FINAL REPORT

Independent Technical Audit of Los Alamos National Laboratory for Compliance with the Clean Air Act, 40 CFR 61, Subpart H in 1999

DOJ File Number: 90-5-1749A
Case Name: *CCNS v DOE*

December 2000

"Setting the standard in environmental health"

RAC

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EXECUTIVE SUMMARY

This report documents results of the second independent audit of Los Alamos National Laboratory regarding compliance with the Clean Air Act, 40 CFR 61, Subpart H for the year 1999. It is concluded that Los Alamos National Laboratory was in compliance with 40 CFR 61, Subpart H for the year 1999. The offsite dose limit under the Clean Air Act regulation is 10 mrem yr^{-1} (0.1 mSv yr^{-1}), and Los Alamos National Laboratory reported a dose for 1999 of 0.32 mrem (3.2 μSv). This dose was confirmed by independent audit team calculations.

This audit was conducted by an audit team led by Dr. John E. Till and other members of the *Risk Assessment Corporation* research team as part of a settlement agreement and Consent Decree that resolved a lawsuit filed by Concerned Citizens for Nuclear Safety against the U.S. Department of Energy and Siegfried S. Hecker, a former Laboratory Director. A separate independent group, the Institute for Energy and Environmental Research, monitored the audit for completeness, quality, and thoroughness on behalf of Concerned Citizens for Nuclear Safety.

The audit team divided its work into four distinct areas that address the major elements of the compliance program. These areas were:

- The radionuclide survey and associated emission data for unmonitored sources
- Effluent monitoring of major release points to air
- Environmental compliance sampling for non-point sources
- Dose calculations

A number of general issues, in addition to specific regulatory requirements, were evaluated for each area, including traceability of data to their original source, documentation supporting compliance, technical competence, quality assurance, and overall confidence of the audit team in the compliance program. Thus the audit encompassed a scope much broader than a typical evaluation for regulatory compliance.

The audit team noted some aspects of the compliance program that could be improved and made a number of recommendations to this end. Examples include increasing automation for compilation of radionuclide usage and calculation of associated emission estimates, improving the quantitative criteria by which environmental samplers are located, revising the methodology by which some specific radionuclide usage and emission estimates are made, and producing a technical summary to accompany the dose assessment annual report.

The public's role in the audit process was critical. The positive interaction between the audit team, Los Alamos National Laboratory, the Institute for Energy and Environmental Research, Concerned Citizens for Nuclear Safety, and other participants confirmed that members of the public can and should play an important role where regulations related to public exposures are concerned.

The audit team commends the Laboratory for addressing the findings of the first audit and also for the concerted effort they have put forth during this audit to make it an open, thorough, and responsive process. Credit for this achievement is also due to Concerned Citizens for Nuclear Safety, who, as a citizens' organization, helped initiate the audit and design its format.

It is noteworthy that this audit was conducted under unusually difficult circumstances created by the Cerro Grande Fire that occurred in May of 2000 and critical issues with regard to security at the Los Alamos National Laboratory throughout this year. The audit's success is a direct reflection of the professionalism and dedication to this process by all involved parties.

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INDEPENDENT AUDIT OF LOS ALAMOS NATIONAL LABORATORY FOR COMPLIANCE WITH THE CLEAN AIR ACT, 40 CFR 61, SUBPART H IN 1999

FINDING

This audit concludes that Los Alamos National Laboratory was in compliance with 40 CFR 61, Subpart H for the year 1999. The audit team commends the Laboratory for their implementation of the recommendations provided in the first audit and also the exemplary spirit of cooperation they have shown during this audit to make it an open, thorough, and responsive process. Several suggestions for continued improvement are detailed within this report.

INTRODUCTION

On January 21, 1997, the U.S. Department of Energy (DOE), Siegfried S. Hecker, and the Concerned Citizens for Nuclear Safety (CCNS) reached an agreement to settle a suit filed by CCNS (CCNS v. DOE, D.N.M. Civ. No. 94-1039M) concerning the status of compliance of Los Alamos National Laboratory (LANL) with 40 CFR 61.90–61.97, Subpart H, *National Emission Standards for Emissions of Radionuclides Other Than Radon From Department of Energy Facilities* (http://www.epa.gov/docs/epacfr40/chapt-1.info/subch-C/40P0061/40P0061H.pdf). As part of that agreement, referred to as the Consent Decree (http://drambuie.lanl.gov/~AirQuality/CD_text.htm), a series of comprehensive technical audits were to be performed. The first audit, covering the year 1996, began in June 1997 and a draft report was issued in May of 1998. The final report on the first audit was issued in November 1999.[1] The findings of the first audit indicated that LANL was not in compliance with 40 CFR 61, Subpart H.

The second audit began in June 2000 and covered compliance for the year 1999. A third audit, if necessary, is scheduled to begin in 2002 for evaluating compliance for calendar year 2001. The audit team has evaluated the need for a third audit in consultation with all parties involved, and has determined that this audit will take place as scheduled. As stated in the Consent Decree, the purpose of these technical audits is to verify whether LANL is in compliance with the Clean Air Act, 40 CFR 61, Subpart H, set forth in the Code of Federal Regulations (CFR). It was agreed in the settlement that *Risk Assessment Corporation (RAC)* would conduct the audits as the independent auditor. Dr. John E. Till, president of *RAC*, assembled a multidisciplinary team of scientists, the Independent Technical Audit Team (ITAT), for this purpose.

The audit was observed and monitored by a separate independent group on behalf of CCNS, the Institute for Energy and Environmental Research (IEER), to ensure the audit was objective and comprehensive. IEER neither performed a separate audit nor were they responsible for the results of the audit. Their role was to monitor the audit for completeness, quality, and thoroughness.

The Laboratory has made significant changes and improvements in its compliance program since the first audit. Many of these changes respond directly to recommendations that were outlined in our first audit report. We explain these changes later. Further, we commend LANL for considering our recommendations and implementing so many of them. As a result, the current program for compliance is significantly improved.

This audit concludes that Los Alamos National Laboratory is in compliance with 40 CFR 61, Subpart H for the year 1999. The audit team commends LANL for their implementation of recommendations provided in the first audit and also the exemplary spirit of cooperation they have shown during this audit to make it an open, thorough, and responsive process. Furthermore, the Rad-NESHAP compliance program at LANL and this audit process could be considered as a model for other DOE facilities. Credit for this achievement is due to CCNS, who, as a citizens' organization and plaintiff in a lawsuit against DOE, helped to initiate the audit and designed its format.

It is noteworthy that this audit was conducted under unusually difficult circumstances created by the Cerro Grande Fire that occurred in May of 2000 and other important issues with regard to security at LANL throughout this year. The audit's success is a direct reflection of the professionalism and dedication to this process by all participating parties. The audit team expresses its appreciation for the spirit of cooperation that made this audit possible.

Background

The Los Alamos National Laboratory is a Department of Energy facility located in Los Alamos County in north-central New Mexico. The Laboratory is located atop a mesa and is surrounded by canyons, making the topography of the site very complex. The primary mission of this facility has always been research and development of nuclear weapons, including weapons development, fission and fusion, and weapons safety. Along with conducting nuclear weapons research goes the responsibility of maintaining environmental controls to limit the release of radionuclides into the environment. These controls and the practice and procedures that accompany them are some of the questions around which this audit was focused.

Figure 1 is a map of the LANL site. This map indicates some of the major release points to air for offsite dose calculations, the locations of major unmonitored point sources, and the locations of some of the environmental samplers used to demonstrate compliance with the 40 CFR 61, Subpart H, regulations.

