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EXHIBIT
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Elimination of Liquid Discharge to the Environment from the TA-50 Radioactive Liquid Waste Treatment Facility

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EXECUTIVE SUMMARY

Determining viable options for eliminating the discharge of treated radioactive liquid waste to Mortandad Canyon was the directive of the outfall 051 elimination working group. It may no longer be in the best interests of Los Alamos National Laboratory (LANL) to continue using this outfall. Incentives for eliminating outfall 051, regulatory and technical issues involved, and recommended steps to accomplish this goal are presented in this report.

Treatment processes used at the Radioactive Liquid Waste Treatment Facility (RLWTF) at Technical Area -50 (TA-50) presently remove radioactive and other contaminants from 18–20 million L of radioactive wastewater per year. The liquid effluent is discharged to Effluent Canyon where it flows a short distance before entering Mortandad Canyon. Over 1.3 billion L have been treated and discharged since the RLWTF was commissioned in 1963.

The existing facility currently uses a precipitation and filtering process for removal of radioactive materials. Radioactive nuclides discharged in waters are regulated by Department of Energy (DOE) Order 5400.5. The existing precipitation technique does not produce water of a quality that can meet this Order. The Phase I upgrade being installed at the RLWTF addresses this problem by using tubular ultrafiltration (TUF) and reverse osmosis (RO) units instead of precipitation. A permeate (product) and a reject (concentrate) stream are produced from the TUF and RO. The permeate stream will meet DOE 5400.5 requirements. Additionally, the New Mexico Environment Department (NMED) has required that LANL discharges to Mortandad Canyon meet all State of New Mexico ground water standards. The effluent from the TA-50 plant does not consistently meet state ground water standards for nitrate, fluoride, and total dissolved solids. The Phase II upgrade addresses the nitrates with a biosystem that will convert the entrained nitrates in the water to nitrogen gas. The Phase I upgrade will take care of the fluoride and total dissolved solids concerns.

Treatment parameters for the Phase I and II upgrades, which were presented in the 95% Conceptual Design Report (CDR), are used in this study. The treatment parameters gained from the optimized Phase I and II upgrades, along with the additional recommendations by this working group, should be used in the design of the new radioactive liquid waste treatment facility. Some recommendations made in this report are not included in the CDR and need DOE approvals. Successful implementation of the Phase I and Phase II upgrades at the RLWTF, and the future construction of a new radioactive

liquid waste treatment facility designed to meet the needs of LANL for the next 30 years are fundamental to the recommendations proposed in this report.

Options considered by the working group for eliminating liquid discharge to outfall 051 are:

1. redirect the treated liquid flow to another discharge point,
2. further treatment and reuse/recycle of the RLWTF effluent, and
3. further treatment and subsequent evaporation of RLWTF effluent.

Evaluation criteria for each option included environmental protection, regulatory compliance, public perception, institutional requirements, corporate excellence and sustainability, technical feasibility, and economic feasibility.

The working group recommends a combination of options two and three that will begin a phased transition toward zero liquid discharge to Mortandad Canyon. Each phase of effort will result in improvements to environmental water quality and will increase stakeholders' confidence in the Laboratory's commitment to environmental stewardship. Zero liquid discharge to Mortandad Canyon will help alleviate public concern regarding the transport of contaminants into and from Mortandad Canyon. Three design and construction phases over the next five years are recommended to maintain the course toward zero liquid discharge.

Phase III deals with the reduction of tritiated wastewaters from the RLWTF influent to less than 20 000 pCi/L, which is the drinking water standard. The segregation and evaporation of Tritium Systems Test Assembly (TSTA) tritiated wastewater would be a step toward reducing tritium to that level. It would also allow decommissioning the cross-country transfer pipeline from TA-21-257 to TA-50-2. Also included in Phase III is the identification and minimization of other radioactive and hazardous constituents and the reduction of flow volumes into the RLWTF. Improved administration and monitoring of waste acceptance criteria (WAC) influent limits are proposed. During this phase, after biodenitrification and ferric hydroxide precipitation treatment, the RO concentrate waste stream will be commingled with the RO permeate and discharged at outfall 051.

Phase IV includes further treatment of the RO concentrate to separate solid and liquid phases. The solids will be removed and packaged for disposal at TA-54. The treated RO concentrate will be mixed with the RO permeate and the combined volume discharged at outfall 051. This additional treatment will further improve effluent quality and prepare the way for industrial reuse of effluent.

Phase V includes the design and construction of an evaporative process(es) that will result in zero liquid discharge to the environment. Productive reuse of the purified water stream to the extent practical is recommended. Evaporative processes were also studied to eliminate the discharge of liquid to Mortandad Canyon and conceptual level recommendations are presented to accomplish this goal.

The working group studied the alternative of discharging treated radioactive liquid waste to the Sanitary Wastewater Systems Consolidation (SWSC) plant as a means of obtaining zero discharge from the RLWTF outfall into Mortandad Canyon. Assuming all regulatory approvals could be obtained, the working group concluded that it would be unwise to mix treated radioactive liquid waste and sanitary wastewater at LANL. This conclusion was reached because of potential contamination of other canyons and facilities, regulatory issues, and public perception concerns.

In summary, the working group advises the Laboratory to set a course toward zero liquid discharge of treated radioactive liquid waste. In pursuit of this goal, the following action steps are advised:

1. complete and optimize the Phase I and Phase II upgrades at the present RLWTF,
2. design, fund, and construct a modern treatment facility with capability to treat LANL's radioactive liquid waste for the next 30 years,
3. initiate Phase III upgrade to segregate tritiated wastes from the RLWTF influent and to identify and minimize radioactive and hazardous wastes and flow volumes to the RLWTF as feasible,
4. undertake Phase IV upgrade to remove dissolved solids from the RO concentrate stream, and
5. begin Phase V upgrade to design and construct an evaporative process that will reuse or evaporate treated radioactive liquid waste and result in zero liquid discharge to the environment.

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ELIMINATION OF LIQUID DISCHARGE TO THE ENVIRONMENT FROM THE TA-50 RADIOACTIVE LIQUID WASTE TREATMENT FACILITY

by

David Moss, Neil Williams, Deb Hall, Ken Hargis, Mike Saladen, Mort Sanders, Stewart Voit, Pete Worland, and Steve Yarbro

ABSTRACT

Alternatives were evaluated for management of treated radioactive liquid waste from the radioactive liquid waste treatment facility (RLWTF) at Los Alamos National Laboratory. The alternatives included continued discharge into Mortandad Canyon, diversion to the sanitary wastewater treatment facility and discharge of its effluent to Sandia Canyon or Cañada del Buey, and zero liquid discharge. Implementation of a zero liquid discharge system is recommended in addition to two phases of upgrades currently under way. Three additional phases of upgrades to the present radioactive liquid waste system are proposed to accomplish zero liquid discharge. The first phase involves minimization of liquid waste generation, along with improved characterization and monitoring of the remaining liquid waste. The second phase removes dissolved salts from the reverse osmosis concentrate stream to yield a higher effluent quality. In the final phase, the high-quality effluent is reused for industrial purposes within the Laboratory or evaporated. Completion of these three phases will result in zero discharge of treated radioactive liquid wastewater from the RLWTF.

INTRODUCTION

Problem Statement

Defining viable steps for eliminating the discharge of treated radioactive liquid waste into Mortandad Canyon at Los Alamos National Laboratory (LANL) is the ultimate goal of the outfall 051 elimination working group's recommendations. The working group was established in October 1997, by the group leaders of Environmental Management/Radioactive Liquid Waste (EM-RLW) and Water Quality and Hydrology (ESH-18).

The liquid effluent from the Radioactive Liquid Waste Treatment Facility (RLWTF) contains constituents that are regulated by federal and state laws, US Department of Energy

(DOE) orders, and Pueblo standards. To meet these increasingly more stringent discharge requirements, LANL is presently installing new processes at the Technical Area 50 (TA-50) RLWTF.

This report defines a path that leads to zero liquid discharge of treated radioactive liquid waste to outfall 051. These recommendations encompass a broad spectrum of radioactive liquid waste management efforts involving waste characterization, liquid waste volume reduction, source minimization of regulated constituents, reuse and recycle, evaporation technologies, and the placement of constituents in their most environmentally benign state.

Evaluation Criteria

Evaluation of various alternatives studied to eliminate the RLWTF discharge was based on the following criteria:

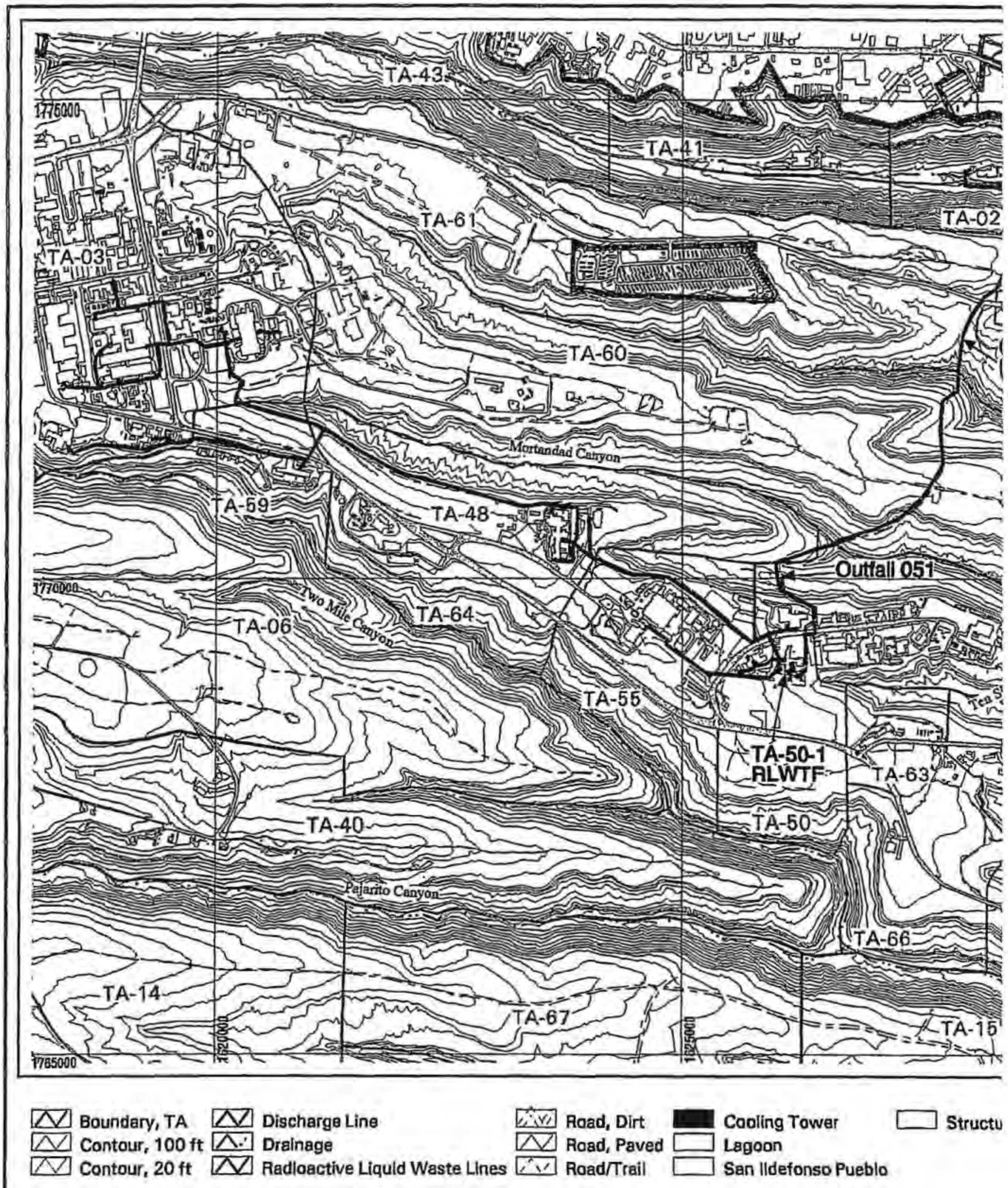
1. ability to provide for long-term protection of the environment,
2. ability to meet regulatory compliance requirements and prevent future legal liability,
3. ability to satisfy public concerns and perceptions,
4. ability to meet institutional requirements with minimal impact,
5. ability to support goals of corporate excellence and sustainability,
6. technical feasibility, and
7. economic feasibility.

ENVIRONMENTAL AND REGULATORY ISSUES

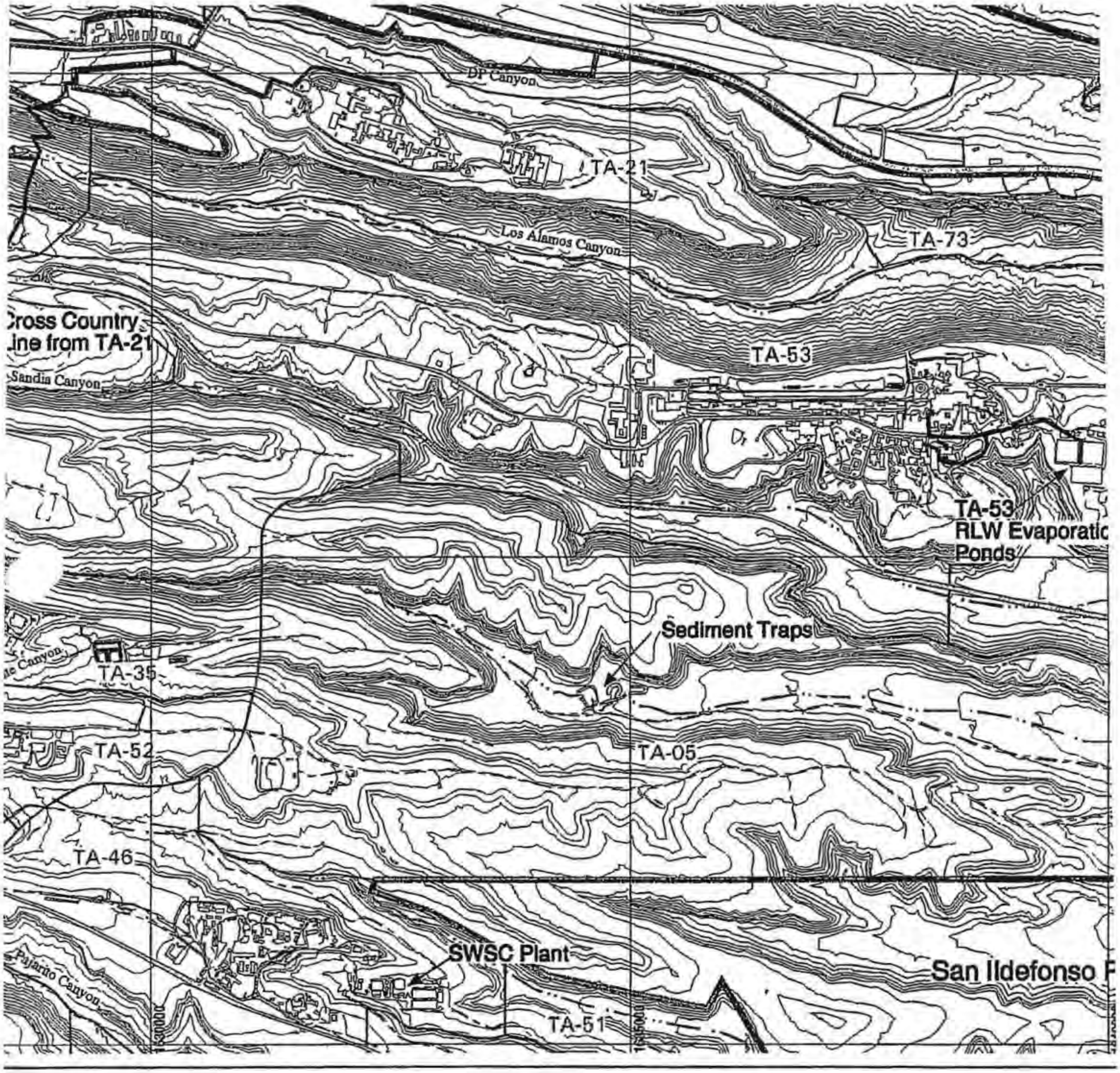
Hydrologic Setting of Mortandad Canyon

Mortandad Canyon is an east to southeast-trending canyon that heads on the western part of the Pajarito Plateau and is tributary to the Rio Grande to the east. The canyon contains a shallow body of ground water recharged by industrial effluent from the RLWTF, other smaller effluent flows, and storm water runoff (see Map 1). The spatial extent of this saturation is within the Laboratory boundaries, extending from near the RLWTF outfall on the west to approximately one mile above the boundary between the Laboratory and San Ildefonso Pueblo.

