NMED/DOE/AIP-94/2

New Mexico Environment Department
DOE Environmental Oversight and Monitoring
Agreement-in-Principle

Assessment of Off-Site Radioactivity Surveillance Systems at the Waste Isolation Pilot Plant

NMED/WIPP 94-002
June 1994

NMED/WIPP DOE
Oversight and Environmental Surveillance
WIPP Site PO Box 3090
Carlsbad New Mexico 88221

New Mexico Environment Department
DOE Environmental Oversight and Monitoring
Agreement-in-Principle

ASSESSMENT OF OFF-SITE RADIOACTIVITY SURVEILLANCE SYSTEMS AT THE WASTE ISOLATION PILOT PLANT

NMED/WIPP 94-002

June, 1994

Prepared for:

Judith Espinosa, Secretary, New Mexico Environment Department
Benito Garcia, Bureau Chief, Hazardous and Radioactive Materials Bureau
John Parker, Program Manager, DOE Oversight and Environmental Surveillance Section

Prepared by:

Paul E. Sanchez, GEO III
&
Patrick W. McCasland, WRS III

DOE/WIPP Oversight
WIPP Site, P.O. Box 3090
Carlsbad, New Mexico 88221

Notice

Acknowledgments

This review is supported by an Agreement-in-Principle between the State of New Mexico and the Department of Energy. Principal investigators stationed at the Waste Isolation Pilot Plant (WIPP) site are administratively attached to the Hazardous and Radioactive Materials Bureau (HRMB)/DOE Oversight and Environmental Surveillance (DOES) Section. Special thanks go to NMED/WIPP staff Jack Colties of the Air Quality Bureau (AQB) for technical review and comment. An AQB review and evaluation of the WIPP Air Quality Monitoring Program by Jack Colties, July 1, 1992 also provides a firm basis for this report. The AQB report verifies sampling locations for FASs, CAMs, and Occupational TLDs, describes methodologies and quality assurance protocols, and reviews potential radiological release source terms. NMED/WIPP staff also acknowledge John Parker (HRMB/DOES Manager), who provided direction and cogent commentary throughout the entire project. Dave Bagget (HRMB) provided technical editing of the final draft. Westinghouse Environmental Monitoring at the WIPP also provided a quality assurance review. Staff especially appreciate assistance from Penny Lamb, who performed editing and copying in preparation of the final draft.

Table of Contents

List of Figures

List of Tables

AIP	- Agreement-in-Principle
ANOVA	- Analysis of Variance
ARM	- Area Radiation Monitor
ASTM	- American Society for Testing and Materials
CAM	- Continuous Air Monitors
CBD	- Lake Carlsbad/Pecos River
CH	- Contact-handled
CMR	- Central Monitoring Room
CMS	- Central Monitoring Station
DOE	- Department of Energy
DP	- Discharge Plan
DQO	- Data Quality Objective
EEG	- Environmental Evaluation Group
EFB	- Exhaust Filter Building
EML	- Environmental Measurements Laboratory
EMP	- Effluent Monitoring Program
EMP	- Environmental Monitoring Plan
ES	- Exhaust Shaft
FAS	- Fixed Air Samplers
FEIS	- Final Environmental Impact Statement
FSAR	- Final Safety Analysis Report
HEPA	- High Efficiency Particulate Air Filters
HLT	- Hill Tank
HPIC	- High Pressure Ionization Chamber
INT	- Indian Tank
LD	- less than detectable
LGS	- Laguna Grande del Sal
LMC	- Lake McMillan
Lo-Vol	- Low Volume Fixed Air Sampler
LWD	- Liquid Waste Disposal
MDL	- Minimum detection limits
MIR	- Maximum individual at risk
NCRP	- National Council on Radiation Protection and Measurements
NES	- Nonradiological Environmental Surveillance
NESHAP	- National Emission Standards for Hazardous Air Pollutants
NMED	- New Mexico Environment Department
NMED/WIPP	- AIP staff stationed at the WIPP site or otherwise responsible for DOE/WIPP Oversight
NORM	- naturally occurring radioactive materials
NOT	- Noye Tank
NPDES	- National Pollutant Discharge Elimination System
NRC	- Nuclear Regulatory Commission
OEMP	- Operational Environmental Monitoring Plan
PCN	- Pierce Canyon/Malaga Bend

PDMP	- Pressure Density Monitoring Plan
PE	- plutonium equivalent
QAPD	- Quality Assurance Program Description
RBP	- Radiological Baseline Program
RCL	- Radioanalytical contractor laboratory
RDT	- Red Tank
RES	- Radiological Environmental Surveillance
RFA	- Request for Analysis
SB	- Support Building
SEC	- Southeast Control
SER	- Site Environmental Reports
SOP	- Standard operating procedures
STLB	- Sampling Tracking Log Book
TLD	- Thermoluminescent dosimeters
TRU	- Transuranic
TUT	- Tut Tank
UPP	- Upper Pecos River
WEF	- WIPP Liquid Effluent
WHB	- Waste Handling Building
WIN	- WIPP Freshwater Influent
WIPP	- Waste Isolation Pilot Plant
WLMP	- Water-Level Monitoring Plan
WQSP	- Water Quality Sampling Program

1.0 INTRODUCTION

This report is a program requirement of the Agreement-in-Principle (AIP) between the State of New Mexico and the Department of Energy (DOE). The AIP authorizes the State to oversee programs at the Waste Isolation Pilot Plant (WIPP) and other DOE facilities in New Mexico. An overall objective of the program is to:

> **assure the public health and safety, and the environment are being adequately protected by DOE programs**

One element of the AIP directs the State to assess DOE environmental programs. The AIP provides the following general guidance for radiological monitoring assessment: "...review the current radioactivity surveillance systems and identify any modifications or improvements needed to meet applicable laws and regulations...". While principally directed at WIPP environmental radiological surveillance, this report also reviews certain aspects of the monitoring program. As indicated in a number of DOE documents, monitoring and surveillance activities are mutually supportive programs. Both programs are oriented toward detecting and assessing the effect of a radiological release on the environment, and each is a component of the Environmental Monitoring Plan mandated by DOE Order 5400.1.

The scope of the report is aimed primarily at environmental monitoring and surveillance issues. The report does not verify DOE/WIPP accident and pathway analyses or present a comprehensive assessment of the DOE/WIPP groundwater monitoring program. For the purposes of this report, the authors have utilized the same contaminant release pathways and accident scenarios used to rationalize WIPP radiological monitoring and surveillance programs. Additionally, an AIP report in progress will expand the discussion of radiological groundwater surveillance to include groundwater monitoring, hydrological conceptual models, and groundwater performance assessment modeling.

The authors of this report have spent over two years conducting research and investigation of DOE/WIPP sampling practices, environmental plans, procedures, annual reports and unpublished data files. Information sources also include DOE Orders, programmatic drivers and guidelines referenced in DOE/WIPP documents, laboratory contracts, and interviews with site personnel. During this interval, NMED/WIPP site staff also observed DOE/WIPP field sample collection and handling procedures and collected independent radiological and nonradiological data. This report assesses the adequacy of plans and procedures and their implementation, and compares sampling histories compiled from published annual reports (1985-present) with original data quality objectives. Pertinent State, EPA, and NRC regulatory guidelines and scientific principles are also referenced as measures of program adequateness.

1.1 Background

The WIPP is a proposed underground geologic disposal facility for transuranic (TRU) radioactive mixed waste generated by defense-related programs. Situated in a relatively isolated area of southeastern New Mexico, the site is approximately 42 kilometers (26 miles) east of Carlsbad and 26 kilometers (16 miles) northeast of Loving (Figure 1.1). The DOE is solely responsible for the WIPP facility's design and operation, as well as management of the 16 section area encompassing the site. Over the next few years, DOE will attempt to demonstrate compliance with a number of regulations governing long-term management and disposal of hazardous and radioactive waste (mixed waste). Current forecasts suggest the WIPP site will not become operational until 1998 or later.

TRU waste contains a variety of waste forms, including plastic, rubber, wood, glass, cloth, metal and sludges, making waste characterization another important preoperational objective. As defined by the DOE and Environmental Protection Agency (EPA), TRU waste contains more than 100 nanocuries per gram of alpha-emitting transuranic isotopes (half-lives greater than 20 years). For waste containers exhibiting a surface exposure rate of less than 200 milliRoentgen per hour (mR/h), TRU waste is categorized as contact-handled (CH). Waste containers exceeding this value are classified as remote-handled (RH). RH-TRU waste will be responsible for as little as 4 percent of the projected total waste volume, but will account for 45 percent of the total 7.7 million curies to be emplaced in the repository (EPA, 1993; DOE/WIPP 91-058). Alpha-emitting isotopes of both CH TRU and RH-TRU waste are believed to pose the most significant hazard due to their high chemical toxicity and long half-lives (EPA, 1993).

1.2 Disposal Facility

Surface and underground facilities at the WIPP are designed to accept 55-gallon drums and waste boxes. Waste will be down-loaded in the Waste Handling Building (WHB) as seven-pack bundles of 55-gallon drums or in box-like containers of variable size. Several redundant engineering safety features are maintained in the WHB, including negative air pressure and continuous air filtration. Waste is transported underground at an air lock located at the waste handling shaft within the WHB. In the underground, the waste packages will be transported to seven-room storage panels, each room measuring about 92 meters long, 10 meters wide, and 4 meters high. Each room is to be back-filled when full; when 7 rooms composing a panel are loaded, the panel is to be sealed.

The process described above would continue on a routine basis for perhaps as much as 20-25 years, the design life of the facility. DOE WP 02-9 reports that 136 drums/day would be handled 250 days out of the year as an average design through-flow for the facility. This rate suggests 34,000 drums would be handled and

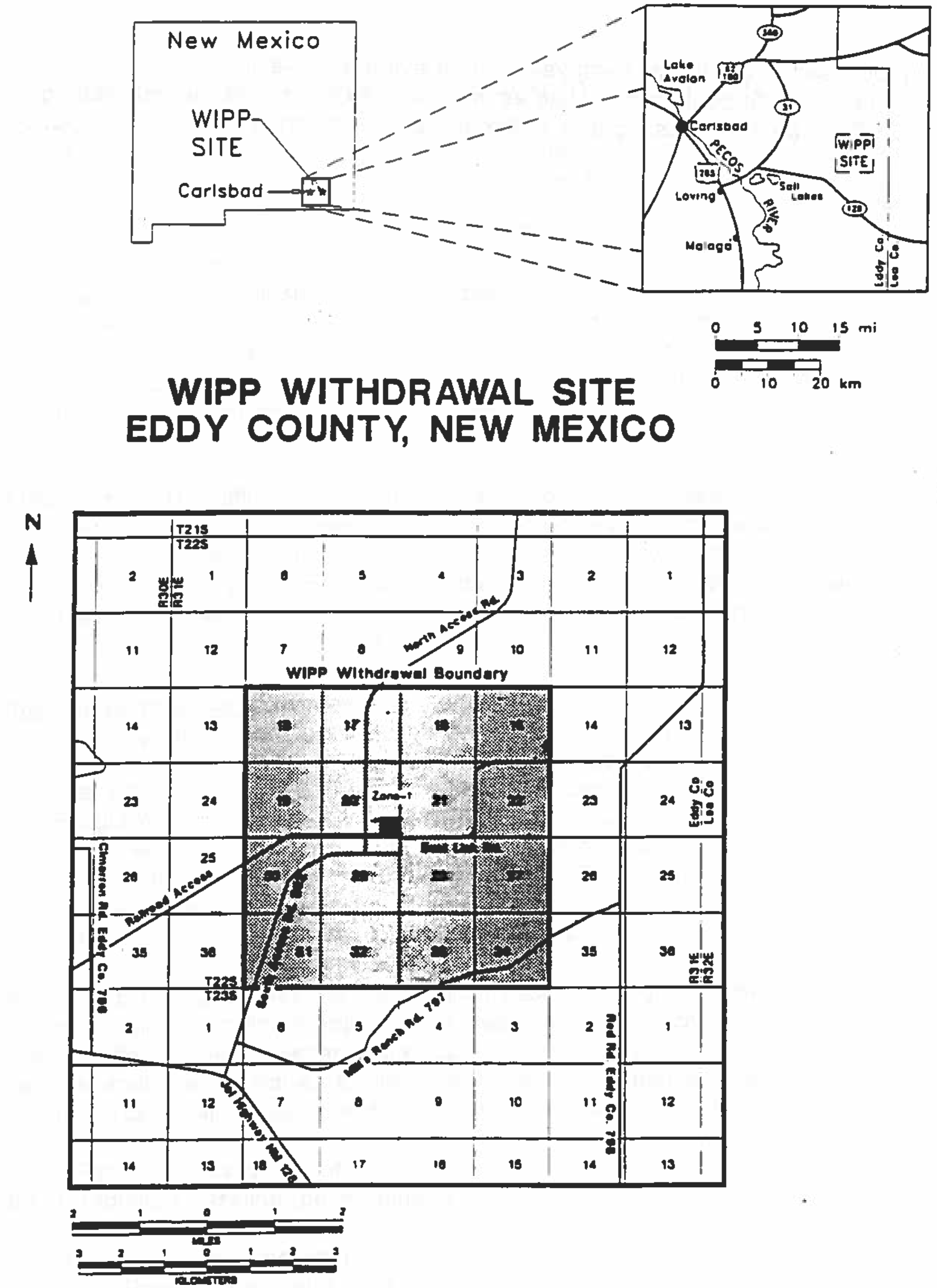


Figure 1.1 Location and boundary of WIPP site and land withdrawal area.

processed at the facility each year. At an average CH-activity per drum of 14.37 curies, the site could accumulate as much as 488,580 curies per year during the initial CH-TRU waste disposal-phase of the operational program (DOE/WIPP 92-058).

2.0 RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM

The radiological environmental monitoring program at the WIPP facility is implemented through DOE Order 5400.1 "General Environmental Protection Program (DOE, 1988d). Additional requirements are defined in DOE Orders 5400.5 "Radiation Protection of the Public and the Environment". Consistent with DOE Order 5400.1, Radiological environmental programs for the WIPP facility are composed of an effluent monitoring program and an environmental surveillance program. The current status of the programs are reported in DOE/WIPP 94-024 "Waste Isolation Pilot Plant Environmental Monitoring Plan" , which updates the original plan described in DOE/WIPP 88-025 Operational Environmental Monitoring Plan (OEMP) (Mercer et al., 1989). Table 2.1 lists the main components of the monitoring plan, as most recently proposed.

Effluent Monitoring. The effluent monitoring system is designed to detect routine and accidental releases resulting from handling and storage operations in the waste handling building (WHB) and underground. Table 2.1 and figure 2.1 identify all three airborne effluent monitoring stations located at the WIPP facility: two stations located at the top of and in-line with the underground Exhaust Shaft (ES) and one situated within the ventilation system of the WHB.

Environmental Surveillance. Environmental surveillance consists of two parallel programs: Radiological Environmental Surveillance (RES) and Nonradiological Environmental Surveillance (NES). The NES program concentrates on near-field nonradiological effects of facility operations, which continues an earlier Ecological Monitoring Program (EMP) described in the 1988 OEMP. Conversely, the RES program is designed to monitor long-term trends in environmental radiation levels in the near-field and far-field (50-mile radius). According to DOE Order 5400.1, the program should also be able to detect and quantify both routine and accidental releases of radioactivity resulting from operation of the facility.

Preceding the RES program was the Radiological Baseline Program (RBP), a plan designed specifically to provide preoperational measurements for comparison with data collected after the facility became operational. The program also provided preoperational analytical objectives for the radiological environmental baseline. As described in Mercer et al. (1989), the RBP consisted of five subprograms:

- Airborne Particulate Baseline (air)
- Ambient Radiation Baseline (penetrating radiation)
- Terrestrial Baseline (soil)
- Hydrologic Baseline (groundwater and surface water)
- Biotic Tissue Baseline (animal and vegetation)

Table 2.1: Environmental Radiological Monitoring Plan at the Waste Isolation Pilot Plant

Activity	Sampling Locations	Sampling Frequency	Parameters/ Radiological Analyses	Comments
Airborne Effluent	3	Continuous	Gross α & β ^{241}Am, ^{238}Pu, ^{239}Pu	Operational Safety Requirements
Atmospheric Particulates	8 (7) - See Note	Weekly	Gross α & β, TSP, radionuclides	To Be Modified
Meteorology	2	Continuous	Wind Speed, Direction etc.	
TLDs	4 (22)	Quarterly	Gamma	Modified
Exposure Rate Meters	1	Continuous	Gamma	
Soil	6 (7)	Biennial	radionuclides	Modified
Surface Water	10 (8)	Annual	radionuclides	Modified
Sediment	4 (6)	Biennial	radionuclides	Modified
Liquid Effluent (Sewage Lagoon)	1	Quarterly Annual	^{226}Ra, ^{228}Ra radionuclides	Modified
Liquid Influent	1	Annual	radionuclides	
Vegetation	4	Annual	radionuclides	
Beef/Deer	WIPP Vicinity (2)	Annual	radionuclides	Deer Added*
Game Birds	WIPP Vicinity (2)	Annual	radionuclides	Modified*
Rabbits	WIPP Vicinity (2)	Annual	radionuclides	Modified*
Fish	2	Annual	radionuclides	
Groundwater	8 (14)	Annual	radionuclides General Chemistry	Modified

TSP- Total Suspended Particulates (40 CFR Part 52)

*Collected as opportunities arise.

Note: Figures in parentheses under sampling locations refers to the number of sampling stations reported in the previous environmental monitoring plan (DOE/WIPP OEMP 88-025).

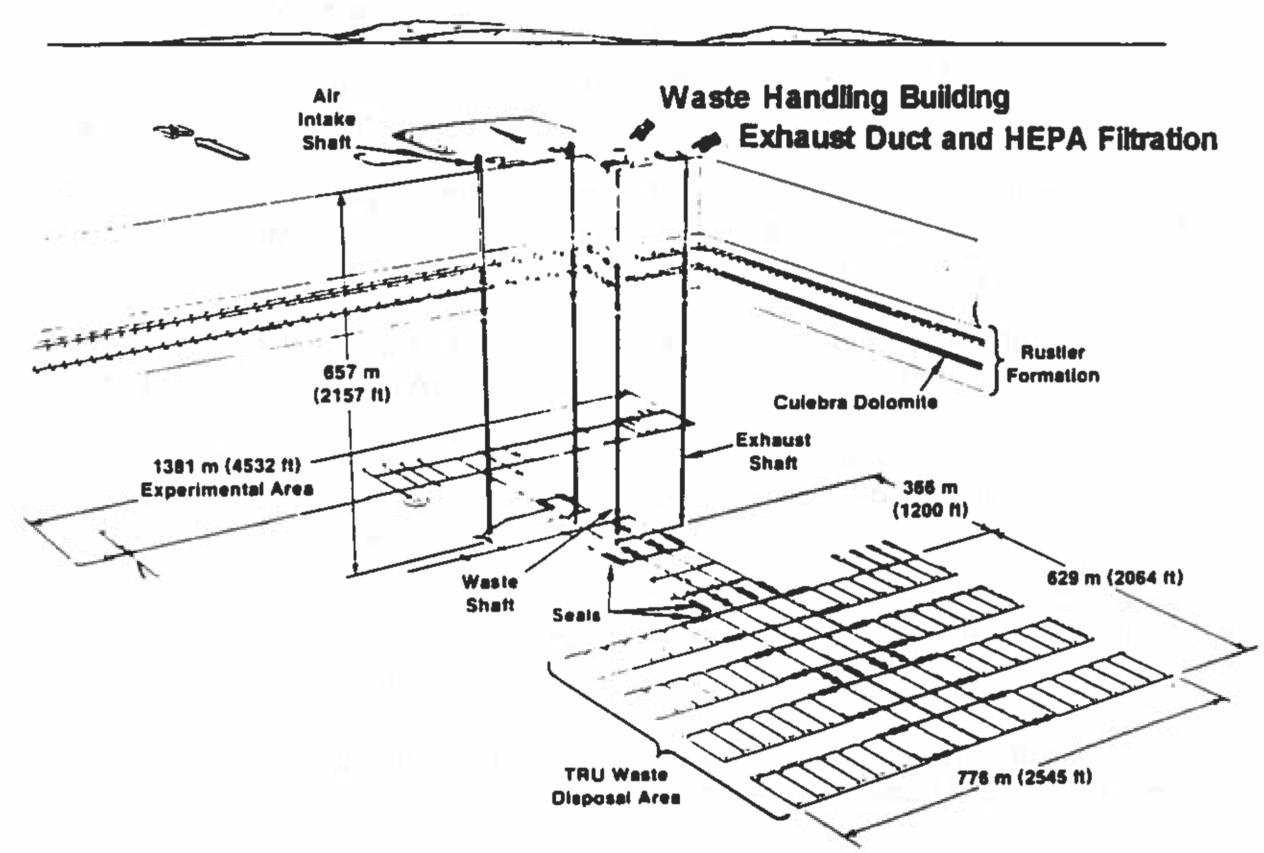


Figure 2.1: General location of airborne effluent sources at the WIPP site (after Davies et al., 1991).

Modifications to the number of operational sampling locations since the original DOE/WIPP OEMP 88-025 are noted in table 2.1. Although sampling locations in parentheses indicate the original number of sampling stations, readers are advised that changes also include selection of different sites. Examples of other revisions include cessation of gross alpha and beta measurements for soil and sediment, addition of quarterly sampling at the sewage lagoon, and reliance on accidental demise for collection of selected fauna.

As documented in DOE/WIPP 94-024, the radiological array currently planned for most operational surveillance activities include the following:

^{238}Pu, ^{239}Pu, ^{240}Pu, ^{241}Pu, ^{233}U, ^{234}U, ^{235}U, ^{238}U, ^{241}Am, ^{228}Th, ^{230}Th, ^{232}Th, ^{226}Ra
^{228}Ra, ^{137}Cs, ^{90}Sr, ^{40}K, ^{60}Co, ^{210}Pb, ^{210}Po.

Be-7 is added to the array for atmospheric particulates (Lo-Vol air samplers). The list includes natural (uranium and thorium series), cosmogenic (Be-7), and man-made radionuclides (fall-out and transuranic waste stream) (NCRP 50, 1988).

The following are radioanalytical arrays originally proposed for baseline and operational sampling (DOE/WIPP 88-025):

<u>RBP</u> Pu-238, Pu-239, Pu-240, Pu-241, Pu-242, U-233,Am-241, Am-243, Th-232, Cm-244, Np-237, Ra-226, Cs-137, Sr-90, K-40, Co-60, natural uranium and thorium (Mercer et al., 1989).

<u>OEMP</u> Pu-238, Pu-239, Pu-240, Pu-241, U-233, U-235, Am-241, Th-232, Ra-226, Cs-137, Sr-90, K-40, Co-60, Be-7, natural uranium and natural thorium (Mercer et al., 1989).

A number of modifications to the radioanalytical array occurred for individual media during the baseline data acquisition. Where possible, this report documents media-specific analytical arrays in the applicable section.

2.1 Source Term and Pathway

Pathway analyses conducted by DOE/WIPP identify an airborne release as the most probable means for radiological exposure of the public and the environment (Figure 2.2) (FSEIS, 1990, FSAR, 1990). EPA (1990) concurred with this assessment for tests that were planned involving radioactive waste on site. A worst-case accident involving combustion of bins/drums in the underground would probably result in a discrete plume emanating from the exhaust stack. If unfiltered, this plume could contain radioactive particulates, which could be inhaled directly or ingested as contaminated food and water. Direct immersion could also result in a whole-body dose. The pathway assessment precludes the potential for an off-site release of

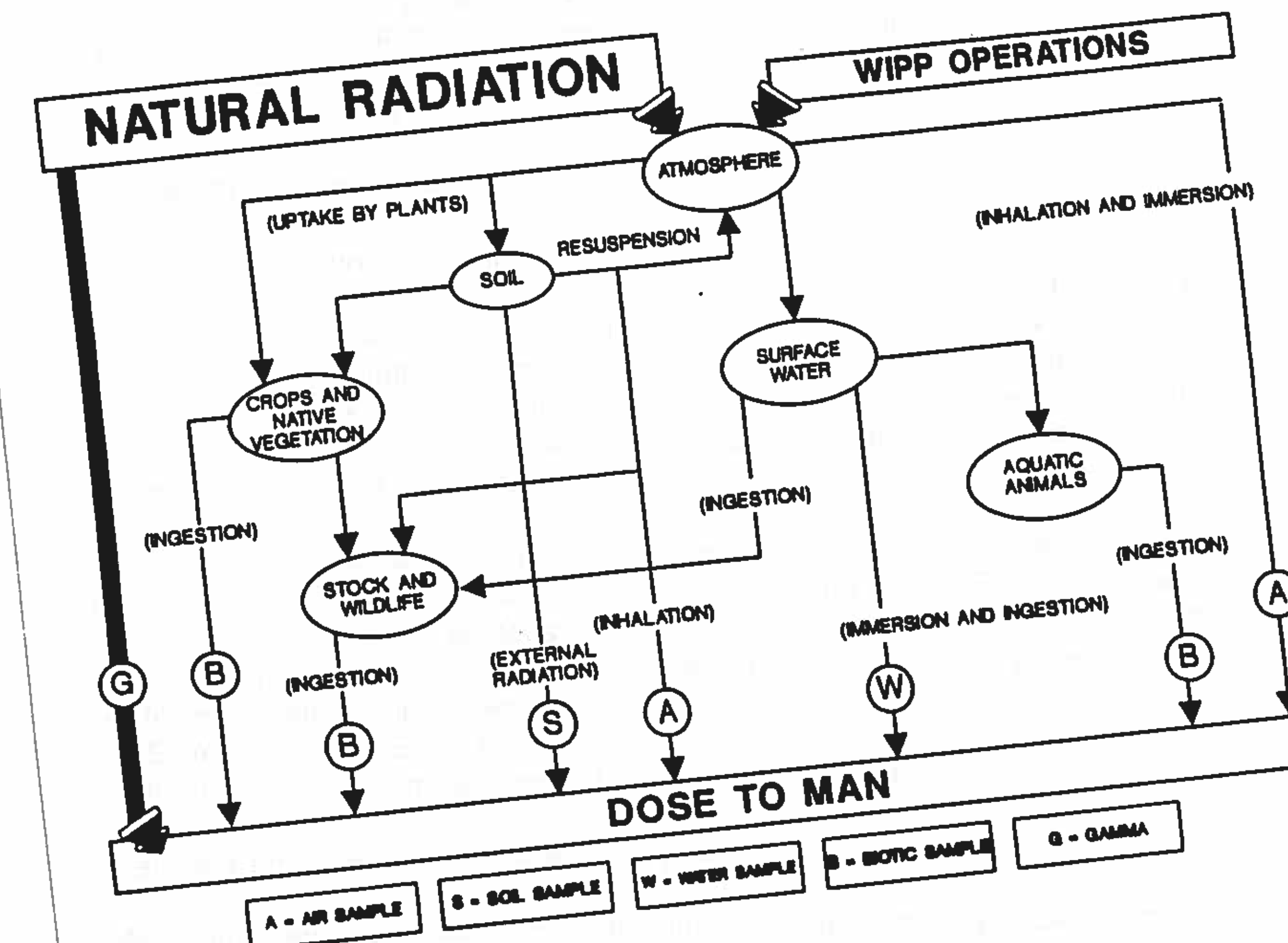


Figure 2.2: DOE/WIPP radiological pathway assessment.

radiation-contaminated liquid waste to surface waters and soil. Groundwater is not considered a pathway, although it is unclear whether this interpretation would apply to post-closure of the facility.

The waste form arriving for disposal at the WIPP site will be composed of primarily alpha-emitting transuranic mixed radioactive waste. DOE/WIPP reports 1.7 x 10^{-3} mrem as an annual committed effective dose equivalent (person) as a result of routine activities during the operational phase. The worst-case accidental release scenario considered in the DOE/WIPP Final Safety Analysis Report (FSAR) is six orders of magnitude higher: 1700 mrem to a maximum exposed individual, 1500 mrem at the WIPP site boundary and 1100 mrem at Mills Ranch. Using less conservative estimates of plutonium equivalent (PE) activity per drum, Steinbruegge (1991) suggests that it would take an accident involving the complete incineration of 160 drums, and failure of the HEPA filtration system, to expose a maximum individual at risk (MIR) to 10 mrem at the site boundary.

2.2 Program Requirements

Radiological monitoring requirements at the WIPP site are mandated or guided almost exclusively by DOE orders and DOE guidelines. The facility is not regulated by the Nuclear Regulatory Commission (NRC) and EPA and State of New Mexico programs have only limited regulatory jurisdiction over DOE environmental radiation monitoring. State public and worker dose limits defined under New Mexico "Radiation Protection Regulations" do not apply to the WIPP facility, primarily because the facility is not a licensee under 10 CFR 20 (NRC).

Table 2.2 shows, however, that two EPA-promulgated programs clearly apply to the WIPP program: radiological airborne dose limits defined in 40 CFR 61 (H) National Emission Standards for Hazardous Air Pollutants (NESHAP) and public dose limits set in 40 CFR 191 (A). EPA also provides standard test methods for water and waste water for gross alpha, gross beta, radium and a few other natural radionuclides (EPA 1975; EPA 1979; EPA SW-846, 1990), but has not developed a comprehensive manual for detection or measurement of transuranic radionuclides in the environment.

The reliance on DOE drivers, rather than public law, pose two issues:

1) Many apparently stringent, but noncompulsory, requirements of DOE Orders can be avoided by a DOE facility's self-interpretation of the order.

2) Consequences for noncompliance with a DOE Order are much less severe than those administered under public law.

