12E+05	2.60E-06	1.52E-01	1.22E+01	4	1.10E-07
	Offsite	900	8.30E+05	1.12E+05	2.60E-06	5.38E-03	4.33E-01	4	3.88E-09

Notes:
Breathing rate is 3.33E-4 m3/sec based on reference EPA data
Dispersion calculated using Reg Guide 1.145 model, 100 meter onsite, 680 meters offsite.
Release height is ground level for all.
Pasquill Stability Class A: High Wind (@ 31 m/s windspeed), Tornado (@ 62 m/s windspeed).
Pasquill Stability Class G @ 0.5 m/s windspeed for earthquake and spill.
"mrem per gram" is shown in inventory data.

Attachment 1

Table 12 - Onsite AWWT Chemical Consequences for Accident Analysis

Onsite AWWT Events	Location	Release Duration (sec)	Chemical	Inventory (grams)	ARF	Dispersion (X/Q) (s/m3)	Material Conc. (mg/m3)
Earthquake	Onsite	900	NaOH	1.96E+07	2.19E-06	1.52E-01	7.22E+00
	Onsite	900	H2SO4	9.99E+07	1.98E-07	1.52E-01	3.35E+00
	Onsite	900	Alum	9.38E+06	3.90E-06	1.52E-01	6.17E+00
High Wind	Onsite	900	NaOH	1.96E+07	1.00E-02	8.22E-06	1.79E+00
	Onsite	900	H2SO4	9.99E+07	1.00E-03	8.22E-06	9.12E-01
	Onsite	900	Alum	9.38E+06	1.00E-02	8.22E-06	8.57E-01
Tornado	Onsite	900	NaOH	1.96E+07	1.00E-02	4.11E-06	8.93E-01
	Onsite	900	H2SO4	9.99E+07	1.00E-03	4.11E-06	4.56E-01
	Onsite	900	Alum	9.38E+06	1.00E-02	4.11E-06	4.28E-01
Spill	Onsite	900	NaOH	1.96E+07	1.10E-06	1.52E-01	3.62E+00
	Onsite	900	H2SO4	9.99E+07	9.95E-08	1.52E-01	1.68E+00
	Onsite	900	Alum	9.38E+06	1.96E-06	1.52E-01	3.10E+00

Notes:
"mg per gram" is shown in inventory data.
Dispersion calculated using Reg Guide 1.145 model, 100 meters onsite.
Release height is ground level.
Pasquill Stability Class A for High Wind (@ 31 m/s windspeed), Tornado (@ 62 m/s).
Pasquill Stability Class G @ 0.5 m/s windspeed for earthquake and spill.

Table 13 - Offsite AWWT Chemical Consequences for Accident Analysis

Offsite AWWT Events	Location	Release Duration (sec)	Chemical	Inventory (grams)	ARF	Dispersion (X/Q) (s/m3)	Material Conc. (mg/m3)
Earthquake	Offsite	900	NaOH	1.96E+07	2.19E-06	5.38E-03	2.55E-01
	Offsite	900	H2SO4	9.99E+07	1.98E-07	5.38E-03	1.18E-01
	Offsite	900	Alum	9.38E+06	3.90E-06	5.38E-03	2.18E-01
High Wind	Offsite	900	NaOH	1.96E+07	1.00E-02	4.77E-08	1.04E-02
	Offsite	900	H2SO4	9.99E+07	1.00E-03	4.77E-08	5.29E-03
	Offsite	900	Alum	9.38E+06	1.00E-02	4.77E-08	4.97E-03
Tornado	Offsite	900	NaOH	1.96E+07	1.00E-02	2.38E-08	5.17E-03
	Offsite	900	H2SO4	9.99E+07	1.00E-03	2.38E-08	2.64E-03
	Offsite	900	Alum	9.38E+06	1.00E-02	2.38E-08	2.48E-03
Spill	Offsite	900	NaOH	1.96E+07	1.10E-06	5.38E-03	1.28E-01
	Offsite	900	H2SO4	9.99E+07	9.95E-08	5.38E-03	5.94E-02
	Offsite	900	Alum	9.38E+06	1.96E-06	5.38E-03	1.10E-01

Notes:
"mg per gram" is shown in inventory data.
Dispersion calculated using Reg Guide 1.145 model, 680 meters offsite.
Release duration of 900 seconds is used as an averaging time
Release height is ground level for all.
Pasquill Stability Class A for High Wind (@ 31 m/s windspeed), Tornado (@ 62 m/s).
Pasquill Stability Class G @ 0.5 m/s windspeed for earthquake and spill.