The greatest potential for the surface transport of contaminants from the RLWTF is with storm runoff, either in solution or adsorbed on sediments. Because of Mortandad Canyon's small drainage area, the presence of sediment traps constructed by the Laboratory, and the large volume of unsaturated alluvium, there has been no record of surface runoff off Laboratory property since hydrologic observations began in 1960.



MAP 1
Radioactive Liquid Waste Collection System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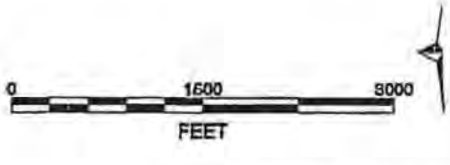
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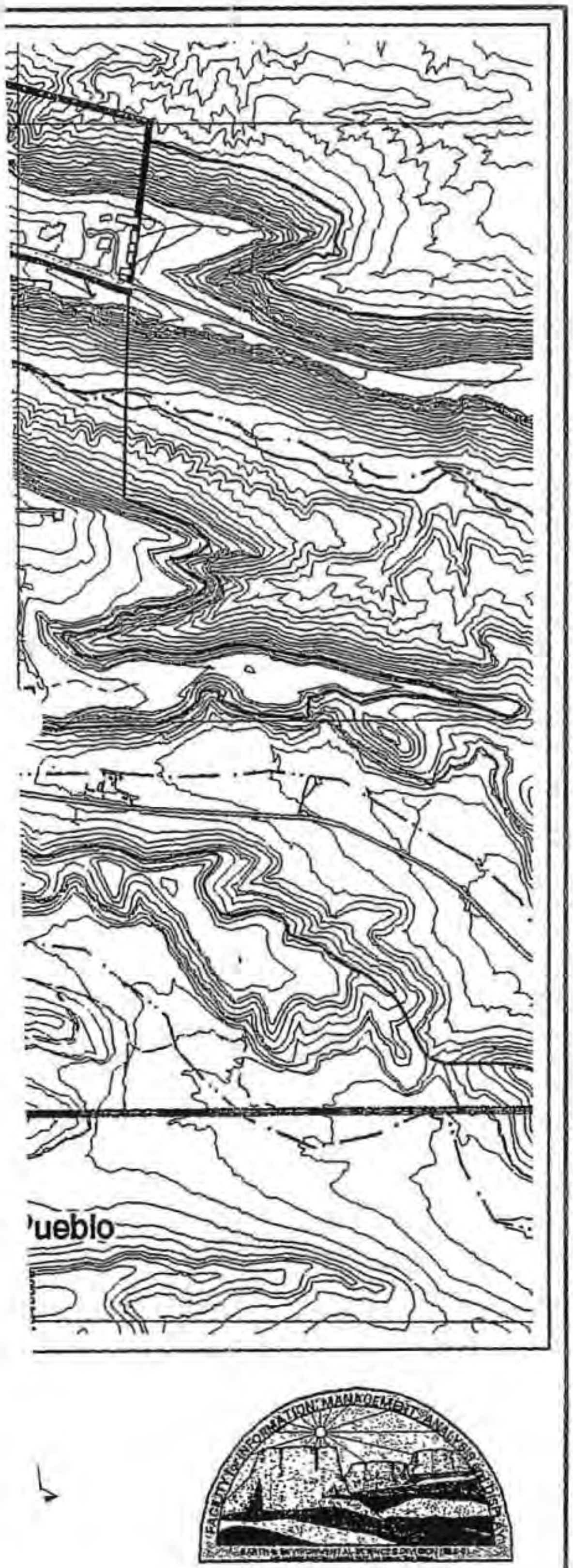

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by 'Marcia Jones' Date: June 02, 1998

Recharge by industrial effluents, principally from the RLWTF, occurs in the upper canyon. Storm runoff recharge is roughly equal to the effluent input volume on an annual basis. The volume of recharge since 1960 has not been sufficient to significantly change the volume of the shallow ground water.

Discharge Quality

Since the existing RLWTF treatment process was designed in the early 1960s for radionuclide removal, the facility's current effluent quality does not routinely meet all of the New Mexico Water Quality Control Commission (NMWQCC) ground water standards adopted in 1977. National Pollutant Discharge Elimination System (NPDES) compliance and RLWTF operational data show that the RLWTF treated effluent has consistently exceeded NMWQCC ground water standards for fluoride and nitrate, and occasionally exceeded the standards for cyanide, total dissolved solids (TDS), and pH.

DOE Order 5400.5 regulates the discharge of radioactive constituents from outfall 051 into Mortandad Canyon. Six radionuclides exceeded their respective derived concentration guideline (DCG) values in the RLWTF effluent during calendar years 1990 through 1996: ^{90}Sr, ^{137}Cs, ^{238}Pu, ^{239}Pu, ^{240}Pu, and ^{241}Am. The nuclides ^{90}Sr and ^{137}Cs exceeded their DCG values only in 1991. DCG values for ^{238}Pu were exceeded in 1994 through 1996. Plutonium-239 and ^{240}Pu exceeded their DCG levels in 1991 and 1995. DCG levels for ^{241}Am were exceeded each year from 1990 through 1996.

Groundwater Quality

Routine environmental monitoring has been conducted in Mortandad Canyon since 1960. The routine monitoring program includes regular collection and analysis of surface water, sediments, shallow alluvial, and main aquifer ground water samples from the canyon. The Environmental Surveillance Report at Los Alamos (1996) contains data on samples collected in Mortandad Canyon.

As RLWTF effluents are released into the canyon and move downgradient, radionuclides (except tritium) and some inorganic chemicals are adsorbed or bound to the bed sediments, reducing the amount of radionuclides or chemicals in the water or effluents. A high buildup of radionuclides or chemicals does not occur in the alluvium at the effluent outfall because periodic storm runoff transports sediments and contaminants down the channel in the canyon. Adsorption of contaminants reduces the concentrations in the perched ground water.

Nonradioactive Contaminants

RLWTF effluent quality has a significant influence on the quality of the shallow ground water. The perched alluvium ground water contains a number of inorganic constituents listed in the NMWQCC 3103 Ground Water Standards. TDS concentrations typically range from 300–600 mg/L.

A comparison of alluvial monitor well data with the NMWQCC nitrate standard shows that the alluvial ground water has consistently exceeded the standard of 10 mg/L for nitrate nitrogen. While high concentrations of nitrate nitrogen have been present as recently as 1994, (61 mg/L of nitrate nitrogen at monitor well MCO-7), the current trend is downward. In 1995 shallow alluvial monitor wells averaged about 15 mg/L as nitrate nitrogen. The current downward trend reflects both reductions in nitrates discharged to the RLWTF by programmatic activities over the recent past and attenuation within the natural canyon system. Purtymun (1977) determined that the loss of nitrates within the shallow ground water could be attributed to uptake by plants, adsorption onto alluvial material, and infiltration into underlying tuff.

A 1994 sampling of Test Well 8, a main aquifer-monitoring well in Mortandad Canyon, showed a nitrate as nitrogen value of 5.1 mg/L, while all other values since 1988 were 0.2 mg/L or less. The 1994 result could be an anomaly or it could represent evidence of actual nitrate contamination migrating from the shallow Mortandad alluvial ground water into the deeper main aquifer.

Beside nitrate, only one parameter, fluoride, has consistently exceeded NMWQCC ground water standards in the alluvium. There is currently a downward trend in fluoride concentrations in the alluvial ground water. Research by Purtymun (1977) indicates that once the concentrations of nitrates and fluorides in the RLWTF effluent are reduced or eliminated, then concentrations of those contaminants in the alluvial ground water will naturally decline due to the relatively rapid turnover of water and chemicals in storage. Comparing chemical concentrations in yearly effluent samples and ground water samples shows that ground water concentrations are about 30–50% of effluent concentrations. Purtymun (1977) concluded that, with regard to these mobile inorganic chemicals, "The rapid loss of water and its associated chemicals from the aquifer prevents chemical accumulation and indicates that cessation of effluent release to the canyon would rapidly improve the quality of water in the aquifer."

Cyanide and TDS have, on occasion, been discharged by the RLWTF at concentrations greater than NMWQCC ground water standards, but recent (1990–1995) monitoring data does not show elevated concentrations in the alluvial ground water. The New Mexico Water Quality Control Commission #3103 Standards are shown in Table 1.

Table 1. New Mexico Water Quality Control Commission Standards

Parameter	(mg/L)
Al	5.0
As	0.1
Ba	1.0
B	0.75
Cd	0.01
Cl	250
Cr	0.05
Co	0.05
Chemical oxygen demand (COD)	NA
Cu	1.0
CN	0.2
Fluoride	1.6
Fe	1.0
Pb	0.05
Hg	0.002
Ni	0.20
NH_3-N	NA
Nitrate-N	10.0
Nitrite-N	NA
N (total)	NA
NO_3–NO_2	NA
pH	6 to 9
^{226,228}Ra	30 pCi/L
Se	0.05
Ag	0.05
Sulfate	600
Total dissolved solids	1000
Total suspended solids (TSS)	NA
Total toxic organics (TTO)	NA
U	5.0
Zn	10.0

No organic chemical constituents (listed in the Resource Conservation and Recovery Act [RCRA] Appendix IX) have been identified in the alluvial ground water (Purtymun, 1988). Similarly, no cores taken in or beneath the alluvium to depths of approximately 100 ft showed any detectable organic chemical (volatiles, semivolatiles, herbicides, pesticides, or polychlorinated biphenyls [PCBs]) contaminants (Stoker et al., 1991).

Radioactive Contaminants

The main radioactive contaminants of concern in the Mortandad system include tritium, cesium, strontium, americium, and plutonium. Most of the radioactive residuals from the RLWTF effluents are removed from the water phase within a short distance of the outfall by adsorption onto sediments, in or immediately adjacent to, the stream channel. Aqueous concentrations are also highest near the RLWTF outfall. The levels of ^{90}Sr and gross alpha and gross beta contamination exceed Environmental Protection Agency (EPA) drinking water standards in many of the monitoring wells. In some years the levels of contamination (except for tritium) exceed DOE DCGs for a drinking water system but do not exceed the DCGs for ingestion of environmental water. The derived concentration guidelines for radioactive contaminants as stated in DOE Order 5400.5 are shown in Table 2.

Recent data indicates variable movement of contaminants into the unsaturated tuff beneath the saturated portion of the alluvium. Some boreholes showed migration of tritium, nitrate, and chloride to depths of at least 195 ft.

Except for tritium, radioactive constituents have apparently moved less than 10 ft in the unsaturated zone, based on analysis of cores from two on-site core holes (Stoker et al., 1991). However, more recent work by the Laboratory's Environmental Systems and Waste Characterization group, CST-7, has indicated that metallic radioactive contaminants may be more mobile in saturated alluvium than previously thought. The metallic radionuclides have been observed to travel in ground water sorbed onto colloid particles. The source and composition of the colloidal particles is not well defined yet, but some may originate as a byproduct of the coprecipitation process involving ferric sulfate and lime used at the RLWTF. Colloid density in the RLWTF effluent may be on the order of tens of millions of particles per milliliter (Longmire, 1997).

In 1993 trace levels (89 pCi/L) of tritium, as tritiated water, were detected in the main aquifer beneath Mortandad Canyon in Test Well 8. These levels are less than 1% of the EPA drinking water maximum contaminant level (MCL) of 20 000 pCi/L. Nonetheless, the levels are significant because they are indicative of recharge from the surface within the past four decades. Tritium is of great interest in evaluating the hydrologic process because tritium, the radioactive isotope of hydrogen, is chemically part of the water molecule and moves with water virtually unaffected by any geochemical processes such as ion exchange, chelation, or adsorption. Accordingly, it can be used as a fundamental conservative tracer to follow the movement of water.

The confirmed movement of water and tritium from the shallow zones to the deep aquifer during the period of LANL operations raises the possibility of ongoing migration of other LANL contaminants into the main aquifer. The present main aquifer monitoring well network is considered inadequate to detect the presence of very low-level radioactive contamination at the surface of the main aquifer. The results of the ongoing Monitor Well Installation Project will provide a much more detailed picture of the extent and movement of contaminants in the Mortandad system.

Table 2. Department of Energy Standards for Radionuclides in Water (DOE Order 5400.5)

Constituent	Uncontrolled Area (pCi/L)	Drinking Water (pCi/L)
^{3}H	2 000 000	80 000
^{7}Be	1 000 000	40 000
^{89}Sr	20 000	800
^{90}Sr	1 000	40
^{137}Cs	3 000	120
^{234}U	500	20
^{235}U	600	24
^{238}U	600	24
^{238}Pu	40	1.6
^{239}Pu	30	1.2
^{240}Pu	30	1.2
^{241}Am	30	1.2

Summary of Regulatory Issues

The following is not a complete summary of environmental regulatory issues facing the RLWTF. Nor is it even a listing of all potential environmental issues affecting implementation of zero discharge. The following text is intended to identify water-related regulatory issues that influenced the working group's recommendations.

Discharges of wastewater from Laboratory facilities are regulated under a complicated system of state and federal laws and regulations that involve a number of permits administered by different state and federal agencies. The regulation and management of radioactive constituents covered under the Atomic Energy Act is delegated to DOE. All other constituents, including some other radionuclides, are regulated by the EPA and the State of New Mexico Environment Department (NMED). Under the Clean Water Act (CWA) amendments of 1987, San Ildefonso Pueblo has the same potential authority to set stream standards as the State of New Mexico.

Clean Water Act

The primary goal of the CWA is to restore and maintain the chemical, physical, and biological integrity of the nation's water. The CWA established the NPDES Program that requires permitting of point-source discharges to the nation's water. The Laboratory's RLWTF is permitted to discharge industrial/radioactive wastewater into Mortandad Canyon through NPDES outfall 051. The RLWTF has consistently met NPDES permit limits with a few exceptions.

Under the authority reserved to EPA and the states by the CWA, the Laboratory's NPDES permit contains effluent limits for ^{226}Ra, ^{228}Ra, and accelerator-produced tritium. Section 1102 G. of the New Mexico Stream Standards requires that the radioactivity of surface waters be maintained at the lowest "practicable" level. In the Laboratory's case, this should minimally be protective of the livestock watering and wildlife habitat designated use. Additionally, NMED has proposed new stream standards for domestic water supplies including: dissolved uranium 5.0 mg/L, ^{226}Ra and ^{228}Ra 5 pCi/L, ^{90}Sr 8 pCi/L, ^{3}H 20 000 pCi/L, and gross alpha (including ^{226}Ra, but excluding uranium). These stream standards could be used as guidelines for future effluent-based limits in NPDES permits. For example, the current limit for tritium would be reduced from 3 000 000 pCi/L to 20 000 pCi/L, and ^{226}Ra and ^{228}Ra may be reduced from 30 pCi/L to 5 pCi/L. NMED has indicated in previous state certifications that these standards should apply to any outfall discharging a "regulated" radionuclide, including those that discharge a mixture of regulated and nonregulated radioactive waste. Additionally, there have been several attempts by Congress recently to pass legislation to amend the CWA and make federal facilities subject to stricter policing authority over nuclear waste that pollutes water.

Use Study

In 1992 the NMED issued a conditional certification of a draft NPDES permit for the Laboratory based upon effluent limits to protect fish in the Rio Grande. The agreement also required that a study be conducted to identify the stream uses associated with watercourses in the canyons into which the Laboratory discharges NPDES-permitted wastes. The study was conducted by the US Fish & Wildlife (USF&W) Service in 1997. The USF&W is currently evaluating its findings from the study and a final report is due in late 1998. EPA and NMED may develop the Laboratory's new NPDES effluent limits based on the findings from this study.

Stream Standards

New stream standards are being developed by NMED that will impact the effluent limits contained in the Laboratory's NPDES permit. The proposed new Wildlife Habitat Standards are quite stringent, including total mercury 0.0012 µg/L, total DDT and metabolites 0.000011 µg/L, and PCBs 0.014 µg/L. In some cases, the proposed standards are below analytical detection limits or minimum quantification limits (MQLs).