Table 2.2 is a summary of the primary DOE Orders, regulations and documents often cited as guidance for monitoring and surveillance activities at the WIPP site. Public

Table 2.2: Radiological Environmental Monitoring and Surveillance Drivers

Activity	Order 5400.1	Order 5400.5	Order 5000.3B	DOE 0173T	40 CFR 61	40 CFR 191	Order 6430.1A	NM WQCR	Public Concern
Airborne Effluent	■	■	■	■	■	■	■		
Atmospheric Particulates	□	□	□	□			□		
Meteorology	■								
TLDs	▼			▼					▼
Exposure Rate Meters	▼			▼					▼
Soil		□		□ See Note					▼
Surface Water	▼			▼					▼
Sediment	▼			▼					
Liquid Effluent Sewage				▼				■	
Liquid Influent				▼					▼
Vegetation	▼			▼					▼
Beef/Deer	▼			▼					▼
Game Birds	▼			▼					▼
Rabbits	▼			▼					▼
Fish	▼			▼					▼
Groundwater	▼			▼					▼

■ Mandatory Effluent Monitoring - Primary pathway and principal means of verification of compliance with applicable regulations and DOE Orders.

□ Mandatory Surveillance - Would satisfy requirements to assess unplanned releases and provide for monitoring one additional pathway to verify compliance with applicable regulations and DOE Orders (See Note).

▼ Elective Surveillance - Verification of compliance by monitoring multiple (redundant) pathways, noncritical pathways, and use of gamma detectors: public interest/scrutiny is an apparent driver.

Note: For the purpose of this table, soil is assumed to be the second required pathway although this is not specified in DOE/WIPP documents; other pathways are represented as elective.

concern is added to reflect "...public interest or concern" and "public relations and state and local commitments", which are identified in DOE Order 5400.1 and DOE/EH 0173T as additional criteria for developing DOE surveillance programs. The following summaries describe relevant aspects of selected drivers and applicability of other programs:

- **DOE Order 5400.1:** "*General Environmental Protection Program*" requires the development of successive three-year "Environmental Monitoring Plans", with surveillance programs designed to accommodate the hazard potential or the degree of specific "local public interest or concern". Annual site environmental reports and environmental reports involving unplanned releases are required. Environmental reporting requirements include sampling locations, procedures and equipment, frequency of analyses, minimum level of detection and accuracy, quality assurance, and alarm settings. Meteorological monitoring is required to document local atmospheric transport and diffusion conditions to support effluent monitoring.

- **DOE Order 5400.5:** "*Radiation Protection of the Public and the Environment*" requires demonstration of compliance to satisfy 40 CFR 61 (H) and 40 CFR 191 (A) and applies to off-site exposures to members of the public from <u>routine</u> WIPP activities. Both effluent monitoring program data and surveillance program data are required. The Order suggests that each facility develop the capability to detect, quantify, and respond to "unplanned releases" using the following: in-place effluent monitoring, meteorological monitoring, and assessment (surveillance). Mandatory reporting is required if the potential exists for an off-site airborne effective dose equivalent of 10 mrem. The WIPP facility is specifically committed to compliance with 40 CFR 191 subpart A.

- **DOE Order 5000.3B:** The "*Occurrence Reporting and Processing of Operations Information*" Order requires each DOE facility to maintain the capability of detecting radioactive releases exceeding normal levels established by baseline sampling. DOE/WIPP 92-007/92-037 proposes warning and action levels for operational surveillance based on probability distributions exhibited by background samples collected during the RBP.

- **DOE Order 5820.2A:** "*Radioactive Waste Management*" is purposely omitted from Table 2.2. Although the order states that environmental monitoring will occur at the Waste Isolation Pilot Plant according to DOE Orders, there are no definitive requirements and standards for monitoring activities, such as those outlined for <u>high-level</u> and <u>low-level</u> radioactive waste storage areas in the same order.

- **DOE/EH 0173T:** "*Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance*" provides detailed requirements and guidelines for selecting sample sites, sample schedules, sampling procedures and equipment, data analysis etc. DOE/EH 0173T supplements DOE Order 5400.1, which provides few specifics in program implementation. General guidelines for surveillance programs include:

Routine surveillance of all pathways if the potential off-site annual effective dose equivalent (routine operations) exceeds 5 mrem. DOE/WIPP FSAR reports a routine dose equivalent of .0017 mrem for a 50 year dose commitment resulting from a one-year exposure.

Periodic surveillance (minimum 5 year interval) to confirm low dose levels if projected annual effective dose equivalent (routine operations) ≤ .1 mrem.

Provisions for detection and quantification of unplanned releases: sites "shall provide capabilities to detect and quantify unplanned releases of radionuclides ...with the potential for off-site impact, and to support consequence assessments as necessary".

At least two environmental pathways should be monitored.

- **DOE Order 5700.6C:** "*Quality Assurance*" lists requirements for sampling, sample custody, calibration, analytical procedures, data quality objectives, data reduction and internal quality control. DOE/WIPP environmental monitoring plans also commit to selected quality assurance requirements of ASME NQA-1 and EPA QAMS-005/80.

- **40 CFR 61:** "*National Emission Standards for Hazardous Air Pollutants*" (NESHAP) establishes an off-site effective dose equivalent limit of 10 mrem/yr at the site boundary for routine operations. The 40 CFR 61 dose limit applies to the boundary of the 16 section land withdrawal area encompassing the WIPP facility (Sections 15-34 Township 22 South, Range 31 East).

- **40 CFR 191 (A):** CFR 191"*Environmental Radiation Protection Standards for Management and Disposal of Spent Nuclear Fuel, High Level and Transuranic Radioactive Wastes*" prescribes dose limits for the WIPP operational phase as follows "...shall not exceed 25 mrems to the whole body and 75 mrems to any organ". CFR 191 (A) applies to routine operations and off-site exposures only.

- **WQCCR Regulations:** "*New Mexico Water Quality Control Commission Regulation*" (WQCCR) 1-203 mandates reporting and remediation requirements in the event of an accidental release to the environment. Although pathway analysis indicates no groundwater risk, an unforeseen release of radiological contaminants would need to be assessed and remediated according to this regulation.

The WQCCR program also requires a WIPP facility Discharge Plan (DP-831) for liquid effluent discharged to the sewage lagoon. Although there is no direct connection between the Waste Handling Building (WHB) and the sewage treatment system, the DP-831 discharge plan requires quarterly sampling of the sewage lagoon for Radium 226 and 228. DOE/WIPP has also self-imposed an annual operational radiological sampling plan on the basis of DOE/EH 0173T guidelines (Table 2.1)

- **NMWSR/Drinking Water Program:** "*New Mexico Water Supply Regulations*" requires radiochemical sampling and analyses for some naturally occurring radionuclides. The City of Carlsbad is responsible for testing drinking water supplied to the site. Although drinking water is not supplied by on-site surveillance wells, monitoring is conducted annually by DOE/WIPP for gross alpha, gross beta, radium and other requirements of 40 CFR 141. Adjacent off-site private wells used for drinking water and livestock are also sampled annually for Safe Water Drinking Act radiochemical constituents by DOE/WIPP. The basis for groundwater monitoring is to "provide data upon which decisions can be made concerning land disposal practices and the management of groundwater resources" (5400.1) and to document "quality through time" (Groundwater Management Protection Plan DOE/WIPP 90-008, 1990). For management purposes, potable groundwater in the Dewey Lake Formation may occur at the southern limit of the WIPP site (Sanchez, 1993; DOE/WIPP Land Management Plan, in preparation).

- **NPDES/Clean Water Act Regulations:** The "*National Pollutant Discharge Elimination System*" (NPDES) regulates stormwater run-off and can drive monitoring for radium and accelerator-produced radioisotopes. The WIPP facility has constructed stormwater ponds to capture run-off from the facility, which exempts the facility from routine NPDES monitoring requirements.

- **CERCLA Regulations:** "*Comprehensive Environmental Response, Compensation, and Liability Act*" regulations and EPA-promulgated requirements defined in 40 CFR 302.4 (Reportable Quantities) contain reporting and remediation requirements for unplanned releases of radiological contaminants into the environment.

- **RCRA/HSWA:** "*Resource Conservation and Recovery Act*" and "*Hazardous and Solid Waste Amendments* " reporting and remediation requirements apply only to nonradiological constituents. However, the RCRA Part B Application (DOE/WIPP 91-005) commits to radiological environmental surveillance, but qualifies the commitment as a conformance requirement of DOE Orders. A draft of the State of New Mexico RCRA Part B Permit contains no specific provisions for radiological environmental surveillance or monitoring. Radiological monitoring at the WIPP facility is also not driven by the No-Migration Determination (40 CFR 268).

- **NEPA:** "*National Environmental Policy Act*" does not drive radiological monitoring at the WIPP site.

- **DOE Order 6430.1A:** "*General Design Criteria*" cites a dose limit for accidental releases, and refers back to dose limits defined in 5400.5. 5400.5 references public exposure limits set in CFR 191 (A). Section 1324-2.2.1 (DOE Order 6430.1A) states that WIPP operations are subject to a maximum 25 mrem (whole body) and 75 mrem (organ) dose limit for any discharge; routine conditions are not qualified.

- **DOE Order 5481.1B:** "*Safety Analysis and Review System*" does not drive radiological monitoring at the WIPP site. The DOE/WIPP Final Safety Analysis Report, however, provides a systematic self-assessment of potential radiological hazards, including potential releases and pathway analyses in the event the environment is contaminated. Release scenarios and pathway analyses have a bearing on the design of the environmental monitoring system.

General comments based on the above review include the following:

1) Many WIPP radiological environmental programs appear to exceed minimum requirements for sampling frequency and number of pathways monitored.

2) Demonstration of compliance with DOE Order 5400.5 for routine releases relies primarily on the Effluent Monitoring Program (EMP). DOE/WIPP 94-024 and DOE WP 02-9 (FSAR) declare the effluent monitoring program as the primary means of documenting radionuclide emission rates and estimating radiation doses to off-site populations. DOE Order 5400.5 states that data from both effluent and environmental surveillance programs should be utilized.

3) There is no mention in the original or current WIPP environmental monitoring plan for use of post-event surveillance (Lo-Vol, soil etc.) to assess the extent of an accidental release. DOE/EH 0173T and DOE Order 5400.1 suggest consequence assessment to verify the radiation doses documented by the effluent monitoring program, and presumably to prove conformance to the 25 mrem and 75 mrem dose limit inferred from DOE Order 6430.1A for "Anticipated Operational Occurrences".

4) The 1700 mrem "worst-case" accident defined in the FSAR apparently exceeds the accidental release limit of 25 mrem, which is inferred from Siting Design Dose Objectives for Normal Operations and Anticipated Operational Occurrences (DOE Order 64301A). DOE Order 6430.1A Section 1324-2.2.1 states: "For the those DOE facilities not regulated by the NRC, the combined annual dose equivalent to any member of the public in the general environment...shall not exceed 25 mrem

(0.25 mSv) to the whole body and 75 mrem (0.75 mSv) to any organ. Section 1300-1.4.3, Routine Releases, provides references for additional limits...".

The Final Safety Analysis Report (FSAR) (DOE/WIPP WP 02-9/DOE Order 5281.1A) only addresses compliance to radiation doses from normal operations. Given that the 1700 mrem worst-case release defined in the FSAR is obviously not an "anticipated operational occurrence", such an event should be defined to resolve the compliance issue relative to 6430.1A.

3.0 ATMOSPHERIC RADIOLOGICAL SURVEILLANCE

Emissions of radiation-contaminated airborne particulates constitute the most probable risk to the environment and the public. Airborne effluent sources are continuously monitored for radioactivity at Stations A, B and C, and atmospheric surveillance is conducted in the vicinity of the WIPP facility and in area communities.

3.1 Airborne Effluent Monitoring

Continuous low volume fixed air samplers (FASs) are used on-site to quantify radiological releases from three potential radiological discharge points:

1) Station A - located at the top of the exhaust shaft, Station A monitors unfiltered effluent from the underground repository;

2) Station B - located downstream of the Exhaust Filter Building, Station B is designed to monitor filtered effluent in the event a release is detected at Station A; and

3) Station C - located downstream of a continuously HEPA-filtered effluent path emanating from the Waste Handling Building (WHB).

Continuous facility effluent monitoring is a requirement contained in DOE Orders 5400.1 and 5400.5, and DOE/EH-0173T. Per DOE order, FASs are used to quantify radiological releases for compliance and environmental management purposes.

The WIPP facility also maintains a system of on-site continuous air monitors (CAMs). CAMs situated at Station A provide emergency notification of a radiological release, while others function primarily for work place surveillance (DOE Order 5480.11). Effluent CAMs are not necessarily required by DOE Order 5400.1 for effluent monitoring, and therefore, are not part of the environmental effluent or surveillance programs. Nevertheless, Station A CAMs are designed to alarm when radiation levels increase to a predefined limit. Consequently, effluent CAMS provide the only real-time assessment capability of an accidental airborne release.

3.1.1 Effluent Sampling Stations

Station A: Station A houses three sampling skids:

West array (A-1) consists of a specially designed **anisokinetic** shrouded probe (to provide accurate aerosol stream sampling), a mass flow measuring device, and a three-way splitter which diverts samples to an alpha CAM (153), a beta-gamma CAM (154), and FAS (A-1-3).

South array (A-2) is identical to A-1 and consists of an **anisokinetic** probe, a mass flow measuring device, and a three-way splitter which diverts samples to an alpha CAM (157), a beta-gamma CAM (158), and an in line filter connected to an alpha 6.

East array (A-3) is configured the same as A-1 and A-2 and is on line continuously. Array A-3 consists of a single FAS that diverts the sample stream to three sampling stations; one for the WIPP, one for the New Mexico Environment Department (NMED), and one for the Environmental Evaluation Group (EEG).

Alpha CAMs 153 and 157 at Station A operate continuously and are configured to alarm after 40 counts per minute of plutonium are detected over a duration of 6.0 minutes. A single CAM alarm is designed to initiate a shift of the contaminated airflow through banks of High Efficiency Particulate Air Filters (HEPA) located in the Exhaust Filter Building (EFB).

Station B: Station B is located down stream of the HEPA filters. Two shrouded extraction probes sample filtered air to verify the performance of the exhaust filtration system. One probe connects to a mass flow measuring device and a three-way splitter which delivers samples to alpha CAM 151, beta-gamma CAM 152, and a FAS. The other probe delivers filtered exhaust to a FAS that supplies samples to NMED, EEG, and WIPP.

Station C: Station "C" is located downstream of the HEPA filters in the WHB effluent (continuously filtered). An **isokinetic** sampling system is connected to an alpha continuous air monitor (CAM) (155), a beta-gamma CAM (156), and a fixed air sampler (FAS). A negative pressure is monitored and maintained inside the WHB at all times and 100 percent of the WHB ventilation exhaust is filtered through a bank of HEPA filters. A mass flow measuring system, consisting of an array of thermal anemometers, provides velocity control for the isokinetic sampling system and records the total air exhaust volume from the WHB. Continuous readouts from the CAMs and interior control pressure instruments register at the Central Monitoring Station (CMS) in the Central Monitoring Room (CMR) of the Support Building (SB).

3.1.2 Effluent FAS Sampling Program

Station "A" sampling location filters are exchanged and surveyed daily for gross alpha and beta. Station "B" and Station "C" filters belonging to the WIPP are exchanged weekly with the same procedural and analytical regimen as for Station A. Information recorded during filter exchanges include starting and ending exhaust flow rates and start and stop times. A record is also generated at Station A to verify the average flow rate and continuous operation of the FAS over the 24 hour recording period. Chain-of-custody documentation is used for transfer of filters to oversight groups NMED and EEG.

Effluent sample filters are stored for 72 hours to allow short-lived radon daughters to decay. The filters are then scanned for gross alpha and beta in the WIPP radiological lab; no routine specific radionuclide analyses are conducted. If radioactivity is detected that is not attributable to natural radon daughters, the filter samples would be sent to an off-site lab for radionuclide analyses (Table 2.1.). Specific radionuclide analysis also occur on an as needed basis to substantiate or characterize CAM function during an alarm occurrence or for quality assurance purposes. A full radionuclide analytical program, consisting of the proposed analytical array described in table 2.1, is planned after the site begins receiving waste during operations.

3.2 Atmospheric Particulates

A release of radioactive particulates to the environment can occur only if one of two conditions are satisfied. One is a malfunction of the Station A alarm system, or two a switch to filtration is otherwise unachieved during a release. If the switch to filtration is achieved, the redundant banks of HEPA filters in the exhaust filter building must also perform as designed. In the event a release passes this containment system, the Low Volume fixed air sampling program would provide monitoring for the closest pathway to man: the inhalation pathway.

3.2.1 Low Volume Fixed Air Samplers

An array of eight Low Volume (Lo-Vol) fixed air samplers has been deployed off site as described in figure 3.2.1. The frequency of sampling is weekly with gross alpha and beta being determined at the WIPP radiological laboratory with periodic verification from a contractor lab. A composite sample for each location is sent to the contracting lab quarterly, for specific radionuclide analysis in accordance with table 2.1.

WIPP Lo-Vol FAS equipment specifications

- o Model CMP-14CV samplers by HiQ Environmental Products
- o Flow rate is 2 cubic feet per minute
- o Filter is a 47-mm glass fiber filter

Provisions for verification of radioactive releases and off-site doses resulting from accidents are required by a number of DOE drivers. Although the Lo-Vol system is not mentioned for this purpose in DOE/WIPP environmental monitoring plans, procedure WP 12-924 identifies Lo-Vol samplers as a means to verify off-site releases of airborne radioactivity. Lo-Vol sampling locations; however, appear to be positioned only for determining general trends, not to assess a discrete event. Sampling locations are either well away from the site boundary, or are distributed inappropriately to detect releases during varied seasonal wind directions.

DOE/EH-24 (in press) noted in an environmental audit that the sample flow rate (2 feet ^{3}/min) also may not be suitable for detecting an accidental "off normal" release. In the event of an off-normal release, higher air volumes would be required to obtain a sample size large enough to achieve the detection limit required for such a short duration event. High-volume standards cited in 40 CFR 50 Appendix B for measuring total suspended particulates require a minimum flow rate of 39 feet ^{3}/min for a heavily loaded filter, and a maximum flow rate of 60 feet ^{3}/min for a clean filter.

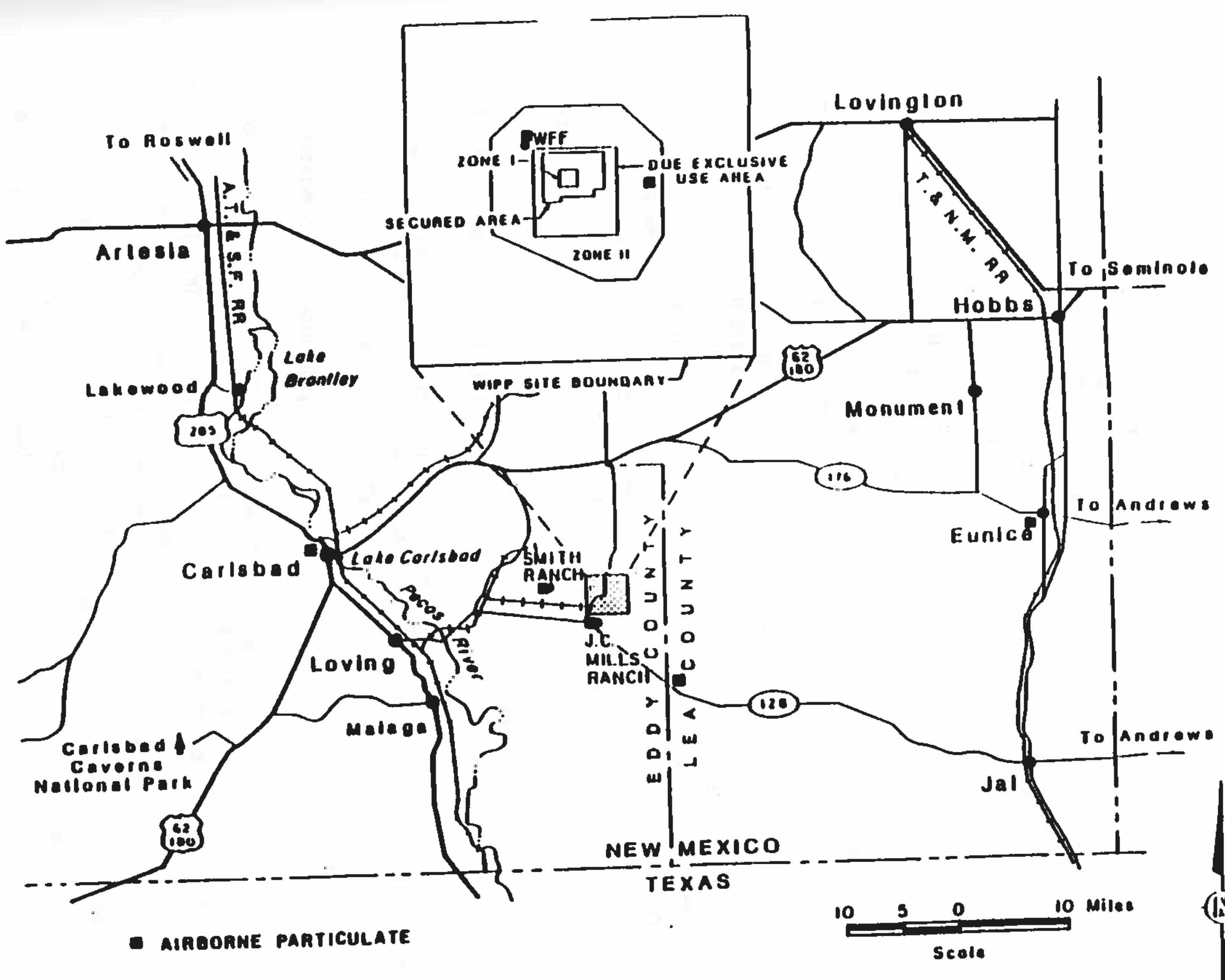


Figure 3.2.1: WIPP Airborne Particulate Far Field Sampling Locations

The DOE/WIPP Lo-Vol array is consistent with the design and siting criteria established in Corley et al. 1981 (DOE/EP-0023). However, there have been a number of recent advances in detection and siting criteria, some of which are defined in 40 CFR 58 Appendix E for particulate matter (PM_{10}) high-volume samplers. In the absence of any other recent or definitive standards for low-volume arrays, selected criteria in the regulation may provide a useful measure of the WIPP program. As defined in PM_{10} guidance, the following siting and design criteria are aimed at measuring particulate matter with an aerodynamic diameter less than or equal to 10 micrometers:

- height of samplers 2 - 15 meters;
- distance from obstacle - at least twice the distance of the height the obstacle protrudes above the sampler; and
- unrestricted air flow 270 degrees around the device, including the predominant wind direction from the pollutant source.

Assuming that siting criteria for high volume and low volume standards are comparable, the height of WIPP Lo-Vol Stations are consistent with particulate matter (PM_{10}) standards defined in 40 CFR 58. However, the southeast control (SEC) station may not meet the distance from obstacle criteria, as the device is surrounded by a chain-link fence and is adjacent to a telephone/power pole. The Lo-Vol design configuration is inconsistent with the 270 degree unrestricted flow criteria; the air samplers protrude in one direction from only one face of the device. The above observations are based on the assumption that these siting and design considerations are independent of flow rate and size of particulate matter (< 10 micrometers for high-volume vs. total suspended particulates for low-volume).

3.2.2 High Volume Fixed Air Samplers

The original locations of intermittent High volume (Hi-Vol) fixed air samplers are shown in figure 3.2.2. Currently, approximately two-thirds of the instruments have been removed and the remaining stations are not maintained.

3.3 Meteorological monitoring

This program employs two meteorological monitoring stations that continuously collect data by monitoring the wind direction, wind speed, ambient temperature, precipitation, humidity, dew point and barometric pressure. Figure 3.3.1 shows the locations of the stations. The 40-meter tower northeast of WIPP provides wind and temperature data points at 3, 10, and 40 meters. The monitoring station located northwest at the WFF Lo-Vol sampling location records similar data at 10 meters. WFF is in-line with the predominant annual wind direction from the facility. The 40 meter tower supplies the bulk of meteorological data to the Central Monitoring Room (CMR). The CMR data logger currently averages and records meteorological data every 15 minutes.

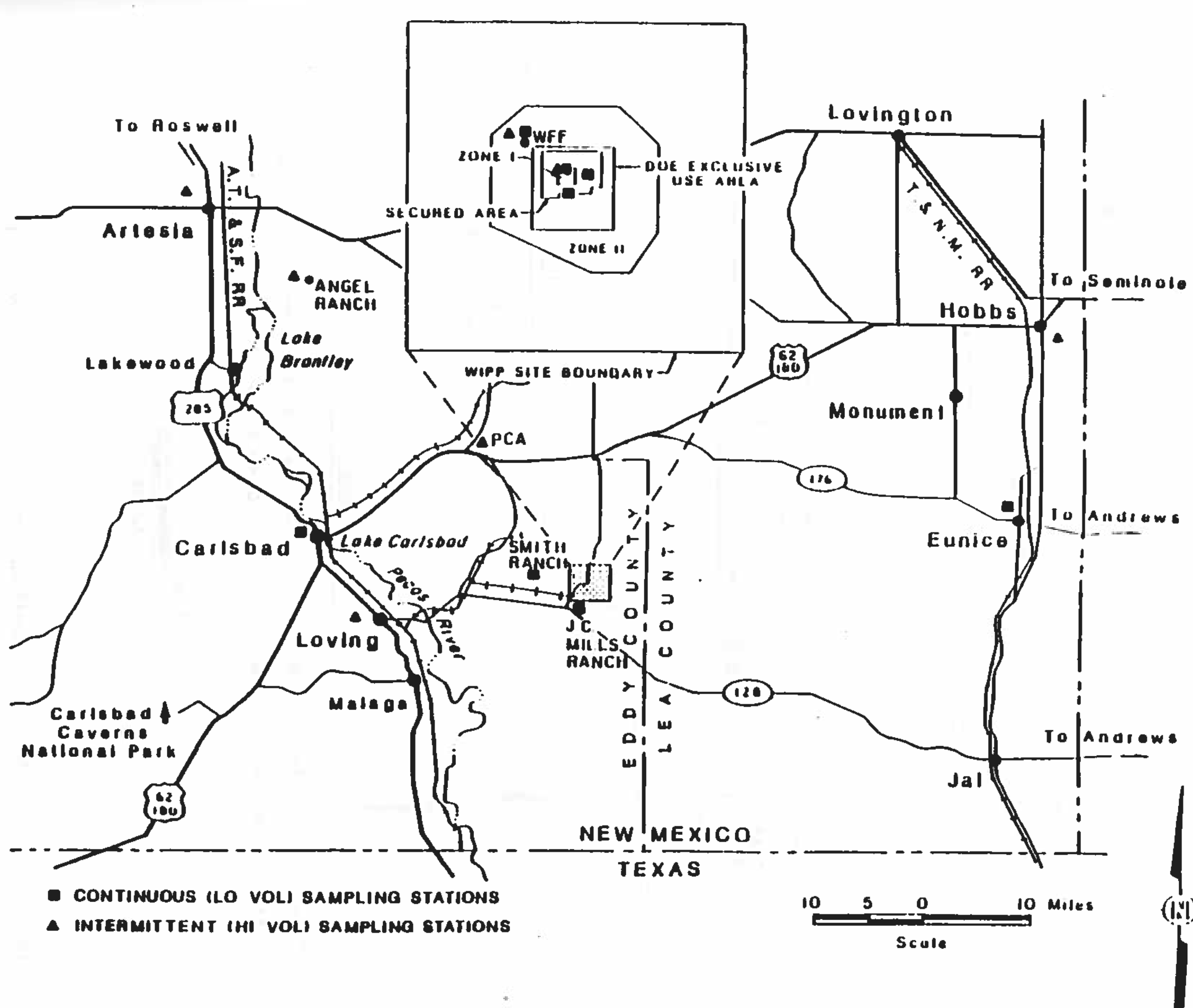


Figure 3.2.2: WIPP Airborne Particulate Near Field Sampling Locations

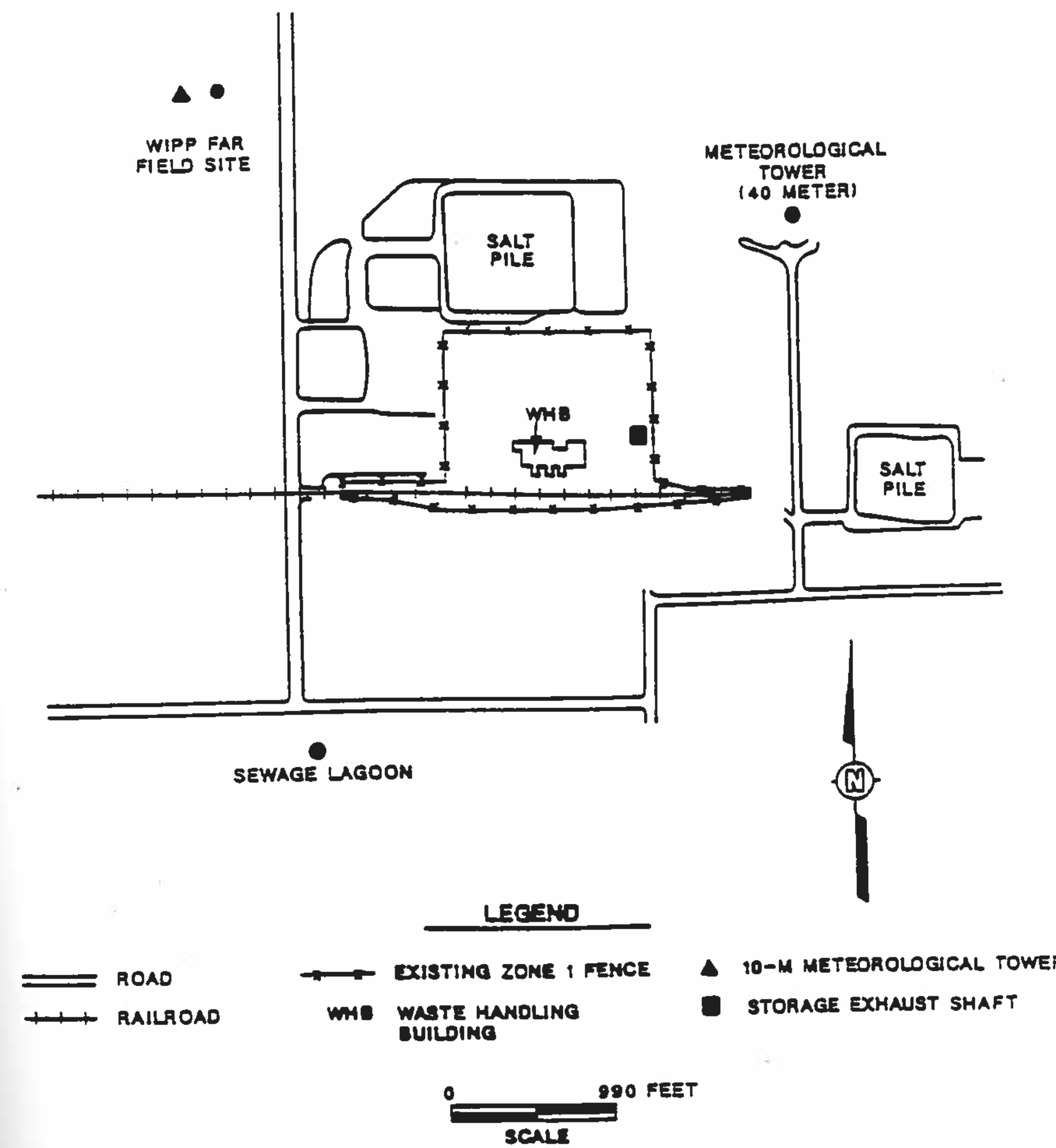


Figure 3.3.1: WIPP Effluent discharge and Meteorological Monitoring Locations

4.0 EXTERNAL RADIATION

This program continues the monitoring activities of the RBP that were in place during the pre-operational baseline defining phase at WIPP. This program is currently a subprogram of the Radiological Environmental Surveillance (RES) Program and will be used to quantify present and future environmental impacts due to human activity or radioactive releases. External Radiation data from previous work by WIPP (1988 Annual site Report), Sandia National Laboratory (SAND87-0843 •UC-41) , and the National Council on Radiation Protection and Measurements (DOE/WIPP-87-004) is presented in table 4.1.1. The potential presence of small amounts of fission and activation products (beta-gamma emitters) in the waste, such as Cs-137 and Co-60, are cited as drivers for this monitoring program. Table 4.1.2 lists the alpha-emitting actinides to be present in the waste.