Attachment 1

Table 14 - Incremental Cancer Risk

Enrichment		Frequency	Event: Earthquake NPH	High Wind NPH	Tornado 7.60E-04	Spill 1.00E-03
1.00%	OFF-SITE	ICR Limit	2.00E-02	2.00E-02	2.00E-04	2.00E-04
U		Uranium (mg)	7.72E-09	1.32E-10	6.59E-11	3.88E-09
Fraction	Chemical	(ICR/mg)				
8.53E-05	U-234	1.62E+05	1.07E-07	1.82E-09	9.09E-10	5.35E-08
1.00E-02	U-235	5.44E+01	4.20E-09	7.18E-11	3.58E-11	2.11E-09
9.90E-01	U-238	8.06E+00	6.16E-08	1.05E-09	5.26E-10	3.09E-08
	ON-SITE	ICR Limit	2.00E+00	2.00E+00	2.00E-02	2.00E-02
		Uranium (mg)	2.18E-07	2.27E-08	1.14E-08	1.10E-07
	Chemical	(ICR/mg)				
8.53E-05	U-234	1.62E+05	3.01E-06	3.14E-07	1.57E-07	1.51E-06
1.00E-02	U-235	5.44E+01	1.19E-07	1.24E-08	6.19E-09	5.96E-08
9.90E-01	U-238	8.06E+00	1.74E-06	1.82E-07	9.08E-08	8.74E-07

Notes:
1. Limits are based on AWWT FSAR Table E-11
2. Assumed uranium at maximum equipment loading
3. Body weight is 70 Kg (EPA)
4. Release Duration is 900 seconds (see calc sheet)
5. Breathing rate is 3.3E-4 m3/s (see calc sheet)
6. See ICR/Bq to ICR/mg conversions below

Isotope	(ICR/Bq)	(Bq/TBq)	(TBq/g)	(ICR/mg)
U-234	7.00E-07	1.00E+12	2.31E-04	1.62E+05
U-235	6.80E-07	1.00E+12	8.00E-08	5.44E+01
U-238	6.50E-07	1.00E+12	1.24E-08	8.06E+00

E.6 References

E6.1) DOE, August 1994. DOE-EM-STD-5502, Hazard Baseline Documentation.

E6.2) DOE, December 1992. DOE-STD-1027-92, *Hazard Categorization and Accident Analysis Techniques for Compliance with DOE Order 5480.23, Nuclear Safety Analysis Reports.*

E6.3) Westinghouse Savannah River Company, April 1992. WSRC-MS-92-206, "Toxic Chemical Hazard Classification and Risk Acceptance Guidelines for use in DOE Facilities," Rev. 1.

E6.4) NUREG-1320, Nuclear Fuel Cycle Facility Accident Analysis Handbook, J.E. Ayer, J. Mishima, U.S. Nuclear Regulatory Commission, May, 1988.

E6.5) FERMCO, September, 1992. SP-A-01-013, Rev 1, "Preparation of Safety Assessments."

E6.6) U.S. NRC Regulatory Guide 1.145, February 1983. *Atmospheric Dispersion Models for Potential Accident Consequence Assessments at Nuclear Power Plants.* U.S. Nuclear Regulatory Commission.

E6.7) Slade, D.H., 1968. *Meteorology and Atomic Energy* TIC-24190. U.S. Atomic Energy Commission, Office of Information Services, Washington, D.C.

E6.8) UCRL-53526, Rev. 1, August 1985. Natural Phenomena Hazards Modelling Project: Extreme Wind/Tornado Hazard Models for Department of Energy Sites.

E6.9) U.S. EPA Federal Guidance Report No. 11, September 1988. *Limiting Values of Radionuclide Intake and Air Concentration and Dose Factors for Inhalation, Submersion, and Ingestion.* Washington D.C.

E6.10) U.S. EPA, 1985. Methodology for Characterization of Uncertainty in Exposure Assessments, Office of Health and Environmental Assessment, Exposure Assessment Group. EPA/600/8-85-009, Washington, D.C.

E6.11) Comment Responses for OU-4 Vitrification Pilot Plant PSAR, No. 69A, May 1994. Ninety-fifth percentile for χ/Q for "G" stability at 0.52 m/sec.

E6.12) UCRL-53582, Rev. 1, Natural Phenomena Hazards Modelling Project: Seismic Hazard Models for DOE Sites.

APPENDIX F

BINNED ACCIDENT ANALYSIS

Table F-1 Binned Accident Analysis

A. Large Spill of Radioactive/Hazardous Materials							
LOW RISK						EXTREMELY LOW RISK	
2.3	5.8	5.11	6.5			2.1	
2.4	5.9	5.12	6.2			2.2	
5.7	5.10		5.13			5.14	
B. Large Spill of Radioactive Material							
LOW RISK						EXTREMELY LOW RISK	
3.2						1.1	
C. Large Spill of High pH, Radioactive/Hazardous Materials							
LOW RISK						EXTREMELY LOW RISK	
2.5	2.8	2.11	2.15	2.26		2.14	
2.6	2.9	2.12	2.16	5.1		2.17	
2.7	2.10	2.13	2.25				
D. Large Spill of High - pH Radioactive Material							
LOW RISK						EXTREMELY LOW RISK	
3.3	3.6	3.12	3.16	3.14	3.21	3.17	
3.4	3.8	3.13	3.10	3.18			
3.5	3.9	3.15	3.11	3.19			
E. Large Spill of Low-pH Radioactive/Hazardous Material							
LOW RISK						EXTREMELY LOW RISK	
none identified						none identified	
F. Large Spill of Hazardous Chemicals							
LOW RISK						EXTREMELY LOW RISK	
2.18	2.21	5.4	7.2			1.1	1.9
2.19	5.2	5.5	7.5			1.3	1.10
2.20	5.3	5.6				1.4	
G. Large Caustic Spill							
LOW RISK						EXTREMELY LOW RISK	
4.2	4.5					none identified	
4.3							
4.4							