San Ildefonso Pueblo

San Ildefonso Pueblo has also drafted stream standards but, to date has not applied to EPA for their approval and adoption under the CWA Amendments of 1987. Section III-I of the draft standards, Water Quality Code for the Pueblo of San Ildefonso (1991), require that "The radioactivity of surface water shall be maintained at concentrations which do not exceed the maximum natural concentrations in surface and ground waters of the Pueblo." This standard would apply to any watercourse that crosses Pueblo lands. Even though storm runoff has not been observed to cross from LANL property onto San Ildefonso property, its standards could affect the Laboratory's NPDES permit.

When San Ildefonso Pueblo finalizes its Water Quality Standard and completes all other requirements set forth in the CWA amendments of 1987, its standards will have to be considered by EPA when it reissues the LANL NPDES permit. Before EPA could reissue the NPDES permit, the Pueblo would have to certify that the permit limits would be adequate to meet the Pueblo's stream standards.

NMWQCC Regulations

The State of New Mexico Ground and Surface Water Quality Protection Regulations (20 NMAC 6.2) authorize NMED to require a discharge plan approved by the secretary of NMED. On April 3, 1996, the NMED Ground Water Bureau (GWB) notified the Laboratory that a discharge plan was required for the discharge of NMWQCC-regulated contaminants at the RLWTF. The Laboratory submitted the Ground Water Discharge Plan for Application for the TA-50 RLWTF to NMED on August 16, 1996. Since then, at the request of NMED the Laboratory has provided technical clarifications in response to NMED's questions and the NMED has proposed some revisions in sampling schedules, etc. The discharge plan application is still pending NMED approval at the time of this report.

Abatement Plan

Subpart IV, Prevention and Abatement of Water Pollution of the State of New Mexico Ground and Surface Water Quality Protection Act (20 NMAC 6.2), was developed to abate pollution of subsurface water so that ground water is either remediated or protected for use as a domestic and agricultural water supply. NMED personnel have indicated that if the ground water or surface water is contaminated above standards and the Laboratory's Environmental Restoration (ER) Project does not address the contamination, NMED can enforce the abatement regulations.

Resource Conservation and Recovery Act and Hazardous and Solid Waste Amendments

The NMED Hazardous and Radioactive Materials Bureau (HRMB) considers the RLWTF to be a low-level waste treatment facility and is aware of the new upgrades or modifications to the facility. HRMB is concerned about the potential generation of RCRA waste streams, especially any process that may generate mixed waste and mixed transuranic (TRU) waste. To alleviate this concern the Laboratory must properly characterize its waste to ensure that there is a mechanism for proper waste storage and disposal. Administrative controls, such as the Waste Acceptance Criteria (WAC), have been adopted to prohibit the discharge of some RCRA-listed hazardous waste into the radioactive liquid waste (RLW) collection system. Some hazardous wastes are allowed under certain circumstances; however, they must meet exemptions. Additional efforts are needed to administratively implement and document the effectiveness of the WAC program. Current monitoring of RLW sources to verify compliance with the WAC is limited and needs to be expanded.

Under RCRA, wastewater treatment facilities that are subject to NPDES permit limits may qualify for exemption from certain RCRA requirements, including engineering design standards. When the RLWTF implements zero liquid discharge, if the NPDES permit for Mortandad Canyon is deleted, current exemptions would not apply. RCRA-listed wastes are already administratively prohibited from the RLW waste stream. However, the potential for exposure to increased RCRA regulatory coverage with zero discharge underscores the need for better administration and documentation of compliance with WAC requirements.

The Laboratory has prepared a site-wide hydrogeologic work plan. The work plan addresses both the RCRA regulatory ground water monitoring requirements and the Hazardous and Solid Waste Amendments (HSWA) hydrogeologic permit requirements.

The work plan describes proposed ground water characterization and monitoring activities Laboratory-wide, including activities in and adjacent to Mortandad Canyon.

The Laboratory has an ongoing ER Project that is responsible for preparing RCRA Facility Investigation (RFI) task or site work plans that establish the technical approach and methodology for environmental investigations. The general purpose of the RFI investigation in Mortandad Canyon is to:

1. determine the potential for contaminant transport into or within Mortandad Canyon watersheds,
2. evaluate human health risks and ecological impacts associated with the presence of contaminants,
3. refine conceptual models for contaminant transport,
4. assess the potential for interconnections between ground water in alluvium, perched intermediate zones, and the regional aquifer, and
5. assess the projected impact that contaminants may have on off-site receptors and the Rio Grande.

DOE Regulations

The Atomic Energy Act establishes a regulatory framework by which DOE, as successor to the Atomic Energy Commission, is authorized to prescribe and enforce regulations and other requirements necessary for sound management of its activities. Under this authority DOE developed Order 5400.5 with DCGs that specify dose and concentration limits for radioactive wastewater discharges. The RLWTF currently does not meet all DOE DCGs for radioactive constituents.

EPA and State of New Mexico authority to regulate radioactive pollutants is limited. Under 40 CFR 122.2, EPA and state authority is confined to "...radioactive materials (except those regulated under the Atomic Energy Act of 1954, as amended)." This same section further notes that "...radioactive materials covered by the Atomic Energy Act are those encompassed in its definition of source, byproduct, or special nuclear materials. Examples of materials not covered include radium and accelerator-produced isotopes."

Other Regulatory Programs

Air Quality and National Environmental Protection Act (NEPA) Requirements

The Laboratory's Air Quality Program (managed by ESH-17) is currently under a Federal Facilities Compliance Agreement (FFCA) that may impact selected treatment options (e.g., evaporators, lagoons, etc.). Additionally, a NEPA review and an environmental assessment, or only a NEPA review, may be needed if treatment options are selected that would move the discharge into another canyon. For example, discharge into Sandia Canyon could impact the wetlands and transport potentially contaminated radioactive wastewater off DOE property. Additionally, impact to Laboratory stakeholders (Pueblos, the public, etc.) must be evaluated.

RADIOACTIVE LIQUID WASTE AT LANL

Generation and Collection

Radioactive liquid wastes from LANL facilities have been treated at the TA-50 RLWTF since 1963. During the past 35 years, nearly 1.3 billion L of treated radioactive liquid waste have been discharged to Mortandad Canyon. Table 3 summarizes the quantity of radionuclides discharged in treated wastewater from the RLWTF from 1963 through 1995 (Longmire, 1997).

Table 3. Quantity of Radionuclides Discharged to Mortandad Canyon from the RLWTF (1963–1995)

Constituent	Curies
^{241}Am	>0.146
^{238}Pu	>0.097
^{239,240}Pu	0.194
^{137}Cs	>2.11
^{89}Sr	>1.06
^{90}Sr	>0.469
Gross beta and gamma	>8.51
^{3}H	817

The amount of effluent discharged yearly to Mortandad Canyon from the RLWTF is shown graphically in Figure 1.

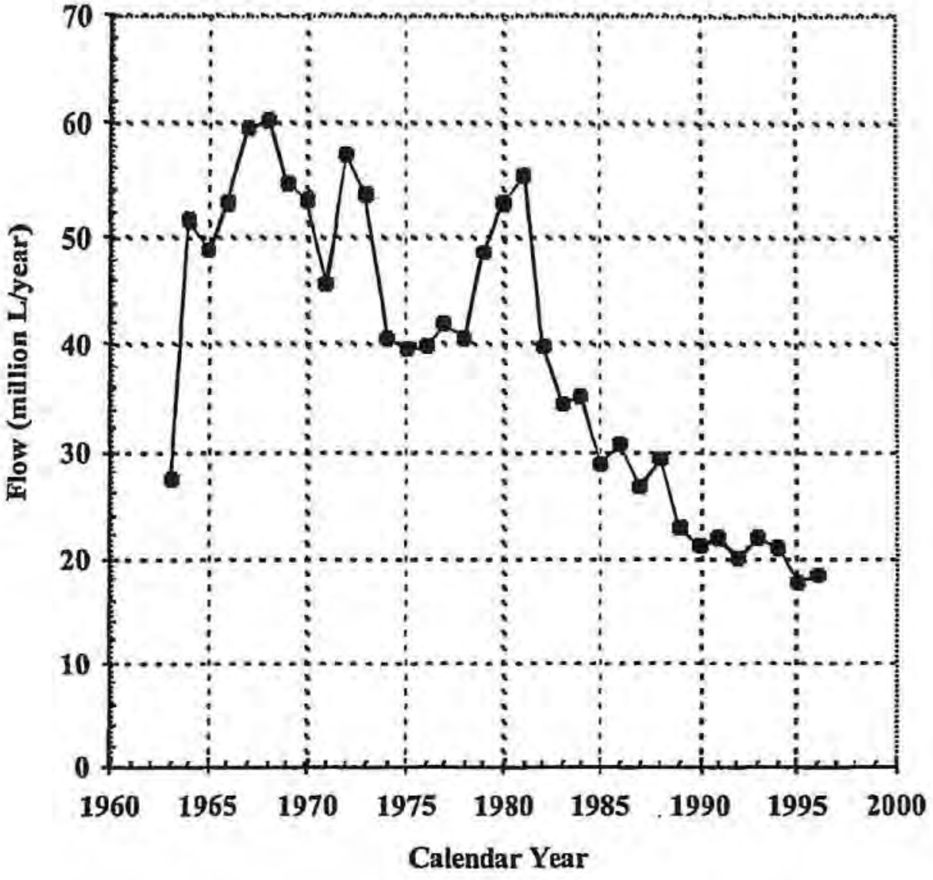

Figure 1. Treated RLWTF effluent to Mortandad Canyon (1963–1996).

Since 1981 the yearly flows have continued to decrease. However, the flows have not decreased significantly during the past five years. The flow is expected to increase, maybe as much as 50%, when the Chemistry, Metallurgy, and Research (CMR) Building becomes fully operational. Flows will also increase when the dual-axis radiographic hydrotest (DARHT) experiments start and when operations at TA-55 increase because of additional mission requirements. The present 20 million L/year influent volume may increase to 30 million L/year over the next few years. Historical data shows that the quantity of waste, as defined in the Influent Design Basis Report (Resource Technologies Group, 1995) is 15.6 million L/year. This is less than the present yearly volume treated at the RLWTF (see Figure 1) and about one-half the estimated level when the CMR Building becomes fully operational. Also, the Influent Design Basis Report does not consider the 20% recirculation rate that may be necessary with the new membrane processes and the additional processes required to obtain zero liquid discharge. The working group would advise that the design influent flow be increased to at least 30 million L/year. This added treatment capacity will accommodate the following factors:

1. seasonal variations (e.g., high flows during the summer when there are many temporary summer workers),
2. the increased flow when the CMR Building becomes fully operational,
3. increased mission requirements at TA-55, and
4. the volume recycled internally as part of new treatment processes

During calendar year 1993, an estimate was made of the relative percentage of radioactive liquid waste influent attributed to various generators at LANL. The result of this estimate is shown in Figure 2. These numbers reveal that in 1993 the four largest generators of radioactive liquid waste accounted for 78% of the volume. These generators are: the CMR Building (TA-3-29), the Plutonium Facility (TA-55), the Radiochemistry Site (TA-48), and the Sigma Building (TA-3-66). The information shown in Figure 2 is not presently valid because the CMR Building has been undergoing renovation and the missions served by the collection system have changed. Figure 2 also shows the large number of facilities served and the Laboratory-wide possible impact that failure of the RLWTF would have on critical LANL defense missions. Although the flow volume from the Plutonium Facility was only 15% during 1993, it was then and is today by far the major source of the actinide activity in the RLWTF influent. The contaminants present in the influent stream to the RLWTF have never been predictable. They fluctuate depending on changes in the Laboratory mission and which generator is discharging to the collection system at any given moment.

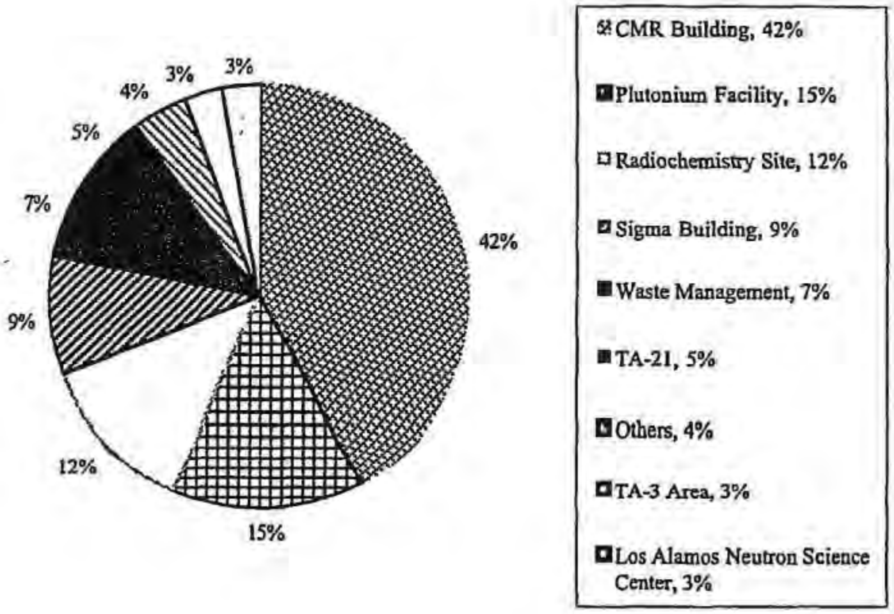

Figure 2. Percentage of liquid waste volume sent to RLWTF by generators in calendar year 1993.

Tritium concentrations in the RLWTF effluent stream are almost equal to the concentration in the RLWTF influent. The concentration in the effluent is less only because of the slightly greater effluent volume; no tritium is removed in the treatment processes. Figure 3 shows the tritium discharges in Curies per year from the RLWTF to Mortandad Canyon from 1980 through 1996. The solid and dashed lines that bound the Curies per year lines represent the discharges calculated to meet the 3.0 μCi/L NPDES limit and the 0.02 μCi/L drinking water limit. During this time period the tritium discharges decreased from a maximum of approximately 100 Ci/year to less than 1 Ci/year . Most tritium-contaminated waste enters the RLWTF from the Tritium Systems Test Assembly (TSTA) Facility through the TA-21 Radioactive Liquid Waste Treatment Plant (RLWTP). The contribution from this source is plotted from 1991 in Figure 3. The data shows that current tritium concentrations in the RLWTF effluent are near the 0.02 µCi/L level. Similar plots of ^{241}Am, ^{238}Pu, ^{239,240}Pu activities in RLWTF effluent from 1980 through 1996 are shown in Figures 4, 5, and 6.

Most radioactive liquid waste is transported to the RLWTF through the radioactive liquidwaste collection system (RLWCS), a gravity flow pipeline. This collection system is shown on Map 1. The main pipeline branches to approximately six technical areas and is eventually connected to over 1 600 sinks and drains within those facilities. The collection system was replaced in 1980 with a double-encased polyethylene pipe to meet waste compatibility and secondary containment issues. The collection system is continuously monitored for breach of containment and consists of conductivity monitors and leak detection devices located within manholes along the collection system. No breach of containment has been detected in the double-encased pipeline.

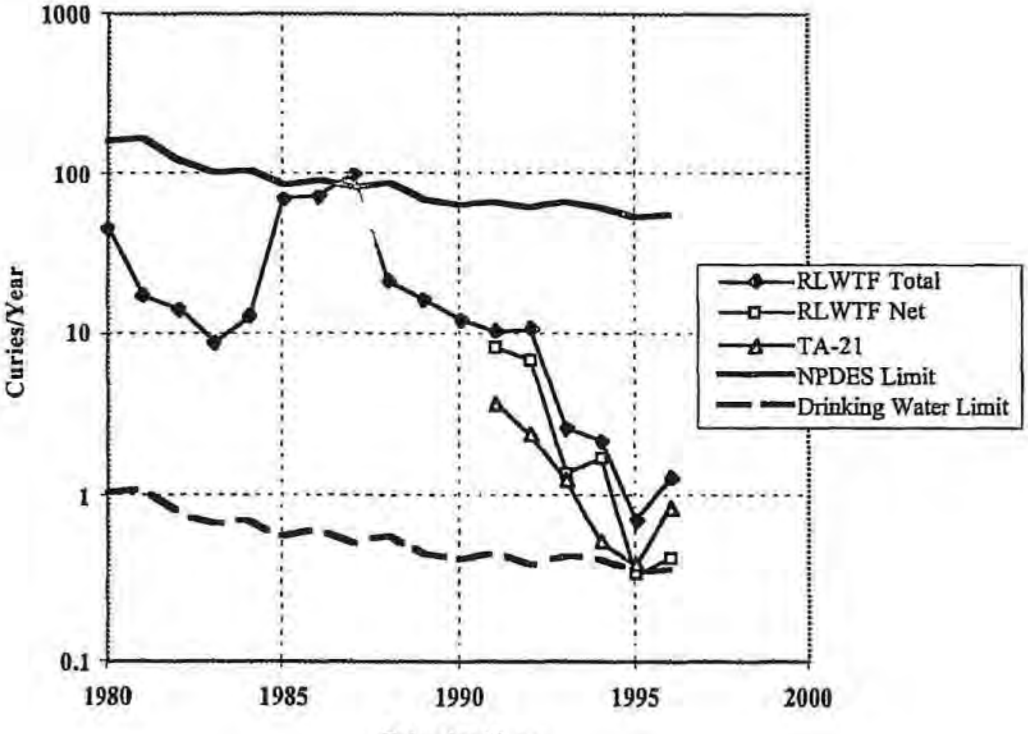

Figure 3. Tritium discharges from the RLWTF, sources and regulatory limits.