4.1 Environmental Thermoluminescent Dosimeters

This program was discontinued after 1987 based on an objective evaluation by WID/WIPP, DOE/WIPP, and the Environmental Evaluation Group. Prior to 1987, environmental thermoluminescent dosimeters (TLD) were placed strategically around

Table 4.1.1: Annual WIPP External Radiation Data Averages

Data Provided By	Aerial Gamma Surveys[1]	High Pressure Ionization Chamber[1]	Thermoluminescent Dosimeters[1]
WIPP - Environmental Monitoring (1987)	65	66	34.03
Sandia National Laboratory (1977-1979)	N/A	68.4	64.9
National Council on Radiation Protection and Measurements (1958 & 1963)	64	N/A	N/A
WIPP - Occupational Dosimetry (TLDs with 100% environmental exposure)	N/A	N/A	80

[1] Units are in mrem per year assuming a quality factor of 1.

the WIPP site and surrounding communities as described in figure 4.1. This allowed quantification of the baseline beta-gamma dose received by the ecosystem associated with the WIPP resulting from ambient radiation. According to the 1990 FSEIS the 22 regional

Table 4.1.2: RADIONUCLIDE CONTENT OF WIPP WASTES

RADIONUCLIDES IN WIPP WASTES	TOTAL ACTIVITY DRUMS (Ci)	TOTAL ACTIVITY BOXES (Ci)	TOTAL ACTIVITY (Ci)	TOTAL MASS DRUMS (gm)	TOTAL MASS BOXES (gm)	TOTAL MASS (gm)	PERCENT TOTAL ACTIVITY	PERCENT TOTAL MASS
Th-232	2.43E-01	3.06E-02	2.74E-01	2.23E+06	2.81E+05	2.51E+06	0.00	15.89
U-233	6.24E+03	1.48E+03	7.72E+03	6.58E+05	1.56E+05	8.14E+05	0.08	5.15
U-235	3.23E-01	4.72E-02	3.70E-01	1.51E+05	2.21E+04	1.73E+05	0.00	1.10
U-238	1.28E+00	1.89E-01	1.47E+00	3.84E+06	5.68E+05	4.41E+06	0.00	27.91
Np-237	8.01E+00	7.11E-03	8.02E+00	1.14E+04	1.01E+01	1.14E+04	0.00	0.07
Pu-238	3.87E+06	1.65E+04	3.89E+06	2.22E+05	9.48E+02	2.23E+05	42.51	1.41
Pu-239	3.13E+05	1.12E+05	4.25E+05	5.11E+06	1.83E+06	6.94E+06	4.65	43.92
Pu-240	7.12E+04	3.40E+04	1.05E+05	3.14E+05	1.50E+05	4.64E+05	1.15	2.94
Pu-241	2.51E+06	1.57E+06	4.08E+06	2.24E+04	1.40E+04	3.64E+04	44.59	0.23
Pu-242	1.13E+01	6.68E+00	1.80E+01	2.90E+03	1.71E+03	4.61E+03	0.00	0.03
Am-241	6.20E+05	1.66E+04	6.32E+05	1.91E+05	5.12E+03	1.96E+05	6.96	1.24
Cm-244	1.25E+04	1.58E+02	1.27E+04	1.50E+02	1.90E+00	1.52E+02	0.14	0.00
Cf-252	2.00E+03	2.53E+01	2.03E+03	3.72E+00	4.71E-02	3.77E+00	0.02	0.00
			9.15E+06			1.58E+07		

TOTAL NUMBER OF DRUMS 3.69E+05

TOTAL NUMBER OF BOXES 2.28E+04

TLD stations will be discontinued with reliance on the Rueter-Stokes High Pressure Ionization Chamber (HPIC) for detection of exposure rates. The Occupational TLD program at the WIPP deploy TLDs at 6 locations with full environmental exposure that may be considered as environmental TLDs. Data from the WIPP Occupational Dosimetry Program TLDs was reviewed and indicate an average of 80 mrem per year background as opposed to the HPIC 66 mrem per year, or the previous WIPP and Sandia data at 34.03 mrem/year and 64.9 mrem/year respectively.

Thermoluminescent Dosimeters Specifications (discontinued after 1987)

- Provided, read, and annealed by Eberline Corporation in Albuquerque, NM.
- Harshaw TLD card
- The reader is a Harshaw 4400C system

4.2 Aerial Gamma Survey

The Final Environmental Impact Statement (FEIS) for WIPP (USDOE, 1980) cites a report by the National Council on Radiation Protection and Measurements (NCRP45, 1975) on national background radiation. Based on aerial surveys taken between 1958 and 1963, an estimate of 64 mrem, assuming a quality factor of 1, annual external whole-body exposure rate from terrestrial sources, cosmic rays, and global fallout was made. A second aerial survey in 1977 confirmed the surface measurements made by Sandia. In April of 1988 another aerial gamma survey confirmed the annual gamma exposure rate to be 65 mrem. Additional aerial surveys are not scheduled but will be conducted as the need arises.

4.3 Continuous Exposure Rate

The WFF location has in place a Reuter-Stokes, model RSS-1012, high-pressure ionization chamber (HPIC) to detect the <u>continuous exposure rate (gamma)</u> at WIPP. The rate has been determined to be 66 mrem annually. This equipment will detect and quantify sudden changes in airborne natural radioactivity, fresh fallout, or other unmonitored sources, and will be used to verify aerosol releases of high energy beta and gamma emitters.

4.4 Waste Handling Building

Surveillance for penetrating gamma radiation inside the Waste Handling Building (WHB) is provided for worker safety, not for environmental compliance or monitoring purposes.

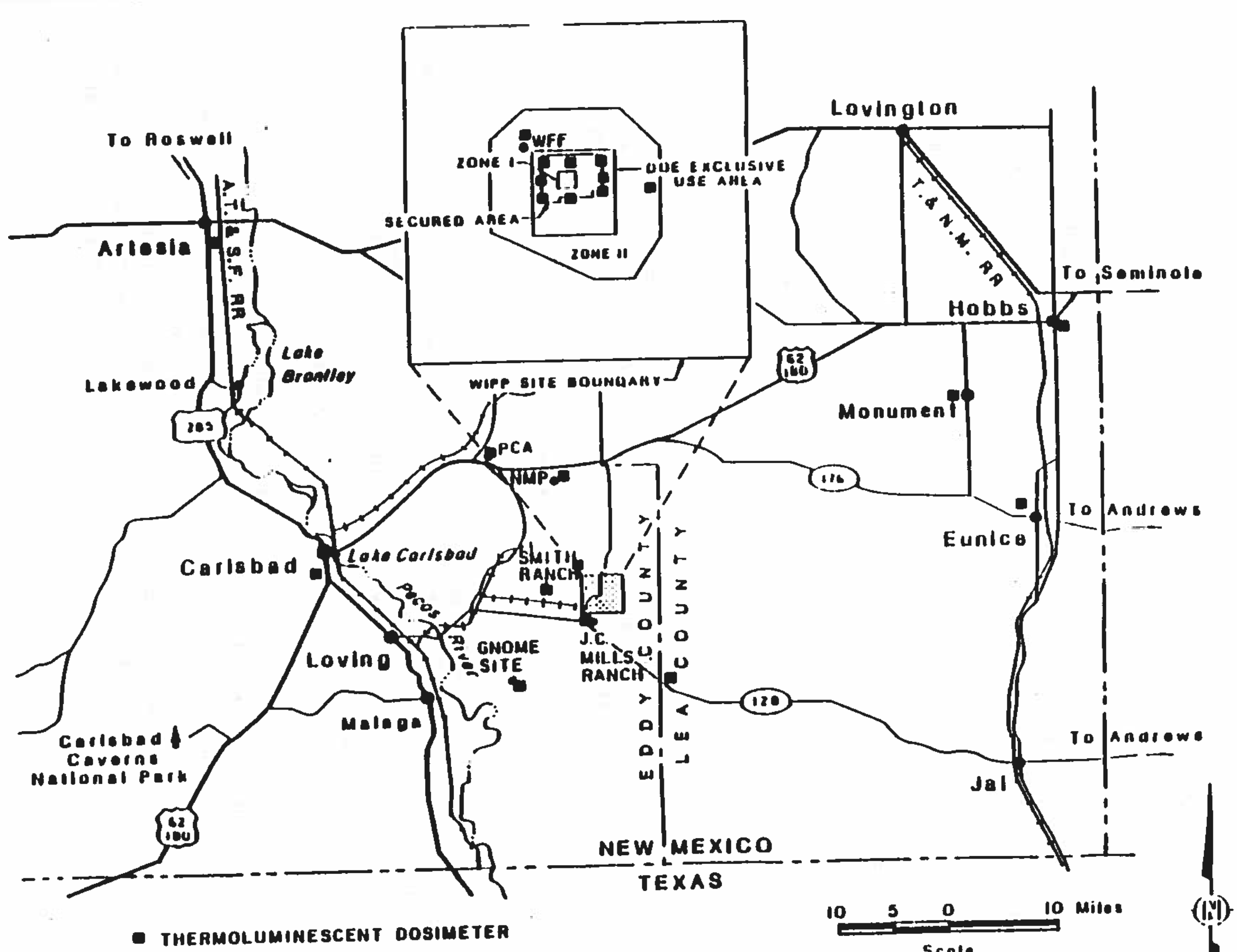


Figure 4.1: WIPP Thermoluminescent Dosimeter Monitoring Locations

5.0 TERRESTRIAL RADIOLOGICAL SURVEILLANCE

Certain worst-case accidental release scenarios from the WIPP underground could result in deposition of radioactive particulates in the terrestrial environment. Preliminary NMED oversight calculations indicate that an airborne release can exceed radiological baseline values for soil, surface water and sediments in the vicinity of the WIPP facility. This section reviews the DOE/WIPP radiological baseline and proposed operational programs for these media.

5.1 Soil

A comprehensive description of the Radiological Environmental Surveillance (RES) program for soil occurs in the 1988 Operational Environmental Monitoring Plan (OEMP: DOE/WIPP 88-025). Procedures for soil sampling protocol are found in the "Environmental Procedures Manual": RES Soil Sampling Procedures WP 02-307. The procedure involves collection of three composite (mixture) samples at each sampling site, each representing three different depths in the soil horizon. A stainless steel sampling template (10cm x 10cm x 10cm) is placed at 10 randomly selected locations at each site, where subsamples are collected at 0-2 cm (surface), 2-5 cm (intermediate) and 5-10 cm (deep). No specific sampling procedures are referenced in the WP 02-307 or the 1988 OEMP; however, staff review finds that many elements of the sampling protocol, sampling schedule and rationale for selecting sites are consistent with NRC Regulatory Guide 4.5 (1974) and ASTM standard C-998 (1990).

Radiological Baseline Program. Baseline radiological soil samples were collected from 37 sampling locations between 1985 and 1990. Table 5.1.1 groups the 37 sampling sites by geographic proximity as: 1) 8 near-field stations at or near the secured fence boundary (WNW-WEE), 2) 16 mid-field stations co-located at former TLD locations (R01-16), and 3) 13 regional locations positioned within a 10 kilometers to 72 kilometers radius of the site. Figure 5.1 illustrates the azimuthal distribution of the locations, notably the 8 kilometers ring encircling the site (RO1-R16) and stations (WNE-WEE) located within 300 to 500 meters of the exhaust shaft. Note that figure 5.1.1 omits 9 regional locations, identifying only Railroad Spur, Gnome, Hobbs Hwy, and Monument.

The radiological baseline database is defined solely by data collected and analyzed during CY 1985 and 1987. The two years of data are consistent with the 1988 OEMP, which suggested that for statistical accuracy, two annual samples should be collected from the original 28 locations shown in figure 5.1.1. Sampling was not conducted during CY 1986 and thirty-seven locations sampled during CY 1988 were not analyzed. Likewise, no analyses were conducted on the samples collected during CY 1989 and 1990. Non-analyzed sample sets were reportedly archived (DOE/WIPP 88-009; DOE/WIPP 90-003).

Table 5.1.1: Soil Radiological Baseline Program: Inventory of Radiological Sampling Locations and Analytical Arrays (1985 and 1987)

	Number of Rounds			
Sample Location	Shallow (0-2 cm)	Intermediate (2-5 cm)	Deep (5-10 cm)	Distance from Site
WNE	2	1	1	
WNN	2	1	1	
WNW	2	1	1	Near-Field
WSE	2	1	1	<1 km
WSS	2	1	1	
WSW	2	1	1	
WWW	2	1	1	
WEE	2	2	1	
R01	2	2	2	
R02	2	2	2	
R03	2	2	2	
R04	2	2	2	
R05	2	2	2	
R06	2	2	2	
R07	2	2	2	Mid-Field
R08	2	2	2	8 km
R09	2	2	2	
R10	2	2	2	
R11	2	2	2	
R12	2	2	2	
R13	2	2	2	
R14	2	2	2	
R15	2	2	2	
R16	2	2	2	

Table 5.1.1: Soil Radiological Baseline: Continued

	Number of Rounds			
Sample Location	Shallow (0-2 cm)	Intermediate (2-5 cm)	Deep (5-10 cm)	Distance from Site
Railroad Spur	2	2	2	10 km WSW
Gnome	2	2	2	14 km SSW
Hobbs Hwy	2	2	2	18 km NW
Monument	2	2	2	56 km ENE
Angel Ranch	1	1	1	53 km NW
Artesia	1	1	1	68 km NW
Carlsbad	1	1	1	42 km W
Eunice	1	1	1	60 km E
Hobbs	1	1	1	72 km ENE
Jal	1	1	1	64 km E
Loving	1	1	1	29 km WSW
New Mexico Potash	1	1	1	14 km N
PCA	1	1	1	26 km NW

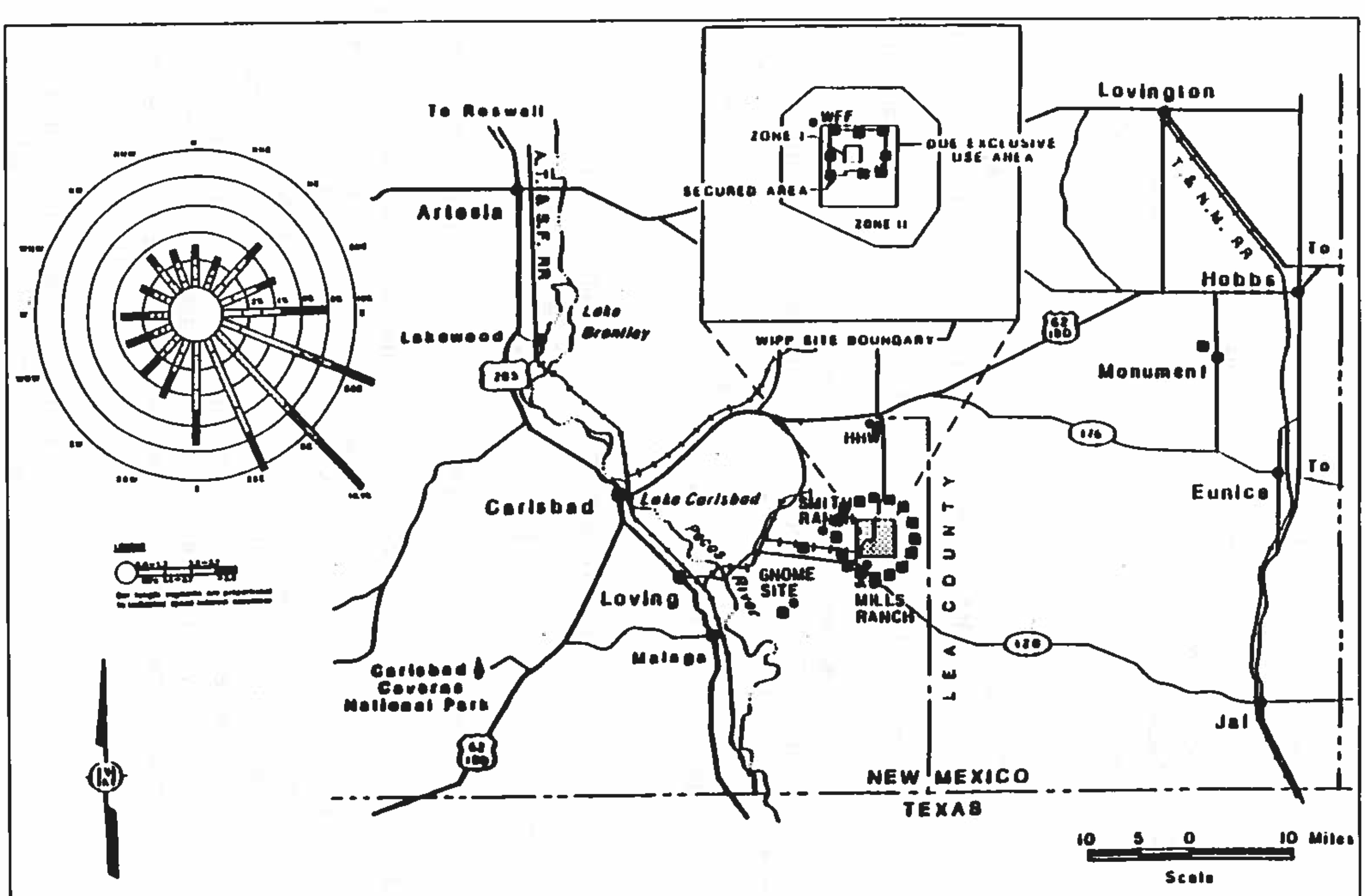
Shallow (0-2 cm): K-40, Co-60, Sr-90, Ra-226, Ra-228, Th-228, Th-230, Th-232, U-233, U-234, U-235, U-238, Pu-238, Pu-239/240, Pu-241, Cs-137, Np-237, Am-241, Cm-244.

Intermediate (2-5 cm): K-40, Co-60, Sr-90, Ra-226, Ra-228, Th-228, Th-230, Th-232, U-233, U-234, U-235, U-238, Pu-238, Pu-239/240, Pu-241, Cs-137, Np-237, ~~Am-241, Cm-244~~.

Deep (5-10 cm): K-40, Co-60, Sr-90, Ra-226, Ra-228, Th-228, Th-230, Th-232, U-233, U-234, U-235, U-238, ~~Pu-238, Pu-239/240, Pu-241~~, Cs-137, Np-237, ~~Am-241, Cm-244~~.

Note: radionuclides analyzed only once per horizon are stricken out

Soil RES Baseline Locations



■ Soil Sampling Location

(Not shown are nine locations sampled and analyzed in 1987, and sampled and archived in 1988 and 1989; and Smith Ranch and J.C. Mills Ranch which were sampled and archived in in 1989 and 1990)

Figure 5.1.1: Inventory of radiological soil sampling locations for the environmental baseline at the WIPP facility. The windrose for 1985 is added for reference.

Table 5.1.1 shows that only stations R01-R16, Railroad Spur, Gnome, Hobbs Hwy, and Monument possess two full annual rounds at all control depths: 0-2 cm, 2-5 cm, 5-10 cm. The radionuclide analytical arrays compiled for the two years of sampling further reveals the following:

- a total of 19 radionuclides define the radiological baseline;
- radiological baseline values, where underlined, are consistent with actinides and activation/fission products characteristic of TRU wastes destined for the WIPP: K-40, Co-60, Sr-90, Ra-226, Ra-228, Th-228, Th-230, Th-232, U-233, U-234, U-235, U-238, Pu-238, Pu-239/240, Pu-241, Cs-137, Np-237, Am-241, Cm-244
- soils are not analyzed for Am-243 and Pu-242, as prescribed in the 1988 OEMP;
- radionuclides U-234, U-235, and U-238, Ra-228 and Th-228 are added to the generic RBP analytical array defined in the 1988 OEMP; and
- plutonium series and Am-241 and Cm-244 are tested only once in subsoil horizons.

The statistical radiological baseline summary presented in DOE/WIPP 92-007/92-037 treats all 37 soil stations sampled during CY 1985 and 1987. Rather than distinguish between sampling years, each location is represented as an average of the two annual measurements. Summary baseline measurements are presented in appendix 5.1, along with minimum detection limits (MDLs) and relevant statistics. General observations from DOE/WIPP 92-007 include the following:

- underlined radionuclides exhibited mean values less than the method detection limit (MDL): K-40, Co-60, Sr-90, Ra-226, Ra-228, Th-228, Th-230, Th-232, U-233, U-234, U-235, U-238, Pu-238, Pu-239/240, Pu-241, Cs-137, Np-237, Am-241, Cm-244.
- no statistically significant differences are found between sample depths

Based on a review of the data above, the WIPP soil RBP program has appropriately focused on an array of important waste stream transuranic actinides with short and long half-lives, such as Cm-244 (18.1 yrs), Am-241 (432 yrs) and Pu-239 (2.4 x 10^4 yrs). Cs-137 and Sr-90 are also fitting baseline parameters, as these radionuclides are fission products found in WIPP waste and may occur as a result of fall-out from past atmospheric nuclear testing (Kenny, et al., 1990). The elevated background measurement of Cs-137 is also significant in that Project Gnome, located 14 km southwest of the WIPP site, resulted in a minor atmospheric dispersion of radioactive particulates from the underground nuclear detonation (DOE NVO/0410, 1978).

As an existing database, the RBP soil baseline seems adequate for evaluating data analyzed during post-baseline sampling. The lack of any significant difference in measurements between sample depths for all sample populations seems to indicate that replicate samples are not required at different subsurface horizons. However, single-round sampling of subsurface horizons may increase the possibility of biasing the conclusion regarding radionuclide concentrations with depth. Bias can be introduced as a result of procedural errors during sample collection, preparation, packaging, and analyses. Falling in this single-round category are near-field stations (WNW-WEE), regional locations Angel Ranch-PCA, radionuclides Am-241 and Cm-244, and the plutonium series (Table 5.1.1).

RES Operational Program Seven post-baseline stations were sampled and archived each in 1989 and again in 1990 (DOE/WIPP 90-003; DOE WIPP 91-008). Six radiological soil samples were collected in FY 1992 but were not analyzed. The six locations sampled in FY 1992 are consistent with the locations proposed in the WIPP Environmental Monitoring Plan (EMP) (DOE/WIPP 94-024):

- WEE (.34 kilometers east of exhaust stack)
- WSS (.46 kilometers southwest)
- WIPP Far-Field (.91 kilometers northwest)
- SEC (16 kilometers southeast)
- Smith Ranch (9.0 kilometers northwest)
- Mills Ranch (5.3 kilometers southwest)

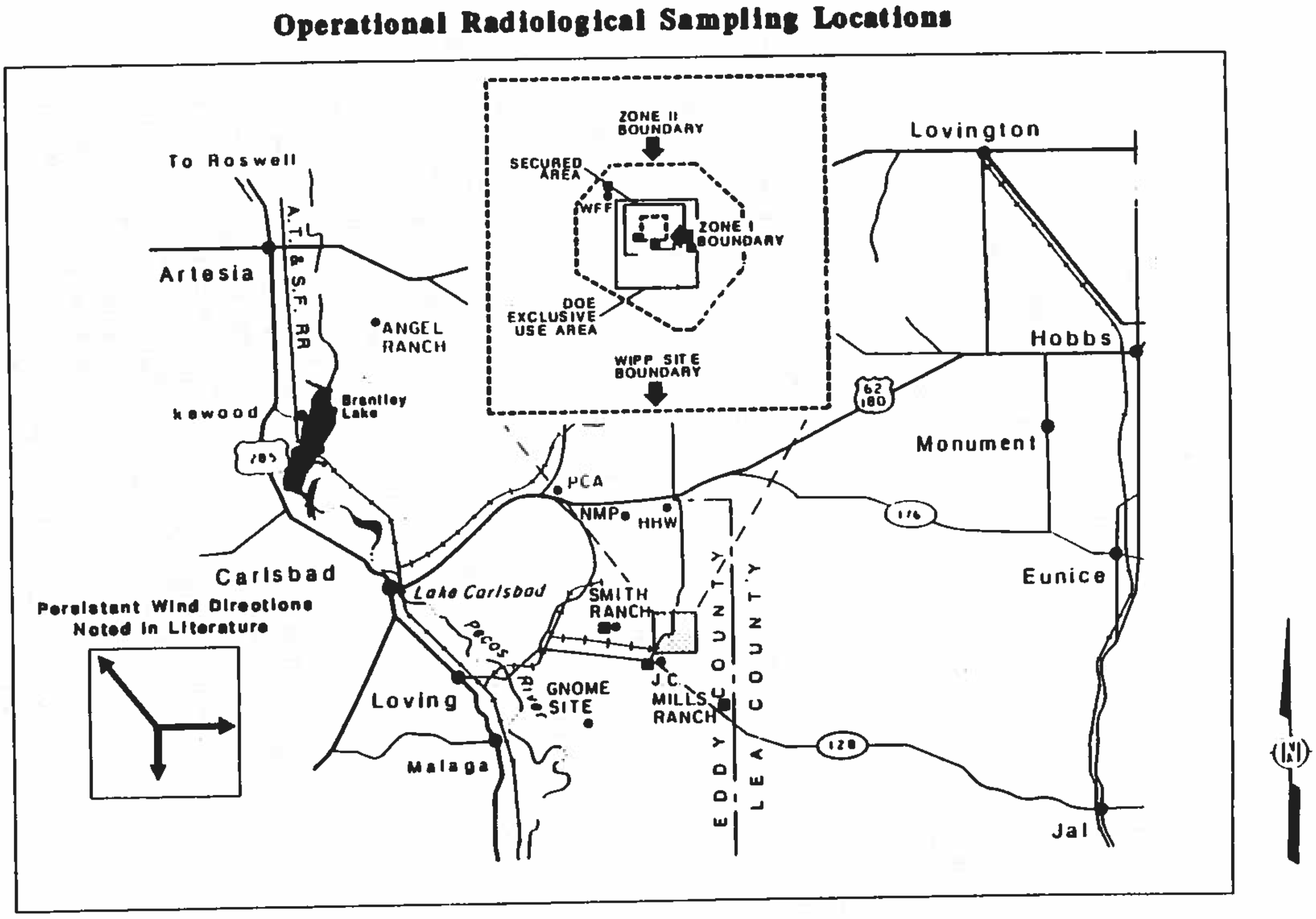
Figure 5.1.2 shows the seven operational radiological monitoring stations proposed in the original OEMP. The 6 stations sampled in 1992 are a subset of the operational group, and 4 of these are different from the preoperational stations used to define the RBP baseline: WIPP Far-Field, southeast control (SEC), Smith Ranch, and Mills Ranch. Once the facility becomes operational, the 1988 OEMP proposes biennial radiological sampling of soil (every two years). As indicated above, to date, no post-baseline analytical data have been collected.

Although the 1988 OEMP proposes an array of operational radionuclides, recently promulgated DOE/WIPP contract laboratory analytical requirements are more representative:

> K-40, Co-60, Sr-90, Ra-226, Ra-228, Th-228, Th-230, Th-232, U-233, U-234, U-235, U-238, Pu-238, Pu-239/240, Pu-241, Cs-137, ~~Np-237~~, Am-241, ~~Cm-244~~ and Po-210, Pb-210.