Table F-1 - Binned Accident Analysis (Continued)

H. Large Acid Spill		
	LOW RISK	EXTREMELY LOW RISK
	4.6	1.2 1.5 1.8
	4.7	
I. Acid Vapor/Mist Release		
	LOW RISK	EXTREMELY LOW RISK
	8.1 8.2	none identified
J. Process Disturbances		
	LOW RISK	EXTREMELY LOW RISK
	6.1 6.3	2.22 3.22 3.7
	7.1 7.3	2.23 3.23 4.1
		2.24 3.24 6.4
		3.1 3.25 7.4
		3.20 3.26
K. Uncontrolled Chemical Reaction		
	LOW RISK	EXTREMELY LOW RISK
	4.9	none identified
	4.10	
M. Caustic Vapor/ Mist Release		
	LOW RISK	EXTREMELY LOW RISK
	9.10	1.6 4.8
		1.7 4.11
N. Excessive Uranium Accumulation		
	LOW RISK	EXTREMELY LOW RISK
	none identified	5.15 5.16

APPENDIX G

CRITICALITY SAFETY ANALYSIS

NUCLEAR CRITICALITY SAFETY ANALYSIS FOR THE ADVANCED WASTEWATER TREATMENT FACILITY

The Advanced Wastewater Treatment (AWWT) Facility treats process wastewater discharged from the General Sump and Biodenitrification Facility, site groundwater/stormwater, perched groundwater, and other sources. Using several chemical additives, the uranium is mixed with a flocculent and precipitated out in an 85,000-gallon clarifier. The slurry is then pumped, as part of the underflow, to holding tanks for additional processing. For the AWWT process, this criticality safety analysis evaluates the potential for a criticality based on safe mass limits and safe concentrations. All process operations and components are evaluated on the two aforementioned criteria.

The first consideration in determining the potential criticality is the presence of enriched uranium in a quantity above the safe mass limit. Should the safe mass limits be exceeded, then the concentration must be shown to be below the safe concentration. Table G-1 summarizes the separate process components, the mass of uranium in each for worst case operating conditions, and the safe mass limits (calculation of the process equipment and U loadings are presented in Appendix H of the AWWT FSAR).

Table G-1 - Uranium Loading of Individual Process Equipment

Process Equipment	Peak Loading (lbs) (Worst Case)[1]	Safe Mass (lbs) Limits for 2 % Enrichment	Safe Mass (lbs) Limits for 1.25 % Enrichment
Clarifier: Process Wastewater Stream	381	252[3]	2000[3]
Clarifier: Stormwater/ Groundwater	138	252	2000
Multi-Tube Filter Bank[2]	82	252	2000
Ion Exchange Column	74.3	252	2000
Recycle Tank	59.4	252	2000
Receiver Tank	74.3	252	2000
Carbon Filter Bed	0.31	252	2000
Waste Slurry Surge Tank	116	252	2000

Notes:
1. Peak Loading (Worst Case) is a result of failures and significant misoperation by operator and equipment
2. An assumed loading of the filter bank is based on the maximum loading being all uranium.
3. See Table III of Reference 2.

As shown in Table G-1, one vessel (the process wastewater clarifier) exceeds the safe mass limit for a 2 percent enrichment but is far below the limit for 1.25 percent enrichment.

The site, as a whole, has processed uranium ranging from depleted up to 2 percent enriched. Very limited quantities of higher enrichment (up to 20 percent) material were utilized only as "sweetener" to increase the average enrichment of other material to the desired enrichment (always less than 2 percent). The production of material near the 2 percent value was done in very short limited duration campaigns. Most material processed on the site was either depleted or natural uranium. Historic samples of water discharged from the site have always shown the uranium enrichment to be less than normal or depleted. Two percent enrichment is a very conservative value for the maximum enrichment of uranium in wastewater from the former process buildings, particularly in quantities that would exceed the safe mass. For stormwater runoff, groundwater, and other non-production building sources, the average enrichment should remain below that of natural uranium and will certainly be less than 1 percent. An infinite amount of uranium homogeneously mixed and optimally moderated with water is sub-critical as long as the enrichment is less than 1 percent.

The peak loading of uranium from the analysis in Appendix H for safe mass limits is based on a calculated mass balance for inflow and outflow for the clarifier and does not consider the time required to reach these inventories or physical limits on maximum slurry concentration. The analysis was performed to bound the quantity of uranium present in the process equipment and the uranium inventory.

The incoming water is expected to have a maximum uranium concentration of 10 mg/l. Using several chemical additives, the uranium will be precipitated out in an 85,000-gallon clarifier and pumped, as part of the underflow, to holding tanks for additional processing. Under expected operating conditions, the underflow will have a maximum uranium concentration of less than 200 mg/l. Under worst-case conditions, the concentration will be less than 1 gm/l. Even at very high enrichments, this concentration is not a criticality concern. As an example, as shown in FEMP-2304, "FMPC Nuclear Criticality Safety Guide," at an enrichment of 10 percent, 50 gm U/l is safe.