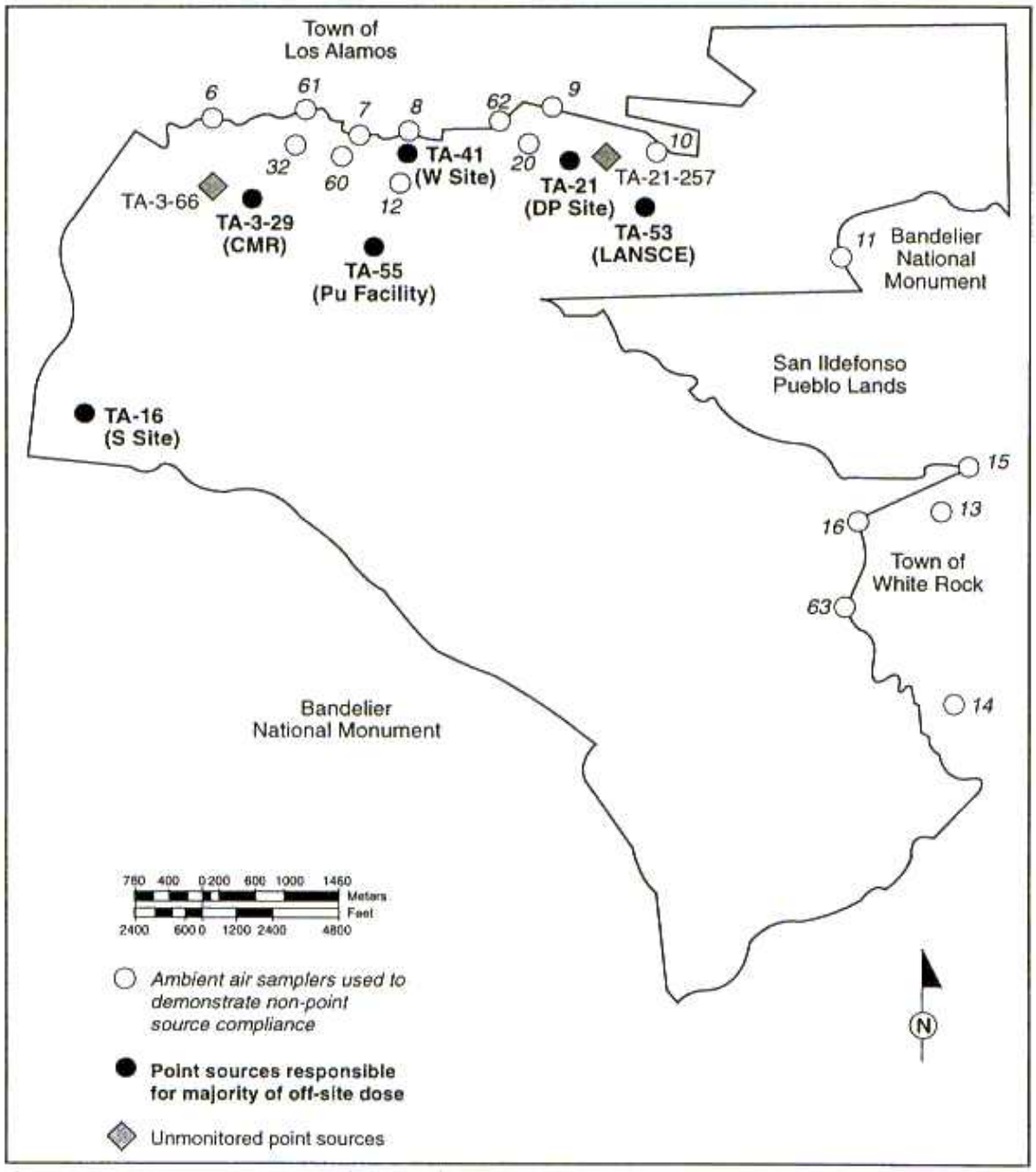

Figure 1. Los Alamos National Laboratory site.

The facilities identified in this figure are the major release points to air, which are discussed at length in the chapter titled "Stack Sampling and Monitoring Evaluation." The Los Alamos Neutron Science Center, or LANSCE, is located at Technical Area (TA)-53 and has traditionally been the biggest contributor to offsite dose at LANL, although this was not true for 1999, as will be described in this report.

For purposes of compliance, the offsite dose must be calculated at the location of maximum dose where a person could reside. The process of calculating dose is described in more detail in the chapter titled "Dose Assessment Evaluation." The location of maximum offsite dose for 1999

was near the sampler numbered 32 in Figure 1. This location, which can change from year to year, is commonly referred to as the maximally exposed individual, or MEI, for LANL.

The Independent Technical Audit Team

Because of the multidisciplinary nature of the audit, the audit team included scientists with a variety of backgrounds. These scientists had a broad range of skills including effluent monitoring, environmental surveillance, quality assurance, dose assessment and modeling, and source term development. The *curriculum vitae* of key scientists on the audit team were included in an appendix to the proposal submitted at the beginning of the audit and are available for review.

The audit team included scientists who are members of the *RAC* research team. *RAC* focuses on research related to risk associated with chemicals and radionuclides released to the environment. Although *RAC's* headquarters are located in South Carolina, *RAC* team scientists live in different parts of the country, and each team member operates as an independent consultant. Key scientists on the audit team are listed below along with a description of the areas on which they focused during the audit.

- John E. Till, audit team leader
- H. Justin Mohler, radionuclide inventory and associated emission calculations, dose calculation methodology
- Paul G. Voillequé, stack monitoring and emissions
- Jill W. Aanenson, environmental monitoring and diffuse source emissions, dose calculation methodology, and quality assurance
- Steven J. Maheras, dose calculation verification
- Arthur S. Rood, CAP-88 and CALPUFF comparison calculations.

For the most part, these scientists evaluated the same areas in both the first and second audits, which streamlined the process considerably for the second audit.

Purpose and Scope of Audit

The audit of LANL focused on issues and procedures that demonstrated the Laboratory's state of compliance with the Clean Air Act as presented in 40 CFR 61.90–61.97. In 1994, a memorandum of understanding (MOU) was approved by DOE and the U.S. Environmental Protection Agency (EPA) addressing the need for facilities to reach an agreement with their regional EPA office on action necessary to achieve compliance. The Federal Facilities Compliance Agreement[2] (FFCA) was drafted jointly by DOE and EPA Region VI in an attempt to bring LANL into compliance by providing some guidance for aspects of the compliance program not well defined in the Clean Air Act.

The scope of work for this technical audit was drafted by *RAC*. The scope of work stated that:

> This work will be performed independently by the audit team and the full cooperation of DOE, LANL, CCNS, and any other participants is expected. It is should also be understood that this audit is the result of a legal settlement resulting from litigation brought about by CCNS, an environmental organization based in Santa Fe and

> representing the concerns of citizens residing near the Los Alamos National Laboratory. Therefore, to the greatest extent possible, the audit will be an open and fully documented process, providing both LANL and CCNS information that can be readily understood and traceable. Further, *RAC* recognizes the important role that will be played by the Institute for Energy and Environment Research (IEER), as a separate, independent group, responsible for monitoring the audit as it progresses. Therefore, throughout the course of the audit, we (will) provide whatever is necessary to allow IEER to fulfill its objectives.

The audit scope included a number of tasks that *RAC* committed to complete. These tasks involved data gathering, a draft report, a final report, and holding workshops and public meetings. The audit team assessed four technical methods by which LANL demonstrates compliance:

- Radionuclide inventory for unmonitored point sources
- Major release point effluent monitoring
- Environmental compliance sampling for non-point sources
- Dose calculation.

The audit team also reviewed the quality assurance plan to examine how the quality assurance plans were implemented for the procedures that affect the compliance calculations. Therefore, quality assurance procedures were assessed by each member of the audit team for that member's area, and the assessments are presented in their respective report chapters. One universal quality assurance issue is discussed in the "Quality Assurance Evaluation" chapter of this report.

The quality assurance, radionuclide inventory, effluent monitoring, environmental sampling, and dose calculation chapters of this report present conclusions drawn by the audit team about LANL's compliance status.

One of the primary reasons to have independent scientists conducting the audit was to ensure that it addressed issues of scientific and technical merit as they applied to the compliance regulations. This audit was designed not to only verify compliance with regulations but also to assess whether the methodology chosen by LANL to demonstrate compliance was scientifically valid and defensible.

The scope of the audit was well defined and maintained, but the auditors also addressed several outstanding issues that were peripheral to the scope of the audit but of interest from a technical standpoint, relating to both adequacy and credibility of the compliance program. These issues included neutrons, the Neighborhood Environmental Watch Network (NEWNET) monitoring system, and complex terrain modeling. These issues are discussed in the chapter titled "Issues Peripheral to the Scope of the Audit."

Compliance as Defined by This Audit

Many important facets of compliance are discussed in the regulation. Most importantly, a facility must achieve a dose to the MEI below 10 millirem per year (mrem yr^{-1}) (0.1 milliSievert

per year or mSv yr^{-1}).[a] The regulation also contains many other requirements, such as measurement methods, procedures, quality assurance, and documentation that must be met for a facility to be in compliance.

As in the first audit report, we classified our findings into three categories: (1) regulatory deficiencies, (2) technical or scientific deficiencies, and (3) additional observations. Not all technical evaluation chapters identify findings for each category and some chapters may contain multiple findings.

A regulatory deficiency is a finding that tracks directly to a regulation or requirement that was not met by the Laboratory for the year 1999. This report cites and paraphrases the regulation, identifies the application to the LANL procedure, and assesses the compliance status. There were no regulatory deficiencies noted in this second audit.

Technical or scientific deficiencies are items related to the Laboratory's compliance program that are not specifically noted in the regulation but are critical to having a valid and defensible compliance program. Although not specifically outlined in 40 CFR 61, Subpart H, these technical issues directly affect the Laboratory's ability to demonstrate compliance.

Additional observations point out practices for which the audit team recommends improvement or clarification. These issues are not noted or implied in the regulation, but they relate to good scientific practice and need to be addressed by the Laboratory.

A complete list identifying all findings is included in Appendix A.

We have also included a section before the evaluation chapters to point out key areas where LANL has implemented significant changes in the program as a result of the first audit, for the year 1996. We were very impressed with the Laboratory's commitment to improvement and quality based on the recommendations of the first audit.

Summary of 40 CFR 61, Subpart H and the Federal Facilities Compliance Agreement

A great deal of history accompanies the development of radionuclide standards for inclusion in the Clean Air Act. While we will not outline that entire history in this report, we did include that detail in the first audit report,[3] which is available via the worldwide web at (http:\\drambuie.lanl.gov\~AirQuality\RACdocuments.htm).

The final radionuclide emission standards included in the Clean Air Act were published on December 15, 1989. The radionuclide emission standard for DOE facilities was established as 10 mrem yr^{-1} (0.1 mSv yr^{-1}); that is, emissions must be such that the resulting dose to any member of the public is less than this amount. The standard was codified in 40 CFR 61, Subpart H, *National Emission Standards for Emissions of Radionuclides Other Than Radon From Department of Energy Facilities*.

The regulatory guidance in 40 CFR 61, Subpart H, is designed to provide the rules that facilities must follow and guidance for the techniques that might be used to achieve compliance. These rules have some flexibility because the EPA can grant prior approval for alternative methodologies that the facility intends to use.

[a] Throughout this report, we have redefined all units in their SI equivalent for universal readability, where applicable. In some cases, such as the discussion of a cited document, it was not appropriate to offer the conversion.

In 1991, the EPA conducted an audit of LANL's compliance status with 40 CFR 61, Subpart H. This EPA audit concluded that LANL was not in compliance with the 10 mrem yr^{-1} (0.1 mSv yr^{-1}) standard. In 1992, EPA issued a second notice of noncompliance to LANL and DOE. In 1994, DOE and EPA drafted a Memorandum of Understanding (MOU) that addressed the need for DOE facilities to reach an agreement with regional EPA offices regarding compliance. This MOU and the EPA audit findings brought about the development of the FFCA between LANL and the EPA.