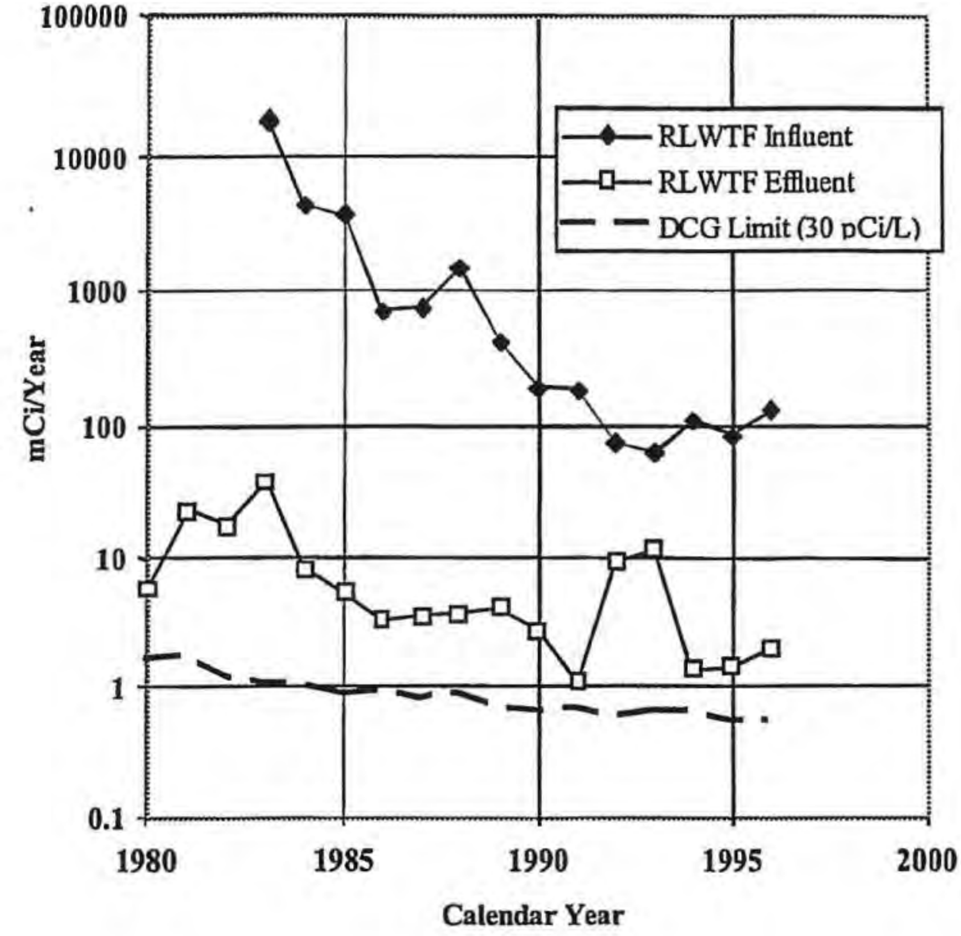

Figure 4. Comparison of ^{241}Am in RLWTF influent and effluent with DOE Order 5400.5 DCG limits.

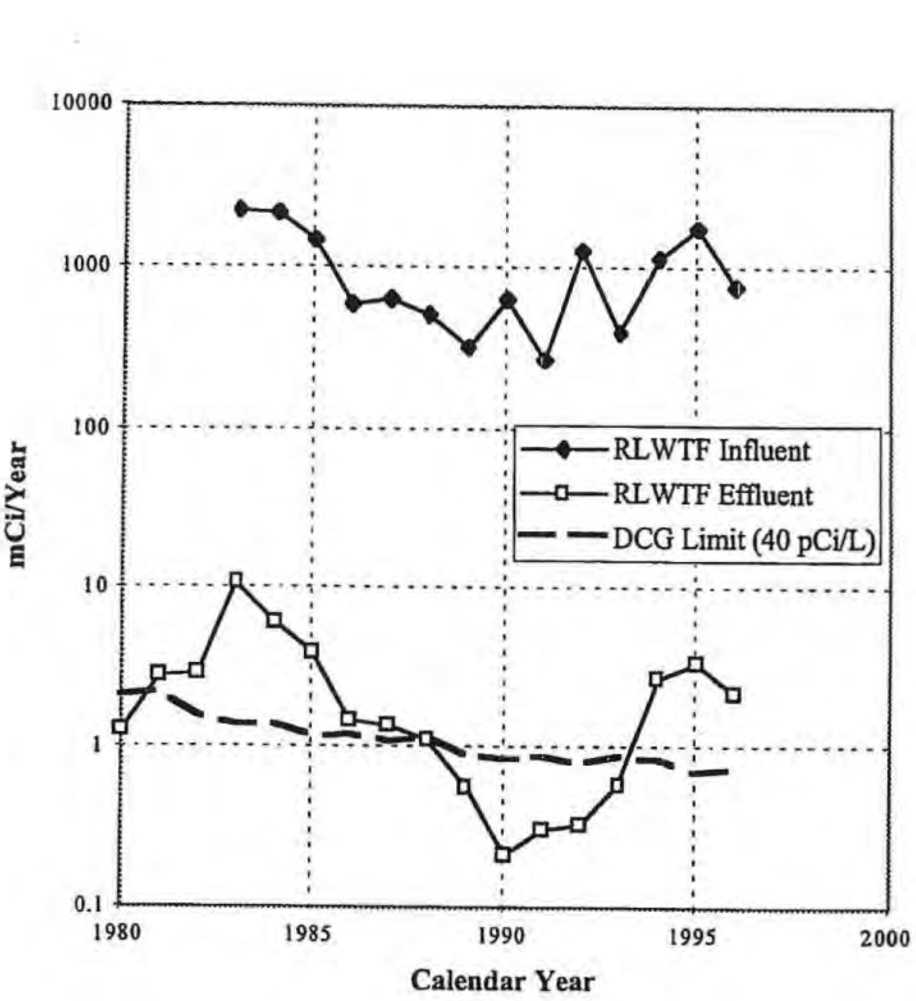

Figure 5. Comparison of ^{238}Pu in RLWTF influent and effluent with DOE Order 5400.5 DCG limits.

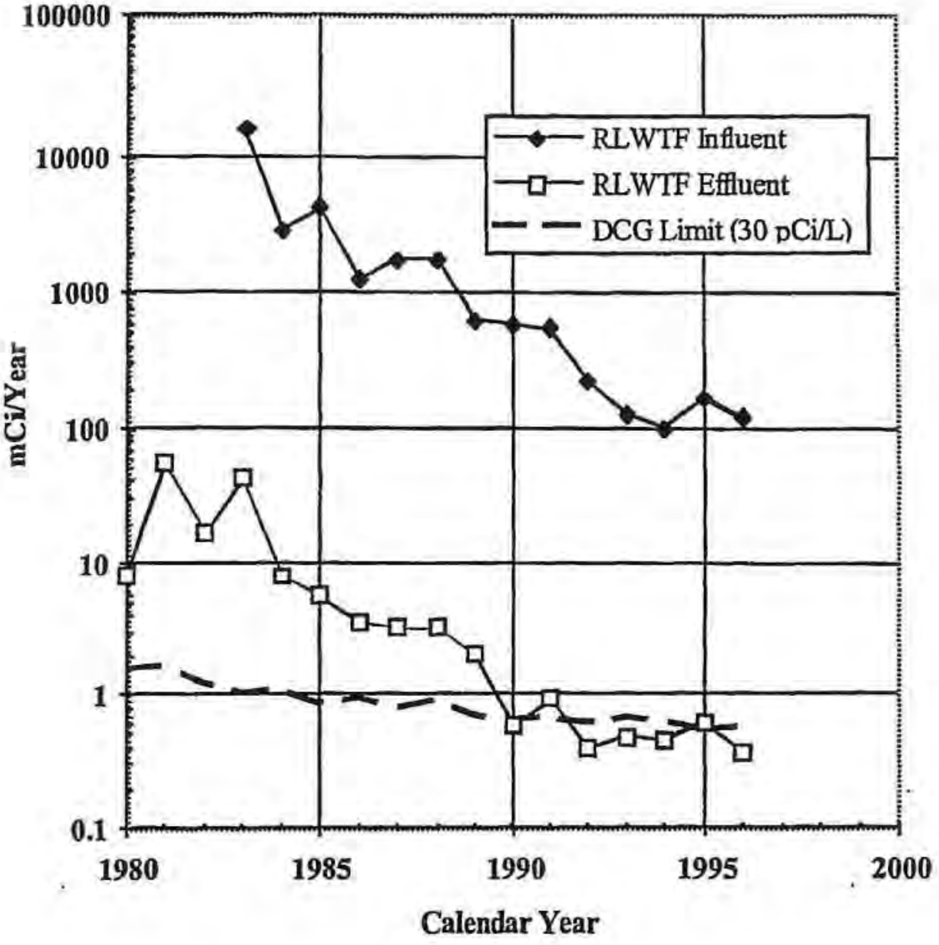

Figure 6. Comparison of ^{239,240}Pu in the RLWTF influent and effluent with DOE Order 5400.5 DCG limits.

Treatment and Disposal

The current main plant treatment operation, which has a capacity of 250 gpm, pumps wastewater from the influent storage tanks to a clariflocculator where ferric sulfate and lime are added to form a ferric hydroxide flocculant. Gravity causes floc particles containing radionuclides to settle at the bottom of the clarifier and form a sludge layer. The supernatant flows over the weir at the top of the clariflocculator. The sludge is transferred to a sludge holding tank in preparation for filtration, which is accomplished by a rotary vacuum filter. The filter cake resulting from this operation is low-level waste (LLW) that is drummed for disposal at TA-54, Area G. Supernatant decanted from the top of the sludge holding tanks and filtrate, and from the rotary vacuum filter are recycled to the influent holding tanks.

The clarifier supernatant is passed through an anthracite gravity filter to remove any unsettled floc. Carbon dioxide is bubbled through the gravity filter plenum to lower the pH below 9 and to reduce scale formation resulting from clarifier operations. The filtered effluent is then collected in effluent holding tanks where pH and gross radioactivity measurements are performed. The contents of the tank are then discharged through NPDES outfall 051 to Mortandad Canyon.

The highly radioactive waste process liquids originating at the Plutonium Facility, TA-55, are transported to the RLWTP in separate double-contained pipelines for monitoring and storage. To concentrate the radionuclides, these wastes are treated in a small, 25 gpm ferric hydroxide precipitation facility at the RLWTP. The concentrated solids are mixed with cement in a double drum–tumbler operation. About thirty 55-gal. drums of the cement paste are produced per year. These drums are TRU waste and are stored at TA-54 for future shipment to the Waste Isolation Pilot Plant (WIPP). Treated liquid from this operation is drained to the influent storage tanks for further treatment in the main plant at the RLWTF.

Phase I and II Upgrades

During the Phase I upgrade, additional treatment process equipment will be installed at the RLWTF. It will include equipment for tubular ultrafiltration (TUF) followed by reverse osmosis (RO). Phase I addresses the concentration levels of radionuclides discharged in waters regulated by DOE Order 5400.5. Because effluent from the current RLWTF treatment processes does not meet these limits, the TUF and RO process equipment is being installed to provide treatment that will meet DOE requirements. A permeate stream (product water with low concentrations of contaminants) and a reject stream (concentrate water with a high concentration of contaminants) are produced by both the TUF and the RO. Nitrates are concentrated in the RO reject stream. A rotary centrifugal ultrafilter is used to further dewater the concentrate that comes from the TUF equipment.

This additional process equipment will enable the RLWTF to:

1. ensure that treated effluent is discharged below the DCGs for radionuclides set forth in DOE Order 5400.5,
2. reduce fluoride concentrations in the treated effluent by reducing its source, the food-grade lime used during flocculation, and
3. concentrate nitrates in the waste stream for removal under Phase II.

The TUF equipment provides enhanced effluent quality by removing suspended solids and most of the radioactive constituents from the waste stream. It provides an effluent free of suspended solids and allows efficient additional treatment through the RO. Filtration capabilities of the RO equipment operate at the molecular level, rejecting dissolved solids from the waste stream at rates greater than 96%. The use of RO has been widely demonstrated in industry and municipalities when high purity product water is required.

The RO equipment is the final treatment process prior to discharge. Permeate from the RO equipment is expected to contain contaminant concentrations below those defined in the NMWQCC ground water standards and DOE Order 5400.5. The reject, or concentrate stream, from the RO equipment will be pumped to the clarifier for further removal of radionuclides and other contaminants. After this treatment step, it will be blended into the RLWTF effluent stream. The significant reduction in the amount of ferric sulfate and lime with the Phase I equipment is expected to reduce fluoride effluent concentration to values below regulated levels.

The objective of the Phase II equipment at the RLWTF is to remove nitrates in the RO concentrate stream to below NMWQCC ground water standards. Biological denitrification, which converts the nitrate ion to nitrogen gas, is the process selected for Phase II equipment. Evaporation and ion exchange resins were also investigated for removal of nitrates from the RO concentrate stream. Evaporation of the high-nitrate RO concentrate stream was ruled out because of safety considerations involving nitrates and unknown concentrations of organic constituents. The ion exchange process for nitrate removal would result in a secondary regenerant waste stream of smaller volume, but of very high nitrate concentration, therefore making the process unacceptable. The biodenitrification process was chosen because it safely destroys the nitrate ion with minimum radiation concerns (at as low as reasonably achievable [ALARA] levels), while producing an effluent that meets the minimum regulatory requirements. Figure 7 is a schematic of the RLWTF treatment process after implementation of the Phase I and Phase II process equipment.

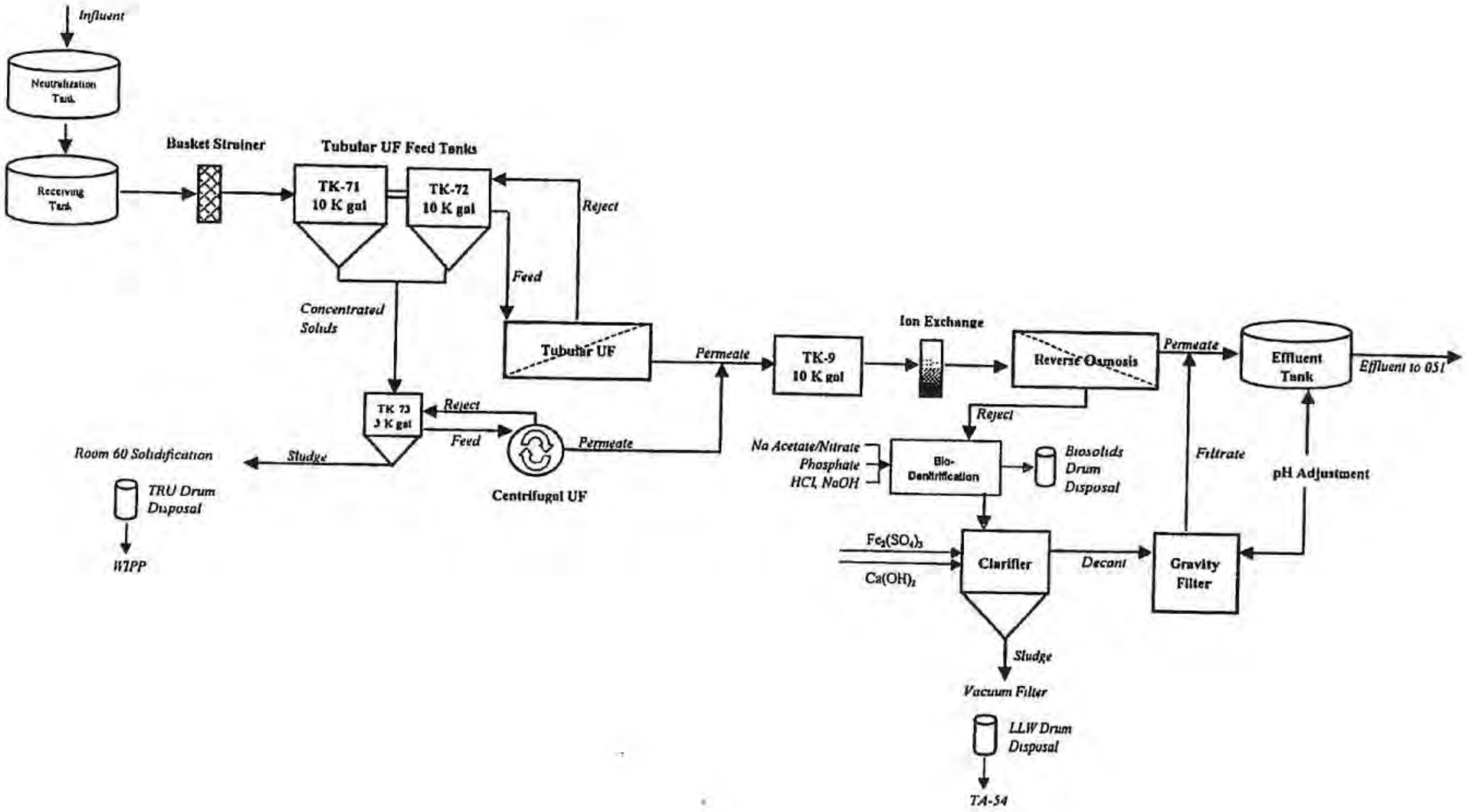

Figure 7. Schematic of the RLWTF treatment process after implementation of the Phase I and II upgrades.