For the mass balance analysis, the upset condition of concern would be if the underflow pump stopped while the incoming solution was allowed to continue. Under this condition, assuming that the mixing arm continues to operate, the overflow solution (or clean water) would continue to leave the clarifier and the remaining solution in the clarifier would increase in uranium concentration. Since the bottom of the clarifier is sloped to the center, the precipitate uranium would collect at the center of the tank. Assuming the clarifier's incoming stream has a maximum uranium concentration of 10 mg/l with a flow rate of 400 gpm, and that all of the uranium remains in the clarifier, that is no uranium leaves via the overflow, the total quantity of uranium would increase at a rate of only 2 pounds an hour. Even though this is a continuous process, failure of the underflow pump which went unnoticed over an entire weekend (64 hours), could raise the uranium mass by a maximum of 128 pounds. Another aspect is that the

process is monitored continuously via a control computer as well as by operators at least once a shift (including weekends).

To accurately determine if there is the potential for criticality in the process wastewater clarifier, the flocculation and settling must be analyzed. For the process wastewater clarifier, the upset condition of concern would be if the underflow pump stopped while the incoming solution was allowed to continue. Under this condition, the overflow solution (or clean water) would continue to leave the clarifier and the remaining solution in the clarifier would increase to some maximum uranium concentration.

The uranium, other metals and solids, and flocculent added precipitate as a slurry based on the pH and the amount of flocculent added. With stoppage of the underdrain pump, the sludge builds up to reach the brim of the tank. Once full, excess sludge is assumed to spill over the decant weir.

The results of a CRU-5 design study (Reference 1) for optimizing AWWT operation indicated a maximum uranium concentration in the slurry of 95 ppm. The study was a bench scale test of actual wastewaters. A jar test with the wastewaters and varying pH and quantity of flocculent were performed. The results which removed the most uranium and generated the least sludge represents the highest concentration of uranium in the slurry. These tests are in a static system, hence they should represent an upper limit on what might be expected with the clarifier.

The greatest concentration of uranium in the slurry of 95 ppm corresponds to 1.4 grams of uranium per liter of slurry assuming the slurry consists entirely of uranium. This can be compared to the limiting value of 900 grams of uranium per liter of water from ARH-600 (Reference 3) for 2 percent U-235 enrichment, or a safe concentration of 250 gm/liter from FEMP-2304 (Reference 2). Thus, even if the sludge becomes compressed due to settling (removal of 95 percent of the water content of the sludge), the sludge would still only have an effective concentration of less than 100 grams of uranium per liter. Therefore, based on available information, there is not a potential for a criticality event regardless of multiple failures or the length of time the operation is neglected.

The prior discussion indicates that, based on expected clarifier performance as determined by laboratory tests of typical wastewater, the maximum uranium concentration will be below that which is safe even at an enrichment of 2 percent. While this is based on the best available information, there is considerable uncertainty with regard to wastewater effluents resulting from the cleanup of the former process area.

To avoid any potential for criticality in the clarifier, it has been decided to control the effluent of the General Sump. Since the concentration is already extremely low, the enrichment will now be limited to less than 1 percent U-235. Per FEMP-2304, "FMPC Nuclear Criticality Safety Guide," compounds and solutions with an enrichment of less than 1 percent U-235 are safe in unlimited quantities. While the procedures for the General Sump restrict incoming streams to a maximum of 2 percent U-235, the

effluent from the sump has historically been depleted. This is the result of the mixing of all of the streams together at the General Sump. To ensure that the 1 percent U-235 limit is not exceeded, the effluent will be sampled and analyzed for enrichment as well as uranium concentration prior to pumping to the AWWT. On receipt of the analysis, the General Sump supervisor will contact the AWWT Utility Services Day Shift Supervisor to report the analysis and receive approval to begin pumping to the AWWT holding tanks.

It should also be noted that even if this enrichment restriction were to be violated, this must occur with numerous transfers of material to the AWWT. At the highest expected uranium concentrations, over 80 batches from the General Sump would have to be transferred at 2 percent enrichment to transfer even the safe mass to the AWWT.

References

1) FERMCO, August, 1994. M:ENG:(TDD):94-0029. Summary of Coagulation/Flocculation Testing for the CRU-5 AWWT Facility.

2) FERMCO, September 1993. FEMP-2304, "FEMP Nuclear Criticality Safety Guide."

3) Carter R.D., G.R. Kiel and K.R. Ridgeway. "Criticality Handbook, Vols. I, II, III, " Atlantic Richfield Company, Report ARH-600, 1968.