In 1996, LANL and DOE negotiated the FFCA, which was submitted to and approved by the EPA. This document provides more explicit guidance for the methodology to be used by LANL to implement their compliance programs as required by 40 CFR 61. In some cases, the FFCA constitutes prior approval for LANL to use alternate methodologies. In other cases, it simply identifies a more detailed discussion of the prescribed techniques identified in 40 CFR 61, Subpart H. The existence of the FFCA does not constitute compliance, but it provides LANL more detailed direction on methods to achieve compliance.

Part of the focus of the lawsuit that initiated the audit was a disagreement that CCNS had with the FFCA. Although a public comment period followed the release of a draft version of the FFCA, there was little opportunity for public input into the creation of the FFCA. In the eyes of the public, the credibility of the FFCA was compromised by not including the public in the process of drafting the FFCA.

Nonetheless, the FFCA is an important part of the compliance process. Regulatory guidance is very limited for certain release scenarios that are important at LANL. The Laboratory needed a framework for assessing the environmental impacts of releases for which compliance procedures either did not exist or were unclear. The FFCA provides this framework.

During the course of the first audit, the audit team reviewed the FFCA and found it, with one exception, to be technically sound.[4] We made recommendations to the Laboratory regarding this issue of sampler siting, and will discuss that issue in the context of the Non-Point Source Monitoring Evaluation chapter of this report. During both audits, IEER challenged the technical validity of the FFCA with regard to its treatment of environmental transport and dose modeling. Although the Clean Air Act regulation allows the use of CAP-88 for compliance modeling, the FFCA makes it a standard at LANL. We find no technical problem with the FFCA, but we strongly encourage LANL to use the results of the complex terrain modeling comparison completed for this audit and carefully assess the need for further model evaluation.

AUDIT PROCESS

For the LANL audit, the team used a combination of different methods to gather and analyze information. The audit team visited Los Alamos, New Mexico, on a number of different occasions, touring facilities, talking with the LANL staff, and reviewing records. The audit team performed independent calculations to verify dose estimates and to determine the validity of assumptions made. Information retrieved in tours, document review, and interviews were carefully logged in the researchers' personal notes. Although some work was carried out at the site, most analyses and reviews of documentation were performed at the individual offices of audit team members. The audit team believed this approach allowed it to thoroughly evaluate relevant aspects of LANL's compliance-related programs. Additionally, this evaluation was more detailed than a typical audit because the scientific and technical merit of each element of the program was closely examined.

In many cases, records to review were identified and sent to the audit team project leader for further distribution to the *RAC* team. A list of all documents requested and received during the audit is included as Appendix B. To keep the IEER scientists informed of materials the audit team was requesting from LANL, Laboratory staff sent two duplicate copies of each document to CCNS, who forwarded one copy to IEER. At the same time, questions raised by IEER were distributed to *RAC*, and an attempt was always made to be certain that LANL personnel also received a copy. A list of all IEER, CCNS, and public issues raised during the second audit is included in Appendix C. These issues are discussed in individual technical chapters of this report or treated within the context of the appendix. The audit team worked to keep all parties informed of issues it was reviewing at every step of the audit.

During visits to the site, the audit team held meetings with LANL staff, CCNS, and IEER to discuss plans for the visit and to summarize findings at the end of each visit. These meetings were open to any individuals who wished to attend.

The audit team substantiated its findings through facts discovered during its review of records, interviews, and facility tours documented in this report. Particular effort was placed upon citing areas in the regulation with regard to how compliance should be met. In some cases, the regulation is not entirely clear with regard to specific issues that affected the audit. In these cases, the audit team used its best judgment and attempted to be fair and unbiased. The audit team, CCNS, and IEER have identified areas where the regulation is not clear and forwarded these issues to the EPA for clarification in future revisions of the regulation. Our communication with the EPA is shown in Appendix D.

Layout and Purpose of Site Visits

The audit team planned and coordinated site visits through a joint effort with LANL, CCNS, and IEER. The audit team generally visited the site for three to four days at a time to gather information and tour facilities. Although different members of the team concentrated on different issues during the audit, site visits were planned to accommodate the interests of all concerned parties. Schedules and objectives for the visits were arranged and distributed to the appropriate people before the visits. Members of the public who participated in visits and tours were kept informed of progress through meetings at the beginning of each scheduled visit and summary meetings at the close of the day.

Site visits served as the primary information gathering mechanism for the audit team. Relevant documents were identified, interviews were conducted, and facilities were toured. A number of processes and procedures were observed. Through the site visits, the audit team gained a good knowledge of the methods by which LANL demonstrates compliance. More conventional audits are generally conducted with a single site visit and observational time. The audit team felt that scheduling multiple site visits with a chance to work, digest information, and read documents between the visits enhanced the value of the time spent at LANL. This type of schedule streamlined the entire process and contributed to a more productive team effort and a more thorough audit.

LANL and IEER personnel accompanied the audit team members when they toured a facility. Additionally, invitations were extended to the public to attend these tours, and several individuals used this opportunity. We would like to particularly commend members of the Pueblo of San Ildefonso and the State of New Mexico staff for their participation in the audit tours and meetings. The audit team recognized that considerable preparation was required on the part of the Laboratory to meet security requirements and allow the audit to be conducted with unprecedented openness. Considerable credit is given to DOE and LANL staff for their cooperation in this regard. At no point during the audit were members of the audit team denied access to facilities that we thought it necessary to visit. Table 1 lists the facilities visited.

Table 1. Facilities Visited During Audit Tours

Facility	Tour date	Purpose of tour
TA-21-155	August 22, 2000	Stack monitoring
TA-21-213	August 22, 2000	Radionuclide survey
TA-33-86	August 22, 2000	Stack monitoring
TA-53	August 22, 2000	Stack monitoring
TA-48-1	August 23, 2000	Stack monitoring and survey
TA-59-1	August 23, 2000	Radionuclide survey
TA-50-69	August 23, 2000	Radionuclide survey
TA-54-33 and -36	August 24, 2000	Radionuclide survey
TA-3-16	August 24, 2000	Radionuclide survey
TA-54-1001	August 24, 2000	AIRNET
TA-55-4	September 12, 2000	Stack monitoring
White Rock Fire Station	September 12, 2000	AIRNET
TA-16-205	September 12, 2000	Stack monitoring
TA-3-29	September 13, 2000	Stack monitoring
TA-3-35	September 13, 2000	Stack monitoring
TA-21-209	September 14, 2000	Stack monitoring
TA-3-102	September 14, 2000	Radionuclide survey
TA-54-1001	September 14, 2000	AIRNET
TA-15 and -36	September 15, 2000	AIRNET

Interviews

Throughout the audit, interviews were conducted with personnel from the Environmental Safety and Health (ESH-17) division of LANL, facility managers, and other people responsible for compliance activities at LANL. Interviews were generally planned ahead of time and usually involved one or more members of the audit team, IEER, CCNS, LANL, and other interested parties. In keeping with the policy of openness, anyone could be a part of any interview. However, if either IEER or LANL wanted to be involved in an interview and was unable to attend, an interview was rescheduled until all interested parties directly involved in the audit could attend. It is a credit to the groups involved that this procedure worked well.

Members of the audit team led interviews, and the interviews focused on procedures relevant to compliance issues. Interviews were quite specific because the first audit had provided the audit team with extensive background knowledge about LANL and its procedures so that well-defined issues could be investigated during this second audit.

Document Retrieval

It was necessary for the audit team to obtain a large number of documents from LANL to support their research of compliance activities. Periodically, documents were requested in writing by the audit team. A copy of every document request was sent to all parties involved in the audit process so that all could be aware of ongoing research and information needs.

The audit team stored all documents at a central location, and copies of necessary documents were distributed to researchers. Documents were tracked throughout the audit, and a listing of the

documents requested and received is included as Appendix B. These and other documents cited in the audit report are included in the reference section to the main audit report. Additional documents used in preparation of the report but not obtained from LANL were not widely distributed to all the parties of the audit. Most of these documents are easily obtained from DOE or EPA web sites or document libraries. Complete citations in the reference list should be sufficient to obtain these references.

Working with LANL Staff

One of the most vital aspects of the audit was the cooperation of LANL and DOE. All audit visits and requested interviews were arranged by LANL staff. Document copying and shipping was completed with reasonable timeliness. The staff were always available for phone calls or to answer electronic messages regarding questions or concerns. This second audit went extremely smoothly, and the team credits the cooperation of LANL and DOE for making this possible.

SIGNIFICANT CHANGES AND IMPROVEMENTS SINCE THE FIRST AUDIT

Because of the significant number of modifications to the ESH-17 program since the first audit, we felt it was important to highlight a few key changes here. We will describe several areas in which the program has improved. Details related to these and additional changes are discussed in the technical sections that follow. Many of the changes discussed here were in response to deficiencies noted in the first audit.

Two important and overall changes in the Rad-NESHAP program and ESH-17 are the commitment to quality and the positive interaction with the public. During the first audit, we noted that LANL had an overall lack of formalized peer review that could have affected the quality of the program. Peer review specifically and quality assurance in general have been increased and formalized. In every aspect of the quality program, it is easy to see the impact that our recommendations had on the Laboratory. Formal peer review is now required in many places where it was not before, and we saw evidence of its use in every technical area of the Rad-NESHAP program.

Voluntary interaction with the public has also improved since our first audit. In that audit, we recommended that ESH-17 increase their communication with the public, as the results of their program have a direct impact on the public. Although there continues to be room for improvement, we witnessed a much greater openness to such interaction. During the dose assessment for 1999, ESH-17 personnel actually sought out public comment and advice, which would have been unlikely in 1996. We encourage this positive attitude toward interaction with the public, and we suggest that such interactions be pursued whenever an opportunity arises.