DISCHARGE ALTERNATIVES

The working group has identified three alternatives for the discharge of the treated radioactive liquid waste from the RLWTF:

1. continued discharge to Mortandad Canyon via outfall 051,
2. discharge RO permeate and/or concentrate to SWSC, and
3. zero liquid discharge.

Continued Discharge to Mortandad Canyon via Outfall 051 (Alternative #1)

In this configuration, treated effluent from the RLWTF would continue to be discharged to Mortandad Canyon. Current upgrades, Phases I and II, to the RLWTF treatment process are designed to bring treated effluent into compliance with the DCGs in DOE Order 5400.5 and NMED ground water requirements for all currently monitored constituents. These upgrades, along with the planned construction of a new operations facility are the minimum efforts that must be made toward improvement of the outfall 051 conditions. Further treatment of the RO concentrate stream has the potential for improving the quality of water discharged to outfall 051. Generators improving characterization of waste and reducing some wastes at the source (i.e., tritium, actinides, nitrates, and organics) would also improve the quality of the effluent stream.

Concerns exist regarding the continued use of Mortandad Canyon for RLWTF treated effluent. Contaminants in Mortandad Canyon soils from the RLWTF outfall have been identified. There is concern that contaminants, particularly those in colloidal forms, may be transported farther down the canyon over time. Studies are under way to determine if there is a connection between the shallow perched ground water bodies and the deep regional aquifer that supplies drinking water to Los Alamos County. If such a hydrologic connection exists, there is a possibility that discharges from the RLWTF to Mortandad Canyon may be adding to the movement of contaminants toward the deep aquifer. If this is shown to be true, discharge to outfall 051 would likely be stopped.

Continued discharge of treated effluent to Mortandad Canyon, even with greatly improved water quality, will always retain characteristic "signature" constituents (e.g., plutonium and americium) traceable to the RLWTF. Some stakeholders protest the discharge of any such waste stream to the environment. Additionally, if the effluent cannot meet future regulatory requirements or contaminants are found to be moving off DOE-controlled land, an alternative to discharging to outfall 051 would have to be found.

Table 4 is a summarized compilation of the evaluation criteria that were considered by the working group in evaluating alternative #1, continued discharge to Mortandad Canyon. Both a summary of issues and a qualitative evaluation of each evaluation basis are given. The continued discharge to Mortandad Canyon alternative is based on the assumption that the Phase I and II upgrades at the RLWTF are installed and operating and the RLWTF effluent is in compliance with DOE Order 5400.5 and the NMWQCC ground water standards.

The working group concurs that the potential contaminant transport to the deep aquifer in Mortandad Canyon is a significant concern. Other alternatives for the discharge of the RLWTF effluent should be considered. Also, there is notable public concern regarding this outfall and the discharge of RLWTF effluent to the environment. While it is unquestionably in the best interests of LANL to improve the quality of this effluent to the highest possible level, it appears to be equally important to consider how the discharge of this liquid stream to the environment can be eliminated entirely.

Discharge RO Permeate and/or Concentrate to SWSC (Alternative #2)

In this alternative, RLWTF effluent would be sent to the SWSC Facility at TA-46. The SWSC Facility operates an activated sludge, biological treatment system to remove pollutants from the Laboratory's sanitary liquid waste stream (Royal Crest Trailer Park is also connected to SWSC). The SWSC Facility also performs biodenitrification of the sanitary wastewater.

Section II 3. d of DOE Order 5400.5 permits the discharge of liquid wastes containing radionuclides from DOE activities into publicly owned sanitary sewerage systems as long as the total fractions of the average concentrations for each radionuclide to its respective DCG value is less than five. Liquid wastes with fractions of the average concentrations for each radionuclide to its respective DCG value greater than five may be discharged into a sanitary sewerage system owned by the federal government (Section II 3. d. (3) of DOE Order 5400.5).

Such a federally owned sanitary sewerage system, having effluent concentrations in excess of the DCG levels, must prescribe the best available technology (BAT) level of treatment if the receiving surface waters contain radioactive material at concentrations greater than the DCG values (Section II 3. a. (1) of DOE Order 5400.5). Implementation of the BAT process for liquid radioactive wastes is not required when radionuclides are already at a low level, i.e., the annual average concentration is less than DCG level. In that case the cost consideration component of BAT analysis precludes the need for additional treatment because any additional treatment would be unjustifiable on a cost–benefit basis. Therefore, additional treatment will not be required for waste streams that contain radionuclide concentrations of not more than the DCG values (Section II 3. a. (2) of DOE Order 5400.5).

DOE Order 5400.5 clearly states that radioactive waste streams containing radionuclide concentrations of not more than the DCG reference values at the point of discharge to a surface waterway normally will not require treatment to further reduce the concentration (Section I 5. b. of DOE Order 5400.5). The working group's interpretation of DOE Order 5400.5 is that it is allowable to send radioactive liquid waste from the RLWTF to SWSC at concentrations greater than 5 times the DCG level because SWSC is owned by the federal government. Also, it would be allowable to continue discharging SWSC effluent into Sandia Canyon as long as the effluent is below the DCG level.

There are three configurations of this alternative for the RLWTF effluent:

1. RO concentrate stream sent to SWSC,
2. RO permeate and concentrate streams sent to SWSC, and
3. RO permeate stream sent to SWSC.

Configuration #1 RO Concentrate Stream Sent to SWSC

The SWSC plant has the ability to treat the RO concentrate stream for nitrates. This configuration would eliminate the need for biodenitrification at the RLWTF and would increase the average daily influent volume to SWSC by 1%. The RO concentrate stream (≈2 000 gpd) would combine with the much larger SWSC influent stream (≈200 000 gpd). This dilution ratio would reduce the 150 pCi/L of alpha activity in the RO concentrate stream to 1.5 pCi/L in the SWSC plant influent. Additional removal of some radionuclides would likely occur by interaction with biosolids at SWSC.

Tritium could be reduced at its sources if generators improved their characterization of wastes sent to the RLWTF. This alternative would allow the RLWTF to discharge only the very clean RO permeate stream (≈18 000 gpd) to the environment through outfall 051.

Configuration #2 RO Permeate and Concentrate Streams Sent to SWSC

In this configuration both the RO permeate (≈18 000 gpd) and RO concentrate (≈2 000 gpd) streams would be sent to SWSC. Biodenitrification at the RLWTF would not be needed. This configuration would increase the average daily influent to SWSC by 10%. The RLWTF could then discontinue the use of outfall 051.

Table 4. Evaluation Matrix of Continued Discharge to Mortandad Canyon Alternative

Evaluation Basis	**Summary of Issues**	**Qualitative Evaluation**
Long-term protection of the environment	It is suspected that a hydrologic connection exists between the surficial alluvial ground water in Mortandad Canyon and the deep regional aquifer hundreds of feet below ground surface. Continuing to release the RLWTF effluent to this canyon contributes to the migration of colloidal and dissolved contaminants through the alluvial ground water and also deeper into the tuff.	Radionuclides remaining in the treated effluent will not be disposed of as solids, their most environmentally stable form.
Present regulatory compliance and future legal liability	The implementation of Phase I and II upgrades at the RLWTF will bring the effluent into compliance with present DOE and NMWQCC regulations. More stringent future regulations would require further water treatment. The potential exists that the perched underground waters in Mortandad Canyon may require abatement and the soil may need remediation. The treated liquid waste is regulated by a NPDES permit that allows the RLWTF to operate with a RCRA exemption.	The implementation of Phase I and II upgrades will bring the RLWTF into minimal compliance with the DCGs and NM ground water standards. LANL has a unique geographic relationship to pueblo lands that may impact regulatory requirements.
Satisfaction of public concerns and perceptions	The State of New Mexico, the Los Alamos community, the DOE, and San Ildefonso Pueblo are very concerned about the environmental impact of discharging the treated radioactive liquid waste into Mortandad Canyon.	Continued discharge to Mortandad Canyon manifests to LANL stakeholders that LANL will only make the minimal effort required to handle radioactive liquid waste.
Minimal impact on LANL institutional requirements	No new impact.	LANL remains vulnerable to regulatory challenges.
Supportive of corporate excellence and sustainability goals	The Phase I and II upgrades at the RLWTF will enable LANL to continue to carry out its current mission capability with minimal environmental compliance. The Phase I and II upgrades are a "band-aid" fix until a new facility and treatment equipment are provided. Sustainability goals may be compromised by continued discharges from the RLWTF to the environment.	LANL's concern for present neighbors and future generations is called into question by continuing discharge to Mortandad Canyon.
Technical feasibility	Phase I and Phase II processes are included in the CDR which will provide treatment capability and redundancy for this standard of operation.	Pilot plant tests suggest the full-scale implementation of Phase I and II upgrades are likely to be successful.
Economic feasibility	Requires DOE and congressional funding of a new process building and equipment.	The Phase I and II upgrades are a temporary fix for RLWTF compliance requirements. A long-term, funding commitment is required to procure a new radioactive liquid waste process facility and process equipment.

Configuration #3 RO Permeate Stream Sent to SWSC

Only the RO permeate stream (≈18 000 gpd) would be sent to SWSC. Daily flows to SWSC would increase by 9%. The RO concentrate stream at the RLWTF would be treated with additional technology to an endpoint where the contaminants in that stream would be solidified, requiring additional treatment beyond the scopes of Phase I, Phase II, and the conceptual design report (CDR). The RLWTF could discontinue the use of outfall 051.

The discharge of RLWTF effluents to SWSC raises five major concerns.

Concern #1 Fate of constituents with RLWTF "signature"

Presently, SWSC effluent is pumped to TA-3 where a small portion is used for industrial cooling operations at the Power Plant and the remainder is discharged to Sandia Canyon. A plan currently exists, the Ground Water Discharge Plan DP-857, for the SWSC effluent to also be discharged to Cañada del Buey (1992). If this plan is implemented, SWSC effluent would cross San Ildefonso Pueblo land. During storm events, there is a possibility of surface flow in this arroyo through White Rock to the Rio Grande.

The impact of the RLWTF contributing water to these areas must be considered. Contaminants with the RLWTF "signature" would be discharged to either Sandia Canyon or Cañada del Buey, or to both canyons. The working group felt that significant public concern about this practice would persist even if radionuclides, such as tritium and the actinides, were discharged at concentrations well below their DCG values. Sandia Canyon already has detectable PCB contamination and the alluvium is difficult to monitor due primarily to the location of the Los Alamos County landfill. Flows beyond LANL boundaries and onto San Ildefonso land occur during wet weather in Sandia Canyon due to its large watershed, high volumes of effluent flows, and high percentage of impervious area. Transport of contaminated water and sediments is a significant issue for Sandia Canyon. Neither Cañada del Buey nor Sandia Canyon is, therefore, not a desirable choice for discharge of liquids containing detectable quantities of LANL "signature" constituents. On the other hand, Mortandad Canyon, due to its small watershed area and smaller effluent discharge, has essentially no off-site surface or subsurface flow.

The discharge of treated RLWTF effluent to SWSC would eliminate input of pollutants to Mortandad Canyon. A subsequent improvement in alluvial ground water quality would be expected. Reduced input of water to the contaminated Mortandad Canyon alluvial ground water would reduce the hydraulic head that drives contaminants deeper into the tuff. Also, any downstream transport of contaminated colloids and sediments in Mortandad Canyon would be reduced.

Concern #2 Additional monitoring for radiological parameters

NMED has indicated they would incorporate internal outfall requirements on the RLWTF if the Laboratory connected the discharge to any other NPDES treatment facility. Additionally, NMED would require a permit modification for the disposal of sludge. EPA may also require the Laboratory to develop and implement pretreatment programs as special conditions of the NPDES permit. Pretreatment programs are developed to control significant industrial discharges for the following reasons: ensure the permittee meets effluent standards, prevent pass-through of contaminants, prevent interference, including interferences with its use or disposal of sludge, and improve opportunities to recycle and reclaim sanitary and industrial wastewater and sludge. Pretreatment requirements may require additional treatment and sampling at the sources of discharge for facilities connected to the RLWTF (i.e., TA-55, CMR Building, Sigma Building, etc.).

Additional regulatory compliance monitoring for radiological parameters would also likely be required at all potential sanitary effluent discharge locations. These locations include the SWSC Plant (outfall 13S), the Central Computing Facility (CCF) cooling tower (outfall 03A-027), the Power Plant (outfall 01A-001), and any future reclaimed water reuse sites. Additionally, administrative requirement (AR) AR 9-6 and the SWSC waste acceptance criteria, which state that no radiological waste may be sent to SWSC, would be violated. The potential contamination of the SWSC plant and all reuse facilities (i.e., tanks, cooling loops, and cooling towers) would have to be taken into consideration.

Concern #3 Modifications to SWSC Regulatory Requirements

Sanitary spills from the SWSC collection system downstream from the RLWTF could be considered reportable radioactive waste releases. SWSC sludge is presently managed as Toxic Substances Control Act (TSCA) waste due to the presence of detectable PCB concentrations. The introduction of RLWTF waters to SWSC may require the sludge be handled as a mixed low-level radioactive waste (MLLW). Because the RLWTF is a RCRA treatment, storage, and disposal facility subject to RCRA hazardous waste material regulations, regulatory permits required at SWSC could be affected. NPDES permits would have to be modified to allow SWSC to accept an industrial waste stream. Industrial waste stream acceptance at SWSC would likely mandate start-up of an industrial pretreatment program or monitoring program for the RLWTF. Thus, discharge of effluent from the RLWTF to the SWSC plant would probably not decrease the required monitoring at the TA-50 RLWTF, but simply move the monitoring location. The NMED would also likely require the preparation of a ground water discharge plan for Sandia Canyon, modification of the current Ground Water Discharge Plan (LANL, 1992), and modification of Ground Water Discharge Plan Application for Sanitary Sewage Sludge Land Application Sites (LANL, 1995). Modification of these regulatory documents is usually a very time-consuming process.

Concern #4 Increased cost of doing business for LANL

A major increase in capital and operations and maintenance (O&M) costs at SWSC would be expected for influent radiological monitoring equipment, new procedures, additional analyses, and extra reporting for waters and for sanitary sludge, grit, and screenings. Additional radiological training, equipment, and hazard analyses for SWSC operators would be required. The SWSC plant and reuse system administration might need to be moved from Facilities Engineering (FE) Division to Environmental (EM) Division to properly manage a radioactive waste.

Costs at the RLWTF would be reduced by sending the RO concentrate stream to SWSC. The need for biodenitrification and salt removal from the RO concentrate stream at the RLWTF would be eliminated.