APPENDIX H

AWWT INVENTORY LOADINGS

H.1 Objective

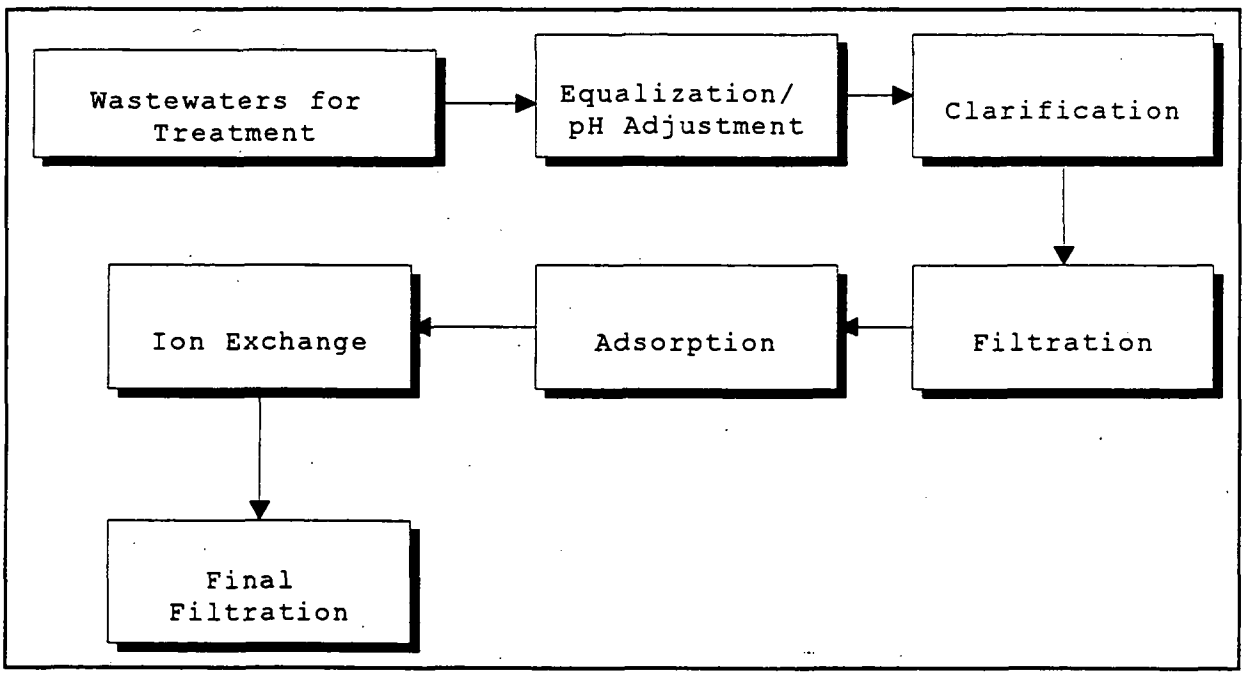
Given the Advanced Wastewater Treatment (AWWT) facility, wastewaters are treated to remove the uranium contamination. Treatment processes include pH adjustment, chemical treatment, filtration, carbon adsorption, and ion exchange treatment. To classify the facility per DOE-EM-STD-5502-94 (Ref. H6.1) and assess the AWWT facility for criticality, this calculation determines the uranium loading or holdup inventory for the separate equipment.

H.2 Background and Approach

The AWWT operation is shown in Figure H-1. The processes given are performed in separate components to calculate the AWWT uranium holdup inventory. The weight of uranium in each component is calculated and summed for a facility total (Ref. H6.2).

The two wastewater feeds are treated in separate process paths. The stormwater/groundwater has a flow rate of 700 gpm and the process wastewater has a flow rate of 400 gpm (Ref. H6.3.).

Figure H-1 - AWWT Operation



H.3 Assumptions

H3.1 The wastewater uranium concentrations used in the design of the AWWT stormwater/groundwater is 0.5 mg/l and the maximum in the process wastewater is 10 mg/l.

A 0.67 mg/l stormwater/groundwater concentration is used for both expected loading. Peak loading of 10 mg/l bounds any process wastewater concentrations (Ref. H6.3).

H3.2 The removal rate of uranium for the clarifiers is assumed to be 100 percent. (All uranium reports in the underflow and no dissolved uranium will remain in the overflow.) This is a worst case for the waste slurry handling system thereby maximizing the U loading for criticality. The only process equipment component that can exceed the safe concentration limits is the clarifier. (See Appendix G for discussion.)

H3.3 For the stormwater/groundwater treatment process there are two clarifiers. It is assumed that the flows are equally split.

H3.4 Individual process equipment are presumed to have a maximum loading or holdup. For the resin and carbon filter beds the maximum is based on the media loading. The multitube filters are bag filters assumed to be completely loaded with uranium for the tube volume.

H3.5 The efficiency of the recycle system for the ion exchange beds is 80 percent on the first blowdown.

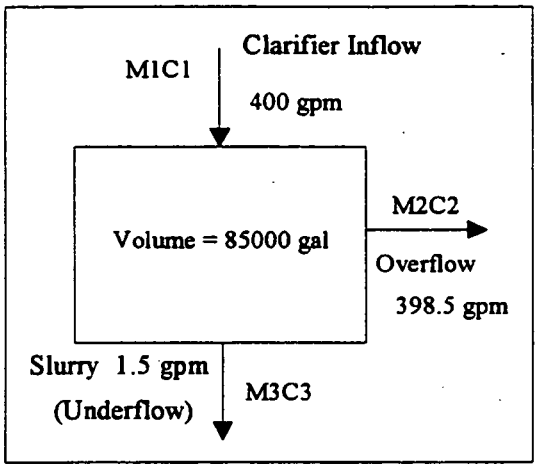
H3.6 Prior to final filtration and release of the waters all uranium in the wastewater has been removed.

H4.0 Calculations

There are two factors which determine the material holdup inventory. The first component is the concentration of uranium in the wastewaters. The second component is the mass flow rates of the wastewaters. Considering above factors, the total uranium balances were made around each process unit operation which did not remove any uranium via process. For the equipment filtering or adsorbing the U the maximum loading is calculated based on the particular media's loading factor.