In the unmonitored point source review, substantial changes have been made since the first audit with regard to the collection and, specifically, the presentation of radioactive material inventory and usage information. An obvious effort has been made to clearly distinguish between radionuclide inventory, or stock, and actual usage of this inventory.

Reliable sampler operations are important to the monitored point source part of the program. Since the last audit, the Laboratory has instituted a program of routine operational checks and preventative maintenance for the effluent air sampling pumps. Most of the carbon vane pumps used in the past have been replaced with better equipment. Both these changes help assure continuous operation of the effluent sampling systems. In response to a finding from the first audit, sample losses during transmission have been determined for three lines and the relatively small (< 10%) corrections for those losses are applied. Isotopic analyses of particulate filters are now used exclusively to estimate releases of alpha-emitters, which is a distinct improvement over the situation observed in the first audit. New sampling locations have been established for some stacks in the Chemical and Metallurgical Research (CMR) facility. These locations are currently being evaluated, but it seems likely that they will be found to provide improvements over current sampling points.

One of the most significant impacts of the first audit on the non-point source and environmental monitoring program related to confirming that the AIRNET monitors, in their current configuration, collect respirable particles with acceptable efficiency. In the summer of 2000, LANL conducted a wind tunnel experiment, comparing their ambient air samplers with several other industry standard samplers. This experiment took considerable preparation and was a major effort to undertake.

Dose calculation methodology and automation has improved considerably as a result of the first audit. We made several recommendations for automation and confirmation of the dose calculations that LANL took seriously. Another significant improvement in this area involves reviewing more than one possible location for the MEI. As the mission and programs at LANL change, it will be very important to continue to complete such an assessment annually.

QUALITY ASSURANCE EVALUATION

Quality assurance was an important focus of this audit. Quality assurance encompasses all those planned and systematic actions necessary to provide adequate confidence that a facility, structure, system, or component will perform satisfactorily and safely in service.[5] CCNS raised the concern that quality assurance may have been documented but not implemented. The audit team assessed quality assurance issues as they applied to various procedures at the Laboratory (e.g., inventory estimates and stack sampling). These issues are discussed in each chapter of this report and address any findings. Additionally, several quality assurance issues were raised specifically by CCNS and documented in a memo. Because those issues were quite detailed, that memo and the audit team's responses to the memo are included in Appendix C (page C-31).

It is important to note here that the audit team reviewed only ESH-17 quality assurance procedures. We recognize that quality assurance procedures are important at all LANL facilities; however, the scope of the audit dictated that quality assurance focus on ESH-17 quality issues.

Most of the quality assurance issues are specific to each segment of the evaluation, but the audit team addressed one quality assurance issue separately in the first audit report, and we considered it necessary to revisit that issue in the same manner in this second report. This issue relates to the ESH-17 practice of conducting audits and having audits conducted of their compliance program. Audits are the principal means of checks and balances within any technical program, so an inadequate or inappropriate audit plan could seriously compromise the integrity of the program.

Audits of ESH-17

Summary of LANL Methodology

LANL is required, by 40 CFR 61, Subpart H, and the FFCA, to ensure that both internal and external audits are conducted regularly on the Rad-NESHAP project within ESH-17. To meet quality assurance requirements, it is also required that ESH-17 conduct an audit of each contracted analytical laboratory annually to ensure that the laboratories conduct themselves within the boundaries of LANL quality assurance requirements as defined by 40 CFR 61, Subpart H. These audits are discussed in later sections of the report.

We discuss three different aspects of the quality assurance process. Peer review and internal assessment is naturally an important part of any good scientific program. Internal audits of the Rad-NESHAP program are conducted by individuals within LANL but outside of ESH-17. External audits are done by individuals or groups outside of LANL.

Evaluation of LANL Methodology

The internal assessment process at ESH-17 appeared to the audit team to be well maintained and documented. The working relationships of the staff enhance the ability to detect errors within their own system. They willingly accept constructive criticism from one another and seem to make changes in procedures and the appropriate documentation whenever it becomes apparent that it is required. There is a comprehensive trail of documentation of revisions to procedures and notification of problems. The ESH-17 group leader is very actively involved in the every day

mechanics of his division and is very aware of problems that exist and need to be corrected. The group leader also conducts periodic management assessments. We reviewed one of these management assessments for 1999.[6] This assessment focused on the Environmental Measurements project, and it focused on important aspects of the project, such as procedures, project goals, and employee satisfaction. We encourage these assessments to continue and for management to make recommendations, even if they are not specific but would relate more to overall project goals.

Additionally, the ESH-17 quality assurance officer is involved in doing periodic assessments of different individual procedures, randomly selected. Although this method of conducting internal assessments is not yet formalized, the audit team encourages continuance of this system and hopes to see it become standard practice in the group.

The audit team noted during the first audit that peer review was not formalized at ESH-17. Many improvements to this have been made, with considerable attention being paid by ESH-17 to not only conducting peer review but to carefully documenting it in a readily retrievable form. Additional descriptions of these enhanced procedures are included in several subsequent sections of the report.

A major technical deficiency noted during the first audit was the conduct of an internal audit by a person within ESH-17 who could easily have been perceived as being responsible for the programs being audited. While we understood the value of having people directly involved in programs making suggestions for improvement, we suggested that a more technically defensible way to conduct an internal audit would be to have someone internal to LANL but external to ESH-17 come in and conduct annual audits. This not only provides more confidence that problems are not potentially being overlooked by someone who may be responsible for those problems, but it also provides an important outsider's view on the compliance program. In the same manner that peer review of calculations and documents provides important insight, a review of entire programs by knowledgeable yet uninvolved peers can have an important positive impact on the quality of a program.

Additionally, we believe public confidence that compliance is assured to be just as important as compliance. A critical way of locating inadequacies in such programs and instilling public confidence that all shortcomings have been found is to have an uninvolved individual survey it.

LANL responded to the audit team suggestion by implementing just such a program for internal audits. In 1999, the ESH-14 Quality Management Group conducted audits of the stack sampling program and of the unmonitored point source program.[7,8] The audit team sees this as a significant improvement and encourages LANL to continue in this manner.

The *RAC* team audits have fulfilled LANL's requirement for periodic external audits for the last several years. It is our opinion that this process of having a completely independent team come in to conduct an audit is truly an asset to the program, and we strongly encourage such a program to continue even after the Consent Decree audits have been completed.

UNMONITORED POINT SOURCE EVALUATION

As specified in 40 CFR 61, Subpart H, emissions must be estimated for all facilities with the potential to discharge radionuclides into the air. This includes all facilities conducting operations using radionuclides in an environment that discharge effluents through a forced ventilation system via a single exhaust stack or point source. This emission estimate is used to determine monitoring requirements for all point sources at each facility. The requirements outlined in § 61.93 (b) state the following:

> Radionuclide emission rates from point sources (stacks or vents) shall be measured in accordance with [the following requirements] or other procedures for which EPA has granted prior approval.

The procedures outlined in 40 CFR 61, Subpart H, however, do not explicitly define the method to be used for estimating potential emissions from unmonitored point sources. In May 1996, the EPA and the DOE established the FFCA to provide further guidance to LANL with regard to such point source potential emission determinations. The FFCA effectively serves as prior EPA approval regarding methods of estimating potential emissions and consequent doses from unmonitored point sources for comparison to the 10 mrem yr^{-1} (0.1 mSv yr^{-1}) standard specified in 40 CFR 61, Subpart H. It also establishes methods for determining monitoring requirements as well as verifying continued low emissions.

A number of methods for estimating emissions are outlined in the FFCA, including the use of historical stack sampling data, 40 CFR 61 Appendix D methodology, duct holdup studies, engineering estimates and judgments, and the need for operational flexibility. Where facility operations are relatively stable, historical stack sampling data are considered the most accurate method for determining potential emissions. Appendix D methodology was originally designed to estimate emissions for new construction or modifications and changes to existing sources, but LANL also relies on this methodology for estimating potential emissions and determining monitoring requirements based on respective facility radionuclide usage information. For determining monitoring requirements, estimated radionuclide release rates are based on the discharge of the effluent stream that would result if no pollution control equipment existed, but the facility operations were otherwise normal.

Any point source with the potential to emit radionuclides in quantities that could cause a member of the public, or MEI, to receive a potential effective dose equivalent[b] in excess of 1% of the standard (0.1 mrem yr^{-1} or 1 μSv yr^{-1}) is defined as a major point source and requires continuous monitoring. Point sources with a radionuclide emission potential and consequent dose of less than 1% of the standard are defined as minor point sources and may be evaluated for compliance with the standard by estimating the potential for emission during the year in question by one or a combination of the methods outlined in the FFCA. For demonstrating compliance with the standard, the FFCA specifies the filtration factors for pollution control equipment specified in Appendix D of 40 CFR 61 may be applied. Additionally, periodic confirmatory

[b] For readability, the precise technical term potential effective dose equivalent is usually replaced with the general term dose in this document. However, the reader should be reminded that this is a possible dose and not an actual measured value that a member of the public received.

measurements are required to verify continued low emissions from unmonitored facilities. The FFCA (Section 2.1.3) specifies that these confirmatory measurements may be based on "…engineering estimates using current inventory measurements or determinations and the other methods described in Section 2.1.1."

It is important to make a clear distinction between radionuclide inventory and radionuclide usage. A number of concerns were raised during the first audit regarding the use of the term "inventory" and whether the reported values for unmonitored point sources represented a snapshot of the inventory at a single point in time, the total inventory throughout the year, or usage during the year. The wording of 40 CFR 61, Subpart H and Appendix D, clearly states that radionuclide use throughout the year is necessary for reporting requirements as well as for use in estimating radionuclide emissions. The FFCA makes numerous references to 40 CFR 61, Subpart H and Appendix D, but its use of the term "inventory" is not clearly defined. It is imperative that radionuclide *use* throughout the year be the starting point for the purpose of estimating potential emissions.