Concern #5 Operational considerations at SWSC

Addition of RLWTF waters, particularly the configurations that include the RO permeate stream, would add to the hydraulic loading of the SWSC plant. The SWSC plant nitrification and denitrification treatment process is vulnerable to hydraulic overloading of the reaction basins. RLWTF effluents to SWSC may need to have nutrients added to maintain a particular food to microorganism ratio in order to achieve the desired denitrification. Addition of excess amounts of water without appreciable biodegradable material adversely affects the process.

The working group recognizes there would be immediate benefits to the RLWTF should alternative #2 (discharge of RO permeate and/or concentrate to SWSC) be adopted. These benefits are: denitrification of the RO concentrate stream could be performed at SWSC, there would be no need to mix the high TDS RO concentrate stream with the RO permeate stream, and no treated radioactive liquid waste would be discharged from outfall 051. However, the costs (economic, regulatory, legal, public perception) far outweigh the immediate benefits. Changes in future regulatory and environmental policy could render this alternative unfeasible, making it at best a temporary solution.

Table 5 is a summary of the factors that were considered by the working group in evaluating alternative #2. This alternative may be shown to be within the limits set by DOE Order 5400.5, but long-term relations with stakeholders and any environmental impact preclude its implementation.

Zero liquid discharge (Alternative #3)

Zero liquid discharge from the RLWTF means that no treated liquid radioactive waste will be discharged to the environment. The working group considered the following three methods to eliminate the RLWTF liquid discharge to outfall 051.

1. Redirect the treated liquid flow to another discharge point. This option merely exports the environmental problem to another location.
2. Totally recycle the RLWTF effluent. This is the ideal option. Contaminants and salts would be removed and solidified and the water would be reused in Laboratory facilities.
3. Totally evaporate the treated liquid waste stream following the removal of contaminants and salts.

Options two and three are zero liquid discharge options. In these options the RLWTF influent would be treated as currently planned in the Phase I and Phase II upgrades. In addition, the biodenitrified RO concentrate stream would be evaporated to a highly concentrated salt solution that can be solidified. RO permeate water would be reused or recycled in LANL facilities or evaporated. Various methods to evaporate the treated RLWTF effluent are being considered: cooling towers, mechanical evaporators, land application, evaporation ponds, and constructed wetlands. There would be no liquid discharges to the environment from the RLWTF.

An important consideration in this alternative would be loss of the RCRA exemption currently provided to the RLWTF due to its oversight by the EPA through the NPDES permitting process. Loss of this exemption would mean that the RLWTF would be required to meet additional RCRA regulatory guidelines regarding waste treatment practices. RCRA guidelines regarding waste treatment at the RLWTF would focus on concentrations of metals and organics in the RO concentrate stream and sludges produced at the RLWTF. Additional sampling procedures would likely be needed at the RLWTF. The RLWTF would need to manage the constituents in the waste stream and so have much better knowledge of, and control over, wastes discharged to it for treatment.

Table 5. Evaluation Matrix of Discharge RO Permeate and/or Concentrate to SWSC Alternative

Evaluation Basis	**Summary of Issues**	**Qualitative Evaluation**
Long-term protection of the environment	Discharge of treated radioactive liquid waste to SWSC increases the possibility of contamination at the SWSC Facility, Sandia Canyon, and TA-3 facilities with the following radionuclides: ^{238,239,240}Pu, ^{241}Am, ^{3}H, ^{137}Cs, and ^{90}Sr. Issues regarding approval of SWSC effluent discharges to Cañada del Buey will be complicated.	The area contaminated by LANL signature constituents will be increased. The present and future exposure of humans to radionuclides is increased.
Present regulatory compliance and future legal liability	The SWSC WAC would need to be changed to accept radionuclides. Monitoring of constituents and regulatory oversight would increase.	The potential exists for legal, technical, environmental, and economic liabilities.
Satisfaction of public concerns and perceptions	The area of radioactive contamination will be enlarged and the potential exposure of humans to radioactivity will increase.	LANL will be perceived as not caring if it contaminates additional facilities, canyons, and noncontaminated environments.
Minimal impact on LANL institutional requirements	This alternative would reverse the current policy to separate the radioactive and nonradioactive liquid waste streams at LANL. There would be major impacts on monitoring and operations at SWSC. The SWSC NPDES permit would need to be modified to allow industrial inputs to the facility. Also, permitting and disposal of solids may be impacted.	This alternative would eliminate the biodenitrification process at the RLWTF. Increased hydraulic loading at SWSC and demand on the SWSC biodenitrification process will result.
Supportive of corporate excellence and sustainability goals	This alternative may produce a new environmental legacy problem. Because of changing environmental regulations and concerns, this may not be a long-term solution.	This alternative may be shown to be within the limits set by DOE Order 5400.5. Long-term relations with stakeholders and environmental impact preclude its implementation.
Technical feasibility	Mixing a small volume of contaminated water (treated RO concentrate) into a much larger waste stream (SWSC influent) is not considered technically sound. Additional water from the RLWTF could adversely affect denitrification at SWSC.	Significant alterations of the SWSC plant operation would be required.
Economic feasibility	Requires DOE and congressional funding of new process building and equipment. Operational costs would decrease for the RLWTP, but would increase at the SWSC. Monitoring costs at SWSC would greatly increase. This alternative would eliminate the 051 outfall with minimal capital cost.	Decreased costs at the RLWTF would likely be counterbalanced by increased costs at SWSC.

Table 6 is a summarized compilation of the factors that were considered by the working group in evaluating alternative # 3, zero liquid discharge. The working group recommends implementation of this alternative at LANL because it would: protect the environment long-term, meet future regulatory standards, satisfy stakeholder concerns, support corporate excellence and sustainability goals, and have minimal impact on LANL institutional requirements.

Table 6. Evaluation Matrix of Zero Liquid Discharge Alternative

Evaluation Basis	Summary of Issues	Qualitative Evaluation
Long-term protection of the environment	Offers the best long-term environmental protection solution. The maximum amount of radionuclides will be solidified for long-term disposal. The majority of tritium will be isolated from the RLWTF. Tritium that does reach the RLWTF will be released to the atmosphere, its most environmentally benign state.	This alternative will dispose of the radioactivity in its most environmentally stable form, decrease the area contaminated, and reduce present and future exposure of humans to radionuclides.
Present regulatory compliance and future legal liability	This alternative would comply with all current regulatory standards and is expected to comply with future regulations governing radioactive liquid waste management.	The minimal amount of radionuclides will be discharged to the environment.
Satisfaction of public concerns and perceptions	San Ildefonso Pueblo and other stakeholders would likely favor the implementation of zero liquid discharge of treated radioactive liquid waste. Concern regarding air emissions could increase.	This alternative will show the RLWTF as being the best steward possible of its solid, liquid, and atmospheric emissions.
Minimal impact on LANL institutional requirements	The loss of the NPDES permit at the RLWTF will cause the loss of the RCRA exemption for the RLWTF. RCRA regulatory oversight will increase at the RLWTF. NPDES regulatory oversight will decrease.	Increased identification and quantification of the RLWTF influent stream will be required.
Supportive of corporate excellence and sustainability goals	This alternative is certainly in line with corporate excellence standard. Zero liquid discharge puts contaminants in their most environmentally benign state.	This alternative best exhibits the goals of corporate excellence and environmental sustainability.
Technical feasibility	This alternative would be the most technically challenging. Additional research and testing of possible treatment equipment will be required. These efforts would place the contaminants in their most benign environmental states.	Major technical efforts in data collection and process testing would be required to implement Phases III, IV, and V.
Economic feasibility	Requires DOE and congressional funding of new process building and equipment. Additional funding required for Phases III, IV, and V.	Substantial funding of design efforts would be required to implement Phases III, IV, and V.

ZERO LIQUID DISCHARGE IMPLEMENTATION

Setting a course toward zero liquid discharge of treated radioactive liquid waste is the recommendation of this working group. Attaining zero liquid discharge of radioactive wastewater will require a stable funding source, competent engineering, concern for the environment, and perseverance over a 5–10-year period. Three additional phases are proposed to take LANL from the Phase I and II RLWTF upgrades to zero liquid discharge of treated radioactive wastewater.

Phase III Upgrade: Minimization and Source Identification of Radioactive Liquid Waste

Phase III involves the identification and minimization of wastes at their sources. This includes an aggressive program of metering, controlling the volume of flow to the RLWTF, and characterization and minimization of actinides, organics, and nitrates when feasible. Phase III also involves the isolation and evaporation of tritiated wastewaters at the several facilities discharging tritium in their radioactive liquid waste.

Flow Metering and Identification

The RLWTF currently monitors and maintains the collection system for radioactive liquid waste. This includes the main underground collection system, as well as waste holding tanks and telemetry units (primarily level gauges and flow meters) within several buildings feeding into the collection system. Aside from the data collected by the flow meters in the field, the earliest data collection point for RLWTF raw influent is the headworks of the plant. At this location flow and pH are measured. Also, a 24-hour composite sample is collected continuously. Analytical information derived from these composite samples reflects the blended waste received from all generator sources that feed into the collection system.

The RLWTF relies on the generators to supply information regarding waste constituents. The RLWTF WAC require a waste profile be completed and approved prior to any discharges. It has been difficult to monitor and enforce compliance with this method of waste identification, and only a small percentage of the flow received at the RLWTF can be accounted for by waste profiles. Many generators do not file the required waste profiles. Some flows are not considered RLWTF influent and therefore not profiled, such as duct wash water or mop water. The waste profile management system is housed at TA-54 and was primarily designed for solid waste tracking and handling.

As regulatory requirements become more stringent and as the possibility of eliminating outfall 051 progresses, it will be important to have complete characterization of wastes discharged to the RLWTF. This is particularly true regarding RCRA-regulated constituents. If the outfall 051 NPDES permit is allowed to be deleted, operation of the RLWTF will fall under RCRA guidelines. Management of waste at the source, including management of the waste generators' WAC and management of facility connections to the collection system, is a necessary part of this process. Specific monitoring regimes will be required by the RLWTF.

The following recommendations should be considered.

1. Begin a deliberate, coordinated effort to bring all LANL RLW generators into compliance with the current RLWTF WAC guidelines and criteria. Establish a method to ensure that complete compliance is maintained. Also, the RLWTF needs direct access to the waste profile management system to procure the required degree and nature of data.
2. Evaluate and designate responsibility for collection system upkeep before connecting to the main RLWTF collection system (at first manhole outside the building, or where the pipe leaves the building).
3. Develop contractual criteria for the condition of connections at facilities connected to the RLWTF collection system. Also, contractual agreements should be formed for any new connections.

Waste Minimization of Actinides and Nitrates

There are several waste minimization and pollution prevention technologies currently under investigation at LANL. The following technologies are being developed and implemented at the Plutonium Facility and in the CMR Building. These are the two major generators of RLW that is treated at the RLWTF.

Historically, aqueous nitrate operations at the Plutonium Facility have processed acid waste streams through a single-stage distillation process in an evaporator. That process concentrated the salts, which were immobilized and disposed at TA-54, and generated an approximately 5 M acid waste stream that was discharged to the RLWTF for treatment. A fractional distillation column has been designed for concentrating the nitric acid to the 12–15 M range. This process recovers 99.99% of the acid, removes most of the radioactivity, and reduces the nitrate concentration to approximately 45 ppm in the liquid waste stream going to the RLWTF. Implementation of this technology at TA-55 and the biodenitrification process at the RLWTF will ensure that nitrate concentrations will not exceed NPDES permitted levels.

The aqueous chloride operation processes material in a series of steps that ends with hydroxide precipitation that produces a TRU solid hydroxide cake and a liquid waste stream discharged to the RLWTF for subsequent treatment. The hydrochloric acid liquid waste stream is a relatively minor waste stream by volume (approximately 10–15% of the volume of the nitric acid waste stream); however it contains approximately 80% of the total inventory of radionuclides discharged to the RLWTF from TA-55. Electrochemical ion exchange is a process that is currently being tested for use in the chloride recovery operations. Preliminary results indicate that this process is expected to eliminate 99% of the plutonium, americium, and dissolved solids from the effluent stream and thus will significantly reduce the radionuclide activity sent to the RLWTF.

In addition to these efforts, better precipitation reagents and improved ion exchange resins that would more completely and more efficiently remove the actinides from the aqueous stream are being investigated to help further reduce the activity burden on the RLWTF.

Volume Reduction in Flow to RLWTF

The CMR Building is the major contributor of radioactive liquid waste volume to the RLWTF. Sources of liquid waste include numerous programmatic activities that generate small volumes of liquid waste, including wash water from custodial activities in radiation control areas (RCAs), duct washdown system water, and effluent from the chilled-water system. Approximately 60% of the liquid waste is from the duct wash-down systems, approximately 30% from the chilled-water system, and the remaining 10% from programmatic and custodial activities. The duct washdown system has not been utilized for months, although it will be reactivated in several wings. It is anticipated that after normal operations are resumed in the CMR Building, the volume of water from duct washdown may increase to historical volumes.

Replacement of the chilled-water system could have a significant impact on the volume of radioactive liquid waste sent to the RLWTF. The chilled-water system was designated for replacement as a part of the CMR upgrades, but replacement has been postponed. The chilled-water system is a series of evaporative-type coolers that provide chilled water to equipment, processes, boilers, and laboratories in the building. The water in the chiller needs to be blown down occasionally and make-up water is added to the system. The blow-down is collected and routed to the RLWTF for treatment. Because the chilled water travels through plumbing in radiologically controlled areas, there is the possibility for contamination and, in the past, low levels of contamination have been found.

The alternative technology to the current chilled-water system is a refrigerated system. A refrigerated system would dramatically reduce the volume of liquid waste generated because compressors and refrigerant would cool the water in contrast to evaporative cooling. Thus, the chilled-water system blow-down would be eliminated.

Satellite treatment of wastes that are presently sent to the RLWTF would also decrease the volume of liquid flow to the facility. Satellite treatment requires a high ratio of effort and expense to volume of waste treated. In some cases, however, satellite treatment of a specific contaminant in a small waste stream can be more cost-effective than treatment of a much larger waste stream with mixed contaminants.

Tritiated Liquid Waste Minimization and Evaporation

Tritium is a naturally occurring isotope of hydrogen produced by the interaction of cosmic rays with the atmosphere. Man-made sources of tritium are produced by nuclear accelerators and nuclear reactors. Natural and man-made tritium are chemically identical. In addition, the chemical properties of tritiated water and regular water are very similar. Thus, to remove tritium from water is very much like trying to remove water from water.

Removal of tritium from aqueous wastewater to near-drinking-water standards (20 000 pCi/L) is currently uneconomical. As a result, tritiated waste streams must be discharged either as a liquid via a permitted outfall or as water vapor to the atmosphere. The tritiated effluent from the RLWTF is currently discharged to Mortandad Canyon outfall 051. From a health physics perspective, the risk associated with discharging tritium to the atmosphere is several orders of magnitude less than the risk associated with discharging tritium in aqueous form. The malfunction at the Three Mile Island nuclear power station in 1979 resulted in a large volume of tritiated water. Rather than dilute the tritiated water by slowly feeding it into the Susquehanna River, evaporation ponds were built to disperse the tritium into the atmosphere. Dispersion of tritium into the atmosphere is environmentally preferable to release of tritium into ground water. As a result, the options listed in this section recommend waste minimization followed by the use of evaporative technologies to discharge the tritium to the atmosphere.

For calendar year 1996, the major generators of tritium in the RLWTF influent are given in Figure 8. In 1996 the RLWTF discharged 1.30 Ci of tritium with 16 537 000 L of effluent. The average tritium concentration in this discharge was 78 612 pCi/L, nearly four times the drinking water standard of 20 000 pCi/L. However, this is far less than the outfall 051 NPDES permit limit of 3 000 000 pCi/L. The working group has recommended that the Laboratory voluntarily adopt the lower drinking water limit. To meet the 20 000 pCi/L drinking water standard, only 0.33 Ci of tritium should have been discharged during that period.