The proposed operational array differs from the preoperational analytical database in a number of ways. Np-237 and Cm-244 are stricken-out to note their deletion from the radiological operational monitoring plan. Polonium-210 and lead-210 are appended to the list of operational monitoring parameters. The basis for including Po-210 and Pb-210 may be their status as members of the uranium decay series, along with Ra-226 and Th-230. It is uncertain; however, the manner in which the Po-210 and Pb-210 data will be utilized, given the fact that there is no standard for comparing this new data with the existing baseline model population distribution. Another change since the original plan is that gross alpha and beta activity are no longer measured as a screening technique.

Operational Radiological Sampling Locations



■ Soil Sampling Location

10 5 0 10 Miles
Scale

Figure 5.1.2: **Proposed operational radiological soil sampling locations identified in the 1988 OEMP. Note that some operational locations are not baseline locations.**

The six operational sites selected in the EMP DOE/WIPP 94-024 are coincident with Lo-Vol air sampling locations. The sampling locations are located at four general azimuths and variable distances from the exhaust shaft: northwest (.91 kilometers and 9.0 kilometers, southwest (5.3 kilometers), south (.46 kilometers) and east (.34 kilometers). Pre-selected at 16 kilometers from the site, the SEC is designed as a control station unlikely to be contaminated from a release. Because wind direction is transient and varies considerably with seasonal changes, one potential problem is the lack of an operational station to the northeast of the site.

The co-location of operational stations with Lo-Vol locations provides data comparability, and is consistent with recommendations in DOE/EH-0173T (1991) "Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance". The locations are also appropriate for comparing new data with defined baseline "model population distributions" for trend evaluation as proposed in DOE/WIPP 92-007. One potential improvement is to establish radiological baselines for WIPP Far-Field, SEC, Smith Ranch, and Mills Ranch. These locations should be included in the RBP database before waste is received at the WIPP facility, or alternatively, before there is evidence for a release.

In general, the soil sampling locations are generally adequate if the program objective is to identify long-term trends for pathway analyses, or to verify that a release has not occurred during routine operations. Consistent with NRC Regulatory Guide 4.5, locations are predetermined and suitable for resampling and situated on level surfaces. This location strategy may not be successful if the objective is to determine the extent and severity of an accidental release to the soil at a particular location. Another deficiency is that some sampling sites are not removed from dusty roads and sites of previous construction by more than 120 m, a recommendation in NUREG 4.5. The following aspects are additional considerations for improvement of the program:

- NRC Regulatory Guide 4.5 indicates that soil sampling following an accidental release can be used to help define contamination contours. This would involve selecting sampling locations determined by judgement at the time of release, which may not coincide with a location sampled for the baseline or selected as an operational station. Although probability distribution models are proposed to define action and warning levels, as demonstrated in DOE/WIPP 92-007, group warning levels should not be used to assess an accidental release. An individual soil location could exhibit an anomalous baseline value relative to the group reading.

- In addition to dominant windrose directions, other pertinent variables, such as distance from the exhaust shaft and local topography may effect the likelihood of deposition. Air dispersion modeling indicates that wind velocity effects the distance contaminants are transported; low velocity winds may carry contaminants farther, while turbulent winds ma cause rapid deposition or deposition and resuspension. The distances at which Lo Vols stations are placed may not be consistent with critical distances or site locations at whic soil deposition may preferentially occur.

- Local physical properties of soils could effect secondary movement of radionuclides: 1) deposition on sand dunes, sand blow-outs or other surfaces with high percolation rates could result in migration deeper than 10 cm below the surface; 2) deposition on surfaces with relatively low permeability (e.g., caliche caprock) could, in the presence of rainwater, result in resuspension and deposition as sheetflow deposits in swales or other nearby shallow depressions. The random selection procedure may not be as effective as judgmental sampling in such cases (NRC Regulatory Guide 4.5).

The current operational program is not designed for assessing the environmental impact and extent of nonroutine releases. If the DOE/WIPP program commits to upgrading the radiological air sampling program (Lo Vols) for this purpose, a soil monitoring plan could augment or verify the Lo-Vol assessment. Possible components of such a plan might include pre-selection of operational stations on the basis of wind direction, distance, and topography. Sampling procedures should also be based on judgement to account for local site effects. Predictive air dispersion models might enhance the selection of potential operational locations better suited to detection, and may also be useful in pre-planning for real-time response following a suspected release (DOE/EH-0173T, 1991).

5.2 Surface Water Surveillance

Procedures for radiological sampling and handling of surface water environmental samples are contained as sections in the controlled document "Environmental Procedures Manual": RES Surface Water and Sediment Sampling Procedures WP 02-309. As with all radiological environmental monitoring at the WIPP facility, the sampling frequency and analytical requirements are derived from the Operational Environmental Monitoring Plan (OEMP) (DOE/WIPP 88-025) until official approval of the WIPP Environmental Monitoring Plan (DOE/WIPP 94-024).

No specific sampling and analytical guidelines were found in the literature to gauge the surface water and sediment sampling program implemented at the WIPP site. The OEMP program, recommended by Prill and Buckle (1986; DOE/WIPP 88-007), is designed to detect terrestrially deposited fall-out from an atmospheric release, not monitor liquid effluent discharges to streams or lakes. Nevertheless, the sampling program, where comparable, is consistent with liquid effluent and terrestrial sampling schemes described in DOE/EH-0173T (1991) and NRC Regulatory Guide 4.5.

Radiological Baseline Program: The 1988 OEMP (DOE/WIPP 88-025) assigned 10 surface water sampling locations to be sampled on an annual basis until the receipt of waste at the site. In fact, radiological sampling for the baseline was conducted intermittently for three years at a number of different locations (Figure 5.2.1) While eight baseline locations were regularly resampled in December 1985, and April and October 1986, the sewage treatment lagoon and two additional locations were sampled for the first time in 1986, followed by sampling at six selected locations in 1987 and ten locations in 1988. The RBP sampling occurred according to the following schedule:

1985: Upper Pecos River in Artesia (UPP), Brantley Lake/Lake McMillan (LMC), Lake Carlsbad/Pecos River (CBD), Pierce Canyon/Malaga Bend (PCN), Laguna Grande de Sal (LGS), Red Tank (RDT), Tut Tank (TUT), Indian Tank (INT).

1986: Upper Pecos River, Brantley Lake, Lake Carlsbad, Pierce Canyon, Laguna Grande de Sal, Red Tank, Tut Tank, Indian Tank, Freshwater Influent (WIN) and Sewage Lagoon Effluent (WEF).

1986: Upper Pecos River, Brantley Lake, Lake Carlsbad, Pierce Canyon, Laguna Grande de Sal, Red Tank, Tut Tank, Indian Tank, Hill Tank (HLT), Noye Tank (NOT).

1987: Laguna Grande de Sal, Red Tank, Tut Tank, Indian Tank, Hill Tank, Noye Tank.

1988: Upper Pecos River, Brantley Lake, Lake Carlsbad, Pierce Canyon, Laguna Grande de Sal, Red Tank, Tut Tank, Indian Tank, Hill Tank, Noye Tank.

The database for the radiological surface water baseline includes a total of twelve individual locations, including livestock tanks, locations along the Pecos River, and salt lakes in the region. Included in the 1988 OEMP surface water monitoring program description, the freshwater influent (WIF) and effluent (WIN) locations and sampling history merit more detailed discussion in a later section of this report. The remaining sampling locations are characterized as follows:

- Livestock Tanks: At distances ranging from about 5-15 kilometers from the exhaust shaft, livestock tanks represent the closest surface water bodies to the WIPP site. A visual survey indicates that the tanks are man-made earthen catchment basins, some of which are capable of receiving run-off during heavy rains.

- Playa Lakes: The RBP surface water database also includes samples collected from a series of playa lakes at the lower end of Nash Draw, approximately 20 kilometers west of the WIPP site: Laguna Grande de la Sal and Laguna Tres. Both lakes are fed by precipitation, surface drainage, and groundwater discharge from springs and seeps tapping the Rustler formation (Hunter, 1985). Since 1942, both lakes appear to have grown as a result of an influx of potash pond spoils and effluent and oil-well brine discharge in the area (Hunter, 1985).

- Pecos River: Regional locations include the Pecos River at Artesia, Brantley Lake, Lake Carlsbad, and Pierce Canyon at Malaga Bend. The closest sampling site is at Malaga Bend, located about 25 kilometers southwest of the WIPP site.

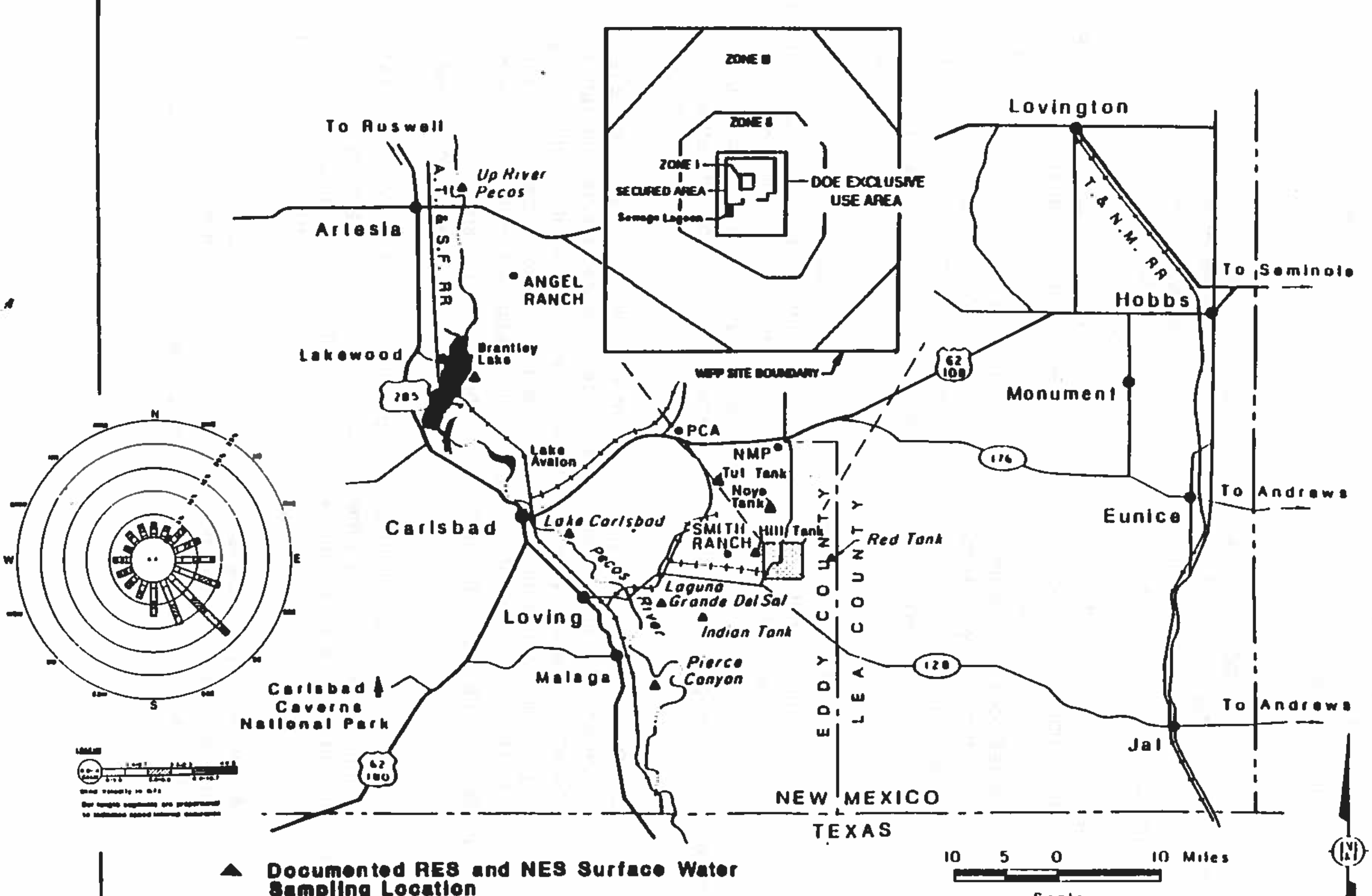


Figure 5.2.1: Surface water sampling locations for radiological baseline. Windrose for 1986 is added for reference.

Although a total of 20 radionuclides are analyzed for the radiological baseline, 18 radionuclides are reported in the statistical baseline summary (DOE/WIPP 92-007; appendix 1.2). To verify the analytical array composing the database, analytical results from DOE/WIPP Annual Site Environmental reports (SER) for CY 1985, 1986, 1987, and 1988 are compiled in table 5.2.1 for comparison. Comments on the baseline program and the statistical summary include:

- This review finds that many radionuclides are measured above detection limits in one or more rounds at the locations compiled in table 5.2.1. In contradiction, the statistical summary reports mean values for these same radionuclides below their respective detection limits. This may indicate quality control deficiencies in the database.

  This type of discrepancy may also be a result of stratifying the data into spatial and temporal groups ie. averaging over the number of rounds for each location, and then categorizing specific analytes from each location into similar geographic groups based on ANOVA and MANOVA. While this method is common and acceptable to the probability model objectives of DOE/WIPP 94-024, this process may have misrepresented site-specific data. DOE/WIPP 94-024 reports that a descriptive statistical analyses of the baseline data would more appropriately characterize the environmental baseline around the WIPP site.

- Although one or more sample rounds are measured above detection limits at several locations, detection of radionuclides is transient with time. With exception of U-234 and U-238, often only a small fraction of the 3 to 5 annual sample rounds conducted at a particular location exhibits reportable concentrations. The paucity of radiological environmental data over time reaffirms the importance of long-term surveillance to establish trends.

- Annual surface water samples are not temporally classified for each location, the rationale being that differences between years are not predictable, and therefore inconsistent with the probability model used in the statistical summary. However, the apparent variation in radionuclide detection and/or concentration from round to round suggests some form of temporal treatment of the data would be useful (DOE/EH-0173T, 1991). Predictable seasonal fluctuations in background may be masked unless a more descriptive statistical analyses is conducted.

- Am-241 and Cm-244 are not included in the statistical database in appendix 1.2, probably because most sites displayed values consistently below detection limits. One sample from drinking water inflow (WIN) apparently exhibited an Am-241 measurement of 2.9 x 10^{-10}µCi/ml (1.1 x 10^{-10}Bq/ml).

- Cs-137 and Np-237 are included in the statistical summary; however, a review of annual site reports indicate that these particular isotopes were never measured above their MDLs at any locations. Several other discrepancies are apparent in annual reports involving

Table 5.2.1: Detected Radionuclides for the Surface Water Radiological Baseline

Radionuclide	Locations where radionuclides detected vs. sample rounds
H-3[1]	None - 4 rounds or 1 round
K-40[1]	TUT*-1/5, HLT-1/3**, PCN-1/4, LGS-5/5
Co-60[1]	None - 5 rounds or 4 rounds
Sr-90	None - 5 rounds
Ra-226	INT-2/5, RDT-1/5, LGS-2/5, PCN-2/4, WIN-1/1
Ra-228	TUT-1/5, UPP-1/4, LMC-1/4, PCN-1/4
Th-228	INT-1/5, LGS-1/5, PCN-1/4, LMC-1/4
Th-230[2]	TUT-1/5, INT-1/4, HLT-1/3, UPP-1/4, CBD-1/4 ? TUT-1/1, INT-1/1, HLT-1/1, UPP-1/1, CBD-1/1 ?
Th-232[1]	None - 5 rounds or 1 round
U-233[1]	LGS-1/5
U-234[1]	INT-1/5, TUT-3/5, RDT-2/5, NOT-1/4, LGS-5/5, UPP-3/4, LMC-4/4, PCN-4/4, CBD-4/4, WIN-1/1, WEF-1/1
U-235[1]	HLT-1/3, LGS-4/5, LMC-4/4, PCN-3/4
U-238[1]	INT-2/5, TUT-3/5, RDT-1/5, NOT-2/3, LGS-5/5, UPP-3/4, LMC-4/4, PCN-4/4, CBD-4/4, WIN-1/1, WEF-1/1
Pu-238[1]	None - 5 rounds or 4 rounds
Pu-239/240[1]	CBD-1/4
Pu-241[1]	TUT-1/5, HLT-1/3, NOT-1/3, LMC-1/4, CBD-1/4
Cs-137[1]	None - 5 rounds or 4 rounds
Np-237[1]	None - 5 rounds or 1 round
Am-241	WIN-1/1 (other locations none: 1 or 2 rounds)
Cm-244	None - (1 or 2 rounds maximum)

* *WIPP acronyms for sample locations: Upper Pecos River in Artesia (UPP), Brantley Lake/Lake McMillan (LMC), Lake Carlsbad/Pecos River (CBD), Pierce Canyon/Malaga Bend (PCN), Laguna Grande de Sal (LGS), Red Tank (RDT), Tut Tank (TUT), Indian Tank (INT), Hill Tank (HLT), Noye Tank (NOT), WIN (freshwater influent), and WEF (sewage treatment effluent).*

** *Ratio of detected rounds to total number of rounds sampled.*

[1] Annual report DOE/WIPP 87-002 or 88-009 show radionuclide not analyzed for certain year(s); however, DOE/WIPP 89-005 suggests analyses were conducted by showing data or "less than detectable (LD)". Maximum rounds shown (detected) or variance in total rounds shown (undetected).

[2] Annual report DOE/WIPP 87-002 does not list Th-230 as being a monitoring parameter 1985-1987, but DOE/WIPP 89-005 lists data and LDs during the same period. Upper line reflects assumption that analyses were conducted; lower line does not.

sample rounds and monitoring parameters, e.g. Th-230 and other radionuclides identified with superscript[1] in table 5.2.1. These discrepancies indicate a potential quality control problem in the environmental database.

The WIPP surface water RBP program has apparently accumulated a minimum of three rounds of sampling from preoperational stations, which meets the 2-year baseline data requirement mandated in DOE Order 5400.1. Uranium and Thorium decay chains, K-40, and selected transuranics, actinides and activation/fission products are also appropriately targeted for the baseline. In general, the range of radionuclides analyzed for the baseline program is adequate, with the exception of the following suggestions:

- Due to the limited ratio of detections to total sample rounds per analyte for many radionuclides, further sampling of Am-241, Cm-244, and Np-237 should be considered. These radionuclides received the least sample rounds per location.

- The database used in the statistical summary should be confirmed for the number of sample rounds involving Th-230 and other radionuclides keyed with superscripts in table 5.2.1.

Due to the lack of any thoroughgoing drainages and natural water bodies in the vicinity of the WIPP site, there are a limited number of potential sampling locations. The sites selected nearest the exhaust shaft include:

- Hill Tank - 4.8 kilometers WNW
- Red Tank - 6.5 kilometers ENE
- Noye Tank - 7.6 kilometers N
- Tut Tank - 11.7 kilometers NW
- Indian Tank - 15.1 kilometers SE

The selection of near-field and far-field sampling locations is appropriate for the objective of the preoperational sampling program. Consideration, however, should be given toward establishing a baseline for other playa lakes that are located nearer the site than Laguna Grande de la Sal or Laguna Tres. It is further noted that, based on preliminary modeling, regional locations along the Pecos River seem unwarranted. The likelihood is low that atmospheric contamination from the WIPP site would ever be detected at many of these regional locations.

RES Operational Program: According to the first OEMP (DOE/WIPP 88-025) and EMP DOE/WIPP 94-024, operational sampling will occur on an annual basis at 10 baseline locations. This apparently includes all RBP sampling sites identified in figure 5.2.1, excluding the sewage lagoon. Situated between 25 kilometers and 69 kilometers from the site, there appears to be little scientific basis for annually sampling far-field locations such as Up River Pecos (UPP), Lake Carlsbad (CBD), and Pierce Canyon at Malaga Bend (PCN). Sampling water bodies closer to the facility seems more appropriate for routine operations.

Recently contracted DOE/WIPP laboratory analytical requirements (1992-1997) specify monitoring of the following radionuclides:

K-40, Co-60, Sr-90, Ra-226, Ra-228, Th-228, Th-230, Th-232, U-233, U-234, U-235, U-238, Pu-238, Pu-239/240, Pu-241, Cs-137, ~~Np-237~~, Am-241, ~~Cm-244~~ and Po-210, Pb-210.

Co-locating nonradiological analyses provides a basis for interpreting radiological data (DOE/EH-0173T, 1991). Although the previous 1988 OEMP (DOE/WIPP 88-025) proposed analyses for TSS and pH, the present EMP DOE/WIPP 94-024 suggests only collection of radiological samples. In addition, gross alpha and beta measurements are no longer proposed as a screening technique for further radioanalyses. Evidently all isotope concentrations will be quantified, regardless of the activity of the sample.

The rationale for the surface water program appears to be similar to soil: to establish long-term trends relative to the baseline during the life of the project. In this respect, the operational sampling program appears well-suited for this objective. Guidance provided in ASTM C-998-90 and NRC Regulatory Guide 4.5 suggests that terrestrial sampling may supplement air sampling to better define the radionuclide distribution from a specific incident. Relevant to surface water sampling, livestock tanks may provide the same opportunity. The unique nature of the catchment basins to collect run-off is well suited for augmenting the soil monitoring program as an indicator of a release. More sample points would provide better control for contouring the extent of contamination.

The following are additional general considerations for the operational program, but also have bearing on the baseline:

- Playa Lakes: Laguna Quatro may contain oil field residual liquids, including naturally occurring radioactive materials (NORM). A radionuclide inventory for this and other nearby playa lakes should be established to preclude WIPP as a source of baseline radiation in the playas. Aerial radiological surveys indicate that Laguna Quatro is a strong gamma radiation source (EG&G, 1989).

- Control: There is no reference to a control station in the program description. The location of each livestock tank "catchment basin" should be assessed to group locations with comparable source water, and then identify a control station within each group having the least potential for receiving fall-out (e.g. rainwater run-off/Red Tank).

The assessment of the operational sampling program (ie., location, frequency) in this section includes general comments on surface water sampling and handling procedures. Comments on selected aspects of "Environmental Procedures Manual": RES Surface Water and Sediment Sampling Procedures WP 02-309" are as follows:

- "avoid areas of algal growth on water surface" - this provision protects against absorption of radionuclides by algae or slime growths, which can become affixed to containers.

- "minimize disturbance of sediment bottom" - this provision ensures detection of only water-soluble radionuclides, a recommendation in DOE/EH-0173T (1991).

- "rinse sampling bottle three times with surface water" - prevents cross-contamination.

- "collect with 1 gallon polyethylene bottles and preserve with nitric acid to pH < 2" - acceptable standard protocol, but important for WIPP project because it ensures correct analysis for Cs-137 (cesium exchanges with potassium in a glass container).

- grab vs. composite sampling - DOE/WIPP procedures describe grab and composite sampling, but do not specify when either method is required. Procedures are also not clear whether samples are composited over time or over an area. Both composite and grab sample rounds are included in the RBP database.

5.3 Sediment Surveillance

The basis for sampling sediment is similar to other terrestrial programs, in that the media is an environmental receptor for an airborne release. The objective is similar as well: to establish a baseline and monitor general trends through the operational phase. As a long-term indicator of past and future accumulation of radionuclides, the subsurface sediment program is well-suited to this objective. The program also facilitates interpretation of data collected in other programs, principally with surface water sampling.

Procedures for radiological sediment sampling are found in the "Environmental Procedures Manual": RES Surface Water and Sediment Sampling Procedures WP 02-309. The radiological baseline and RES surveillance programs are described in WIPP site environmental monitoring plans DOE/WIPP 88-025 (former) and DOE/WIPP 94-024. As with surface water, specific guidance concerning sample locations and sampling frequency is derived from DOE/WIPP 88-007 (Prill and Buckle, 1988). As this document is not available in the WIPP library, DOE/EH-0173T (1991) serves as a main reference in assessing the sediment.sampling program at the WIPP facility.

Radiological Baseline Program: The 1988 OEMP identified five (5) RBP locations to be sampled annually, with the number of sample rounds unspecified. Two years of baseline data are currently referenced as a minimum requirement for many environmental baselines, including sediment data, citing DOE Order 5400.1 (DOE/WIPP 91-008; DOE/WIPP 92-007). Staff review finds that the RBP database consists of six (6) locations representing field years 1985 through 1988. The following sampling history identifies the six locations:

1985: Pierce Canyon/Malaga Bend (PCN), Laguna Grande de la Sal (LGS), Upper Pecos/Artesia (UPP), Indian Tank (INT)

1986: Pierce Canyon/Malaga Bend, Laguna Grande de la Sal, Upper Pecos/Artesia, Indian Tank

1986: Pierce Canyon/Malaga Bend, Laguna Grande de la Sal, Upper Pecos/Artesia, Indian Tank, Hill Tank (HLT)

1987: Indian Tank, Hill Tank, Noye Tank (NOT)

1988: Pierce Canyon/Malaga Bend, Upper Pecos/Artesia (UPP), Indian Tank, Hill Tank

Figure 5.3.1 denotes preoperational sediment locations as solid triangles. The sewage lagoon and Red Tank are distinguished from the baseline group with solid squares. Livestock catchment basins Indian Tank, Hill Tank, and Noye Tank all receive run-off and sediment from sizable depressions surrounding the sites, ranging in area from .30 kilometers^2 to .60 kilometers^2.

Indian Tank is also inset within a larger watershed that drains from the southeast, including the operational and fall-out area from Project Gnome. The distance and azimuth of the livestock tanks from the WIPP exhaust shaft are as follows:

- Indian Tank - 15.1 kilometers SE
- Hill Tank - 4.8 kilometers WNW
- Noye Tank - 7.6 kilometers N

Radiological and nonradiological sampling histories for the subsurface sediment program are compiled in table 5.3.1. As evident from the table, radiological sediment sampling locations (1st column) correspond with certain surface water sampling locations (listed on the left border). Although included in the surface water baseline, Red Tank and Tut Tank are excluded from the RBP for sediment. Several reasons argue for obtaining baseline data from these locations:

- Both Red Tank and Tut Tank require a means for correlating undissolved radionuclides found in sediments with soluble radionuclide concentrations found in surface water. In response to physical disturbance or a change in water chemistry, insoluble hydroxides (e.g $Th(OH)_4$, Np(OH)5 etc.) present in the sediment might be detected in future surface water sampling. Alkalinities in livestock tanks are known to range between pH 7.0 to 8.8, and most have elevated total organic carbon from algal growth.

- Red Tank is a proposed operational station, yet has not been sampled as part of the baseline.

- Tut Tank is located in the path of the prevailing wind direction 11 kilometers northwest of the WIPP site. A baseline from this location would represent a large watershed within Nash Draw several kilometers in area

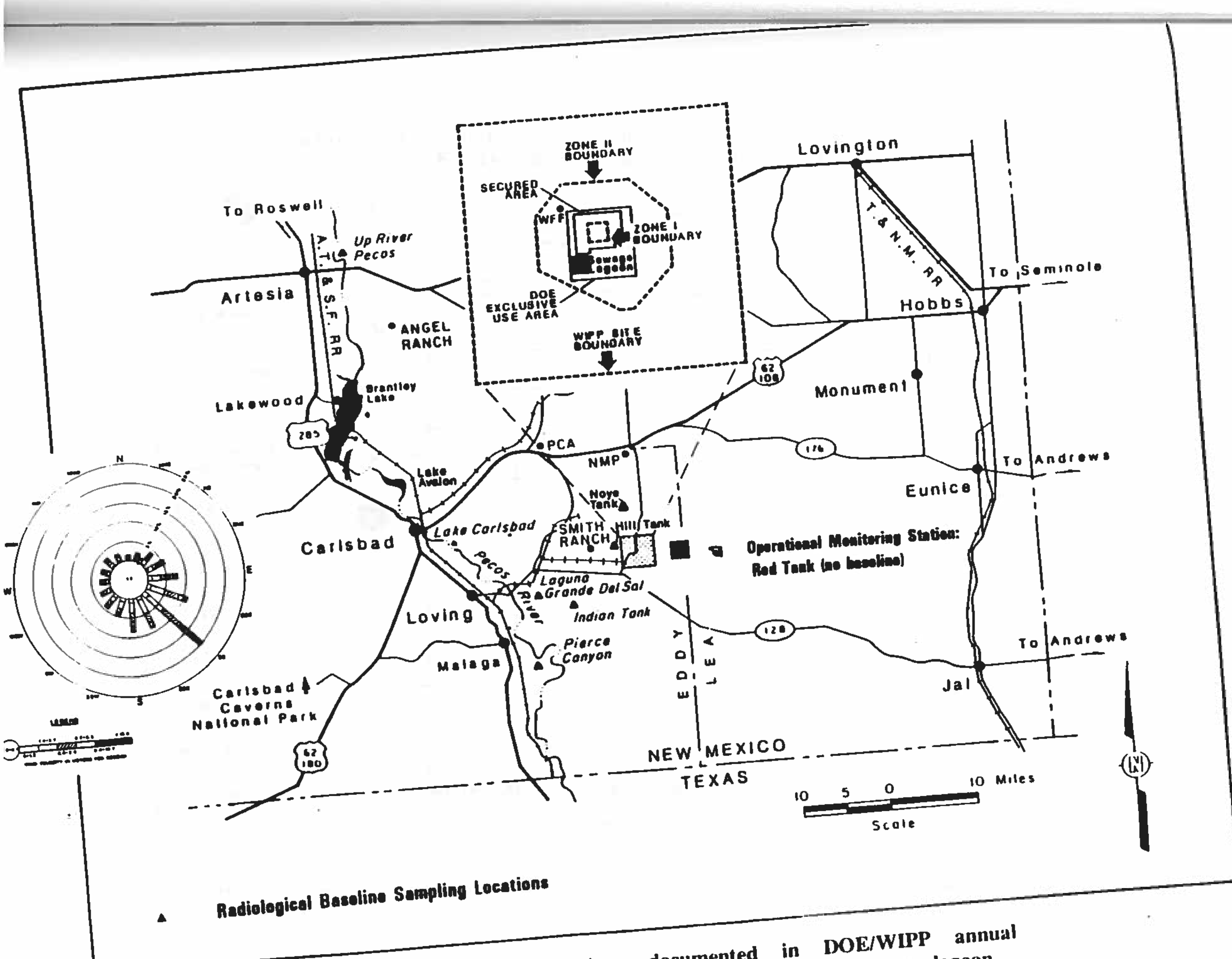


Figure 5.3.1: Sediment sampling locations documented in DOE/WIPP annual environmental reports. No evidence found for sampling sewage lagoon.