A defensible and credible record of radionuclide usage is clearly an integral part of demonstrating compliance as specified in 40 CFR 61, Subpart H. It not only serves as the basis for the accepted method of determining monitoring requirements and verifying continued low emissions, but it is also used to directly estimate releases and consequent doses for unmonitored (minor) point sources. In addition, the usage survey data are applied to determine those radionuclides contributing to 10% or more of the total dose at monitored point sources and, therefore, evaluate the appropriateness of current monitoring equipment. The audit team's efforts during the second audit focused on evaluating the accuracy and adequacy of the inventories and associated emission estimates reported for 50 unmonitored point sources at 40 facilities that had a potential for radionuclide release during 1999.

A complete and thorough evaluation of LANL's methodology for tracking radionuclide usage, emission determinations, and consequent dose calculations in 1999 involved assessing the adequacy and appropriateness of the procedures in place during the time the data for 1999 were collected and evaluated. This included evaluating the accuracy and completeness of the reported radionuclide usage and associated emission estimate calculations for a number of facilities. These evaluations were completed through reviews of ESH-17 documentation, facility visits, and personnel interviews.

During the first audit, we used radionuclide screening factors[9] to prioritize facilities and individual radionuclides with the potential to create the largest dose based on release of the entire inventory of radionuclides contained in that area. Because of heightened security at the onset of the current audit, we were forced to select facilities to visit before the inventory and usage information was available. Therefore, a number of facilities were randomly selected to include an approximately equal number of Tier III and Tier IV facilities (discussed later), based on the 1998 unmonitored point source dose evaluations.

The following sections describe and evaluate the methodology LANL employed to compile 1999 inventory and usage information, estimate potential emissions, and calculate consequent doses from unmonitored point sources. These sections also discuss any changes LANL made to address concerns raised during the first audit and as part of the Laboratory's periodic procedure revision system. Quality assurance and quality control implementation is discussed for each specific procedure to which it applies. The audit findings, including regulatory deficiencies,

technical or scientific deficiencies, and other observations are presented for each process description.

Radioactive Material Usage Data Collection

Summary of LANL Methodology

Facility radionuclide usage data serves as the primary basis for determining potential emissions from unmonitored point sources. Collection of these data attempts to encompass all usage, processes, and potential emission involving radionuclides during varied facility operations as well as potential duct hold-up and residual contamination.[10] The data collection focuses on potential emission sources for a given year, but future emission source data (e.g., sealed sources or material kept in safes) are also collected in less detail. This information is gathered for all unmonitored exhaust systems with the potential to actively exhaust radionuclides through a forced ventilation system via a single stationary point. LANL also compiles inventory and usage information for monitored point sources, but this evaluation focuses on the data collected and used for assessing unmonitored point sources.

These point sources are identified through various mechanisms, including historical classification, the Air Quality Review process (discussed later), facility contacts, and field investigations. The Quality Assurance Project Plan[11] requires that ESH-17 personnel evaluate all point sources with the potential to emit radionuclides and ensure that all point sources are categorized and identified properly. Additionally, ESH-17 staff evaluated 20 facilities not currently classified as unmonitored point sources through field investigations in April and May 2000 to verify the absence of radioactive point sources.[12] No improperly classified facilities were identified during the point source evaluations carried out according to ESH-17:00-299 and required by ESH-17-RN. During 1999 and 2000, 25 exhaust systems at 12 facilities were inspected through field investigations to verify their classification as point sources[13]. Of the 25 exhaust systems evaluated, 19 met the definition of a point source, and 6 did not meet the definition of a point source.

To initiate the process of updating radionuclide usage information, ESH-17 personnel contact the facility manager and/or the designated point of contact for the facility to inform them of the upcoming usage survey update. If it is deemed necessary, a meeting is scheduled with the facility point of contact to explain the survey process. In addition to explaining the purpose of the survey during the meeting, a usage survey is completed and documented.[14] If a meeting is not necessary, the latest usage survey information (in this case, information for 1998) is provided to the point of contact. Following collection and compilation of updated usage information, discrepancies and/or incomplete data are resolved via phone and e-mail interviews or site visits. The compilation of all 1999 usage survey information is documented as Terp et al.[15] Additional details related to each process are collated in file folders and ESH-ID Air Quality Review documentation maintained for each facility by ESH-17.

In addition to the primary radionuclide usage data collected as part of the survey process, ESH-17 staff review ESH-ID Air Quality Reviews on a monthly basis to supplement survey data and incorporate relevant information into the current usage survey update. This additional review step has been added to help ensure that new and modified operations are incorporated into the current survey. ESH-17 relies on identifying all new or modified radionuclide air emission

sources at LANL through the Laboratory ESH-ID process or through notification directly to ESH-17 by facility project managers familiar with regulatory requirements.

Air Quality Reviews can be initiated through the ESH-ID process or by contacting ESH-17 directly. A facility must first determine that the proposed activity qualifies as a new source, new construction, or change in process and requires an Air Quality Review as documented in LIR404-10-01.1, which requires that facility managers and supervisors identify and mitigate hazards associated with new activities and projects.[16] Appendix 2 of this Laboratory Implementation Requirement requires contact of ESH-17 for an air quality requirements determination for any activity involving the use of radionuclides that includes a change in process or radionuclides, an increase in quantity, or relocation to a different exhaust system. New Source Review project personnel assess such new or modified radioactive air emission sources according to the procedures outlined in ESH-17-103.[17]

In addition to the information described above, ESH-17 considers and incorporates into the usage survey report other elements that could influence emissions including actual and potential duct holdup data and room or area contamination data. The steps taken to estimate emissions from these sources are not repeated annually in all cases, and facility operational stability is considered in this regard. ESH-17 makes this determination based on information from facility representatives, best health physics practices, and best professional and engineering judgments.

Duct holdup is based on historic monitoring data, information derived from facility personnel, or actual duct holdup estimates, when available. When historic monitoring data are used to estimate duct holdup, data from one of the last 2 to 4 years of available monitored emissions are used. Monitored emissions are multiplied by the appropriate filtration factor (e.g., 2000 for single stage high-efficiency particulate air [HEPA] filtration, as specified in the FFCA) to estimate potential emissions. Duct holdup inventory is estimated by dividing potential emissions by the reduction factor for particulates (1×10^{-3}) provided in Appendix D, except in cases where the duct holdup consists of tritium, in which case the reduction factor for gases (1) is used.

In 1999, historic monitoring data, when available, were used to estimate potential duct holdup for a number of unmonitored point sources. There were nine instances where available historic monitoring data were not used, and the justification for not including these data as part of the usage survey is provided by Terp.[18] For these nine point sources, potential doses based on historic monitoring data were compared to doses based on 1999 usage survey data. The dose based on historic monitoring data was lower than that based on current usage survey data for eight of the nine sources. The single source that exhibited a higher dose based on historic monitoring data underwent significant renovation in 1999, so the historical monitoring data were no longer representative of current operations. Duct holdup in this case was based on information in the Materials Accountability and Safeguards System database maintained at TA 3-66.

Residual contamination is also considered and is derived from sources including previous inventory/usage surveys, interviews with facility representatives, and radiological survey data. Best engineering judgment calculations attempt to estimate potential emissions resulting from residual contamination and take into account operational stability.

To assess the validity of the 1999 usage survey and operational process information, ESH-17 personnel conducted five facility spot checks.[19] Three facilities were checked for reported operations and usage data, and two facilities were checked for reported operations only. No

problems were identified during these five spot checks. The Cerro Grande fire prevented the completion of additional spot checks.[20]

The usage data reported by each facility and collected by ESH-17 are compiled using a relational Access® database developed for this purpose. Additionally, historical data from previous years are included as archived tables in the database. Data are verified and validated by project personnel by 100% verification of hand-entered data and 10% verification of electronically transferred data and professional evaluation (peer review) of all data for usability.[21] This verification and validation process is documented in the file folders maintained by ESH-17 for each facility.

To conduct work in a manner that ensures appropriate emphasis on sources that have significant potential or actual emissions to the environment, ESH-17 has adopted a graded approach to categorizing unmonitored point sources and updating radionuclide usage survey information based on the calculated potential doses for the previous year. ESH-17-RN describes four separate tiers of sources and indicates how the sources falling within these tier levels will be treated during each radionuclide survey update.[22] The following tier levels have been defined by ESH-17:

- Tier I – Any source with actual emissions that contribute greater than 1 mrem yr^{-1} (0.01 mSv yr^{-1}) to any member of the public (as defined by Subpart H) according to the previous rolling twelve month period.
- Tier II – Any source with the potential to contribute greater than 0.1 mrem yr^{-1} (1 μSv yr^{-1}) to any member of the public (as defined by Subpart H) according to the last usage survey.
- Tier III – Any source that does not have the potential to contribute greater than 0.1 mrem yr^{-1} (1 μSv yr^{-1}) but that does have the potential to contribute greater than 0.001 mrem yr^{-1} (0.01 μSv yr^{-1}) according to the last usage survey.
- Tier IV – Any source that does not have the potential to contribute greater than 0.001 mrem yr^{-1} (0.01 μSv yr^{-1}) to any member of the public according to the last usage survey.

Per 40 CFR 61 Subpart H requirements, all Tier I and II sources require continuous monitoring to determine emissions and consequent doses. Tier I and II sources will be updated as part of the usage survey every 2 years, beginning with calendar year 1999, and need only meet the record keeping requirements for Tier IV sources. Tier III sources will be evaluated annually to confirm and verify that emissions and associated potential doses remain below Tier II classification requirements, and the information presented in the annual usage survey will be traceable to a secondary source of documentation (e.g., monitoring data, logbook, and database). Tier IV sources will be evaluated at least every 2 years to confirm and verify that emissions and associated potential doses remain below Tier III classification requirements, and usage survey information does not need to be traceable to a secondary source of documentation. In summary, a partial usage survey (including only Tier III sources) will be conducted for calendar year 2000, a comprehensive usage survey (including Tier I, II, III, and IV sources) will be completed for calendar year 2001, a partial usage survey will be done for calendar year 2002, and so on.