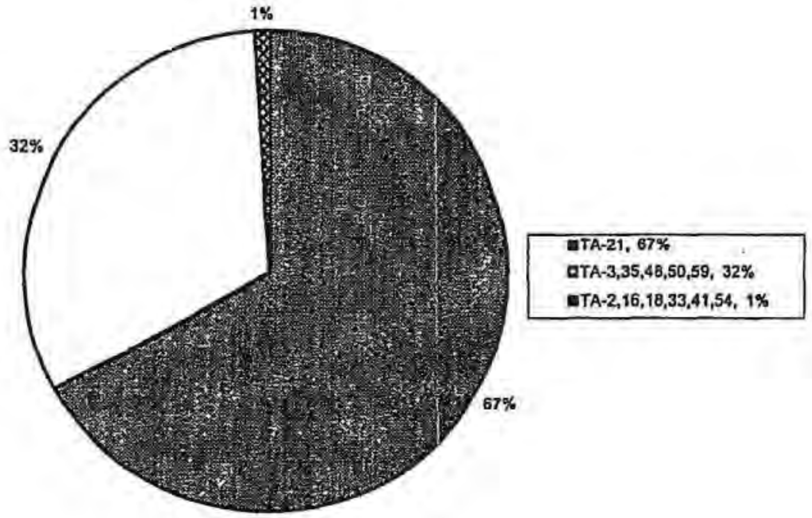

Figure 8. Major generators of tritium to the RLWTF by technical area (calendar year 1996).

As shown in Figure 8, the TSTA Facility and the Tritium Science Fabrication Facility (TSFF) at TA-21 are the largest contributors of tritium activity sent to the RLWTF. The TSTA Facility is dedicated to developing, demonstrating, and integrating technologies related to the deuterium-tritium fuel cycle for large-scale fusion reactor systems. The TSFF Facility provides support for tritium-related experiments. Presently, the TSTA and TSFF Facilities discharge an average of 2500 L/day with an activity of approximately 1.2 µCi/L. The sources include primary coolant loop flushing, component washing, hand washing, cooling tower blow-down, and custodial activities. The fidelity of these numbers is somewhat unclear because a faulty blow-down controller for an aging cooling tower and heat exchanger at the TSTA Facility intermittently sends 20 000 L of tritiated water to the RLWTF. A replacement cooling tower has been purchased and is ready for installation. With the installation of the new cooling tower and heat exchanger, there will be no contamination crossover from the primary to the secondary cooling loop. Therefore the blow-down will no longer be contaminated with tritium. Upon completion of this work the tritium activity discharged by TSTA to the RLWTF will be greatly reduced.

The next largest contributor of tritium to the RLWTF is 0.41 Ci/year from the collection system that includes sources from TA-3, 35, 48, 50, and 59. Waste profiles from the tritium generators at these sites are presently incomplete: therefore, it is not possible to distribute the 0.41 Ci/year among the various sources.

In addition, tritium-contaminated wastewater is trucked to the RLWTF from TA-2, 16, 18, 33, 41, and 54. These sources combined contribute only 1% of the total tritium activity sent to the RLWTF.

Tritium reduction in the RLWTF effluent must be accomplished by eliminating tritium in the RLWTF influent because there is no practical treatment option for tritium. Isolating tritiated wastewater from the RLWCS is essential to the RLWTF discharging an effluent that meets the drinking water standards for tritium. Historically, programmatic activities produced tens to hundreds of Curies of tritium per year that have been released to the environment through outfall 051. Future mission needs at LANL may once again yield highly tritiated waste streams. The collection and handling of these streams apart from the RLWTF is advised.

As stated above, the TSTA and TSFF Facilities are the largest contributors to the tritium activity discharged to the RLWTF. By demonstrating that this waste stream can be eliminated from the RLWTF influent, it is possible to reduce the tritium concentration in the RLWTF liquid effluent to nearly 20 000 pCi/L. The recommendations listed below focus on this waste stream with the intent that a more detailed effort may determine that other generators can benefit from the same disposition. Further reductions can be realized by addressing upstream segregation and minimization at the source generator.

Current Tritiated Wastewater Disposition at TA-21

Tritiated wastewater from the TSTA and TSFF Facilities are currently pumped to a tank at TA-21-257 (the TA-21 Radioactive Liquid Waste Treatment Facility). The waste is transferred to the RLWTF through the cross-country line. This is shown schematically in Figure 9. The cross-country line emanates from TA-21-257 and follows DP Road west toward the Los Alamos townsite. Approximately one-quarter mile west of the TA-21 front gate, the line turns south and crosses Los Alamos, Sandia, and Mortandad Canyons before it terminates at TA-50 (see Map 1). Presently the TSTA and TSFF wastewater are the only influent to the TA-21- 257 treatment facility. If this wastewater source is re-routed, then the cross-country line could be removed. This would enable the DOE to release this land to Los Alamos County.

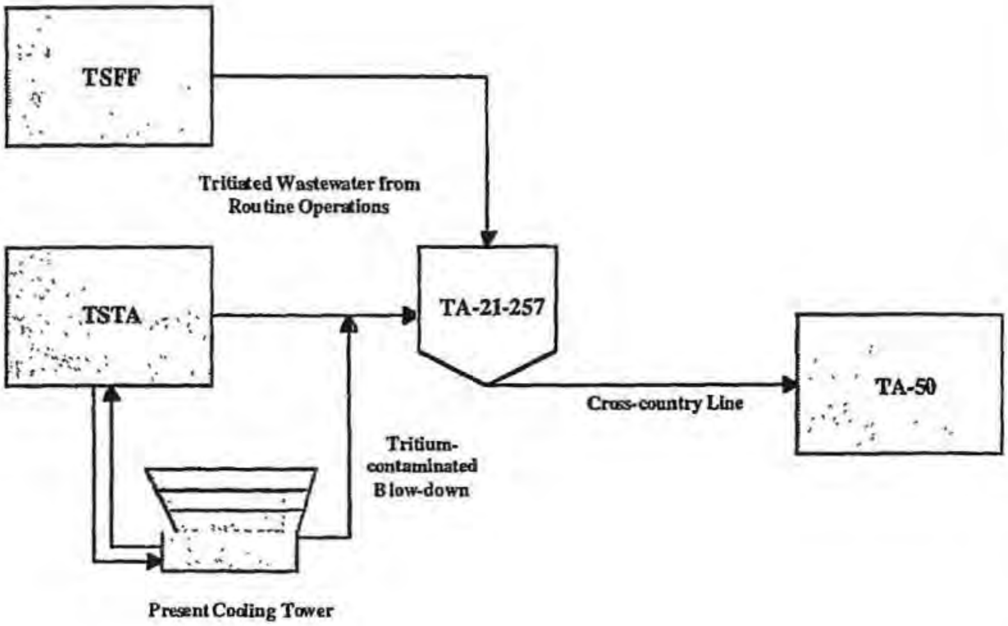

Figure 9. Current TA-21 to TA-50 radioactive wastewater flow sheet.

The two options listed below operate with the underlying assumption that the new cooling tower at the TSTA Facility will be installed, therefore providing a reduction in the volume of tritiated wastewater from approximately 2500 L/day to approximately 275 L/day. With this smaller volume, several options become available for the elimination of this influent stream to TA-50.

Option 1 Transfer of tritiated wastewater to TA-53

Tritiated wastewater from TSTA and TSFF operations will be collected in a 5000-gal. storage tank. The storage tank will be pumped down once per month and the wastewater will be trucked to the radioactive wastewater lagoon at TA-53 for evaporation. Figure 10 shows the proposed radioactive wastewater flow sheet for this option. The LANSCE Facility at TA-53 routinely produces tritiated water from programmatic activities. Currently this water is sent to a lagoon where the short-lived activation products decay and the tritium evaporates by natural convection to the atmosphere. In 1995 the lagoon at TA-53 released approximately 95 Ci with a total annual dose to the nearest off-site residence of 6.8×10^{-3} mrem. The effluent from TSTA will introduce approximately 0.25 Ci per year. At this level, the radiation dose to the public at the lagoon will still be well below the applicable health physics limits.

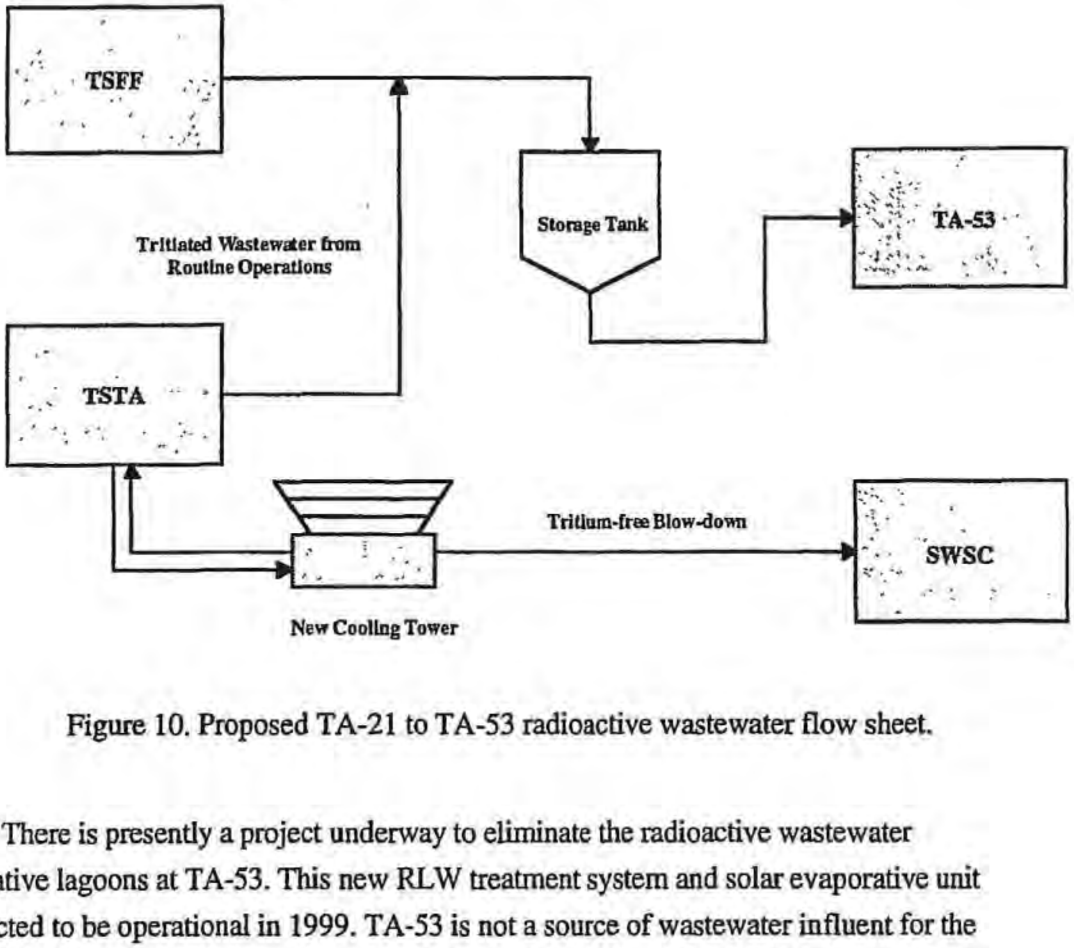

Figure 10. Proposed TA-21 to TA-53 radioactive wastewater flow sheet.

There is presently a project underway to eliminate the radioactive wastewater evaporative lagoons at TA-53. This new RLW treatment system and solar evaporative unit is expected to be operational in 1999. TA-53 is not a source of wastewater influent for the TA-50 RLWTF. However, to reduce the burden on the RLWTF, the TA-53 treatment system may be a sink for the tritiated wastewater generated at TSTA and other facilities.

Once the new wastewater treatment system has been implemented at TA-53, the tritiated wastewater from TSTA can be treated by this system. A preliminary engineering analysis has concluded that this system can accommodate the tritiated wastewater streams from the TSTA Facility and other generators as long as analysis of the influent is sufficient to ensure compatibility of the constituents. Before the implementation of this scenario, a WAC and waste profile must be established for the TA-21 waste stream to provide administrative controls. In addition, to ensure compliance with Clean Air Act (CAA) and RCRA regulations, the waste stream will have to be monitored periodically for any listed or characteristic hazardous constituents. The TA-53 air release permit must also be modified.

Benefits of option 1 include:

1. collection of the wastewater in a temporary storage tank and trucking the waste to TA-53 will allow the elimination of the cross-country line,
2. the major tritium source to the RLWTF will be eliminated,
3. risk associated with the release of tritium into the atmosphere is several orders of magnitude less than for liquid discharge, and
4. the TA-53 radioactive wastewater treatment and evaporation system is already planned for construction and operation by 1999.

Option 2 Install a dedicated evaporator

Under this option, tritiated wastewater from TSTA and TSFF operations would be collected in a 5000 gal. storage tank. As shown in Figure 11, the waste would be fed into a continuously operated open-air evaporator. With an open-air evaporator, the wastewater is boiled off and discharged to the atmosphere as water vapor. There is no secondary distillate stream and only a small amount of residue must be drummed for disposal.

The proposed unit will have the capacity to evaporate 5 times the volume estimated from TSTA and TSFF and therefore has the potential to accommodate other tritiated wastewater sources. For example, radioactive liquid waste that is currently trucked from TA-16 to the RLWTF may instead be transferred to this unit for evaporation. The introduction of a new point source for radionuclide air emissions will require CAA permitting. A WAC and a waste profile must be established for this waste stream to provide administrative controls. In addition, to ensure compliance with the RCRA regulations, the waste stream will have to be monitored periodically for any listed or characteristic hazardous constituents.

An analysis of the radioactive air emission limits has estimated the evaporation of the 0.8 mCi/day estimated for TSTA and TSFF will result in a dose of 1.5×10^{-5} mrem/yr to the nearest off-site residence. This is several orders of magnitude below the specific evaluation limit.

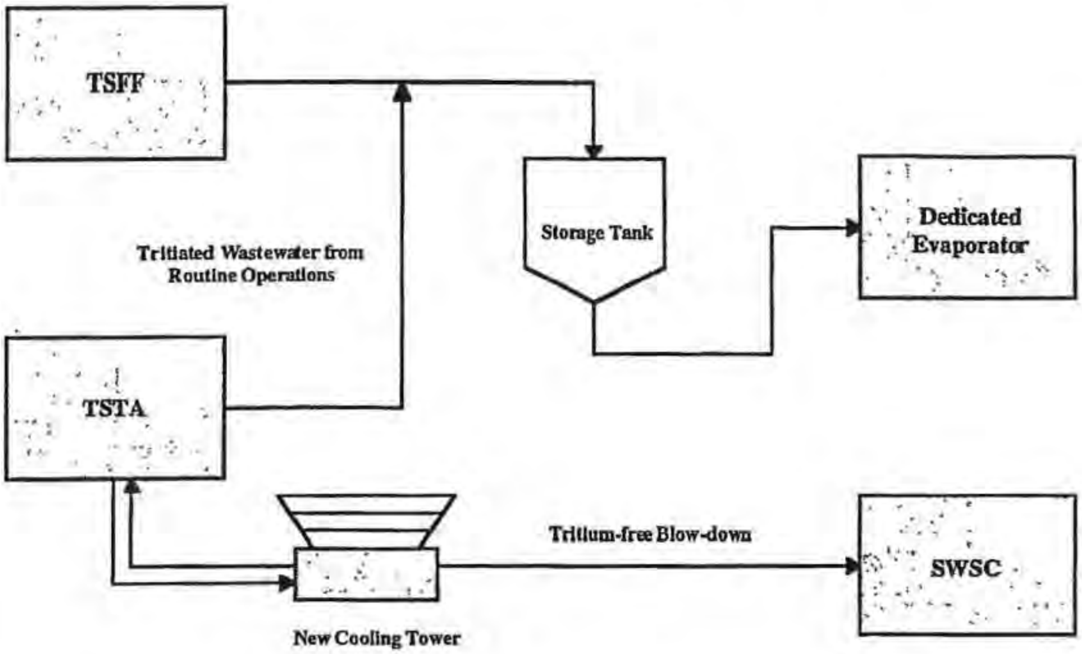

Figure 11. Proposed TA-21 to a dedicated evaporator radioactive wastewater flow sheet.

Benefits of option 2 include:

1. evaporation of the liquid waste stream will allow elimination of the cross-country line,
2. the evaporator can be used to eliminate tritiated wastewater from other generators,
3. there will be no dependence on the TA-53 new treatment and evaporation system,
4. the major tritium source to the RLWTF will be eliminated, and
5. the risk associated with release of tritium into the atmosphere is several orders of magnitude less than for liquid discharge.

In an effort to put these additional releases of tritium to the atmosphere into perspective, the following facts and calculations are presented. During 1996, 680 Ci of tritium were discharged into the atmosphere through monitored stacks at LANL (Environmental Surveillance at Los Alamos, 1996). During calendar year 1996, the RLWTF discharged only 1.3 Ci of tritium to Mortandad Canyon. If all this tritium were atomized and discharged to the atmosphere, it would increase the LANL-wide total emission of tritium by less than 0.2% based on 1996 numbers. If released to the atmosphere, the 0.87 Ci of tritium from the TSTA and TSFF Facilities would be an even smaller fraction of the LANL-wide emissions.