Table 5.3.1: Constituents Monitored and Sample Rounds for WIPP Sediment Environmental Baseline 1985-1988

● Radiological (RES) ○ Non-Radiological (NES) (C) Composite (RES constituents only)

(4) ← Maximum # Sample Rounds

	Radiological	General Chemistry	Metals Cations	Nutrients	Phenols/ Phosphate	Cyanides	Mercury	VOC (400 ml glass)	TOC/TOX	TDS/TSS
Upper River Pecos (Artesia)	(C) 4									
Brantley Lake										
Lake Carlsbad										
Pierce Canyon (Malaga Bend)	(C) 4									
Laguna Grande de la Sal	● 3	(3)	(3)		(3)			(2)		
Red Tank		(4)	(4)		(4)			(2)	(3)	
Hill Tank	(C) 3	(4)	(4)		(4)			(2)	(3)	
Tut Tank										
Indian Tank	(C) 5	(4)	(4)		(4)			(2)	(3)	
Noye Tank	(C) 1									
Sewage Lagoon Outfall	No baseline information encountered									

Sources: Unpublished notes obtained from Westinghouse and annual environmental monitoring reports (see references).

Note: Composite sample is mixture of several subsamples used to represent a single site for radiological analyses.

Staff review finds that 14 radionuclides compose the radiological baseline for the subsurface sediment program (DOE/WIPP 87-002; DOE/WIPP 88-009; DOE/WIPP 89-005). With the exception of manmade isotopes in the plutonium series and Cs-137, most radionuclides detected during the baseline program are members of naturally occurring decay chains. The detection of Cs-137 in nearby livestock tanks is significant, in that this isotope is reported as a principle remnant at the Gnome site. The following are additional general comments on the baseline program, some of which are relevant to the operational program:

- In contrast to this review, the statistical baseline summary for the RBP (DOE/WIPP 92-007) reports 17 radionuclides as part of the bottom sediment baseline (appendix 1.3). Staff review of DOE/WIPP annual reports (1985-1992) finds no evidence for analyses of Th-230, Th-232, and Np-237. These radionuclides are included in the statistical summary presented in appendix 1.3.

- Table 5.3.2 emphasizes that several RBP constituents are absent from the baseline sampling record, most notably Cm-244 and Am-241.

- Detection of Pu-241 at Indian Tank is proposed to be a manifestation of laboratory detection sensitivity (DOE/WIPP 87-002). Pu-241 decays to Am-241 within a relatively short period of time (14 year half-life), providing a rationale for establishing an Am-241 baseline at this location.

- With the exception of Noye Tank, table 5.3.1 and table 5.3.2 indicate that most sediment sampling locations possess 3 to 5 sample rounds for each radionuclide. Noye Tank has not met the minimum sample round requirement recommended in DOE Order 5400.1.

- Other playa lakes near the WIPP site, like Laguna Quatro, may prove useful in a sediment baseline program. In particular, sediment in Laguna Quatro may contain a record of naturally occurring radioactive materials (NORM) or manmade isotopes from the Gnome project. In the event bottom sediments are disturbed, insoluble radionuclides may become suspended or transform into a soluble phase detectable in surface waters. This scenario could result in contamination being mistakenly attributed to the WIPP project.

In general, the baseline radiological sampling program for sediment should be expanded to include near-field locations, within 15 kilometers of the site. Due to the inherent tendency for transuranics to be concentrated in the sedimentary environment, the bottom sediment program should inventory the omitted radionuclides identified in table 5.3.2 (DOE/EH-0173T, 1991; Whicker et al., 1990). Lastly, the inconsistency between radiological baseline data presented in DOE/WIPP annual reports and the latest baseline summary in DOE/WIPP 92-007 requires resolution.

__RES Operational Program__: The EMP DOE/WIPP 94-024 describes biennial (2 year) sampling for specific radionuclides at 4 locations (see Table 2.1). Referring to figure 5.3.1, operational sampling would occur at four baseline stations: near-field locations Hill Tank and

Table 5.3.2: Detected Radionuclides for the Sediment Radiological Baseline

Radionuclide	Locations where radioanalytes detected vs. sample rounds
~~H-3~~[1]	Not Analyzed
K-40	PCN*-4/4, LGS-3/3**, UPP-4/4, INT-5/5, HLT-3/3
Co-60	INT-1/5, UPP-1/4
Sr-90	None - 5 rounds
Ra-226	INT-5/5, HLT-2/3, NOT-1/1, LGS-2/3, PCN-3/4, UPP-3/4
Ra-228	INT-5/5, HLT-3/3, PCN-3/4, UPP-2/4, LGS-1/3, NOT-1/1
Th-228	INT-5/5, HLT-3/3, NOT-1/1, PCN-4/4, UPP-4/4, LGS-3/3
~~Th-230~~	Not Analyzed
~~Th-232~~	Not Analyzed
U-233	None - 5 rounds
U-234	INT-5/5, HLT-3/3, NOT-1/1, PCN-4/4, UPP-4/4, LGS-3/3
U-235	INT-3/5, HLT-1/3, PCN-1/4, UPP-2/4, LGS-2/3
U-238	INT-5/5, HLT-3/3, NOT-1/1, PCN-4/4, UPP-4/4, LGS-3/3
Pu-238	None - 4 rounds
Pu-239/240	INT-1/4, PCN-1/2
Pu-241	INT-2/4, PCN-1/3, UPP-1/3,
Cs-137	INT-5/5, HLT-3/3, NOT-1/1
~~Np-237~~	Not Analyzed
~~Am-241~~	Not Analyzed
~~Cm-244~~	Not Analyzed

[1] *Strike-out highlights radionuclides tested for surface water but not sediment.*

* *WIPP acronyms for sample locations: Upper Pecos River in Artesia (UPP), Brantley Lake/Lake McMillan (LMC), Lake Carlsbad/Pecos River (CBD), Pierce Canyon/Malaga Bend (PCN), Laguna Grande de Sal (LGS), Indian Tank (INT), Hill Tank (HLT), Noye Tank (NOT).*

** *Ratio of detected rounds to total number of rounds sampled.*

Indian Tank and regional sites at the Pecos River in Artesia (69 kilometers) and at Pierce Canyon (26 kilometers). The previous OEMP (Mercer et al., 1989: DOE/WIPP 88-025) listed Red Tank and the sewage lagoon as operational stations. The following are comments on the DOE/WIPP operational sampling plan:

- The sewage lagoon is an appropriate station for periodic monitoring for cumulative and instantaneous airborne releases from the WIPP site. A complete RBP baseline should be established for the sewage lagoon. Sampling should be administered by the DOE/WIPP Westinghouse Environmental Monitoring Section to ensure that OEMP data quality objectives are met.

- Deemphasize the frequency of far-field sampling locations along the Pecos River. Emphasize more frequent sampling of near-field locations, including stock tanks Noye Tank and Red Tank, and establish full RBP baselines for these locations before operational sampling.

- The two year sampling frequency for the WIPP facility seems appropriate; however, sampling should occur at the same time each year (DOE/EH-0173T, 1991).

- Proposed requirements through 1997 specify monitoring of the following radionuclides:

  K-40, Co-60, Sr-90, Ra-226, Ra-228, Th-228, Th-230, Th-232, U-233, U-234, U-235, U-238, Pu-238, Pu-239/240, Pu-241, Cs-137, ~~Np-237~~, Am-241, ~~Cm-244~~ and Po-210, Pb-210.

  A baseline should be established for radionuclides Am-241, Cm-244, and Np-237, Th-230 and Th-232. Depending on the outcome of the baseline, it may be appropriate to periodically sample for deleted radionuclides Np-237 and Cm-244 during operational monitoring. Gross alpha and beta activities are no longer measured, only specific radionuclides.

A recurring comment in reference to soil and surface water sampling is that OEMP programs are not designed to assess the impact of a particular release. Sampling closed depressions within and adjacent to the WIPP site boundary provides such as opportunity. Field reconnaissance and air photos reveal several localized topographic lows near the site that may provide a record of sediment accumulation on the land surface (e.g. T22S R30E Sections 12, 13). Obtaining a terrestrial record from such locations would augment the soil sampling program by providing data in areas where intermittent run-off is directed. Current soil sampling locations are not selected on this basis, and near-field bottom sediment locations are limited to stock tanks.

Procedure WP 02-309 describes the use of a dredge or shovel to collect sediment samples from surface water bodies. Only the top 6 inches of sediment are represented in a typical composite sample (Table 5.3.1). This procedure is adequate for stock tanks or other surfac water bodies with a suspected thin veneer of sediment. However, core sampling may be more appropriate when a greater thickness sediment is known or suspected. For example, sediment cores from nearby playa lakes are recommended for a number of reasons:

- Sediment cores provide a record of radionuclide distribution with depth (DOE/EH-0173T, 1991). Sediments located 30 cm or deeper below grade are susceptible to reentrainment during a disturbance of the playa bottom. Sampling following such an event might reveal previously undetected radionuclides as redeposited sediment, suspended sediment or as soluble anions in solution.

- Sediment cores provide a history of the water body, documenting whether or to what extent the surface water body is of artificial or natural origin. This information may be useful in interpreting potential environmental impact.

- Sediment cores provide a measure of the total depth of the lake sediments, and a stratigraphic log for climatic and hydrologic cycles. Unrelated to monitoring, this information supplements WIPP knowledge of the Pleistocene climate in southeastern New Mexico as an indicator for future climatic conditions.

Depending on the soil profile, a core or split-tube sampling technique would also be preferred within certain land surface topographic depressions. Although caliche may prevent a total sample from being obtained, sampling equipment should be capable of obtaining a core as deep as 30 cm below grade where possible. Additional data useful for interpretation of analytical results would include: particle-size distribution, pH, ion-exchange capacity, organic and moisture content (DOE/EH-0173T, 1991; NCRP 50, 1988).

6.0 LIQUID EFFLUENT AND INFLUENT MONITORING

Potable drinking water is supplied to the WIPP site by the Double Eagle Water System, owned and operated by the City of Carlsbad. Under New Mexico Water Supply Regulations, the City of Carlsbad samples to satisfy 40 CFR 141 Community Drinking Water System requirements. The WIPP Liquid Waste Disposal (LWD) System is operated under a New Mexico Environment Department Discharge plan with quarterly sampling requirements for radium 226 and 228. The DOE-driven liquid influent/effluent subprogram supplements this sampling to quantify inadvertent chemical and radiological discharges through the liquid waste disposal (LWD) system, and to verify dose limits prescribed in DOE 5400.5. According to the DOE/WIPP 94-024, liquid influent (public water supply and bottled water supply) and effluent (sewage discharge) are to be sampled and analyzed annually as described in table 2.1. Specific radionuclide sampling and analysis of the influent and effluent liquids occurred in April of 1986 for baseline purposes. Table 6.1 gives data from the 1986 baseline sampling event.

Table 6.1
WIPP LIQUID INFLUENT / EFFLUENT RADIOLOGICAL BASELINE

SOURCE [1] µCi/ml	Ra-226 (E-09)	U-234 (E-10)	U-238 (E-10)	Am-241 (E-11)
WIPP Liquid Influent (WIN)	13 (5.7)	6.0 (2.5)	1.7 (1.3)	29 (23)
WIPP Liquid Effluent (WEF)	LD	4.2 (2.7)	3.4 (2.3)	not analyzed

[1] Data presentation format: Numbers are to the exponent at the top of the column; number in parenthesis is two standard deviations.

6.1 Liquid Influent Surveillance

There are two primary sources of liquid influent to the WIPP Site; the potable drinking water from the Double Eagle Water Supply system and bottled drinking water supplied by the Water Works of Carlsbad. Both sources originate from production wells owned by the City of Carlsbad and transported by the Double Eagle Water System. Radiological compliance sampling for gross alpha, gross beta, radium 226, and radium 228, required by the NMED Water Supply Regulations is the responsibility of the City of Carlsbad Double Eagle Water Supply. Routine annual operational sampling and analysis, as driven by DOE Order for analytical parameters in table 2.1, have not begun.

6.2 Liquid Effluent Surveillance

Facility liquid effluent, other than storm water run-off, consists of domestic sewage. The EMP states that there is no direct pathway for radioactive or hazardous contaminants associated with handling "TRU-waste" to enter the WIPP sewage system. Two indirect sources include a sump in the waste handling building and smaller liquid waste sumps located in WIPP analytical laboratories. DOE/WIPP 94-024 states that liquids collected in the sump from leaking mixed waste or fire sprinkler water would be sampled, and if radioactive, would be managed as derived mixed waste. Likewise a small liquid waste sump located in the WIPP analytical laboratory collects waste liquids resulting from decontamination of laboratory equipment. Sampling is to be conducted to verify a Derived Concentration Guide limit below 3E-8 μCi/ml for plutonium-239 (DOE Order 5400.5, section iii) before placement in the sewage lagoon. If above the limit, the water will be immobilized and emplaced in the repository. As with the influent liquid, routine DOE-driven annual sampling has not been initiated. Quarterly sampling for radium 226 and 228, as required by a New Mexico Environment Department Discharge plan, has begun.

7.0 BIOLOGICAL RADIOLOGICAL SURVEILLANCE

This surveillance program serves to detect possible food chain impact resulting from operations of the WIPP facility, by inhabitants of the WIPP area biome. Vegetation, beef, and game mammals, fish, and birds (Mule deer, Lagomorphs, Fish, and Scaled quail) are sampled. DOE/EP-0023 (Corley et al., 1981) recommends annual biotic radiological sampling. Sample results of prior years sampling are presented in DOE/WIPP 92-037, March 1992, "Statistical Summary of the Radiological Baseline Program for the Waste Isolation Pilot Plant" (SSRBP), under the Plan annual sampling sites and analytical array shown in table 2.1. A significant release event may be cause to sample the tissues of the biotic community more frequently if warranted. Sampling and analysis protocols are specified in the Environmental Procedures Manual (WP-02-03).

7.1 Vegetation

Figure 7.1 shows the various vegetation sampling stations for radioanalysis as described in the OEMP. Sufficient material will be collected, composited, desiccated, and transmitted to the contracting laboratory where the sample will be analyzed for the specific radionuclides indicated in table 2.1.

7.2 Beef

Annual sampling of muscle tissue from beef grown on vegetation down wind from WIPP is suggested by Corely. When waste handling begins, WIPP will obtain annual samples from beef grown northwest of WIPP and a control sample from one grazed locally but not exposed to the area of release. The SSRBP contains baseline data from to samples of both tissue and bone. Table 2.1 indicates the analytical array. Replicate samples will be provided to NMED for analysis.

7.3 Game Animals

Muscle tissue from Quail, Lagomorphs (rabbits), and Mule deer are collected annually during hunting seasons, ideally from locations northwest and within five miles of WIPP. Samples are also collected from road killed animals with permission from the New Mexico Department of Game and Fish. Control samples are taken 12.4 miles southeast of the WIPP at the control air sampling station. Muscle tissue samples from individual specimens representing each type of animal are collected, composited, desiccated, and transmitted to the contracting laboratory where it is analyzed as shown in table 2.1.

7.4 Aquatic Foodstuffs

Aquatic foodstuff samples, specifically, muscle tissue of bottom feeding catfish, will be sampled annually at a location near Carlsbad and a control location near Artesia (50 miles

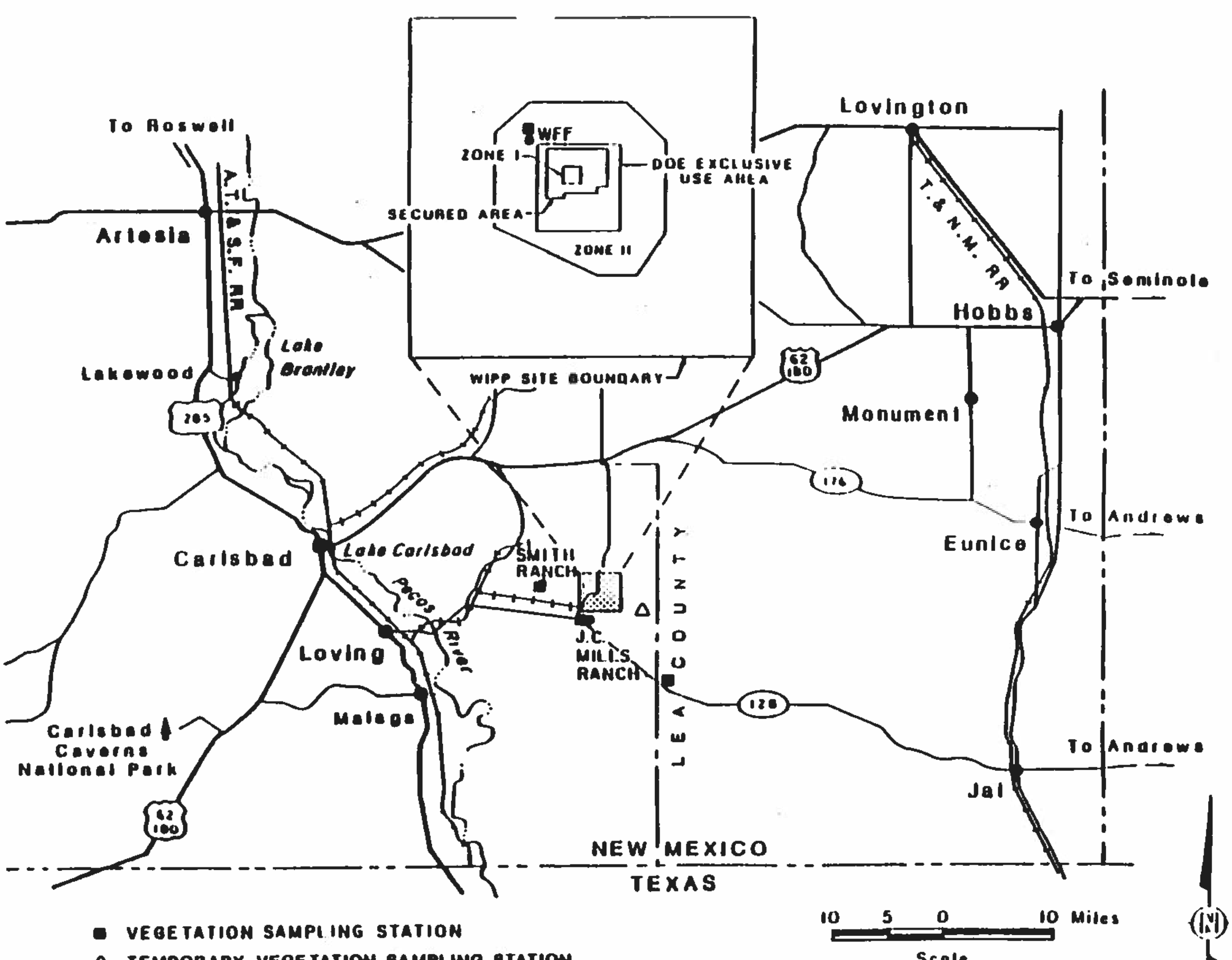


Figure 7.1: RBP Sampling Locations for Vegetation

north). Sample collection is accomplished with trotlines and traps and on occasion specimens are provided by the New Mexico Department of Game and Fish. The analysis will be according to table 2.1.

8.0 GROUNDWATER RADIOLOGICAL SURVEILLANCE

By design, geologic isolation should limit groundwater contaminant migration from the WIPP repository. Nevertheless, potential groundwater migration pathways are being studied. Undisturbed post-closure scenarios involve migration pathways through fractured anhydrite layers or clay partings near the mined opening, or upward through plugged shafts. Another post-closure scenario involves direct discharge of contaminants into overlying water-bearing units, in the event the repository is breached by drilling (SAND92-0070). Although this section foreshadows long-term detection, it primarily focuses on evaluating radiological monitoring conducted between 1985 and 1991. The configuration of the DOE/WIPP groundwater program during this period emphasizes groundwater characterization to establish long-term trends, not to monitor a release. A more comprehensive study of the regional hydrogeology and long-term groundwater monitoring program is in progress (Agreement-in-Principle (AIP) Deliverable X.A.B.1).

8.1 Programs and Procedures

No state or federal regulation has mandated or currently guides sampling schedules, sample locations or analytical arrays for groundwater radiological sampling. The sole higher-tier document directing radiological sampling, DOE Order 5400.1, requires groundwater sampling to determine and document the "effects of DOE operations on groundwater quality and quantity". The following objectives and guidelines are also applicable to this assessment:

- "collect representative and reproducible groundwater samples from water-bearing zones in the area of the WIPP site" (DOE/WIPP 92-007). This is a stated objective of the DOE/WIPP sampling program.
- "obtain data for the purpose of determining baseline conditions" (DOE/EH-0173T; Mercer et al., 1989). Baseline data will be discussed in a section on constituents sampled.
- "demonstrate compliance with and implementation of all applicable regulations and orders" (DOE/EH-0173T).

Three DOE/WIPP programs implement environmental surveillance of ground water: Water Quality Sampling Program (WQSP), Water-Level Monitoring Plan (WLMP), and Pressure Density Monitoring Plan (PDMP) (DOE/WIPP 90-008; WP 02-1/Rev 2). They are described as follows:

> The Water Quality Sampling Plan (WQSP) is a part of the "Ground Water Monitoring Program Plan and Procedures Manual" (WP 02-1/Rev 2). Annual sampling for the Radiological Baseline Program occurred under the WQSP. The WQSP currently supports ongoing annual sampling for radiological and nonradiological groundwater constituents. Periodic hydrogeochemical studies to investigate flow regimes and relationships between groundwater chemistry and radionuclide solubility are also

supported by the program.

The Water-Level Monitoring Plan (WLMP) also occurs in WP 02-1/Rev 2. Measurements are taken monthly and quarterly at 65 operational well sites. The objective of the WLMP is to characterize ground water flow directions in the Forty-Niner and Culebra and Magenta Dolomite Members of the Rustler Formation, the Dewey Lake and Bell Canyon Formations, and along the Rustler/Salado contact.

The Pressure Density Monitoring Plan (PDMP), the third element of WP 02-1/Rev 2, monitors formation pressures and densities. To accurately characterize hydraulic gradients of hydraulic flow systems in the vicinity of WIPP, potentiometric surfaces must be corrected for variations in fluid density that occur both vertically in the water bearing zone and aerially from well to well. Calculation of this "fresh water" head is necessary in the highly density-variable saline waters contained in the formations being monitored. These measurements were conducted between 1986 and 1988.

The Radiological Baseline Program (RBP) was superseded by the radiological environmental surveillance (RES) program in 1989. The following summaries describe the programs as originally proposed.

Radiological Baseline Program: The RBP plan presented in the original OEMP proposed two rounds of sampling at 23 wells. The 23 wells are identified in DOE/WIPP 85-002 as follows:

H-2a, H-3a, H-3b3, H-4a, H-4b, H-5b, H-6a, H-6b, H-7b, H-8b, H-9b, H-11b3, H-12, P-14, P-17, DOE-1, DOE-2, WIPP-25, WIPP-26, WIPP-29, Engle Well, Ranch Well and Twin Well

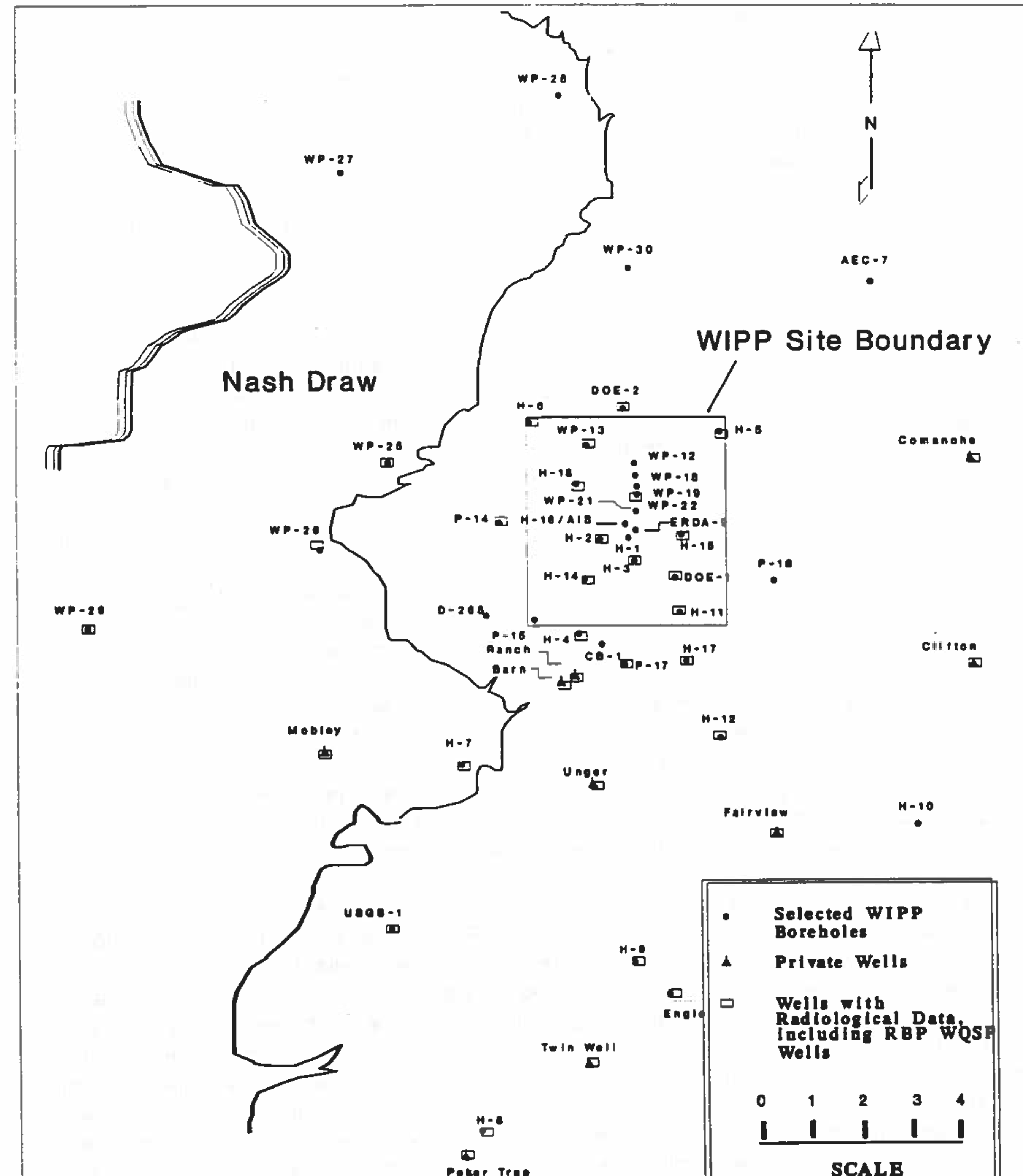
The radionuclide suite is identical to that defined for all OEMP analyses (See Section 1.1).

RES Operational Program: The RES plan presented in the first OEMP proposed annual sampling at 14 well locations. The 14 wells are identified in Mercer et al., 1989 as follows:

H-2, H-3, H-4, H-5, H-6, H-11, H-15, H-18, WIPP-19, DOE-1, DOE-2, Barn Well, Ranch Well, Mobley Well, Twin Well

No well subsets are identified (ie. H-2a etc.). The radionuclide suite is identical to that defined for all OEMP analyses (See Section 1.1).

Figure 8.1.1 shows all wells that have been or continue to be utilized for groundwater



Note: Radiological Baseline Program (RBP)

Figure 8.1.1: RBP Water Quality Sampling Plan (WQSP) Wells and Water-Level Monitoring Plan Well Sites

surveillance. The borehole locations sampled for radiological parameters are outlined with a square. Between 1985 and 1988, 28 DOE/WIPP wells and 10 private wells were sampled for radiological parameters. Of these 38 wells, 27 appear to meet the baseline criteria of two full sample rounds. Between 1989 and 1991, 20 wells were sampled as post-baseline wells. As of 1991, these post-baseline samples were collected but not analyzed. The following sections focus on an assessment of program based on the wells utilized in the RBP and the strategic location of the wells. Based on a review of analytical parameters sampled per round at each location, the completeness of the baseline is also discussed.

8.2 Sample Locations

Table 8.2.1 highlights the subset of 94 WIPP test holes that have been modified to support ground water surveillance at the WIPP facility (SAND89-7147). The underlined wells denote WQSP wells and wells used in the water level program. Not counting private windmills, which are also underlined, these test holes were originally designed and used for a variety of purposes: WIPP site characterization, hydrologic testing (H-wells), and potash (P-wells) and oil resource evaluation (Cabin Baby). Wells modified to monitor two zones at a single location are indicated in table 8.2.1. The well-casings are typically constructed of standard oil-field steel, which is easily corroded by the highly saline waters in the area. With the exception of H-2a, the casing is either shot-perforated or completed as an open hole in the sampling zone.

Hydrogeologic Units. The various water-bearing units in which WIPP observation wells are completed are illustrated in figure 8.2.1. Most WIPP test wells in the program are completed in the Rustler Formation, which contains the only regionally continuous aquifer in the WIPP site area. Used for livestock watering in the region, Sandia and EEG studies have concurred that the Culebra Member of the Rustler Formation is the most likely pathway for contaminant migration under a number of different release scenarios. Of the 28 wells sampled for radiological parameters, 25 produce water from the Culebra Dolomite. Five other wells are completed in another water-bearing unit within the Rustler, the Magenta Dolomite. WIPP-25 is completed in both the Culebra and Magenta. The members are located roughly 427 meters (1400 feet) and 439 meters (1440 feet) above the repository level, respectively.