ESH-17 has taken additional steps to allocate resources to release points with the potential to impact the cumulative offsite dose and/or monitoring requirements and to more complex and dynamic operations throughout the Laboratory. Certain point sources meeting established criteria

will be removed from future usage survey reports.[23] While full usage survey updating efforts will not be conducted for these point sources, they will remain as part of the usage survey update record and will be evaluated to ensure that these sources continue to meet the required criteria. The criteria required for removal from the full usage survey update are that the release point has a potential effective dose equivalent less than 0.0001 mrem yr^{-1} (0.001 μSv yr^{-1}) *and* the facility active operations have and are expected to remain constant or are decreasing or the facility is inactive.

Also in the interest of conserving time and resources, certain point sources meeting established criteria will not require onsite interviews or walkthroughs of facilities or laboratories for future usage survey updating purposes.[24] A phone or e-mail interview will be considered adequate for these facilities, which include any facility that does *not* meet one or more of the following criteria:

- A new facility contact or operations that has not had an initial site visit interview by an ESH-17 representative *and* the calculated dose is a significant contributor to the stack's radionuclide emissions
- The operations and/or radioactive materials are continuously changing
- The operation and/or material have undergone a significant change
- A new release point of radionuclide emissions has been identified.

ESH-17 personnel will verify the appropriateness of this approach by performing spot checks, as discussed previously.

At the request of the Rad-NESHAP Project Leader, an assessment of the unmonitored point source program was completed by ESH-14 (Quality Management Group) during June 1999 as part of an effort to support quality assurance requirements in LANL operations.[25] The assessment focused on a review of various areas of the unmonitored point source emissions estimate methodology and monitoring requirement determination to ensure that the proper quality assurance and control mechanisms were in place and implemented.

A project verification and peer review process has been implemented by ESH-17 to assure the quality of reported data and to ensure that specific project requirements are met.[26] Point source identification requirements are evaluated by visits to selected Laboratory areas not included in the usage survey to verify appropriate omission, peer review of TA and building lists to ensure accurate status, and peer review to verify that point source classification is valid. These requirements were initiated in part because of the identification of two point sources that were missing from the 1998 usage survey report (TA 50-69 and 3-102) and resulted in a revision to ESH-17-RN. Point source radioactive materials usage survey requirements are assessed by visiting selected facilities and spot-checking reported usage and process information. Additionally, steps that include verification of data entry processes have been implemented (discussed previously). Completion of the requirements outlined for this process is documented in ESH-17:00-294.[27]

Evaluation of LANL Methodology

We assessed the methodology used by ESH-17 with regard to radioactive material usage data collection through detailed reviews of the file folders maintained for each facility as well as

visits and tours to eight separate facilities (TA 21-213, 48-1, 59-1, 50-69, 54-33, 54-36, 3-16, and 3-102), including nine individual rooms or laboratories at TA 48-1 and five at TA 59-1. During the course of the facility tours, it was clear that the points of contact responsible for supplying usage data were both knowledgeable about the work they performed and familiar with the ESH-17 process of compiling usage data.

For each of the facilities we visited, we reviewed the supporting documentation (hand-written notes and e-mail correspondence maintained by ESH-17) related to compilation of radioactive material usage. Additionally, we thoroughly evaluated the methodologies and procedures outlined in the numerous documents that provide descriptions and guidelines for carrying out the various processes related to assessing unmonitored point source emissions.

The Laboratory has made a concerted effort to evaluate all unmonitored exhaust systems with the potential to emit radionuclides. Specific steps were carried out to ensure that all facilities requiring an evaluation were properly assessed. ESH-17 has also implemented procedures that attempt to capture and review all new or modified sources. This is evidenced by the unmonitored point sources that were added in 1999 as a result of air quality reviews or notification by facility project management (e.g., TA 3-39, 15-446, 16-205, 21-418, 53-7, and 53-365) as well as the specific process evaluations included for a number of other point sources. Additionally, duct holdup and residual contamination were considered as potential emission contributors to a number of exhaust stacks. It should be noted that using historic monitoring data to estimate duct holdup is a conservative approach because such data inherently include all operational releases in addition to any potential releases related to duct holdup.

Significant changes have been made since the first audit with regard to the collection and, specifically, the presentation of radioactive material inventory and usage information. An obvious effort has been made to clearly distinguish between radionuclide inventory, or stock, and actual usage of this inventory. All processes with the potential to emit radioactive material are categorized separately for each facility, laboratory, or room vented by a given exhaust system. Source type (present or future), inventory amounts and basis, usage amounts and basis, physical state, and primary containment information is collected for all radionuclides used in each separate process. Further, a description for each process is provided, as well as an assessment of any heating that is done and its potential impact on the chemical and physical state of each radionuclide involved in the process. This information is all provided in the annual usage survey compilation.[28] This represents a substantial improvement since the first audit in the amount of information provided to the public and, in most cases, helps provide a reasonably clear picture of each process potentially impacting radionuclide emissions. In combination with the file folders maintained by ESH-17, which include documentation of e-mail communications, it is possible to understand how the data were collected, updated, and assembled into usage estimates.

A special effort has been made to assure the quality of data reported by facilities and compiled by ESH-17. An Access database has been developed to compile and document all collected radionuclide usage information. We examined the structure of this database, and it is well designed and adequately serves the purpose for which it is currently intended. This move toward a more automated compilation process is wise, particularly considering the complexity of usage in some facilities, such as TA 48-1, and it helps ensure data quality and reduce calculation errors. Procedures have been implemented to verify the accuracy of data provided by facilities, as well as to verify the accuracy of data compiled by ESH-17 and appropriateness of methodologies used to categorize point sources. Completion of these procedures is documented in the file folders

maintained by ESH-17 for each facility, and it is clear that these efforts have resulted in a more robust and defensible radionuclide material usage data compilation. It should be noted, however, that verification of reported data was limited in 1999 to five facilities, because the Cerro Grande fire prevented completion of the spot-checks required by ESH-17-RN, and consequently did not include some of the more complex and dynamic facilities such as TA 48-1.

ESH-17 staff initiated an assessment by ESH-14 to evaluate the project performance against work process procedures and the Quality Assurance Project Plan of the unmonitored point source program.[29] Several out of date procedures were identified as in need of revision, and a number of deficiency reports had not been addressed by corrective actions to ensure that proper resolution had taken place. For the most part, these issues have been addressed by ESH-17. However, it does not appear that the recommendation for removal of the process described in ESH-17-RN to "visit selected Laboratory areas that are not included in the Laboratory's RCA list…" to reflect the fact that the Laboratory no longer maintains a Radiological Controlled Area list has been addressed.

Additional requirements are being established as the compliance program continues to evolve in an attempt to focus resources on those point sources that may require more attention because of their complex and dynamic nature and/or that are potentially most important in terms of impacting dose or monitoring requirements. This move toward an efficient and effective program that continues to satisfy regulatory requirements is commendable and we strongly encourage ESH-17 to continue these efforts as part of future changes to compliance related processes.

Findings

Technical or Scientific Deficiencies. Please see discussion in following section titled "Potential Emissions and Dose Estimation" related to inventory, usage, and emission estimation at TA 21-213 for a description of this technical deficiency.

Additional Observations. The apparent focus ESH-17 is placing on increased automation of data compilation and dose calculations is an important step in developing an efficient and credible method for determining radionuclide usage and associated emissions and potential doses to members of the public. However, this entire process can still be improved and strengthened, while being made more efficient and accurate. We have identified a number of references that illustrate the utility of a database application for developing a very efficient and accurate methodology of maintaining a highly credible radionuclide inventory in different settings, including university and medical programs subject to U.S. Nuclear Regulatory Commission or state radiation control.[30,31,32]

At LANL, radionuclide receipt, use, transfer, disposal and consequently emissions could be easily and accurately tracked and recorded for each exhaust stack, for each building, and for each technical area using a database application similar to the ones described by the above references, particularly Mehta.[33] Annual sitewide inventory reports could be quickly generated, and emission and dose estimates (per regulatory methodology) for each emission source could be automatically calculated, based on input by individual researchers carrying out activities that impact emissions or by ESH-17 staff. The calculations necessary for emission estimates are simple and

straightforward and could easily be handled by a database application, particularly since ESH-17 has now developed millirem per curie factors[c] for each facility.

Such a system would improve reliability, accuracy, and timeliness of data entry and recordkeeping, ensure rapid accessibility to both current and past records, allow for centralized recordkeeping which would greatly simplify auditing, and help generate a greater sense of security and trust by the public in the validity of data provided by LANL. Inventory values would automatically be updated following receipt, use, transfer, decay, and disposal. All facilities could be easily connected to a site-wide intranet, thereby providing simultaneous access to the database for individual users via their personal computers, and ESH-17 could maintain and have access to all information compiled in the inventory part of the system. Access could be provided only to those needing it (i.e., restrictions could be placed on access to sensitive records). Such a system would easily satisfy regulatory recordkeeping requirements. Also, once the system is established, the possibility for introducing errors is greatly reduced because the computer does most of the work, providing a correct answer every time (as long as the computation is set up properly).