Phase IV Upgrade: Treatment of Reverse Osmosis Concentrate to Allow Reuse

Once the Phase III waste minimization and monitoring programs are in place and excess tritium is removed, the next logical step toward zero discharge is to prepare the water for productive reuse as a supply of industrial makeup water. To meet practical requirements for an industrial water supply, the effluent would need further treatment to be near drinking-water quality.

Ideally, industrial reuse would occur near TA-50 to minimize the cost of piping the water. Potentially attractive uses in the vicinity of TA-50 include washing the containment vessels from the DARHT Facility, water for plutonium processing at TA-55, and augmenting potable water makeup in an existing heating, ventilation, and air conditioning (HVAC) cooling tower.

The quality of water required for reuse is determined by the particular use and protection of public health and the environment. Recirculating cooling water systems are subject to problems such as scaling, corrosion, biological growth, fouling, and foaming if makeup water quality is poor. The limits recommended by the EPA for cooling water makeup for conventional (nonradioactive) contaminants are shown in Table 7.

As a matter of policy, the working group feels that industrial reuse water at LANL should also meet DOE's DCGs for drinking water for radioactive constituents (see Table 2). This is prudent to minimize user concerns and to protect the public health in the event of an accidental cross connection between the industrial reuse system and the potable water supply system.

Table 7. Conventional (nonradioactive) Contaminant EPA Limits for Cooling Water Makeup

Parameter	**Recommended Limit (ppm)**
Chloride	500
TDS	500
Hardness	650
Alkalinity	350
pH	6.9–9.0 units
Chemical oxygen demand	75
Total suspended solids	100
Turbidity	50
Biochemical oxygen demand (BOD)	25
Organics	1.0
NH_4-N	1.0
PO_4	4
SiO_2	50
Al	0.1
Fe	0.5
Mn	0.5
Ca	50
Mg	0.5
HCO_3	24
SO_4	200

In order to meet the proposed industrial water quality limits and implement a closed loop recycle scheme, it is necessary to have some kind of a "sink" to remove dissolved contaminants from the recycle system. Otherwise, dissolved contaminant levels would rise with each reuse of the water, leading to unmanageable concentration increases with scaling, corrosion, and contamination concerns. In the new RLWTF process the RO concentrate stream will contain the majority of the contaminants remaining in the plant effluent at the completion of Phase II. To satisfy industrial water quality requirements with a recycled water supply, it will be necessary to divert the RO concentrate stream from the product water. To do this without discharging liquid waste to the environment, the RO concentrate stream will need further treatment to reduce its volume, allowing disposal of its contaminants as dry solids.

RO Concentrate Disposal Options

Option IV-1

RO concentrate ⇒ solar evaporation

An option considered for removing the salts from the RO concentrate stream is the use of a solar evaporation pond. A double-lined pond with a leak detection system would be required to protect ground water from leakage. Based upon annual rainfall data and evaporation rates in the Los Alamos area, a pond with a surface area of 1 acre should evaporate 2 000 gpd of water. Evaporation ponds at Public Service Company of New Mexico's San Juan Power Generating Facility near Farmington, NM, were designed for 1.25 gpm of evaporation per acre. To evaporate 2 000 gpd, 1.11 acre of pond surface would be required. The San Juan Power Generating Facility is actually measuring more than 3 gpm of evaporation per acre.

An evaporation pond would have the advantage of not requiring electrical energy to evaporate the RO concentrate stream. In contrast, it would present several disadvantages. There could be concerns of wind dispersion of concentrated radioactive materials in aerosols generated from wave action. Radioactive salts would accumulate in the pond and require periodic removal. Management of these solid residues in the pond could be more difficult than with a mechanical evaporator. The land area required for a pond and buffer zone is also considered a disadvantage for this technology given the scarcity of flat terrain near TA-50.

Option IV-2

RO concentrate ⇒ mechanical evaporator

Another option for reducing the volume of the RO concentrate stream is use of a mechanical evaporator. A vapor-compression brine concentrator evaporator was considered. This equipment would use electric energy to distill the concentrate. The cost of energy is minimized by recondensing the distillate vapor to a liquid for heat recovery. After heat recovery, the high quality distillate would be combined with the RO product water for reuse.

At the 2 000 gpd flow estimated for the RO concentrate, the estimated annual energy cost of approximately $3 800 is moderate. A conceptual-level budget estimate for a skid-mounted brine concentrator evaporation system is $850 000, exclusive of design costs, installation, or housing. The evaporator column itself is well insulated and may be located inside a building or outdoors. Some peripheral components and controls would best be installed inside a building for weather protection and ease of maintenance.

The evaporator bottom blow-down, estimated at approximately 40 gpd would amount to approximately 2% of the original concentrate volume. The blow-down, containing virtually all of the dissolved contaminants remaining after ultra-filtration, would then be solidified with Portland cement for disposal at TA-54, Area G. A number of engineering issues associated with heat evaporation of the Laboratory's radioactive liquid waste concentrate will need to be evaluated during the Phase I through III operational period. A detailed characterization will be required of the concentrate stream's chemistry under actual operating conditions. This characterization must address potential safety concerns associated with heating concentrated mixtures of organic and inorganic constituents. The working group considers the proposed Phase III programs to characterize and limit potentially hazardous constituents in the influent streams essential precursors to any program involving industrial reuse of the treated RLW.

Phase V Upgrade: Eliminate Treated Radioactive Liquid Waste Discharge to the Environment

Eliminating liquid discharge of the treated radioactive liquid waste will occur in the Phase V upgrade. Four options are presented. The liquid discharge will be eliminated by evaporation.

Elimination of Liquid Discharge

Option V-1

Effluent ⇒ land application

One evaporative alternative involves land application of the treated effluent. The irrigation field would be large enough, and designed and operated in such a way so that no runoff is produced and no water percolates into ground water. On an annual net basis, all applied water would be evaporated directly or transpired by vegetation.

As long as effluent is not discharged to a watercourse, an NPDES point source permit is not needed. It is possible, however, that the EPA would choose to regulate land application of nonradioactive constituents under the Laboratory's storm water NPDES permit. NMED approval of a ground water discharge plan would still be required, as it is for the current RLWTF discharge to Mortandad Canyon, to demonstrate that the system did not adversely impact ground water. Residual contaminants discharged with the effluent would accumulate slowly over time in the land application area soil. This accumulation would not represent a major environmental risk because in Phase IV the effluent would have been pre-treated to near-drinking-water quality before land application.

Land application of treated radioactive liquid waste would require an irrigated area of approximately 6.9 acres. A large storage volume would be required to hold the effluent during cold months when the soil is frozen and irrigation is not possible. A winter storage reservoir of approximately 2.65 million gal. would be required, assuming a very conservative six-month storage requirement. This storage reservoir could be either an aboveground steel tank or a lined pond approximately 1.4 acres in area with a 6-ft depth.

A relatively flat irrigation site would be required to avoid surface runoff. Spray irrigation would maximize evaporation and a dedicated buffer area surrounding the irrigation field would be needed to avoid wind drift of spray onto other areas. Discharges of contaminants by evaporation and drift would have to be below applicable DOE limits for doses to the public and workers.

The principal advantages of land application are the ability to dispose of liquid without surface water or ground water contamination or evaporative energy costs. On the other hand, land application systems involve liquid discharge to the environment and cannot properly be described as a zero liquid discharge system. A prominent disadvantage of land application is the relatively large area of flat land required. Another disadvantage is that the effluent would not be recycled for industrial purposes and subsequent savings of potable water.

Option V-2

Effluent ⇒ pond/wetlands

An evaporation pond sized to handle 20 000 gpd of treated radioactive liquid waste would need to be approximately 10 acres in surface area. A combined evaporation pond/wetlands would also require about 10 acres of land area. The advantages and disadvantages of either the evaporation pond or the evaporation pond/wetlands are the same as those mentioned in Scenario IV-1. Discharges of contaminants by evaporation and drift would have to be below applicable DOE limits for doses to the public and workers.

Option V-3

Effluent ⇒ cooling tower

Evaporating the RO permeate in a dedicated cooling tower or in a tower at a LANL facility is possible. Several small cooling towers exist near TA-50. The evaporation rate from LANL cooling towers is about 1% of the recirculation rate per 10^0F temperature change. Using this assumption, a recirculation rate of 1 400 gpm is estimated to evaporate the 20 000 gpd of RO permeate from treatment operation at the RLWTF.

Because the TDS in the RLWTF effluent water will be quite low, concentration factors higher than those normally found in cooling towers could be obtained. It is reasonable to expect that a concentration factor of 10 could be obtained prior to blow-down. This would require about 2 000 gpd of blow-down to be recirculated to the RLWTF influent holding tanks for treatment.

Any tritium remaining in the effluent after Phase III would be released to the atmosphere while the nonvolatile constituents would be returned to the RLWTF in the cooling tower blow-down. Drift, the fine droplets of liquid dispersed from a cooling tower, would contain low concentrations of actinides. This activity could be as high as 12 pCi/L, assuming the cooling tower was operated at 10 cycles of concentration and the makeup water had 1.2 pCi/L of plutonium and americium. Discharge of contaminants by evaporation and drift would have to be below applicable DOE limits for doses to the public and workers.

Option V-4

Effluent ⇒ mechanical evaporator

A mechanical evaporator that could evaporate the entire 20 000 gpd RO permeate would likely be a scaled-up version of the mechanical evaporator suggested in alternative IV-2. A significant difference is that the evaporated water will not be recondensed and therefore, energy from recondensation will not be available to help evaporate more water. This would result in a very energy-inefficient evaporator, but would result in zero liquid discharge of the liquid effluent. Discharges of contaminants by evaporation and drift would have to be below applicable DOE limits for doses to the public and workers.

Figure 12 illustrates the course this working group proposes LANL follow to achieve the goal of zero liquid discharge of treated radioactive liquid waste.

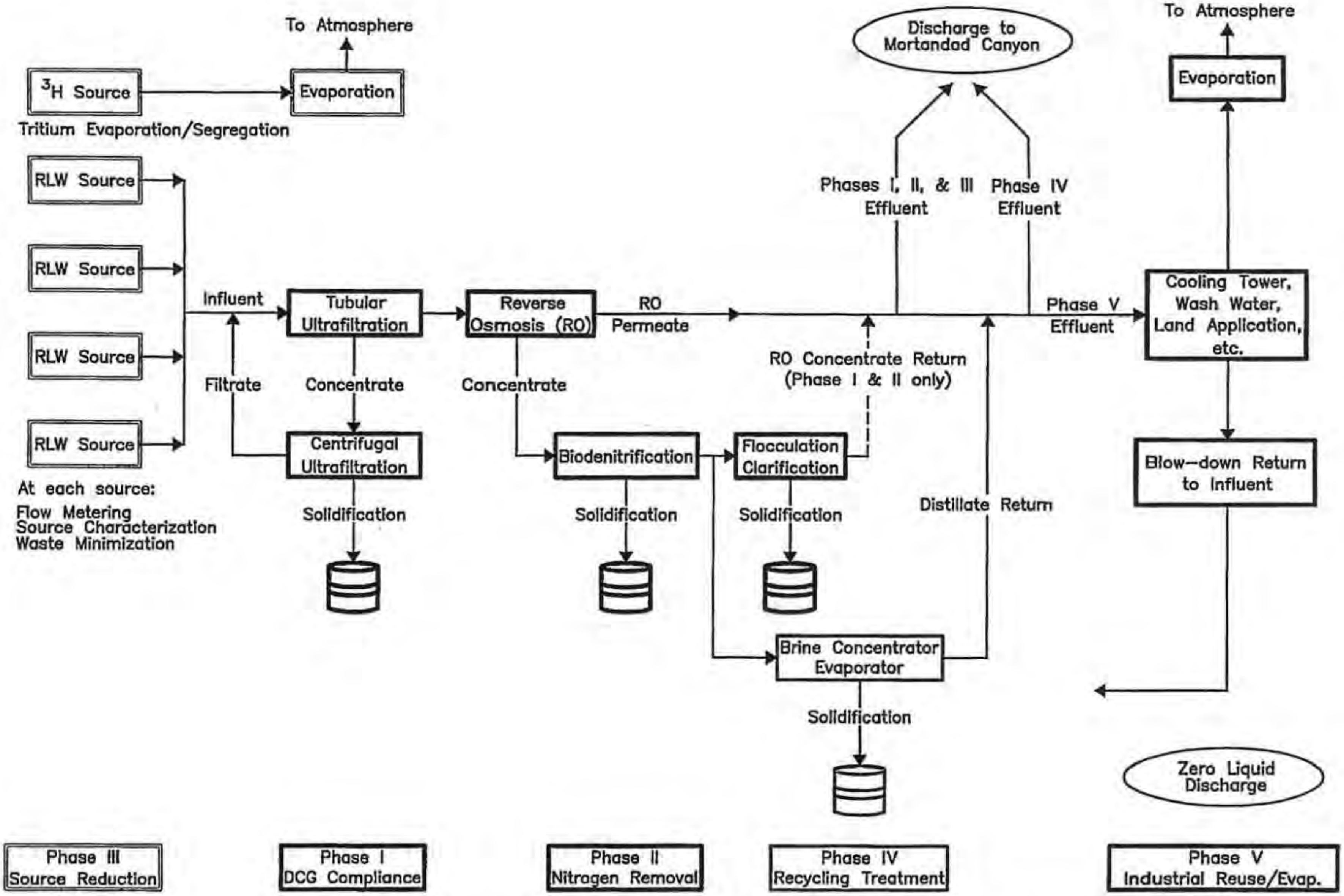

Figure 12. Conceptual phases for implementation of zero liquid discharge at the RLWTF.

SUMMARY OF RECOMMENDATIONS

This report defines the steps that LANL must follow to achieve zero liquid discharge of treated radioactive liquid waste from outfall 051. These recommendations encompass a broad spectrum of radioactive liquid waste management efforts involving waste characterization, liquid waste volume reduction, source minimization of regulated constituents, reuse and recycle, evaporation technologies, and placing of constituents in their most environmentally benign state.

Recommendations Pertaining to Phase I and Phase II Upgrades

1. Newly installed Phase I and II upgrades at the RLWTF should be run as a full-scale pilot project to develop engineering design parameters that would be used to design a new radioactive liquid waste treatment facility.
2. Treated radioactive liquid waste effluent from the RLWTF should not be discharged to the SWSC plant
3. The proposed Phase II biodenitrification facilities should be constructed as planned.

Recommendation Pertaining to Construction of a New RLWTF

1. Design, fund, and construct a modern treatment facility that has redundant process equipment with capability to treat LANL's radioactive liquid waste for the next 30 years.

Recommendations Pertaining to Phase III

1. Tritium sources should be identified and isolated from the RLWTF collection system. The Laboratory should voluntarily construct facilities to evaporate tritiated wastewaters. Isolating the tritiated TSTA and TSFF waste streams from the influent to the RLWTF would make it possible to remove the cross-country radioactive liquid waste pipeline from TA-21 to TA-50.
2. The Laboratory should aggressively minimize the mass of pollutants at their sources, strengthen enforcement of the RLWTF WAC, and improve monitoring of the RLWTF influent at the sources.

Phase IV Recommendations

1. The Laboratory should design and construct facilities to further improve the quality of the RLWTF effluent by removing the pollutants contained in the RO concentrate stream from the effluent discharged to Mortandad Canyon. This will result in discharge of water of near-drinking-water quality
2. Evaporation processes, such as solar ponds and mechanical evaporation, should be investigated as a method of removing dissolved solids from the liquid phase.
3. Solidification technologies should be studied.

4. Minimization of waste stream volume by electrodialysis reversal and ion exchange should be studied.
5. Liquid effluent should continue to be discharged to Mortandad Canyon until zero discharge is implemented. The outfall 051 NPDES permit should be kept for the RLWTF in the event of potential need resulting from operational upsets or dramatic changes in the Laboratory's mission.

Phase V Recommendations

1. The Laboratory should eliminate all discharges of treated liquid radioactive waste to the environment.
2. Radioactive wastewater should be treated to near-drinking-water quality and recycled for reuse in industrial processes or evaporated. Reuse and recycle options for the treated radioactive liquid waste should be identified. Evaporation methods for the treated radioactive liquid waste (evaporation ponds, constructed wetlands, land application, cooling towers, and mechanical evaporators) should be compared.

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