Throughout the wastewater treatment process, uranium is continuously accumulating in some process equipment. For the multitube filters, carbon beds, and the ion exchange filters the uranium loading is increasing with continued treatment. The maximum loading is calculated based on volume and loading capabilities to determine the quantity of U present. The clarifiers are modeled as having two different uranium concentrations.

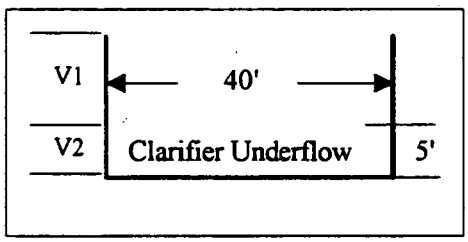
4.1. A. Clarifier for Process Wastewater - Expected Loading



Given: Flow as modeled in figure (Ref. H6.3)
Average concentration of 0.67 mg/l
Assume: C2 = 0 mg/l
100% U removal at clarifier
Find: M2 and C3
Mass Balance: M1 = M2 + M3
System Balance: M1C1 = M2C2 + M3C3

	Flow (gpm)		Conc (mg/l)
M1	4.00E+02	C1	6.70E-01
M2	3.99E+02	C2	0.00E+00
M3	1.50E+00	C3	1.79E+02

Now Find: Expected Loading - Uranium Hold Up
Given: Total Clarifier Vol = Vol1 + Vol2 for underflow
Height to calculate Underflow (V2) is depth of rake
(Neglect slope of tank bottom)



Vol of V2 Pi*(d2/2)^2*h =
= pi*(40/2ft)^2*5ft*28.31(l/ft^3)
1.78E+05 (l)
Vtotal = V2 + V1
V1 = 85000gal(3.785l/gal) - 1.78E5 (l)
= 1.44E+05 (l)

Expected Uranium Loading = V1C1 + V2 C underflow = 1.44E5 (l)(0.67mg/l) + 1.78E5 (l)(179mg/l)

Expected Uranium Loading = 3.19E+07 (mg)(lb/454g)(1g/1E3m 7.02E+01 lb

4.1. B. Clarifier for process wastwater - Peak Loading (Worst Case) Loading

Given: Clarifier Model as above
Mass Balance: M1 + M2 = M3
System Balance: M1C1 + M2C2 = M3C3
Assume: Maximum input from facility (BDN) for max concentrations and flowrate.
(Reference 7.2)

	Conc (mg/l)	Flow (gpm)
BDN =	10	132
Makeup water =	0.5	268

Use inflows with highest concentrations, i.e. general sump water has a lower concentration and C2 = 0

Find: M2 and C3 as above

C = (132(gpm)/400(gpm))*10(mg/l) + (268(gpm)/400(gpm))*0.5mg/l = 3.64E+00 mg/l

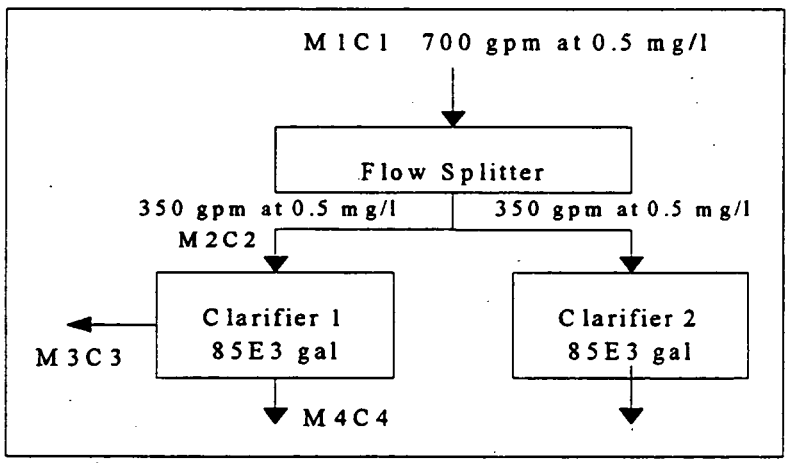
Therefore, peak loading values are:

	Flow (gpm)		Conc (mg/l)
M1	4.00E+02	C1	3.64E+00
M2	3.99E+02	C2	0.00E+00
M3	1.50E+00	C3	9.69E+02

From above, the total U in underflow for the peak loading case = M1C1 + M2C2

Peak (Worst Case) Uranium = 1.73E+08 (mg)(lb/454g)(1g/1E3mg) = 3.81E+02 lb

4.2. A. Clarifier for Stormwater/Groundwater - Expected Loading



Given: Flow as shown in figure
Clarifiers are same as above
V1 and V2 are same as above
M4 = 1.5 gpm
C1 = 0.5 mg/l
Assume: Clarifier 1 equals Clarifier 2 flow
100% U removal
Find: expected U Loading using methodology above

Mass Balance:
M2 = M3 + M4
System Balance:
M4C4 = M2C2 -M3C3

Solving System Balance C4 = ((350 gpm)(0.5mg/l) - (348.5gpm)(0mg/l))/1.5 gpm
C4= 1.17E+02 mg/l for the slurry

Expected U Loading = V1C2 + V2C4 = 2.08E+07 (lb/454g)(1g/1E3mg) = 4.59E+01 lb

4. 2. B. Clarifier for Stormwater/Groundwater - Peak Loading (Worst Case)