It would obviously take some time and effort to develop, but once in place it should be easy to maintain, and it would substantially reduce the number of person hours ESH-17 currently expends in an effort to track, compile, and verify radionuclide usage information. The system could be quite user friendly and easy to adopt in everyday use, and potential users could be trained quickly. Given current advances in technology and the wide availability of computers capable of performing these tasks, LANL should consider the opportunity for developing an application similar to the one described by Mehta.[34] It would be a logical continuation of the efforts ESH-17 is currently putting forth toward focusing efforts on important and complex sources, while developing an efficient overall process. If the system was employed to track transfer, receipt, and storage of radionuclides in addition to use, it would also alleviate concerns raised by IEER (Appendix C, page C-9) related to safe inventories and matching supply and receiving room logs. Such a system could replace the many currently disconnected methods of tracking radionuclides and would require little to no additional effort (once established), but the benefits would be tremendous.

The current system used by ESH-17 introduces a reasonable probability that at least some radionuclide usage will not be identified, particularly at complex facilities like TA 48-1. This is evidenced by the mistakenly omitted usage of 10 and 15 mL of ^{137}Cs solutions in Room 307 during 1999, which was clearly posted on hood B-5 in the room. If LANL would take additional steps to adopt a more comprehensive database for radionuclide receipt, use, transfer, and disposal, this type of information could be recorded with the same amount of effort, but it would not escape identification. And, the potential dose consequences associated with the use of this (or any other) material would be calculated with no additional effort since the database application would accomplish this automatically. Not all instances would allow individual radionuclide users to enter usage data, and ESH-17 personnel would certainly need to continue to be an integral part of the process. However, several data transfer steps and number and calculation verification reviews that are currently part of the dose calculation process could be eliminated, allowing time and resources to be spent accomplishing other tasks that cannot be automated. During the last audit,

[c] The millirem per curie factor can be multiplied by 2.7×10^{-4} to obtain units of millisievert per gigabequerel. The term millirem per curie is used several times in explanation of the techniques associated with it, but defined only here in its relation to SI units.

LANL was developing a Space Hazards Inventory Program to track real time radionuclide inventory and use in an Access database, but this effort apparently has not contributed to the current process of compiling radionuclide usage data.

Per the requirements established by LIR404-10-01.1, an air quality review is required for any activity involving the use of radionuclides that includes a change in process or radionuclides, an increase in quantity, or relocation to a different exhaust system.[35] Based on the 1998 and 1999 radionuclide usage survey reports, there are a number of instances where radionuclides or processes that were not part of the 1998 usage survey were used in 1999 (e.g., ^{135}Cs, ^{137}Cs, ^{178m}Hf, and ^{172}Lu in Room 314 at TA 48-1; ^{239}Pu, ^{58}Co, ^{59}Ni, and ^{63}Ni in Room 414 at TA 48-1; ^{239}Pu and ^{237}Np in room 309 at TA 48-1; and processes 2 through 5 in Room 416 at TA 48-1). Given the complexity and dynamic nature of operations at TA 48-1, it is difficult to know whether this usage represents a real change in radionuclides or processes, or if it may represent a radionuclide or process that may have been present at some point before 1998.

The requirements set forth by LIR404-10-01.1 and the ESH-ID process are directed at assessing the potential impact of new radionuclides or processes on doses and monitoring requirements. The handling limits for use of beta or gamma emitting materials in a laboratory at any one time at TA 48-1 set forth by CST-SOP-037, R.7 require a health physicist consultation for any planned work involving quantities approaching 75% of 10 mCi (0.37 GBq).[36] Using ^{137}Cs as an example [mrem per Ci factor of 3.7 for TA 48-1 (mSv per GBq factor of 1×10^{-3})], usage of quantities in a gaseous form (i.e., heated to greater than 100°C) approaching these limits only four times in a given year would result in a potential impact on emissions monitoring requirements. It is very conceivable that this could occur in the nine laboratories comprising ES-11 or the 12 laboratories comprising ES-15 at TA 48-1, so it is clear that the usage limits imposed by CST-SOP-037, R.7 do not preclude the need for monitoring at this facility. It is also clear that all new radionuclides or process were not reviewed per LIR404-10-01.1 requirements. It is not efficient or practical to expect an Air Quality Review for any new radionuclide or process in a given laboratory at a facility as dynamic and complex at TA 48-1. However, it is reasonable to expect that there be some mechanism in place to assess the potential impacts of operational changes before they occur. A database application such as the one described above would allow for simple and nearly instantaneous assessments of potential impacts related to new or proposed operations.

While the new procedures ESH-17 has adopted and the new format for the usage survey report help considerably to distinguish between radionuclide usage and inventory, there is still some confusion and inconsistency in the use of the term inventory. As noted by IEER (Appendix C, page C-9), in a number of instances (e.g., TA 59-1-108 and TA 3-102), the inventory and usage amounts were reported to be the same, when in fact the annual usage exceeded the inventory in the room at any one time during the year. In other instances, it appears that this was taken into account (e.g., TA 59-1-104), and the inventory accurately reflects the maximum quantity in the room at any given time during the year. ESH-17 should take steps to ensure that inventory and usage amounts appropriately reflect the conditions and operations that exist in each facility.

It is interesting to note that in the assessment of the unmonitored point source program[37] the "In Storage Basis" column on the usage survey form was omitted. This requirement involved recording whether the amount of material is a "snapshot" of what is presently in storage (inventory) or an estimate of total "calendar year" storage. Revisiting this concept and perhaps

including this data collection step, modified as necessary, could assist with clarifying inventory values. It would also be helpful to include usage survey initiation and closeout dates on the forms for each facility.

Because the usage survey data are now being used to identify 10% contributors to dose and evaluate monitoring status for all monitored facilities, the accuracy of usage data at these facilities becomes more important. Currently, ESH-17 procedures do not specify the frequency of usage survey updates for Tier I monitored facilities, but interviews with personnel have indicated that updates will be completed for both Tier I and Tier II monitored facilities every 2 years. The air quality review process described by LIR404-10-01.1[38] appears to be aimed at determining whether or not monitoring is required for a particular facility or operation and not at assessing the adequacy of current monitoring capabilities. ESH-17 should evaluate whether the controls in place to identify 10% contributors through biannual usage survey updates are adequate to ensure that facility operational changes that could impact the type of monitoring required do not escape identification.

Potential Emissions and Dose Calculations

Summary of LANL Methodology

Based on the radionuclide usage survey information that is collected using the methodology described in the previous section, ESH-17 estimates potential emissions from each unmonitored point source. These emission estimates are, in turn, used to estimate potential doses to the MEI for each unmonitored point source. During the first audit, ESH-17 staff used the procedures outlined in ESH-17-102 to estimate potential doses for unmonitored point sources. Since that time, ESH-17 has revised this document to focus only on the compilation of radionuclide material usage information, and a new procedure, ESH-17-137, has been implemented to provide guidance for estimating potential emissions and doses from unmonitored point sources in 1999.[39]

To estimate potential emissions from unmonitored point sources, ESH-17 uses the radioactive materials usage survey data, which may include potential duct holdup, room or area contamination, and historic monitoring data, in addition to the actual usage data provided by each facility. The Access database, in which usage survey information is compiled, is used to create a table of each radionuclide and corresponding usage amounts for a given facility. These data are copied into Excel® spreadsheets designed to calculate emission estimates. Data are verified and validated by project personnel by 100% verification of hand-entered data and 10% verification of electronically transferred data and professional evaluation (peer review) of all data for usability.[40] ESH-17 documents data entry verification reviews for each point source and maintains this documentation in each facility file folder. Completion of the requirements outlined for these verification and review processes is documented in ESH-17:00-294.[41]

Appendix D methodology and guidance provided by the FFCA are used to perform an emissions estimate calculation for materials used in various work processes at each facility or otherwise made available for release to the environment (e.g., waste drum inspection and characterization). This calculation considers the physical state of the material during the work processes that may involve radionuclide release, and appropriate reduction factors are used to estimate potential airborne emissions from solids (1×10^{-6}), particulates and liquids (1×10^{-3}), and gaseous materials (1). A material is considered to be a gas if it is heated to greater than

100°C, unless it is covered under the enhanced 100°C rule described in the FFCA. This methodology was reviewed during the course of the first audit, and it was deemed appropriately conservative.[42]

Best engineering judgment, information from facility representatives, and other methods are used to estimate potential emissions based on smear and survey data. This may relate to surface contamination in a room or area that could be released via a point source to the environment or to contaminated equipment that could be a source of release to the environment. Historic monitoring data are used, when available and appropriate, to estimate potential duct holdup emissions, which was also considered in the potential emission estimates for a number of facilities in 1999. When historic monitoring data are used to estimate duct holdup, data from one of the last 2-4 years of available monitored emissions are used. Monitored emissions are multiplied by the appropriate filtration factor (e.g., 2000 for single stage HEPA filtration, as specified in the FFCA) to estimate potential emissions. Further details regarding duct holdup estimates are discussed in the preceding section regarding radioactive material usage data collection.

Potential doses are calculated according to ESH-17-511[43] (discussed below), and this calculated value is the dose recorded in the usage survey for all unmonitored point sources with initially calculated doses less than or equal to 0.001 mrem (0.01 μSv). Because ESH-17 elects to initially calculate potential doses using conservative assumptions, additional information may be obtained from facility representatives for point sources with calculated potential doses exceeding 0.001 mrem (0.01 μSv) to determine if a more realistic emissions estimate can be made. Additional information is obtained as necessary using best professional judgment until the calculated dose incorporates all relevant data, at which time it is recorded in the usage survey.

To estimate doses from unmonitored point sources, ESH-17 uses the potential emission estimates made for each facility (described above). Potential doses (in millirem) are determined by multiplying emission estimates (in curies) by millirem per curie factors that have been calculated for the purpose of performing dose assessments for existing, new, or proposed facilities without having to run a dose model. These dose factors have been calculated for up to 300 radionuclides at each LANL facility with the potential to emit radionuclides via a point source according to the procedures outlined in ESH-17-511.[44] These calculated potential doses are used for establishing point source tier level, determining monitoring requirements, and reporting annual dose to the public.