No wells within the WIPP site boundary completed in the Dewey Lake Formation have been sampled for radiological constituents. Radiological data from the Dewey Lake exist for only private wells located off-site. Dewey Lake wells are primarily used for livestock watering, but some wells also produce drinking water of potable quality. Some wells produce enough water to supply tremendous amounts for oil field operations in the area. The formation is routinely described in DOE/WIPP documents as containing only "localized" zones of perched groundwater (Mercer, 1983). It is not known with certainty, the extent to which the zone extends within the southern portion of the WIPP site (Sanchez and McCasland, 1994; Beauheim, 1987). The Dewey Lake water-bearing zone occurs at roughly 73 meters (238 feet) below the surface along the southern boundary of the site.

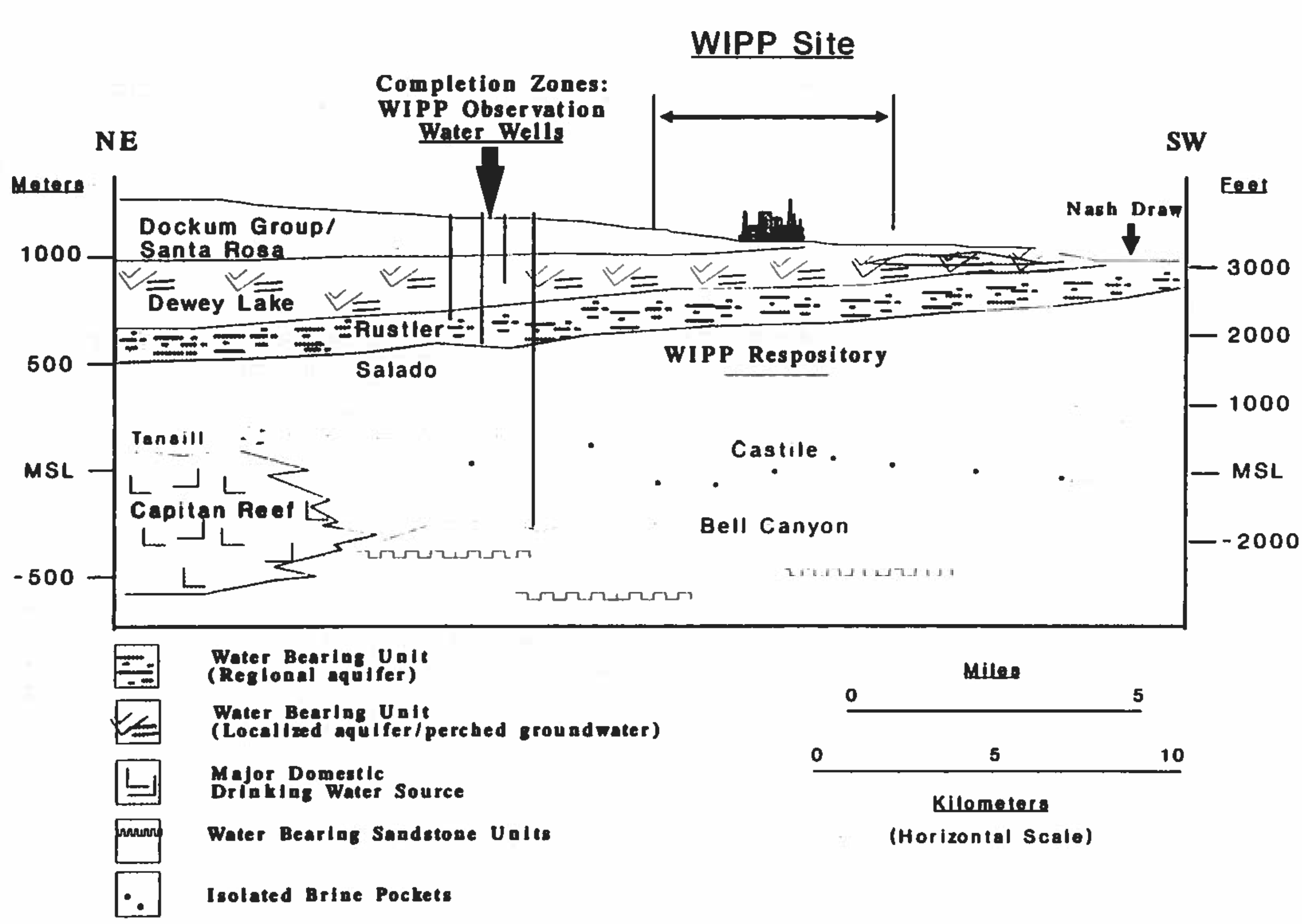


Figure 8.2.1: Schematic geologic cross-section illustrating key hydrogeologic units. (Modified after Kenney, 1991)

Table 8.2.1

Documented WIPP Test Holes: Some Modified for Ground Water Surveillance

Well	Zone	Well	Zone
H-1	(M,C)	P-1	
H-2a	(C)	P-2	
H-2b1	(M)	P-3	
H-2b2	(C)	P-4	
H-2c	(C)	P-5	
H-3b1	(M)	P-6	
H-3b2	(C)	P-7	
H-3b3	(C)	P-8	
H-3d1	(DL,FN)	P-9	
H-4a	(M)	P-10	
H-4b	(C)	P-11	
H-4c	(M)	P-12	
H-5a	(M,C)	P-13	
H-5b	(C)	P-14	(C)
H-5c	(M)	P-15	(C)
H-6a	(M)	P-16	
H-6b	(C)	P-17	(C)
H-6c	(M)	P-18	(C)
H-7a	(M)	P-19	
H-7b1	(C)	P-20	
H-7b2	(C)	P-21	
H-7c	(R/S)	WIPP-11	
H-8a	(M,C)	WIPP-12	(C)
H-8b	(C)	WIPP-13	(C)
H-8c	(R/S)	WIPP-14	
H-9a	(C)	WIPP-15	
H-9b	(C)	WIPP-16	
H-9c	(C)	WIPP-18	(C)
H-10a	(M)	WIPP-19	(C)
H-10b	(C)	WIPP-21	(C)
H-10c	(R/S)	WIPP-22	(C)
H-11b1	(C)	WIPP-25	(M,C)
H-11b2	(C)	WIPP-26	(C)
H-11b3	(C)	WIPP-27	(M,C)
H-11b4		WIPP-28	(R/S)
H-12	(C)	WIPP-29	(C)
H-14	(C)	WIPP-30	(M,C)
H-15	(C)	WIPP-31	
H-16	(DL,M)	WIPP-32	
H-17	(C)	WIPP-33	
H-18	(C)	WIPP-34	
		WIPP-35	

Well	Zone
DOE-1	(C)
DOE-2	(C)
DOE-2BC	(BC)
D-268	(C)
ERDA-6	
ERDA-9	(C)
ERDA-10	
AEC-7	(C)
AEC-8	(BC)
Cabin Baby	(C)
Engle Well	(C)

Private Wells

Well	Zone
Barn Well	(DL)
Ranch Well	(DL)
Twin Well	(DL)
USGS-1	(DL/C?)
Fairview	(DL)
Unger Well	(DL)
Mobley Well	(DL)
Clifton Well	(SR)
Comanche Well	(SR)
Poker Trap	(C/DL?)

Explanation

H - Hydrologic Test Hole
P - Potash Test Hole
H-12 Underline indicates wells used in water leveling and sampling programs (past and present), including private wells.

SR - Santa Rosa/Dockum Group
DL - Dewey Lake Formation
FN - Forty-Niner Member (Rustler Fm)
M - Magenta Member (Rustler Fm)
C - Culebra Member (Rustler Fm)
R/S - Rustler Salado Contact
BC - Bell Canyon Formation

Groundwater Flow. Figure 8.2.2 highlights wells sampled between 1985 and 1991 for selected radionuclides, tritium or gross alpha and gross beta. The general direction of ground water flow in the Magenta and Culebra Members and the formation of completion for each borehole are indicated. Note that the Magenta Member/aquifer flow direction is represented by an arrow outline, while the Culebra flow arrows are solid.

Eighteen Culebra wells sampled for radiological analytes are located south of the latitude of the proposed repository. Three wells within the WIPP site boundary lie immediately downgradient along a potential flow path from the proposed underground waste panels: H3b3, DOE-1, and H-11b3. H-3 is located approximately 110 meters (360 feet) south of the southern extent of the proposed waste panel complex. All three wells lie in a high transmissivity field indicative of abundant open fractures ($T > 10^{-6} m^2/s$) (Jones et al., 1992). Four additional wells just outside and south of the WIPP boundary are also completed along the general groundwater flow pathway: H-4, H-17, P-17 and H-12. Five more Culebra wells are located farther south a considerable distance from the site.

Radiological data exists for four wells completed in the Magenta Formation. The wells are situated northwest and south of the repository, and none appear well positioned to monitor a potential release from the repository. Given the regional direction of Magenta flow, the best location for a Magenta well would be immediately west of the repository. Located some 4270 meters (14,000 feet) from the repository, well H-6b is closest in the northwest direction. H-3b1 is located near the southern boundary of the waste panels.

Five private wells known to be completed in the Dewey Lake Formation have been sampled for the radiological baseline. The two closest wells are situated roughly 1.6 kilometers (1.0 mile) south of the WIPP site: Ranch Well and Barn Well. Groundwater occurs at these locations 30 meters (94 feet) and 65 meters (212 feet) below the surface, respectively. Within 300 meters (1000 feet) of the surface projection of the waste panels, Dewey Lake ground water stands at 90 meters (300 feet) below the surface at Well H-3d. No hydraulic test or well configuration data are documented for H-3d.

8.3 Radiological Sampling

Tables 8.3.1 outlines the general types of analyses conducted on groundwater samples collected for the WQSP. General chemistry, gas content and oxidation/reduction (redox) samples provide needed data on the solubility and transport of radionuclides in water-bearing zones. The general chemistry and metals groups are used to identify mixing between aquifers (ie. Salado vs Rustler), as a check against the accuracy of field lab measurements taken during well drawdown, and as an environmental baseline. As evident from table 8.3.1, the cumulative list of radionuclides actually sampled between 1985 and 1988 are more numerous than the original arrays proposed for the Radiological Baseline Program (RBP) and the 1988 OEMP. The only radionuclide proposed but not sampled for was Be-7, probably because a cosmogenic origin and short half-life (53 days) reduce the likelihood of encountering this radionuclide in groundwater.

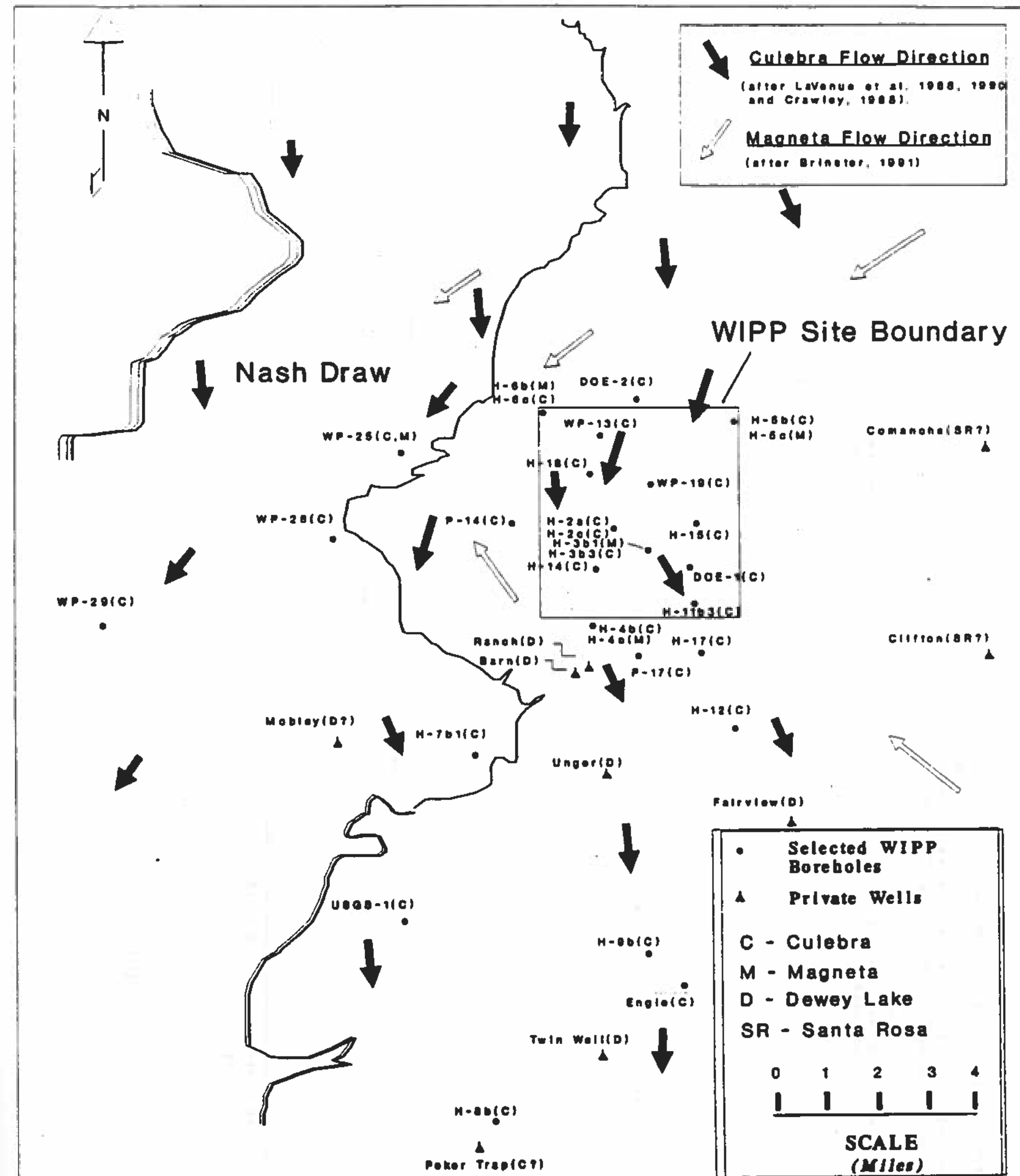


Figure 8.2.2: Correlation of Sample Locations, Formation, and General Groundwater Flow Direction

Note: Sample locations include all wells with radiological data, including RBP WQSP wells.

Table 8.3.1: List of Constituents Sampled for Groundwater Programs

General Chemistry	Metals	Gases [c]	Redox Couples [c]	Radionuclides	Organics
Alkalinity	Aluminum	Argon	Ammonia	Am-243 (RBP) [b]	Volatiles
Bromide	Antimony	Oxygen	Nitrate	Pu-242 (RBP)	Semi-Volatiles
Chloride	Arsenic	Nitrogen	Total Iron	Am-241 (RBP/OEMP)	PCB's
Cyanide	Barium	Carbon Dioxide	Ferrous Iron	Pu-241 (RBP/OEMP)	Pest/Herbicides
Flouride	Beryliulm	Carbon Monoxide	Arsenic (III)	Pu-239/240 (RBP/OEMP)	
Iodide	Boron	Methane	Arsenic (Total)	Pu-238 (RBP/OEMP)	
Nitrate	Cadmium	Ethane	Iodide	U-238 (RBP/OEMP)	
pH	Calcium	C-3	Iodate	U-235 (OEMP)	
Phenolics	Cesium	C-4	Selenium (IV)	U-234	
Phosphate, Total	Chromium	C-5	Selenium (Total)	U-233 (RBP/OEMP)	
Residue, Filterable	Cobalt	C-6		Th-232 (RBP/OEMP)	
Residue, Nonfilterable	Copper	Sum of CO2		Th-230	
Specific Conductance	Iron	Total Gas		Th-228	
Sulfate	Lead			Ra-228	
Total Organic Carbon	Lithium			Ra-226 (RBP/OEMP)	
Total Organic Halogen	Magnesium			Np-237 (RBP)	
	Manganese			Cm-244 (RBP)	
	Mercury			Pb-210	
	Molybdenum			Cs-137 (RBP/OEMP)	
	Nickel			CO-60 (RBP)	
	Potassium			Po-210	
	Selenium			Tritium (1988 Only)	
	Silica			K-40 (RBP/OEMP: 1988 Only)	
	Silver			Sr-90/Yt-90 (RBP/OEMP: 1988 Only)	
	Sodium			Be-7 (RBP, no recorded samples)	
	Strontium				
	Thallium				
	Tin				
	Titanium				
	Zinc				

Note: Compare with EEG Ground Water Analytical Suite:
Am-241, Pu-239/240, Pu-238, U-238, U-235, Th-232, Th-230, Th-228, Ra-228, Ra-226, Cs-137, Tritium, Sr-90, Gross A/B.

(a) Includes constituents monitored for Radiological Environmental Surveillance (RES) and Nonradiological Environmental Surveillance (NES).

(b) RBP - Radiological Baseline Program begun in 1985 for preoperational radiological environmental data and component of RES. OEMP - Operational Environmental Monitoring Plan to change scope of RES program once facility is operational.

(c) Gases and Redox Couples mainly for performance assessment purposes.

altogether from WP 02-309 (Surface Water and Sediment). A review of procedures also indicates that WP 02-306 "RES Equipment Maintenance and Control" is not referenced in Lo-Vol airborne particulate sampling procedure WP 02-312. In general, media-specific sample management requirements should be summarized and/or reinforced in the particular sample collection procedure, instead of depending on cross-references.

Routine Surveillance. Based on field audits during field years 1991 and 1992, NMED/WIPP staff observed no problems involved in the collection, preservation and field management of environmental surveillance samples. Groundwater samples were collected, filtered, and preserved with HNO_3 inside a mobile laboratory. For water samples, the DOE/WIPP contractor laboratory provided insulated shipping chests and sample containers with pre-measured preservative. No special preservation techniques were used for nonwater samples. In general, groundwater, soil, air (Lo-Vols) and biotic radiological sampling was conducted in accordance with procedures reviewed for this assessment. NMED/WIPP staff have also observed Westinghouse quality assurance audits for RES soil sampling and Lo-Vol filter collection events.

Off-Normal Occurrence. Environmental surveillance programs are a component of a DOE/WIPP strategy to verify off-site dose assessments in the event of a radiological release (DOE/WIPP 92-040). Real-time off-site dose estimates are initially based on Continuous Air Monitor (CAM) data, with subsequent verification from Fixed Air Sampler (FAS) data collected at effluent monitoring stations A and B. In a supportive role, Lo-Vol air filters and terrestrial sampling (soil an biota) would be employed to verify CAM and FAS data (DOE/WIPP WP 12-924). Upon an alarm at Station A, procedure WP 12-924 "Emergency Response to Off-site Releases of Airborne Radioactivity" outlines the following plan:

- Lo-Vol air filters and smear samples for alpha and beta radiation would be collected at Lo-Vol stations indicated by meteorological data;
- If radioactivity is detected above background, field teams would notify the EOC and assess the extent and quantity of contamination deposited off-site on the soil, vegetation, and road surfaces using alpha probe HP-260 and beta/gamma probe AC-3-8;
- An on-site counting lab would conduct alpha spectrum analysis of filter and smear samples and convert CPM to µCi/ml to obtain air concentrations for dose assessment verification;
- Within 24 hours, field teams would return to Lo-Vol stations and collect Lo-Vol filters replaced during the initial response, and obtain soil and vegetation samples using SOPs from the radiological surveillance program.

Radiation Safety personnel are to conduct initial surveys and sample collection, succeeded by follow-up sampling by the WID Environmental Monitoring Section, a team normally task

9.0 SAMPLING AND LABORATORY PROCEDURES

To maintain random and systematic errors within tolerable limits, quality control must be maintained through standard operating procedures (SOPs) at all stages of the sample management process. This section assesses the more general aspects of sampling SOPs previously covered in media-specific radiological monitoring programs. Also discussed are DOE/WIPP contractor laboratory standards for processing and analyzing radiological environmental samples.

9.1 Sampling Procedures and Methods

Environmental plans published in DOE/WIPP 88-025 and DOE/WIPP 94-024 describe the rationale and data quality objectives for the baseline and operational sampling programs. Environmental sampling and sample management procedures are contained in DOE/WIPP operating procedure manuals. Field and site environmental personnel utilize DOE/WIPP SOPs located in the following controlled documents:

- Environmental Procedures Manual (WP 02-3)
- Groundwater Monitoring Procedures Manual (WP 02-1)
- Radiation Safety Manual (WP 12-5)

Fundamentally, all procedures reviewed by staff appear consistent with guidelines provided in DOE/EH-0173T "Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance". Flow charts and checklists, describing basic tasks of sample acquisition and recordkeeping, are standard. Where applicable, procedures also provide guidance to prevent sample cross-contamination and to facilitate conformance with sample preservation and holding time requirements. Procedures are maintained up-to-date with a DOE Document Control System.

Groundwater procedures are by far the most comprehensive; WP 02-1 contains a specific list of quality control samples (blanks/duplicates) and an internal quality assurance plan, including provisions for routine audits by an external Westinghouse section. All phases of the sample management process are addressed, including tracking, shipping and quality assurance records. In contrast, sample collection procedures for other media rely on cross-references to related documents:

- WP 02-302 NES/RES Quality Assurance/Quality Control Implementation
- WP 02-303 RES Scheduling, Documentation, and Field Preparation
- WP 02-304 NES/RES Sample Tracking Procedure

Guidance for collecting quality control samples is lacking in most radiological sampling procedures. Quality assurance, quality control, and records management topics are absent

8.5 Operational RES Program

Currently, radiological sampling occurs at eight WIPP wells located within or immediately adjacent to the WIPP site boundary: H-2c, H-3b3, H-4b, H-5b, H-6b, H-11b3, H-14, and WIPP-19. Samples continue to be collected but not analyzed, a practice conducted since the establishment of the baseline in 1988. A current DOE/WIPP groundwater laboratory analytical contract suggests operational sampling and analyses will begin annually during FY 1994 as described in the Environmental Monitoring Plan (DOE/WIPP 94-024). The contract specifies the following radionuclides:

K-40, Co-60, Sr-90, Ra-226, Ra-228, Th-228, Th-230, Th-232, U-233, U-234, U-235, U-238, Pu-238, Pu-239/240, Pu-241, Cs-137, ~~Np-237~~, Am-241, ~~Cm-244~~ and Po-210, Pb-210.

Semi-annual gamma spectra and gross alpha or beta analyses are not specified in the current operational contract. Not included in the operational analytical array are Cm-244 and Np-237, which are minor transuranic radionuclides present in the WIPP waste. Major radiological constituents of WIPP waste, plutonium and americium, are monitored.

WIPP wells targeted for operational sampling are all completed in the Culebra Member of the Rustler Formation. Barn Well and Ranch Well, both completed in the Dewey Lake Formation, will also continue to be sampled but they are not part of the surveillance program. The radiological array planned for these off-site Dewey Lake wells is not documented. No wells completed in the Magenta Member of the Rustler are included in the operational plan, and no monitoring is planned within the site boundary for Dewey Lake groundwater.

Table 8.3.2: Groundwater Wells Sampled for Radiological Analyses 1985-1991

Sampled Wells	Sample Rounds	1985	1986	1987	1988	1989	1990	1991
1) H-2a	2[1]		■	■ ■		□		
2) H-2b1	0					□		
3) H-2c	0					□	□	□
4) H-3b1	3	■[2]	■	■		□	□	□
5) H-3b3	3	■	■	■		□	□	□
6) H-4b	3	■	■	■		□	□	□
7) H-4c	2			■	■	□	□	□
8) H-5b	3	■	■		■	□	□	□
9)H-5c	1				■ ■	□	□	□
10)H-6b	3	■	■	■		□	□	□
11)H-6c	3		■	■	■	□	□	□
12)H-7b1	3		■	■	■	□	□	
13)H-8b	2			■	■			
14)H-9b	3	■		■	■		□	
15) H-11b3	3	■	■	■		□	□	
16) H-12	1			■				
17) H-14	2			■	■	□	□	□
18) H-15	2			■	■			
19) H-17	1			■				
20) H-18	2			■	■			

1 Duplicate samples counted as a single sample round; see text for further explanation of details of sample rounds analyzed for RBP.

2 Filled in square indicates radiological analyses verified. Hollow square indicates radiological sample was never analyzed. Two boxes indicate duplicate samples.

Note: Shaded box indicates well is within 16 section WIPP site area. Sources include DOE/WIPP 86-002, 87-002, 88-009, 89-005, 90-003, 91-008, & SAND89-7068/2.

Table 8.3.2: Groundwater Wells Sampled for Radiological Analyses 1985-1991

Sampled Wells	Sample Rounds	1985	1986	1987	1988	1989	1990	1991
1) H-2a	2[1]		■	■ ■		□		
2) H-2b1	0					□		
3) H-2c	0					□	□	□
4) H-3b1	3	■ [2]	■	■		□	□	□
5) H-3b3	3	■	■	■		□	□	□
6) H-4b	3	■	■	■		□	□	□
7) H-4c	2			■	■	□	□	□
8) H-5b	3	■	■		■	□	□	□
9)H-5c	1				■ ■	□	□	□
10)H-6b	3	■	■	■		□	□	□
11)H-6c	3		■	■	■	□	□	□
12)H-7b1	3		■	■	■	□	□	
13)H-8b	2			■	■			
14)H-9b	3	■		■	■		□	
15) H-11b3	3	■	■	■		□	□	
16) H-12	1			■				
17) H-14	2			■	■	□	□	□
18) H-15	2			■	■			
19) H-17	1			■				
20) H-18	2			■	■			

1 Duplicate samples counted as a single sample round; see test for further explanation of details of sample rounds analyzed for RBP.

2 Filled in square indicates radiological analyses verified. Hollow square indicates radiological sample was never analyzed. Two boxes indicate duplicate samples.

Note: Shaded box indicates well is within 16 section WIPP site area. Sources include DOE/WIPP 86-002, 87-002, 88-009, 89-005, 90-003, 91-008, & SAND89-7068/2.

Well Sampling History. Table 8.3.2 is a compilation of groundwater wells having documented radiological analyses published in DOE/WIPP annual Site Environmental reports. As previously indicated, sampling and analyses occurred only between 1985 and 1988. Although this baseline phase resulted in an adequate database for most wells, there are exceptions:

- H-8b (1986): Th-228 and Tritium only
- WIPP-25 and WIPP-26 (1987): gross alpha and beta and Tritium only
- DOE-1 (1987): sampled only once for Tritium
- Comanche and Clifton (1988): sampled only for plutonium isotopes, uranium isotopes and Sr-90
- Unger and Poker Trap (1988): plutonium isotopes and Sr-90 only
- Fairview and Twin Well (1988): plutonium isotopes, uranium isotopes, Sr-90 and K-40.

While baseline analytical and statistical objectives are met for the majority of groundwater baseline wells, some wells have other deficiencies. As indicated above, some well samples were not fully analyzed for all radionuclides twice, some wells were sampled only once, and several were sampled only for a single round of duplicate samples. These locations include wells H-5c (Magenta), H-8b (Culebra), H-12 (Culebra), H-17 (Culebra), WIPP-13 (Culebra), P-17 (Culebra), WIPP-25 (Magenta-Culebra), WIPP-26 (Culebra), DOE-1 (Culebra), Engle Well (Culebra), USGS-1 (Culebra) Poker Trap (Culebra), Twin Well (Dewey Lake), Unger (Dewey Lake), Fairview (Dewey Lake) and Comanche and Clifton Wells (Santa Rosa/Dockum Group). Therefore only 23 of 38 wells sampled for radiological parameters between 1985 and 1988 satisfy the original analytical objectives of the RBP. It remains unclear which wells are used in the radiological baseline summary presented in DOE/WIPP 92-037.

8.4 Radiological Baseline

For the radiological baseline analyses presented in DOE/WIPP 92-007/92-037, WIPP RBP wells are initially divided into Culebra and Magenta statistical groups. A single group represents private wells, though the wells are completed in three different formations. The formations are grouped and reported as a single statistical group for each radionuclide for summary statistics. The final baseline radionuclide array includes H-3, K-40, C-60, Sr-90, Cs-137, Ra-226, Ra-228, Np-237, thorium isotopes, uranium isotopes, and plutonium isotopes. The only naturally occurring radionuclides frequently detected above minimum detection limits are Ra-226, U-234, U-235 and U-238. Naturally occurring radionuclides detected less frequently include Th-228 and K-40.

with routine environmental surveillance. Procedure WP 12-924 does not provide guidance on the size and density of possible grid systems for hand-held instrument surveys.

An underlying issue is the reliance on predetermined environmental surveillance sampling locations for post-release assessments. The effectiveness of the current Lo-Vol and radiological soil sampling locations for post-release assessment has been questioned (Section 3.2.1 and Section 5.1). Inasmuch as a selected Lo-Vol location may receive less radioactive particulates than an adjacent unmonitored area, some provision should be made for testing other near-field areas. Likewise, if the objective is impact assessment, the location of the soil/biota grid system should be based on characteristics of the particular plume, not on locations selected for assessing long-term trends. Because using hand held probes in the field to determine alpha contamination can be very imprecise, more areas should be tested.

9.2 Sample Identification

NMED/WIPP staff have confirmed the use of an adequate sample identification system used to label sample containers and data sheets. Environmental program labels consist of a four-tiered hierarchy of sample-specific information that identifies the environmental subprogram, location, date, and the sequence of the sampling event. An example is below:

AC-SMR-19931212-3.12

AC - SMR - 19931212 - 3.12

(Continuous Air Sampling) (SMith Ranch) (December 12, 1993)(3rd sample of 12)

The WIPP facility uses three separate Sample Tracking Log Books (STLB); one for the Nonradiological Environmental Surveillance Program, one for the Radiological Environmental Surveillance Program, and one for compliance sample tracking pertaining to Discharge Plan #831 (Liquid Waste Disposal Facility). These log books are stored in a fireproof cabinet in the Environmental Monitoring Section Office and entries are made by the individual conducting the sampling. Field observation indicates that WIPP personnel are implementing the WP 02-303 procedure governing sample identification and record keeping.