Given: Clarifier model as above
Assume: Input from facilities for max concentrations and same flowrates
C1 = C2 = 1.5 mg/l

Mass Balance: M2 = M3 + M4
System Balance: M4C4 = M2C2 -M3C3

Solving System Balance C4 = ((350 gpm)(0.5mg/l) - (348.5gpm)(0mg/l))/1.5 gpm
C4= 3.50E+02 mg/l for the slurry

Peak Uranium Loading = V1C2 + V2C4 =	6.25E+07 (lb/454g)	(1g/1E3) =	1.38E+02 lb

Because the Uranium loading is for 2 clarifiers:

Expected Uranium Loading =	9.17E+01 lbs
Peak Uranium Loading =	2.75E+02 lbs

4.3. Ion Exchange Resin Bed - 6 Vessels Total

The build up of uranium in the ion exchange bed is a function of the resin loading. Operations are conducted to have one bed loaded, one lagging and one regenerating. Design of the IX resin bed calls for regeneration when the U reaches approximately 15 lbs (Ref. H6.3.) This value is used for the expected loading.

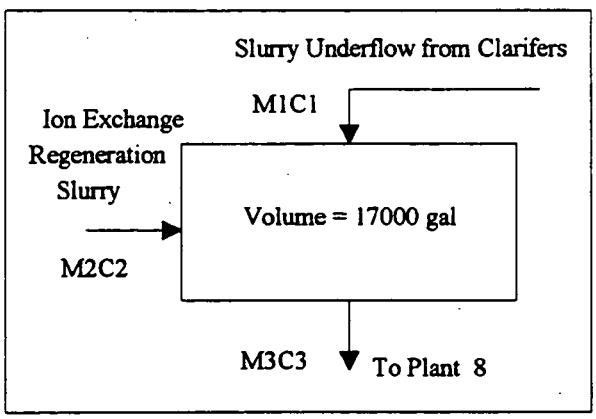
	Volume	Density	Resin Loading
Given:	(ft3)	(lbs/ft3)	(lbs U/lbs resin)
	130	45	1.27E-02

Peak Loading (Worst Case) = (130)*(45)*(1.27E-2) = 7.43E+01 lbs/vessel

Because there are 6 beds which could be fully loaded

Expected Uranium Loading =	90 lbs
Peak (Worst Case) U Loading =	4.46E+02 lbs total

4.4. A. Waste Slurry Surge Tank Loading - Expected Loading



Given:
The clarifiers' flowrates and concentrations above and the ion exchange regeneration rate of one vessel per day
Find: waste slurry tank expected and peak loadings
Assume: an average combined concentration for the process and storm/ground wastewater clarifiers flow and a flow rate of 0.5 gpm for the regeneration slurry with one resin bed being regenerated in 5000 gal (volume of first recycle tank)

For C2 = 74.3 lbs/5000gal = 1.78E+03 mg/l
For C1 = (1.79E2 + 1.17E2)/2 = 1.48E+02 mg/l

Expected loading is solved for a full tank with the known flowrates
mg U = 1.48E2(mg/l)(3/3.5)(17000*3.785) + 1.78E3(mg/l)(0.5/3.5)(17000*3.785)
mg U = 2.45E+07

Expected Waste Slurry Tank Loading =	5.40E+01 lbs U

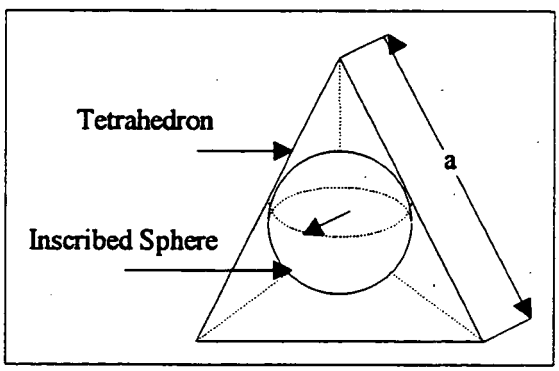
4.4. B. Peak (Worst Case) Waste Slurry Surge Tank Loading

Solving for M1 for peak loading concentrations for process and storm/ground wastewaters
For C1 = (9.69E2 + 3.50E2)/2 = 6.60E+02 mg/l

Peak (worst case) loading is solved for a full tank with the known flowrates
mg U = 6.60E2(mg/l)(3/3.5)(17000*3.785) + 1.78E3(mg/l)(0.5/3.5)(17000*3.785)
mg U = 5.28E+07 mg

Peak (Worst Case) Waste Slurry Tank Loading =	1.16E+02 lbs U

4.5. Multitube Filter Banks - 4 Banks total



The multitube filter banks are tubes with bag filters there being four banks total.

Given:
Filters effective to 1 micron
Each filter tube capacity of 36" length,
6" diameter
Find: uranium loading in filter tube banks
Assume:
Only material filtered in uranium
Close packing is a tetrahedral geometry.
UO2 is the flocculated filtrate of 1micron
Calculate the ratio of volume occupied by uranium and total filter bank volume

For an inscribed sphere in a tetrahedron, the radius of the sphere can be used to solve the tetrahedron leg length and hence the volume (Ref. H6.4.)

r = 1/12*a*sqrt(6), therefore a = 12*r/sqrt(6)
a = 2.449E-06 m
Volume of tetrahedron = 0.1178*a^3 = 1.73E-18 m^3
Volume of sphere = 4/3*pi*r^3 = 5.24E-19 m^3
Filter bed void fraction = Vtet - Vsph = 1.21E-18 m^3

Void volume fraction = Vfilt bd/ V tetra = 6.98E-01

Finally calculate the material loading and the uranium present. The uranium density is 8.39 g/cc (Ref. H6.5.)
Calculate the filter tube loading.