A unique sample identification system is described in WP 02-303 for the Water Quality Sampling Plan (WQSP). WQSP samples are identified by the following:

- Well Name: H11B3 (third borehole on H-11 pad)
- Name of Formation: C-Culebra; M-Magenta; DL-Dewey Lake
- Round Number: e.g. R2 or R3 for second or third sample rounds, respectively

- Sample Number: e.g. N5 means the fifth sample taken, which is keyed to a sample collection form designating specific analyses for sample number 5.

An example of a WQSP identity code is H11B3CR7N5.

9.3 Packaging and Shipping of Samples Off-Site

DOE/WIPP procedure WP 02-304 governs shipment of samples to the contractor laboratory. Quality Assurance is maintained through management of quality control documents, i.e., the Sample Tracking Log Book (STLB), Chain of Custody forms (C of C), Transmittal letters, Request for Analysis (RFA), and Acknowledgement of receipt (AOR). Samples shipped off-site must comply with 49 CFR 179 (Carrier requirements). Information entered into the STLB include the name of the person sampling, shipment date, C of C number, RFA number, AOR date, and date of receipt of the analytical results. It is the responsibility of the sampler to reconcile shipping or data problems.

9.4 Laboratory Procedures

A recent DOE/WIPP statement of work (DOE/WIPP SoW) for radioanalytical contractor laboratories (RCL) includes the following requirements:

> "Analysis of all samples (radiological) shall be in accordance with appropriate EPA approved test methods or the U.S. DOE, Environmental Measurements Laboratory (EML) Procedures Manual, HASL-300. In cases where satisfactory EML or EPA-approved methods are either not available or are not adequate, alternate methods of analysis can be used. However, such alternate methods must have documented evidence showing that they give reliable results."

The EML Procedures Manual, HASL-300 lists generic methods used in separation and electrodeposition of the actinide fractions in preparation for alpha spectrometry. Alternative methods for measuring transuranic radionuclides, such as those developed by a particular laboratory or those under consideration of the American Society for Testing and Materials (ASTM), are evidently permitted so long as proper quality assurance controls and documentation are implemented. Each contractor laboratory must also maintain an approved Quality Assurance Program and conduct quality control sample analyses.

NMED/WIPP staff have learned that a number of different radiological contractor laboratories have been and will be utilized over the duration of the WIPP environmental program. Such past and future changes can introduce a source of systematic variability in the database, despite requirements for contract labs to use standard methods.

9.5 Laboratory Reporting

The DOE/WIPP RCL is required to document and include in the raw data package all Quality Assurance performance analyses and calculations supporting Level IV Analytical Data Reporting (DOE/HWP-65/R). The DOE/WIPP SoW requires documentation of the following:

- Minimum percent yield of 75 percent
- Lower Limits of Detection
- Quality Control results of blank, duplicates, and matrix spikes analyses

Raw radiological data packages from the RCL were not available for review by site staff to confirm the methods used, results of blank, duplicate, or spike matrix analyses, or the determined practical quantitation limits of the equipment and process.

9.6 Quality Assurance

Environmental procedures contain references to quality assurance requirements and contractor laboratories must have a DOE/WIPP approved Quality Assurance Program. The following quality assurance drivers are cited in various DOE/WIPP plans, procedures and contracts:

- DOE Orders 5700.6A and 5700.6B, DOE Quality Assurance Requirements

- WID Quality Assurance Program Description (QAPD: WP 13-1)

- ANSI/ASME NQA-1, 1989 Edition, Quality Assurance Program Requirements for Nuclear Facilities

- QAMS-005/80, 1983, Interim Guidelines for Preparing Quality Assurance Project Plans

The data quality objective (DQO) of the WIPP program is Level IV data, as defined in DOE/HWP-65/R1. The WIPP program requires documentation of data quality with calibration and quality control records. Laboratories are obligated to periodic DOE/WIPP audits of laboratory personnel qualifications and training, equipment, and analytical procedural methods. DOE/WIPP radiological contractors are also required to participate in the DOE/EML interlaboratory quality assurance program administered by the DOE Environmental Measurements Laboratory (EML). At this time, NMED/WIPP site staff have not verified contractor participation in the DOE/EML program.

10.0 DATA ANALYSES AND VALIDATION

Collection and interpretation of environmental data for the WIPP project is complicated by two intrinsic factors: the low concentrations of natural and man-made isotopes in the background environment, as well as those expected from both routine and accidental releases from the facility. Environmental data needs to be valid and of known accuracy and precision to satisfy the analytical objective of the project: to compare new data with data collected during the baseline phase. DOE/WIPP environmental monitoring plans list several levels of validation prior to statistical analyses:

(1) determination of the accuracy of each point measurement by means of the quantification and control of precision and bias;

(2) evaluation of the effects of auto-correlation due to the location and time of sampling on the expected value of the point measurement;

(3) treatment of data anomalies, such as values below the limit of detection, negative values, missing data, and outliers; and

(4) identification of an appropriate model of variability (i.e., a probability density distribution) for each point measurement and the calculation of descriptive statistics based on that model.

This section discusses data validation and statistical methods described in DOE/WIPP environmental plans and reported in annual reports.

10.1 Data Quality and Validation

Both WIPP environmental monitoring plans DOE/WIPP 88-025 (current) and DOE/WIPP 94-024 (draft) summarize methods used to screen environmental data for statistical analyses. Except for data validation, most accepted quantitative measures of data quality are addressed: accuracy and precision, completeness, treatment of data anomalies, and detection limits (ASTM STP 837, 1983).

Accuracy and Precision. Accuracy is the agreement between a measured value and an accepted reference or true value. Laboratory accuracy of a single data point measurement is usually expressed as a percent recovery. Because determination of accuracy includes the effects of variability (precision), accuracy should be reported as a 95 percent probability interval (percent recovery $\pm$ 1.96 sigma) (ASTM STP 867, 1983). Although contractor laboratory analytical reports are supposed to include such information in data packages to the WIPP facility, this data (e.g. percent recovery) is never reported in DOE/WIPP annual reports. Annual reports do include central values and ranges of variation (two standard deviations).

Although there is no "field reference" in environmental sampling, accuracy can be greatly enhanced through control of bias and precision during the sampling process. Following SOPs during sampling minimizes systematic error (bias), but not precision. Precision is a measure of the mutual agreement among individual measurements. In terms of field sampling plans, DOE/WIPP controls precision through periodic performance of the following types of measurements:

- measurement of replicate samples (two or more separate samples taken at the same time, from the same location, and with the same procedures);

- measurement of duplicate samples (two or more aliquots of one sample) or the repeated measurement of the same sample (as in two or more counts of a single air filter);

- measurement of blank samples; and

- measurement of standard pseudo-samples (samples of an equivalent medium containing a known amount of the target species).

DOE/WIPP environmental plans report that quality control samples are collected as follows:

- one replicate sample collected for each ten samples collected;

- at least one duplicate or one repeated measurement made for each discrete set of samples analyzed, or for each tenth sample analyzed, whichever is more frequent;

- one blank sample analyzed for each discrete set of samples analyzed (for radioactivity counts, the background count is not considered a blank); and

- measurements of pseudo-samples performed once per year.

The frequency of quality control sampling described above is in agreement with an EPA (1987) criteria, which requires a minimum of 10 percent of all samples collected to be analyzed in duplicate. Conforming with this guidance, groundwater sampling procedure WP 02-1 specifies one acid blank and one duplicate sample for each sampling event. However, procedures for soil, sediment and surface water contain no such guidance on their respective final sample collection data sheets.

Two or more counts of a single Lo-Vol filter are considered quality control duplicates. Station A and B effluent FASs are measured in triplicate, with filters collected routinely by DOE/WIPP, NMED and EEG. However, there is enough variability in the gravimetric analyses in the three samples to suggest that there could be a large variation in counts/minute/sample in the event of a release (J. Colties, NMED/WIPP 1993 Pers. Comm.). The three Station A and B filters might be better characterized as co-located samples. Lo-

Vol filter samples are not "duplicate" samples either, as duplicate sampling is defined as a "division of a single sample into two equal aliqouts" (EPA, 1990).

Based on a review of the procedures, it remains unclear how quality control sampling guidance is implemented for the TLD program. For the High Pressure Ionization Chamber (HPIC) program, annual calibration to National Institute of Science and Technology (NIST) reference standards (C-60/RA-226) provides a control on accuracy. NMED/WIPP staff, however, have confirmed that the HPIC has not been calibrated for over three years (1990-1993).

Data Outliers and Anomalies. Defined as abnormally high or low values, data outliers can often be identified by a marked deviation from a defined statistical probability group. Once radiological analyses recommence, DOE/WIPP 92-037 suggests only 10 percent of WIPP data will be correlated to the statistical subgroups defined in the radiological baseline summary. Data exceeding 2.3 or more standard deviations above or below the mean (normal distribution) will be considered outliers (DOE/WIPP 94-024). The 2.3 standard deviation confidence band is consistent with NCRP 50 guidelines, which suggests values between 2 and 3 sigma. The 10 percent test of new data was reconsidered in the final EMP DOE/WIPP 94-024. Presently, essentially all data will be compared to the baseline.

Only artificial and systemic sources of error should be excluded from the data analysis, such as those attributable to data input, equipment malfunction, or errors made during sampling. DOE/EH 0173T (1991) suggests that temporal/control plots should also be used to identify outliers and characterize seasonal and diurnal fluctuations for each subgroup. If presented along with 1, 2 and 3 sigma confidence bands, such plots would be useful for presentation in annual reports.

Other data anomalies are treated as follows:

- When possible, DOE/WIPP states that actual values below detection limits will be incorporated into the data base for statistical analysis.

- Missing data points greater than 10 percent of the data set will reportedly be identified in the results.

In reference to values below the detection limit, past DOE/WIPP annual reports have not listed actual values below the detection limit. Only the LD symbol (less than detectable) is listed in data tables, apparently to note that the sample is below the laboratory standard of accuracy and precision. If this data is not reported, but is used in statistical analyses, independent verification is not possible.

Completeness. Completeness is an important part of data quality and validation, since missing data may reduce the precision of estimates, introduce bias, and result in greater uncertainty. Comments in this report in the terrestrial and groundwater sections regarding completeness of sampling rounds fall in this category. As defined by the EPA, completeness is a measure of the amount of valid data obtained from a measurement system, expressed as a percentage of the total number of samples planned. There are several examples (sample locations) in the aforementioned sections that do not meet the required sampling rounds defined by the first OEMP (Mercer et al., 1989) data quality objectives, yet the data are still used in the statistical analyses. This issue is not addressed adequately in the statistical summary presented in DOE/WIPP 92-037.

Minimum Detection Limits. The minimum detection limits in effect during the acquisition of baseline radiological data are presented in table 10.1. The values are presented in curies (DOE/WIPP 88-025) and becquerels (DOE/WIPP 92-037), as DOE currently requires radiological data to be presented in SI units. As suggested in the discussion of outliers, analytical results less than the MDL have been incorporated into the baseline statistical database (DOE/WIPP 92-037). ASTM STP 867 encourages this approach. However, the baseline summary also includes maximum values (value of the DL) in the analysis, a practice that can excessively bias statistical results (DOE/EH 0173T, 1991).

The definition and presentation of minimum detection limits in DOE/WIPP reports need improvement. If the minimum detection limit is a method detection limit, the limit varies with method, counting period, sample size, matrix etc. (EPA, 1989). There are additional definitions for method quantitation limits, instrument detection limits, and practical quantitation limits. EPA/600/4-89/019 (EPA, 1989) defines detection limits for their off-site Surveillance Program as 3.29 sigma, where sigma equals the counting error of the sample. The DOE/WIPP program should follow EPA (1987) and NRC Regulatory Guide 4.14 (1980) guidelines for reporting environmental radionuclide concentrations. For short-lived radionuclides, the counting results should be decay-corrected to the time of collection. Detection limits should be reported and explained more thoroughly in annual site environmental reports and data summaries. As indicated in the next section, the following should be reported: the actual detection limit and value below the detection limit for each sample, and the number of Less Than Detection Limit samples for data sets.

Issues regarding the high MDLs displayed in the groundwater sampling program involve data usability. High TDS groundwater samples require dilution prior to analysis. During the acquisition of baseline data, the use of different laboratories and/or dilution factors may have resulted in inconsistent MDLs from round to round. Large sample dilutions have generally decreased sensitivity of the radiochemical analyses and increased MDLs. The statistical problem is that high MDLs increase the number of nondetections and can magnify spurious, near-MDL detections. Many nondetections also hinder discrimination between false negatives and equipment malfunctions or procedural errors.

Data Validation. DOE Order 5400.1, Chapter IV, Section 10, paragraph d., requires that environmental monitoring programs at DOE facilities maintain an independent data verification and validation program. Existence of this program could not be confirmed through DOE/WIPP. NMED/WIPP staff, however, find that certain data validation objectives

Table 10.1: Minimum Detection Limits for Radionuclides

Analyte	47 MM Filter E-9μCi/composite[3] (Becquerels per ml x 10^{-12})[1]	Water pCi/L (Becquerels per gram x 10^{-4})	Soil & Sediment pCi/gram (Becquerels per gram x 10^{-3})	Tissue & Vegetation pCi/gram (Becquerels per gram x 10^{-3})
H-3	N/A[2]	150 (56)	N/A	N/A
Be-7	N/A	N/A	N/A	N/A
K-40	N/A	N/A	N/A	N/A
Co-60	3 (.015)	8 (3.0)	0.1 (3.7)	0.5 (18)
Sr-90	30 (.150)	20 (7.4)	2 (74)	2 (74)
Pb-210	20 (.100)	N/A	N/A	N/A
Ra-226	5 (0.025)	15 (5.6)	0.2 (7.4)	1.0 (37)
Ra-228	N/A	N/A	N/A	N/A
Th-228	3 (0.015)	10 (3.7)	0.1 (3.7)	0.4 (15)
Th-230	2 (0.010)	1 (.37)	0.1 (3.7)	0.1 (3.7)
Th-232	2 (0.010)	1 (.37)	0.1 (3.7)	0.1 (3.7)
U-233	1 (0.005)	1 (.37)	0.1 (3.7)	0.1 (3.7)
U-234	1 (0.005)	1 (.37)	0.1 (3.7)	0.1 (3.7)
U-235	N/A	N/A	N/A	N/A
U-238	1 (0.005)	1 (.37)	0.1 (3.7)	0.1 (3.7)
Pu-238	4 (0.020)	0.4 (0.11)	0.4 (15)	0.4 (15)
Pu-239/240	2 (0.010)	2 (0.74)	0.2 (7.4)	0.2 (7.4)
Pu-241	100 (0.499)	100 (37)	10 (370)	10 (370)
Cs-137	2 (0.010)	5 (1.9)	0.1 (3.7)	0.2 (7.4)
Np-237	2 (0.010)	1 (.37)	0.1 (3.7)	0.1 (3.7)
Am-241	1 (0.005)	1 (.37)	0.1 (3.7)	0.1 (3.7)
Cm-244	1 (0.005)	1 (.37)	0.1 (3.7)	0.1 (3.7)

(After DOE/WIPP 88-025 and DOE/WIPP 92-037)

1 - Minimum Detectable Average 2 - (N/A) Not Established 3 - Composite refers to a varying number of filters in the sample

are defined in the following document: WP 02-302 *NES/RES Quality Assurance/Quality Control Implementation Procedures*. The procedure provides for a checker, other than the person who performed the work, to review raw data and computer input and identify discrepancies. It is not known whether this procedure satisfies, in whole or in part, Chapter IV of DOE Order 5400.1. The New Mexico Environment Department and the Environmental Evaluation Group (New Mexico Institute of Mining and Technology) also provide the capability to verify data through acquisition and analyses of duplicate and co-located samples. According to ASTM STP 867 (1983), comparison among different samplers is an acceptable method of data verification. This verification concept is different and separate from an internal DOE data validation program, which would focus on validating (verifying) analytical data before being used in statistical analyses. Staff could not find evidence of a validation program directed at laboratory analytical reports, although outliers are identified during statistical analyses.

Laboratory analytical validation is achieved through participation in interlaboratory comparison programs. In addition to the DOE Environmental Measurements Laboratory (EML) quality assurance program, NMED/WIPP staff confirm that DOE/WIPP contract laboratories must also participate in the EPA cross-check Interlaboratory Comparison Program. The EPA program pertains only to EPA standard test methods, including method 9310 for gross alpha and beta screening, and method 9315 for measurement of radium isotopes. Participation in interlaboratory cross-check programs is assumed to minimize or control bias.

10.2 Data Analyses and Reporting

Statistical analyses and reporting requirements are described in DOE/WIPP annual environmental reports, with supplemental discussion of baseline statistical analyses occurring in DOE/WIPP 92-037. In addition to discussing environmental monitoring statistical methods, this section continues commentary on DOE/WIPP reporting practices.

Descriptive Statistics. As discussed in the previous section, environmental data in past annual reports have been reported as a central value and range of variation (two standard deviations). This is consistent with the required 95 percent probability interval for a single measurement. For data sets containing less than 10 values, DOE/WIPP environmental plans state that the range defined between the 0.25 and 0.75 percentiles will be used to characterize variation. DOE/EH 0173T (1991) suggests that the median (rather than mean) should be used as a measure of central tendency for small data sets (less than 10), especially if many less-then-detectable measurements exist (DOE/EH 0173T, 1991). Given the small number of measurements to date, with many less than detectable values, presumably annual reports published to date report the median value and the .25-.75 percentile. The standard deviation will be used only if the data set consists of more than 10 points (DOE/WIPP 94-024).

For descriptive statistics, DOE/WIPP environmental plans describe provisions for ensuring normal distributions are demonstrated prior to statistical analyses. In agreement with DOE/EH 0173T (1991), normal distribution is checked utilizing probability plots, the W Test or D'Agostino's test for data sets containing more than 10 data points. For smaller data sets, the log-normal distribution is assumed and analyzed using parametric or nonparametric analysis of variance techniques.

Based on a review of past environmental reports, a main shortcoming of DOE/WIPP radiological analytical reporting is that annual reports do not report cumulative descriptive statistics. For adequate validation, cumulative data summary tables should report data by location and by parameter. The following information should be included in a parameter summary table:

Sample Parameter
Sample Location
Number of Samples
Number of Less than Detection Limits
Mean Value
Median Value
Standard Deviation
Coefficient of Variation
Minimum Value
Maximum Value

In addition to the generic program descriptions, data tables and statistical graphics commonly found in annual reports, an appendix needs to be included to explain the statistical assumptions and precise methods used to treat or define particular data sets. DOE/WIPP 92-037 and DOE/WIPP 92-013 (section 4) provide examples of the level of explanation required for verification of conclusions.

Temporal and Spatial Analysis. DOE/WIPP environmental plans emphasize the importance and applicability of time series analysis of WIPP environmental data. Although the 1988 OEMP commits to describing temporal variation either in tabular form or as time plots, a review of past radiological surveillance sections of annual reports reveals no cumulative, descriptive studies of temporal and site-specific trends. Temporal trends are also not described in the radiological baseline summary presented in DOE/WIPP 92-037. Temporal plots should be included in annual reports and/or data summaries to illustrate possible seasonal fluctuations or outliers. Periodic temporal characterization is a general weakness in DOE/WIPP environmental reporting.

Given the static location of sampling stations in the DOE/WIPP environmental program, the variation of radionuclide concentration at any location is more dependent on time than on space. If samples are collected at locations other than those pre-established in the DOE/WIPP program, spatial analysis would be critical. Sampling in support of assessment of an accidental release provides an example of such a situation. To a certain extent, the geographic subgroups defined in the radiological baseline summary provide a basis for assessing spatial variability. The RBP summary, discussed in the next section, suggests that new data can be compared with baseline data for conformance to the predictive probability model defined for different geographic subgroups.

Radiological Environmental Baseline. The analytical objective of the baseline summary is to derive probability models for the RBP data for comparison with similar data collected during the operational phase. Data are first subjectively grouped into data sets based on spatial distribution, followed by a comparison of the mean values of the data groups using ANOVA and multivariate ANOVA. From this analysis, homogeneous groups are defined at the 95 percent confidence level or modeled independently (DOE/WIPP 92-037). Warning and action levels for operational monitoring are proposed based on probability distributions exhibited by the statistical groups defined from the baseline data. The evaluation described in DOE/WIPP 92-037 can be summarized as follows:

- Compilation of RBP data into a Statgraphics file format.
- Definition of homogeneous subgroups on the basis of subjective judgement and statistical analyses.
- Determination of summary statistics for each subgroup and, where possible, definition of a probability distribution.
- Definition of critical values (alarm values) for each subgroup for four probability levels: 0.80, 0.90, 0.95, and 0.99.

DOE/WIPP 92-037 cautions that the RBP analyses does not adhere to "assumptions of underlying accuracy and precision" described in DOE/WIPP environmental plans. A review of the DOE/WIPP 92-037 methodology suggests that normality is not violated for either Analysis of Variance (ANOVA) and multivariate ANOVA or probability distribution modeling. Inasmuch as a cumulative presentation of descriptive statistics is not provided in the baseline summary, it remains unknown which underlying assumptions are disregarded. In fact, while the statistical methodology described in DOE/WIPP 92-037 appears sound, there is no cumulative descriptive baseline report with which to verify assumptions or conclusions. Two issues include:

- Assumptions involving distribution of variances. In an analysis of variance, it is assumed that variances in the different groups are identical. Although outliers are identified to minimize contribution to extreme variances within data sets, actual data may manifest violations of this assumption. Without a cumulative report of descriptive statistics, independent reviewers cannot verify this assumption.

- The baseline summary treats many annual and/or successive sampling rounds as "duplicate" samples. It remains unclear how the treatment of successive sample rounds as duplicate samples effects data analyses. Duplicate samples are usually defined as being two replicate samples created by dividing a sample into two or more separate aliquots (EPA, 1987). DOE/WIPP 92-037 does not fully explain this procedure, which seems critical to interpretation of the statistical analysis.

- As demonstrated by example compilations of baseline radiological data in appendix 1, it is not clear why some standard error columns contain N/A (not applicable). In these cases, there are a sufficient number of n values to report error, which is always applicable.

11.0 ISSUES AND RECOMMENDATIONS

The DOE/WIPP radiological environmental program can be characterized at present as a pre-operational/post-baseline radiological environmental program. In terms of sampling frequency and number of pathways monitored, the DOE/WIPP program exceeds minimum requirements for both the baseline and proposed operational sampling programs. The design and implementation of the program, however, remain subject to performance assessment. Program requirements are almost exclusively guided or mandated by DOE Orders, which are general enough to be subject to interpretation. In general, the environmental surveillance program is adequately designed to establish long-term trends, but is not configured to detect and quantify a real-time release. DOE Orders and guidelines require at least one pathway be configured to verify off-site dose calculations established by effluent monitoring.

Atmospheric Radiological Surveillance

1) Station A is the principal airborne effluent monitoring location and compliance point for the facility. NMED/WIPP staff verify that sampling and quality assurance programs are being implemented at Station A according to procedure. Effluent filters are currently archived if no gross alpha or beta radiation is detected.

2) In certain operational modes and ventilation configurations, NMED/WIPP staff have observed exhaust air escaping from the waste handling shaft instead of through the exhaust shaft. Although this issue is not addressed in detail in this report, this potential condition could seriously undermine and invalidate effluent monitoring efforts in the event of a release.

3) The location and number of Lo-Vol samplers appears adequate for documenting long-term trends. Quarterly analyses of composite air filter samples are occurring for each off-site Lo-Vol location.

4) In terms of detecting an off-normal release, Lo-Vol samplers are either too far away, too few (only four relatively near the site), or distributed inappropriately to detect releases during varied seasonal wind directions. Lo-Vol samplers also do not have the required air flow capacity to achieve the detection limits required for quantifying expected low-levels of radiation in the event of a release.

5) DOE/WIPP Lo-Vol sampler heights and distances from obstacles are consistent with guidelines in 40 CFR 58 Appendix E. WIPP Lo-Vol Stations appear to not meet the 270 degree unrestricted flow criteria; the air samplers protrude in one direction from one face of the device.

6) While there are many apparently unnecessary regional Lo-Vol FAS locations, there is no Lo Vol FAS located in Loving, New Mexico, the closest community to the WIPP Site.

Recommendations:

- DOE/WIPP should investigate and report the root cause explaining observations of exhaust air escaping through the waste handling shaft in specific operational modes and ventilation configurations.

- Detailed plans and data quality objectives for quantifying an off-normal release using Lo-Vols should be addressed in the DOE/WIPP Environmental Monitoring Plan. The discussion should reference procedure WP 12-924, which identifies Lo-Vol samplers as a principal means of verification.

- Only routine discharges and several worst-case release scenarios are addressed in the FSAR; an "anticipated operational occurrence" (6430.1A/1324-2.2.1) needs to be defined to quantitatively establish a data quality objective for the Lo-Vol system.

- The location, number and configuration of Lo-Vol samplers should be reevaluated on the basis of the program objective: establishing long-term trends or detecting a discrete airborne release. Lo-Vol FAS locations in the near field should include at least 4 additional samplers symmetrically located due west, northeast, southeast, and southwest of the site to provide better coverage for seasonal variations in wind direction.

- Lo-Vol FAS instruments should be secured against tampering and WP 02-306 "RES Equipment Maintenance and Control" should be referenced in the Lo-Vol airborne particulate sampling procedure WP 02-312.

- An additional regional Lo-Vol sampling station should be located in the Town of Loving, New Mexico, and WIPP Lo-Vol stations should be assessed against the EPA requirement for unrestricted flow 270 degrees around air samplers.

External Radiation

1) The High Pressure Ionization Chamber (HPIC), used as a standard to check TLD data against, has not been calibrated for over three years, despite requirements for annual calibration.

Recommendation:

- Improve information on how quality control sampling is maintained in the TLD and HPIC programs, and ensure annual calibration of the HPIC to NIST standards.

Terrestrial Radiological Surveillance

1) There are specific terrestrial sampling locations where data completeness (samples collected vs. samples planned) is an issue, but overall the number of samples collected should provide an adequate baseline. This cannot be verified without a cumulative descriptive statistical summary of the baseline data. A recently published baseline statistical analysis (DOE/WIPP 92-037) focuses on developing predictive probability models for specific geographic groups, not for individual sampling locations.

2) The current operational program is not designed for assessing the environmental impact and extent of a real-time nonroutine release. The DOE/WIPP program relies solely on radiological Lo-Vol sampling locations for assessing real-time releases. Within 24 hours of a release, soil samples are to be collected at Lo-Vol locations by the same procedure used to establish long-term trends. Given the limited coverage of the Lo-Vol system and variability of wind direction from seasonal changes and weather events, plans to include sampling other terrestrial locations could fill in potential data gaps.

3) Predictive air dispersion models might enhance the selection of potential operational locations best suited to detection, and may also be useful in pre-planning for real-time response following a suspected release (DOE/EH-0173T, 1991). Baseline and operational sampling sites are not currently selected for this purpose. The locations are selected on the basis of an average northwest wind direction, which is consistent with the AIRDOS-EPA computer code. The locations are not based on the potential for a real-time release which could disperse at any azimuth from the exhaust shaft. The CAP-88 computer code utilized by the DOE/WIPP Westinghouse Radiological Engineering Department is designed for real-time releases.

4) Playa Lakes: Laguna Quatro may exhibit levels of radiation above background, resulting from naturally occurring radioactive materials (NORM) contained in oil field residual liquids and venting of man-made isotopes to the atmosphere during Project Gnome.

5) Consideration should be given to collecting sediment samples from deeper horizons. Sediment cores provide a record of radionuclide distribution with depth; such documentation could help explain anomalous measurements in the event radionuclides buried below the surface become resuspended.

6) According to NRC Regulatory Guide 4.5, soil sampling locations should not be placed within 120 meters of dusty roads and sites of previous construction. A number of DOE/WIPP soil sampling sites are inconsistent with this guidance. Random selection of composite subsamples at such locations could result in the collection of unrepresentative samples. If composite subsamples are taken in areas away from roads etc., but in very sandy soils, samples should also be collected at greater depth. Radioactive particulates may migrate deeper than the current maximum sample depth of 10 cm in some highly permeable/low retardation soils around the WIPP.

7) Red Tank and Tut Tank are excluded from the RBP for sediment but are surface water sampling locations. The tanks have not been sampled for radiological background levels. Insoluble hydroxides (e.g $Th(OH)_4$, $Np(OH)_5$ etc.) present in the sediment might be detected in future surface water sampling in response to physical disturbance or a change in water chemistry.

8) Radionuclide data for Th-230, Th-232, and Np-237 are reported in the statistical summary for sediments presented in appendix 1.3. NMED/WIPP staff request verification of this data, as a review of DOE/WIPP annual reports (1985-1992) finds no evidence for such analyses.

9) The treatment of terrestrial radiological baseline data in DOE/WIPP 92-007 routinely categorizes specific analytes into similar geographic groups, not by sample location. To a certain extent, this process has diminished the significance of site specific data. The treatment of terrestrial radiological baseline data in DOE/WIPP 92-007 does not temporally classify data for each location, the rationale being that differences between years are not predictable, and therefore inconsistent with the probability model used in the statistical summary. However, a variation in radionuclide detection and/or concentration from round to round is observed for all terrestrial media at some locations. Predictable seasonal fluctuations in background may be masked and individual sites may be misrepresented unless a more descriptive baseline statistical analyses is conducted. See discussion in Data Analyses and Reporting Section.

Recommendations:

- A radiological soil baseline should be established at Mills Ranch and Smith Ranch. Other baseline data gaps include locations sampled only once, or sampled twice but without full radiological analyses on the second round.

- The baseline radiological sampling program for sediment should be expanded to include near-field locations within 15 kilometers of the site (Red Tank and Tut Tank) and Laguna Quatro.

- DOE should select or plan to sample additional terrestrial sampling locations with the objective of filling in data gaps in the event of a real-time release. The soil baseline sampling sites are chosen on the basis of an average northwest wind direction; they may not be sited adequately to detect a release under different wind conditions.

- Consider obtaining deeper baseline samples in soils of high permeability and within sedimentary materials (e.g. Laguna Quatro).

- A radionuclide inventory Laguna Quatro and other nearby playa lakes should be established as a pre-operational baseline.

- Red Tank and Tut Tank should be sampled in case the sediment displays anomalous radiological background levels.

- Future sampling activities and data analyses should consider statements 7, 8 & 9.

- Nonradiological samples should be co-located with surface water radiological samples (e.g. TSS and pH) to facilitate interpretation of radioanalytical results. This procedure is missing from the draft EMP DOE/WIPP 94-024. Additional data useful for interpretation of soil and/or sediment analytical results would include physical properties such as: particle-size distribution, pH, ion-exchange capacity, organic and moisture content (DOE/EH-0173T, 1991).

- Gross alpha and beta measurements should also be taken for terrestrial samples, in part to establish a baseline for screening following an accidental release.

Liquid Effluent and Influent Monitoring

1) WIPP site liquid influent and effluent were sampled and analyzed in 1986 for baseline purposes. Subsequent sampling for specific radionuclides, however, has not been initiated. Because seven years have elapsed, the baseline data presented may not be comparable to data collected later. Current annual environmental monitoring plan schedules for 1993 do not include Effluent and Influent sampling.

Recommendation:

- Initiate sampling of the WIPP site liquid influent and effluent semiannually as committed to in DOE/WIPP environmental monitoring plans. This sampling represents the WIPP site Radiological Budget Plan and should include accurate influent and effluent volume determinations.

Biological Radiological Surveillance

1) Biotic sampling of game species does not include radioanalyses of bone or viscera, only the muscle tissues. The DOE guideline document, (DOE/EH-0173T) makes the assumption that the viscera and bones are typically not consumed by the public and therefore radioanalysis would not be justified although certain nuclides may concentrate preferentially in these organs (strontium 90 in bone, cesium 137 in muscle tissue, and Iodine 131 in the thyroid). ^{90}Sr has an ecological concentration factor of 500 in bone (Fundamentals of Ecology, Odum, 1971) and could provide an addition element of surveillance.

Recommendation:

- Add bone and specific organ radioanalysis to the biotic sampling program, acknowledging radionuclide ecological concentration factors.

Groundwater Radiological Surveillance

1) For comparison with long-term trends, DOE/WIPP background radiological data adequately documents a pre-disposal phase baseline. One potential deficiency is that analyses for Am-241 and Cm-244 are not documented. Both radionuclides are part of the original RBP and will be represented in the WIPP waste stream. Radionuclides Am-241, Po-210, Pb-210 are also designated operational monitoring parameters, yet a baseline has not been established for these constituents.

2) Only 23 of 38 wells sampled for radiological parameters between 1985 and 1988 satisfy the original analytical objectives of the RBP. The radiological baseline summary presented in DOE/WIPP 92-037 does not identify which baseline wells are used in developing the probability model. Statistical baseline analyses should be presented by well location and grouped according to geographic zones and formation.

3) A long-term and site-wide radioactive tracer test in the Culebra Formation proposed by Sandia National Laboratory will disrupt groundwater surveillance for several years. No further environmental sampling of the Magenta Formation is planned.

4) Current groundwater observation wells are not suitable for detection, and will not have the operating life necessary for long-term monitoring. The following comments concerning the adequacy of the baseline do not preclude that some sort of monitoring or detection system may be necessary:

   - DOE-1 is well located along a critical potential groundwater release pathway postulated to occur in certain groundwater release scenarios (Reeves et al. 1991). The well has been sampled only once for Tritium; a more comprehensive radionuclide database for this well location seems appropriate.

   - Current Magenta observation wells are located outside potential contaminant migration pathways. Although the Magenta is not considered in formal risk analyses conducted in support of the Performance Assessment, a ground water monitoring system may require consideration of the potential for contamination of the water-bearing zone. Some investigators have suggested that leakage downward from the Magenta Formation may be a component of recharge for the Culebra water-bearing unit (Mercer, 1983; Seigel et al., 1991). The groundwater radiological baseline could be improved by sampling the Magenta water-bearing zone in the potential contaminant flow path and closer to the western boundary of Zone II (extent of underground excavation).

- No background radiological data exists for the Dewey Lake water-bearing zone within the site boundary. Sampling of Well H-3d would improve characterization of the radiological background. In general, more information is also needed to characterize the distribution and hydraulic properties of Dewey Lake groundwater on the southern half of the WIPP site.

5) Although the DOE strategy is to obtain a No-Migration Variance for the Disposal Phase, a requirement for long-term groundwater monitoring during operations or post-closure remains a possibility. Baseline data collected from the current observation wells must be comparable to possible future systems, which may include wells constructed and completed according with RCRA requirements. It is advisable to either collect groundwater samples from similar wells prior to the disposal phase or to plan for this contingency.

6) Drilled and completed using oil field techniques, existing wells are composed of standard steel casing and are extensively corroded. Depending on the redox environment, the casing is altered to corrosion products Fe $(OH)_2$ or Fe $(OH)_3$, materials that are known to adsorb radionuclides and heavy metals. Because adsorption can appreciably affect measurements of trace quantities of these constituents, baseline data collected for these constituents must be validated.

Recommendations:

- Plan at least one more baseline annual sampling round for wells completed in the Magenta Formation, and recognize the formation as a contaminant pathway through potential recharge of the Culebra.

- Sample Well H-3d (Dewey Lake Formation) for water quality and radiological baseline parameters.

- Plan at least one more round of sampling for Well DOE-1.

- Consider statements 1 & 2 above in planning sampling activities and data analyses in future annual reports.

- If new wells are to be drilled for hydraulic and/or tracer tests, evaluate use of well casings designed for long-term performance, and pre-plan for their potential use for monitoring. The comparability of existing wells to future wells constructed to monitoring standards should be demonstrated.

- Baseline measurements for radiological and heavy metal constituents should be validated through comparison of data from existing (steel-cased) wells with similar data collected at future wells constructed to monitoring standards.

Sample Collection, Handling and Laboratory Procedures

1) DOE/WIPP maintains updatable environmental sampling procedures. Based on field audits during 1991 and 1992, NMED/WIPP staff confirm the use and proper implementation of procedures for groundwater, soil, air (Lo-Vols), and biotic sampling.

2) Guidance for collecting quality control samples is lacking in terrestrial sampling procedures. Although these procedures reference WP 02-302 (Quality Assurance/Quality Control), quality control sampling per se is not the subject of that particular document.

3) Guidance for conducting post-release assessment radiation surveys near Lo-Vol locations is not documented in a specific plan or procedure. Post-survey soil/biotic sampling at Lo-Vol locations, as described in WP 12-924, will not fill in gaps in coverage inherent to the spacing of Lo-Vol samplers.

4) The DOE/WIPP environmental monitoring program implements a rigorous identification, shipping and tracking sample management QA program. Laboratory quality assurance and reporting requirements for contractor labs are also adequate: raw data packages are required containing methods used, detection limits achieved, results of blank, duplicate and spike analyses, recovery percentages and practical quantitation limits.

Recommendations:

- Quality control sampling guidance should be included on final sample collection sheets or otherwise addressed in media-specific sampling procedures; quality control sampling should also be discussed in quality control procedure WP 02-30.
- Survey and sampling plans for post-release assessments need to be developed.
- Report in annual reports raw data received from contract laboratories (e.g. methods used, detection limits achieved, results of blank, duplicate and spike analyses, recovery percentages and practical quantitation limits).

Data Analyses and Data Validation

1) DOE/WIPP has generated an enormous amount of baseline data and will collect even more environmental data during the operational phase. A tremendous volume of baseline and preoperational data is already stored on high-density computer diskettes in DBase III. A better system of data management will be necessary for data validation and verification, especially for groundwater sampling which requires information on both well completion and sampling history. Groundwater and other off-site sampling programs would benefit from a geographic information system (GIS) for principle investigators to track and easily communicate sampling histories to external reviewers, internal QA auditors, and line management.

2) NMED/WIPP staff have learned that a number of different radiological contractor laboratories have been and will be utilized over the duration of the WIPP environmental program. Such past and future changes can introduce a source of systematic variability in the database, despite requirements for contract labs to use standard methods.

3) Missing data may reduce the precision of estimates, introduce bias, and result in greater uncertainty. Although missing data are accounted for in DOE/WIPP environmental plans, comments in this report in the terrestrial and groundwater sections regarding completeness of sampling rounds are an issue.

4) The recently released baseline study DOE/WIPP 92-037 utilizes incomplete data sets (see above) and treats samples collected during different years as duplicate samples. Measurements below detection limits are used in the baseline summary but have never been published. More emphasis on descriptive statistics is required to verify the analyses conducted in the radiological baseline study.

5) A main shortcoming of DOE/WIPP environmental reporting is that a cumulative radiological statistical summary of data has not been developed. DOE/WIPP should report data summaries by sample location and by sample parameter, and include the following information: sample location, number of samples, number of less than detectable measurements, mean, median, standard deviation, coefficient of variation etc.

6) Annual reports should include temporal plots to characterize seasonal and diurnal irregularities and to illustrate outliers.

7) Current plans for testing only 10 percent of newly acquired data for irregularities (outliers) is not adequate. New data will reportedly be correlated with probability models defined in the statistical baseline summary DOE/WIPP 92-037.

8) Past DOE/WIPP annual reports report only LD (less than detectable) as a data value; actual values below the detection limit should be reported.

9) DOE/WIPP minimum detection limits for ground water are much higher than those identified in the literature. The statistical problem is that high MDLs increase the number of nondetections and can magnify spurious, near-MDL detections. Many nondetections also hinder discrimination between false negatives and equipment malfunctions or procedural errors.

Recommendations:

- Develop a Geographic Information System (GIS) environmental data management program. The database should be able to include sampling history, field reports, analytical data, field and lab QA data, and graphics showing well configurations or sample locations on large-scale maps.

- Improve data characterization by reporting annual cumulative descriptive statistics as outlined in number 4, 5 and 6 above, including temporal control plots to identify outliers.

- Define minimum detection limits annual site environmental reports according to EPA (1987) and NRC Regulatory Guide 4.14 (1980) guidelines for reporting environmental radionuclide concentrations. Report minimum detection limits achieved and actual values measured below the detection limit.

- An effort should be made to achieve lower groundwater program detection limits and decrease the number of nondetections in the database.

- An independent data verification program needs to be developed beyond that inferred from procedure WP 02-302 Quality Assurance/Quality Control, and should formally reference DOE/WIPP oversight groups and their function/work plan. If DOE/WIPP oversight sampling by NMED and other groups are interpreted to fulfill data verification requirements defined in DOE Order 5400.1 at the WIPP, this should be described in a DOE document such as the Environmental Monitoring Plan.

- A DOE/WIPP program should be defined to validate DOE data prior to DOE statistical analyses in an appropriate document (procedure or Environmental Monitoring Plan).

12.0 REFERENCES

ANSI/ASME NQA-1, 1989 Edition, "Quality Assurance Requirements"

ASTM STP-867, 1983, Quality Assurance for Environmental Measurements: in Taylor/Stanley eds., ASTM Publication Code No. 04-867000-16 441p.

ASTM C 998-90, 1990, Standard Practice for Sampling Surface Soil for Radionuclides: American Society for Testing and Materials, Designation C 998-90.

Beauheim, R.L., 1987, Interpretations of Single-Well Hydraulic Tests Conducted at And Near the Waste Isolation Pilot Plant (WIPP) Site 1983-1987: Sandia National Laboratory Report SAND87-0037.

Colties, J., 1992, WIPP Air Quality Monitoring: New Mexico Environment Department, Air Quality Bureau, unpublished report.

DOE 5400.1, 1988 General Environmental Protection Program Requirements.

DOE 5400.5, 1990, Radiation Protection of the Public and the Environment.

DOE 5481.1B, 1988, Safety Analysis and Review System

DOE 5700.6A, 1981, Quality Assurance

DOE 5700.6B, 1984, Quality Assurance

DOE 5820.2A, 1988, Radioactive Waste Management

DOE 6430.1A, 1989, General Design Criteria

DOE/EH-24, in press, Environmental Assessment of the Waste Isolation Pilot Plant (1993): Office of Environment, Safety, and Health/Environmental Audits

DOE/EH-0173T, 1991, Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance.

DOE/EIS-0026-FS, 1990, Final Supplement Environmental Impact Statement, Waste Isolation Pilot Plant, U. S. Department of Energy, Office of Environmental Restoration and Waste Management.

DOE/EML HASL 300, 1992, Environmental Measurements Laboratory Procedures Manual, Volume 1, 27th Edition.

DOE/EP-0023, Corley et al., 1981, A Guide for Environmental Radiological Surveillance at U.S. Department of Energy Installations, U.S. Department of Energy, Washington, D.C.

DOE/HWP-65/R, Rev. 1, July 1990, Hazardous Waste Remedial Actions Program Requirements for Quality Control of Analytical Data.

DOE/NVO/0410, 1978, Gnome Site Decontamination and Decommissioning - Phase 1 Radiological Survey and Operations Report, Carlsbad, New Mexico: Reynolds Electric and Engineering Co., Inc. unpublished report CN#-76-C-08-0410.

DOE/WIPP 85-002 (Fischer), et al., 1985, Ecological Monitoring Program at the Waste Isolation Pilot Plant: Semi-Annual Report for Calendar Year 1985.

DOE/WIPP 86-006 (Uhland and Randall), 1987, Annual Water Quality Data Report for the Waste Isolation Pilot Plant (September, 1986).

DOE/WIPP 87-002 (Fischer), et al., 1987, Annual Site Environmental Monitoring Report for the Waste Isolation Pilot Plant: Calendar Year 1986.

DOE/WIPP 87-003 (Fischer), et al., 1987, Ecological Monitoring Program at the Waste Isolation Pilot Plant: Annual Report for Calendar Year 1986.

DOE/WIPP 87-004, Compilation of Historical Radiological Data Collected in the Vicinity of the WIPP Site: Westinghouse Electric Corporation.

DOE/WIPP 87-006 (Uhland), et al., 1987, Annual Water Quality Data Report for the Waste Isolation Pilot Plant (March 1987).

DOE/WIPP 88-006 (Randall), et al., 1988, Annual Water Quality Data Report for the Waste Isolation Pilot Plant (May 1988).

DOE/WIPP 88-008 (Fischer), et al., 1988, Ecological Monitoring Program at the Waste Isolation Pilot Plant: Annual Report for Calendar Year 1987.

DOE/WIPP 88-009 (Flynn), et al., 1988, Annual Site Environmental Monitoring Report for the Waste Isolation Pilot Plant: Calendar Year 1987.

DOE/WIPP 88-025 (Mercer et al.), 1989, Operational Environmental Monitoring Plan for the Waste Isolation Pilot Plant.

DOE/WIPP 89-001 (Lyon), 1989, Annual Water Quality Data Report for the Waste Isolation Pilot Plant (June 1989).

DOE/WIPP 89-005 (Flynn), et al., 1989, Annual Site Environmental Report (SER) for the Waste Isolation Pilot Plant: Calendar Year 1988.

DOE/WIPP 90-003, 1991, Annual Site Environmental Report for the Waste Isolation Pilot Plant: Calendar Year 1989.

DOE/WIPP 90-008, 1990, Groundwater Protection Management Plan.

DOE/WIPP 91-008, 1991, Annual Site Environmental Report for the Waste Isolation Pilot Plant: Calendar Year 1990.

DOE/WIPP 92-007, 1993, Annual Site Environmental Report for the Waste Isolation Pilot Plant: Calendar Year 1991.

DOE/WIPP 92-037, 1992, Statistical Summary of the Radiological Baseline Program for the Waste Isolation Pilot Plant in DOE/WIPP 92-007, WIPP Site Environmental Report for CY 1991.

DOE/WIPP 94-024, 1994, Waste Isolation Pilot Plant Environmental Monitoring Plan (during draft review document identified as DOE/WIPP 92-040).

DOE/WIPP 91-058, 1993, Radionuclide Inventory for the Waste Isolation Pilot Plant Rev. 0

DOE WP 02-1, 1992, Ground Water Monitoring Program Procedures Manual: Waste Isolation Pilot Plant Control Document Rev. 2.

DOE WP 02-3, 1991, Environmental Procedures Manual: Waste Isolation Pilot Plant Control Document Rev. 1.

DOE WP 02-9 (FSAR) Final Safety Analysis Report, May 1990, Rev. 0.

DOE WP 12-5, Radiation Safety Manual: Waste Isolation Pilot Plant Control Document, Rev. 0.

EEG-49: Kenney, J.M., 1991, Preoperational Radiation Surveillance of the WIPP Project by EEG during 1990: Environmental Evaluation Group 80 p.

EG&G, 1989, An Aerial Radiological Survey of the Waste Isolation Pilot Plant; EG&G Survey Report AMO-8809 17p.

EPA, 1975, Interim Radiochemical Methodology for Drinking Water: Environmental Monitoring and Support Laboratory: EPA-600-4-75-0000.

EPA, 1979, Handbook for Analytical Quality Control in Water and Waste Water Laboratories: EPA 600-4-79-019.

EPA, 1986 (Revised 1990), "Test Methods for Evaluating Solid Wastes"-SW-846.

EPA, 1987, Office of Solid Waste and Emergency Response, Data Quality Objectives for Remedial Response Activities Development Process: EPA 541-G-87- 003.

EPA, 1987, Quality Assurance Program Plan: U.S. Environmental Protection Agency Report EPA/600/X-87/241, EMSL, P.O. Box 93478, Las Vegas Nevada 89193-3478.

EPA, 1989, Off-Site Environmental Monitoring Report: U.S. Environmental Protection Agency Report EPA/600/4-89/019, EMSL, P.O. Box 93478, Las Vegas Nevada 89193-3478.

EPA, 1990, Conditional No-Migration Determination for the Department of Energy Waste Isolation Pilot Plant (WIPP): Environmental Protection Agency Final No-Migration Determination; Federal Register FRL-3860-1; V. 55, No. 220.

EPA, 1993, High Level and Transuranic Wastes: Background Information Document for Proposed Amendments: EPA 402-R-93-007.

Jones, T.L., Kelley, V.A., Pickens, J.F., Upton, D.T., Beauheim, R.L., and Davies, P.B., 1992, Integration of Interpretation Results of Tracer Test Performed in the Culebra Dolomite at the Waste Isolation Pilot Plant Site: Sandia National Laboratory Report SAND92-1579.

Mercer, J.W., 1983, Geohydrology of the Proposed Waste Isolation Pilot Plant Site, Los Medanos Area, Southeastern New Mexico: U.S. Geological Survey Water-Resources Investigations Report 83-4016 178p.

Mercer et al., 1989, Operational Environmental Monitoring Plan: DOE/WIPP-88-025.

NCRP45, 1975, National Council on Radiation Protection and Measurements Report on Background Radiation.

NRC Regulatory Guide 4.5, 1974, Measurements of radionuclides in the Environment--Sampling and Analysis of Plutonium in Soil: U.S. Regulatory Commission.

Odum, E.P., 1971, Third Edition, "Fundamentals of Ecology".

OEMP, 1988, Operational Environmental Monitoring Plan: DOE/WIPP 88-025.

Prill , S.D. and Buckle, G.R. 1988, Guidance Manual, Surface Water and Sediment Sampling for the Environmental Monitoring Programs, WIPP, DOE/WIPP 88-007.

Sanchez, P.E. and McCasland, P.W, 1993, Assessment of Solid Waste Management Units, Supporting Documentation for WIPP RCRA Facility Assessment: NMED/WIPP 94-001 & NMED/DOE/AIP-94/1 (State of New Mexico/Department of Energy Agreement-in-Principle).

SAND 84-2233 (Hunter), R.L., 1985, A Regional Water Balance for the Waste Isolation Pilot Plant (WIPP) Site and Surrounding Area; Sandia National Laboratories.

SAND 89-7147 (Brinster), K. B., 1991, Preliminary Geohydrologic Conceptual Model of the Los Medanos Region Near the Waste Isolation Pilot Plant for the Purpose of Performance Assessment: Sandia Contractor Report SAIC 200 p.

SAND 92-0070, 1992, Preliminary Performance Assessment for the Waste Isolation Pilot Plant-V. 1: Third Comparison with 40 CFR 191, Subpart B: Sandia National Laboratory Report SAND92-0070/1.

Seigal M.D., Lambert S.J., and Robinson K.L., 1991, Hydrogeochemical Studies of the Rustler Formation and Related Rocks in the WIPP area: Sandia National Laboratory Report SAND88-0196.

Steinbruegge, K., 1991, Safety Assessment Report - The Inventory of Radioactive Material in the Event of Underground Accident at the Point of Release and it's Pathway to Station "A" and the Consequence Off-Site Dose to the Public: unpublished report.

Thompson, D.J., 1988, Environmental Thermoluminescent Dosimetry Measurements at the WIPP Site, 1976 - 1985: Sandia National Laboratory Report SAND 87-0843.

APPENDICES

APPENDIX 5.0

TERRESTRIAL RADIOLOGICAL SURVEILLANCE

Appendix 1.1
Statistical Summary and MDLs for Soil Radiological Baseline Program (after DOE/WIPP 92-007)

Radio-nuclide	Group	MDL	n	Mean		s.e.	s	c.v.
^{40}K	O	---	35	340	+/-	20	130	0.38
	R	---	79	180	+/-	10	60	0.33
	W	---	33	200	+/-	10	30	0.15
^{60}Co	ALL	3.7	114	< 2.4		N/A	N/A	N/A
^{90}Sr	ALL	74	145	0.06	+/-	0.06	0.78	13
^{137}Cs	O	3.7	24	8.1	+/-	1.3	6.3	0.78
	R/W	3.7	121	4.7	+/-	0.4	4.9	1.04
^{226}Ra	O	7.4	35	20	+/-	2	10	0.50
	R/W	7.4	111	9.6	+/-	0.2	2.2	0.23
^{228}Ra	ALL	---	144	< 80		N/A	N/A	N/A
^{228}Th	O	3.7	35	18	+/-	2	9	0.50
	R/W	3.7	112	7.8	+/-	0.2	2.5	0.32
^{230}Th	O	3.7	24	19	+/-	5	26	1.37
	R/W	3.7	129	9.1	+/-	0.8	9.1	1.00
^{232}Th	ALL	3.7	154	11	+/-	1	13	1.18
^{233}U	ALL	3.7	145	0.02	+/-	0.04	0.55	27.50
^{234}U	O	3.7	25	12	+/-	1	7	0.58
	R	3.7	96	6.8	+/-	0.5	5.3	0.78
	W	3.7	32	5.4	+/-	0.2	1.4	0.26
^{235}U	O	---	17	0.63	+/-	0.17	0.70	1.11
	R	---	96	0.40	+/-	0.04	0.41	1.02
	W	---	32	0.16	+/-	0.06	0.34	2.12
^{238}U	O	3.7	25	11	+/-	1	6	0.54
	R	3.7	96	5.9	+/-	0.2	2.4	0.41
	W	3.7	33	5.7	+/-	0.3	1.6	0.28
^{237}Np	ALL	3.7	154	-0.03	+/-	0.03	0.35	11.67

Appendix 1.1
(Continued)

Radio-nuclide	Group	MDL	n	Mean		s.e.	s	c.v.
^{238}Pu	ALL	15	145	-0.1	+/-	0.1	1.1	11.00
$^{239/240}$Pu	ALL	7.4	145	0.20	+/-	0.06	0.73	3.65
^{241}Pu	ALL	370	145	160	+/-	50	560	3.50
^{241}Am	ALL	3.7	58	1.7	+/-	0.3	2.0	1.18
^{244}Cm	ALL	3.7	58	0.21	+/-	0.11	0.83	3.95

Abbreviations:
Groups: O - Outer Sites; R - Five-mile Ring; W - WIPP Site
MDL - Minimum Detection Limit
n - Sample size
s.e. - Standard error
s - Standard deviation
c.v. - Coefficient of variation
N/A - Not Applicable

Units are in Becquerels per gram x 10^{-3}

Supplementary definitions of sample locations:

O - Regional Locations
R - Mid-Field Locations
W - Near-Field Locations

Appendix 1.2
Statistical Summary and MDLs for Surface Water Radiological Baseline Program (after DOE/WIPP 92-007)

Radio-nuclide	Group	MDL	n	Mean		s.e.	s	c.v.
^{3}H	ALL	56	41	-26	+/-	7	43	1.65
^{40}K	TANKS/PECOS	---	39	< 100	+/-	10	80	0.80
	LGS	---	5	10000	+/-	1000	2000	0.20
^{60}Co	ALL	3.0	44	< 13		N/A	N/A	N/A
^{90}Sr	ALL	7.4	43	0.28	+/-	0.08	0.52	1.86
^{137}Cs	ALL	1.9	44	< 6.9		N/A	N/A	N/A
^{226}Ra	ALL	5.6	40	< 4.8	+/-	1.1	7.2	1.5
^{228}Ra	ALL	---	40	< 8.4	+/-	0.6	3.9	0.46
^{228}Th	ALL	3.7	40	< 2.3	+/-	0.3	2.2	0.96
^{230}Th	ALL	0.37	44	0.10	+/-	0.04	0.29	2.9
^{232}Th	ALL	0.37	44	0.032	+/-	0.013	0.087	2.72
^{233}U	TANKS	0.37	23	-0.016	+/-	0.008	0.040	2.5
	LGS	0.37	5	0.07	+/-	0.06	0.12	1.71
	PECOS	0.37	16	0.001	+/-	0.013	0.053	53.00
^{234}U	TANKS	0.37	23	0.11	+/-	0.04	0.19	1.73
	LGS	0.37	5	5.7	+/-	1.5	3.3	0.58
	PECOS	0.37	16	1.2	+/-	0.2	0.7	0.58
^{235}U	TANKS	---	22	0.006	+/-	0.004	0.020	3.33
	LGS	---	5	0.13	+/-	0.04	0.09	0.69
	PECOS	---	15	0.045	+/-	0.009	0.036	0.80
^{238}U	TANKS	0.37	22	0.046	+/-	0.012	0.054	1.17
	LGS	0.37	5	2.8	+/-	0.7	1.6	0.57
	PECOS	0.37	16	0.56	+/-	0.06	0.22	0.39
^{237}Np	ALL	0.37	41	0.003	+/-	0.005	0.035	11.67
^{238}Pu	ALL	0.11	44	-0.004	+/-	0.013	0.085	21.25
$^{239/240}$Pu	ALL	0.74	44	-0.006	+/-	0.006	0.041	6.83
^{241}Pu	ALL	37	44	9	+/-	2	13	1.44

Abbreviations:
MDL - Minimum Detection Limit
s.e. - Standard error
c.v. - Coefficient of variation
N/A - Not Applicable
n - Sample size
s - Standard deviation
LGS - Laguna Grande de la Sal

Units are in Becquerels per gram x 10^{-4}

Appendix 1.3
Statistical Summary and MDLs for Sediment Radiological Baseline Program (after DOE/WIPP 92-007)

Radio-nuclide	Group	LGS	MDL	n	Mean		s.e.	s	c.v.
^{40}K	TANKS	+	---	12	670	+/-	60	220	0.33
	PECOS	-	---	8	210	+/-	20	60	0.28
^{60}Co	ALL	+	3.7	20	< 2.6		N/A	N/A	N/A
^{90}Sr	ALL	+	74	20	1	+/-	5	23	23.00
^{137}Cs	TANKS	-	3.7	9	16	+/-	3	8	0.50
	PECOS	+	3.7	11	1.2	+/-	0.4	1.4	1.17
^{226}Ra	TANKS	-	7.4	9	30	+/-	2	6	0.20
	PECOS	+	7.4	11	17	+/-	2	6	0.35
^{228}Ra	TANKS	-	---	9	< 39		N/A	N/A	N/A
	PECOS	+	---	11	< 12		N/A	N/A	N/A
^{228}Th	TANKS	-	3.7	9	31	+/-	2	5	0.16
	PECOS	+	3.7	11	9.0	+/-	1.3	4.5	0.50
^{230}Th	ALL	+	3.7	20	1.7	+/-	0.4	2.0	1.18
^{232}Th	ALL	+	3.7	20	2.1	+/-	0.6	2.7	1.28
^{233}U	ALL	+	3.7	20	0.39	+/-	0.22	0.98	2.51
^{234}U	ALL	+	3.7	20	22	+/-	5	22	1.00
	ALL	-	3.7	17	16	+/-	1	4	0.25
^{235}U	ALL	+	---	20	0.97	+/-	0.21	0.97	1.00
^{238}U	ALL	+	3.7	20	17	+/-	2	10	0.59
^{237}Np	ALL	+	3.7	20	-0.04	+/-	0.06	0.27	6.75
^{238}Pu	ALL	+	15	20	0.1	+/-	0.3	1.2	12.00
$^{239/240}Pu$	ALL	+	7.4	20	0.36	+/-	0.15	0.66	1.83
^{241}Pu	ALL	+	370	20	50	+/-	60	280	5.60

Abbreviations:
- LGS - Laguna Grande de la Sal, data included (+) or excluded (-)
- MDL - Minimum Detection Limit
- n - Sample size
- s.e. - Standard error
- s - Standard deviation
- c.v. - Coefficient of variation
- N/A - Not Applicable

Units are in Becquerels per gram x 10^{-3}