Filter tube volume = Pi*(r^2)*h = pi*(6/2)^2*36 = 1.02E+03 in^3
Filter tube loading capacity is calculated by: = 1.67E-02 m^3
Filter tube loading = V tube*(1- Void volume fraction)*density uranium *(molecular wt U /molecular wt UO2)

Filter tube loading = 1.67E-2m^3*(1 - 6.98E-1)*(8.39 g/cc)*1E6*(238/270) = 3.73E+04 grams

There are four multitube filter banks that could be loaded

Peak (Worst Case) Filter Tube Loading =	3.29E+02 lbs

4.6. Carbon Filter Bed Loading - 8 Beds Total

The build up of uranium in the carbon filter bed is a function of the carbon loading.
The AWWT carbon filter beds have the following conditions (Ref. H6.3.)

Given:	Volume (ft3)	Density (lb/ft3)	Carbon Loading (microg U/4g C)
	200	30	2.05E+02

Uranium Loading = (200)*(30)*(2.05E+2) = 3.08E-01 lbs/vessel

Because there are 8 beds total

Peak (Worst Case) Carbon Filter Bed Loading	2.46E+00 lbs total

4.7. Recycle Tanks

The recycle tanks receive the uranium held in the ion exchange resin when regenerated.
To bound the concentration of uranium present in a recycle tank, the first rinse is assumed to regenerate a resin bed that is loaded to a theoretical maximum (see No.4.3.)
The expected uranium loading for the ion exchange bed is 15 lbs (see No.4.3.)
That is, the assumed maximum uranium loading is recovered in the first rinse which is 5000 gallons. An assumed 80% efficiency in the first rinse is used.

For one vessel: 7.43E+01 lbs
For first rinse: 5.00E+03 gal Concentration = 1.78E+03 mg/l U

Because there are two sets of recycle tanks the quantities are doubled.

Expected Uranium Loading =	2.40E+01 lbs
Peak (Worst Case) Uranium Loading =	1.19E+02 lbs

4.8. Receiver Tanks

The tanks receive the recycle tanks contents after the regeneration of the ion exchange. All uranium heldup in the recycle tank is pumped to the receiver tank. The expected loading of the receiver tank are determined on the expected loading of the recycle tanks. A bounding loading is determined based on the theoretical maximum loading of the ion exchange beds.

For one tank: 7.43E+01 lbs
Because there are two tanks the quantities are doubled.

Expected uranium loading =	30 lbs
Peak (Worst Case) Uranium Loading =	1.49E+02 lbs

4.9. Piping Runs from AWWT to Plant 8

The AWWT effluent piping is 2" in diameter, and 1420' long. This yields an effective volume of (Pi) * r^2 * L = 3.14*((2/12)^2)*1420 = 1.24E+02 ft^3
There are 28.8 liters per cubic foot, this yields 3,600 liters. At the effluent concentration of 1.43 g/l, this yields a total uranium loading of 3,600 l * 1.43 g/l * 1/(454 g/lb) = 1.13E+01 lbs

Expected uranium loading =	1.13E+01 lbs

5.0 Conclusion

Table H-1 - Results for Uranium Loading of Process Equipment

Process Equipment	Expected Loading (lbs)	Peak Loading (lbs) (Worst Case)[1]
Clarifier: Process Wastewater Stream (1) (South Containment)	70.2	381
Clarifiers: Stormwater/ Groundwater Stream (1 each) (South Containment)	91.7	275
Multi-Tube Filter Banks[2] (4) (Building 51)	161[3]	329
Ion Exchange Beds (2 sets of 3 each) (Building 51)	90	446
Recycle Tanks (2 sets of 3) (South Containment)	24	119
Receiver Tanks (2 Tanks) (South Containment)	30	149
Carbon Filters (8 beds) (Building 51)	2.5	2.5
Waste Slurry Surge Tank (1) (South Containment)	54	116
Waste Slurry Pipe to Plant 8	6	12
Total	529.4	1829.5

Notes:

1. Peak Loading (Worst Case) is a result of failures and significant misoperation by operator and equipment
2. Design loading of the multitube filter banks is unknown, assumed maximum loading is all uranium.
3. Assumed 50 percent of peak loading

H.6.0 References

H6.1 DOE , July, 1994. DOE-EM-STD-5502-94, *Hazard Baseline Documentation.*

H6.2 Westinghouse Materials Company of Ohio, Inc., July 27, 1989. *Design Criteria for Environmental, Health and Safety Improvements Phases IV, Volume 3. Two Fiscal Year 1990 Subprojects, Part II: Wastewater Treatment Improvements - Plantwide.*

H6.3 Specification Package 02902-3502, 100 Percent Review Issue, June 1992.

H6.4 Avallone, E., ed. 1987. *Mark's Standard Handbook for Mechanical Engineers*, Ninth ed., New York: McGraw-Hill

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