Calculating the millirem per curie factors is accomplished by first obtaining appropriate information for each release point, including the physical height, diameter, exit velocity, and X-Y location coordinates for each stack. Default CAP88 values are used in cases where actual information is unavailable. A multi-year average of meteorological data is gathered for four meteorological towers at LANL (TA-6: February 1, 1992 to February 1, 1999; TA-49: January 1, 1989 to January 1, 1999; TA-53: February 10, 1992 to February 10, 1999; and TA-54: February 1, 1992 to February 1, 1999) for use in CAP88 calculations. The maximally exposed individual (MEI) or highest dose receptor location is determined and documented for each facility by performing preliminary CAP88 runs, enabling identification of appropriate X-Y receptor location coordinates as well as the distance and direction from the source to the receptor. A generic list of radionuclides is appended to the CAP88 input file for the source term input, and other radionuclides are added on a site-specific basis. A source term of 1 Ci (37 GBq) is assumed for each radionuclide, and progeny or decay products are included in the source term, where

appropriate. The CAP88 output is cut and pasted into an Excel spreadsheet for each release point for use in subsequent dose calculations.

Potential emission calculations and dose estimates for each facility are peer reviewed to verify that calculations are accurate, assumptions are at least conservative, estimates are valid or at least conservative, and data entries into spreadsheets were performed correctly. These reviews are performed according to ESH-17-RN and are documented in the file folders maintained by ESH-17 for each facility.[45] Completion of the requirements outlined for this process is documented in ESH-17:00-294.[46]

Evaluation of LANL Methodology

We assessed the methodology used by ESH-17 with regard to potential emission and dose estimate calculations through detailed reviews of the file folders maintained for each facility. All calculations and assumptions related to estimating potential emissions are clearly documented, as are data verification and peer reviews. It is apparent that ESH-17 expends a significant amount of effort in an attempt to calculate emissions in a thorough, accurate, and consistent manner, as supported by the examples reviewed by the audit team.[47]

An Access database has been developed to compile collected radionuclide usage information, which allows for the automatic creation of complete listings of radionuclide usage amounts and appropriate physical state reduction factors for each radionuclide used at each exhaust stack. These are pasted into Excel spreadsheets along with the calculated millirem per curie factors, enabling relatively simple and somewhat automated dose calculations for each facility. This trend toward more automation and focusing of efforts by simplifying the dose calculations for the unmonitored point sources is encouraging and commendable. It should be noted that the statement on page 11 of ESH-17-501 indicating that "…dose calculations for the rest of LANL…use the actual annual-average meteorology for the year in which emissions occurred" is not correct because of the use of calculated millirem per curie factors in dose calculations for unmonitored point sources.[48]

For estimating duct holdup and potential emissions based on historic monitoring data, using the FFCA filtration factor (i.e., 2000 for single-stage HEPA filtration) is a more conservative approach than using the factor provided in Appendix D of 40 CFR 61, which corresponds to a single-stage HEPA filtration factor of 100 when used in this manner. Additionally, as mentioned previously for the usage information collection methodology, using historic monitoring data to estimate potential emissions related to duct holdup is a conservative approach because such data inherently include all operational releases in addition to any potential releases related to duct holdup.

All unmonitored point source dose calculations are performed for the maximally exposed location or receptor, and they are based on potential emissions assuming no existing filtration mechanisms are functioning. The doses for each point source are then summed, and this collective potential dose is reported as the actual dose for all unmonitored point sources. This a conservative method of reporting doses for unmonitored facilities, and the actual doses related to emissions from these facilities would in fact be less than the 0.11 mrem (1.1 μSv) dose reported in the 1999 annual report if existing filtration capabilities were taken into account.

Findings

Technical or Scientific Deficiencies. The methodology employed for inventory, usage, and emission estimates at TA 21-213 is not scientifically defensible or conceptually accurate (TA 21-213 file), as noted by IEER (Appendix C, page C-9). Weekly swipes are taken from two locations on the floor of this storage shed, which houses equipment internally contaminated with tritium. ESH-17 based its inventory and emission estimate on the results of the two highest weekly smear data values. The emission estimate was made assuming the floor, ceiling, and four walls were uniformly contaminated with gaseous tritium at levels suggested by the smear data. The emission estimate was assumed to be equivalent to the inventory, suggesting that the entire quantity of surface contamination is emitted each year. This is not supported by the historical weekly smear data (TA 21-213 historical smear data). The inventory and emission estimates were calculated based only on the ceiling, floor, and wall surface area. The shelves and equipment stored in the shed, which were not accounted for, contribute substantially more to the total surface area in the building.

A thorough review of the TA 21-213 file indicated that the area was historically monitored before entry, but there was never any measurable tritium detected so the practice was discontinued. Based on the sensitivity levels for the detectors used for this monitoring (5 μCi m^{-3} or 185 kBq m^{-3}) and the flow rate of the wall blower in the shed (500 cfm or 14 m^3 min^{-1}), up to 37 Ci (1.4 TBq) of tritium could be emitted from the facility annually assuming air concentrations at or below the detector sensitivity levels. The use of these detectors and their inability to detect airborne tritium does not satisfactorily support the assumed low emission rates for this facility. Further, it is noted in the TA 21-213 file that weekly smear data would show an increasing trend (not the case for this facility) if off gassing was occurring from the stored equipment. It is indicated that this is based on experience at TA 33, but an inquiry into data that would support this showed that the comparison could not be substantiated and is not valid since the TA 33 smears were directed at locations or material known to be contaminated by specific off gassing and release events.

The total inventory in the shed (composed of "sealed" sources not available for 1999 emissions) was assumed to be 100 Ci (3.7 TBq) and is based on an upper bound value for which materials accounting for tritium would be required. A logbook was maintained to document surface contamination for each piece of equipment placed in the shed, but there are no supporting calculations that document a total inventory of 100 Ci (3.7 TBq). As IEER pointed out, "there should be an identifiable and scientifically defensible method of estimation" for all inventory values (Appendix C, page C-9). Emission estimates for past years have been based on an assumed 10% release of the assumed 100 Ci (3.7 TBq) inventory, a method which also is not scientifically defensible because of the unsupported inventory value.

IEER has suggested collecting air sample data to estimate air concentrations and associated emissions, or using proposed experimental data related to measurements of surface contamination to air concentration ratios. Either of these methods could be employed to develop a conceptually defensible method of estimating emissions. Hayashi et al. (1998)[49] reported on tritium behavior in the processing rooms at the Tritium Systems Test Assembly (TSTA or TA-33), based on experiments that examined tritium migration and residual contamination following a planned release. These experiments involved the release of 1 Ci (37 GBq) into a 3000 m^3 tritium handling area that is ventilated at a rate of approximately five air exchanges per hour. Surface

contamination levels of a few Bq cm^{-2}, as reported in Hayashi et al., were detected following the release, and those levels decayed to background levels after a few days. By comparison, TA 21-213 has a volume of 800 ft^3 (23 m^3) and is ventilated at a rate of 500 cfm (14 m^3 min^{-1}), which corresponds to approximately 38 air exchanges per hour. Surface contamination levels measured at TA 21-213 over the past 5 years have varied between 0.5 and 14 pCi cm^{-2} (0.02 and 0.5 Bq cm^{-2}), but they have not shown any consistent increasing or decreasing trends. The larger room air exchange rate at TA 21-213 would be expected to reduce surface contamination levels at a more rapid rate. This suggests that existing surface contamination at TA 21-213 may be fixed and not readily removed or emitted. Increased surface contamination levels of a few Bq cm^{-2} resulting from the release of 1 Ci (37 GBq) were detected in the experimental area compared to a maximum of 13.5 pCi cm^{-2} (0.5 Bq cm^{-2}) in TA 21-213. The fact that the release of 1 Ci (37 GBq) into a volume more than 2 orders of magnitude greater than that of TA 21-213 resulted in greater (and noticeably increased) surface contamination levels suggests that the release rate at TA 21-213 is small. It is also possible, though, that the higher air exchange rate at TA 21-213 results in lower surface deposition. Different existing surfaces in the facilities could also be responsible for the lower surface contamination at TA 21-213 because surface type had an impact on the amount of detected surface contamination at TSTA. The differences between these two facilities limit the comparisons that can be made and the conclusions that can be drawn from this experiment, but this type of data may be useful for establishing credible emission rates from TA 21-213.

It is not likely that emissions resulting from this shed contribute significantly to potential offsite dose to a member of the public, but propagating a methodology that is not scientifically defensible to other similar situations where potential doses may be larger could result in not identifying an important dose contributor. A defensible method of inventory and emission estimation needs to be developed by ESH-17 for this facility, and the feasibility of adopting this methodology in other similar situations where emission estimates may be based on smear data should be investigated.

Additional Observations. Please see discussion in "Radioactive Material Usage Data Collection" Additional Observations section related to increased automation for inventory and usage data compilation and emission and dose calculation.

Because of the adoption of millirem per curie factors by ESH-17 for dose calculations and monitoring requirement and status determinations, an assessment of their efficacy and application is important. Currently, a limited amount of documentation provides a sound basis for the implementation of this methodology. ESH-17 has produced a document entitled "Calculating mrem/Ci Factors,"[50] but the majority of this document is dedicated to documenting the procedures used to calculate dose factors for non-CAP88 radionuclides, with only a few pages related to the millirem per curie factors. ESH-17 should consider revising the title of this document to reflect its content more closely.

ESH-17 should also consider more thoroughly and clearly documenting the entire procedure for calculating the millirem per curie factors for each facility, perhaps as a stand-alone document. During interviews with ESH-17 personnel, it was indicated that fluctuations of meteorological data from year to year are quite minimal and do not appreciably impact the calculated doses or the MEI locations. This document should include some support for the assertion that the use of historical annual-average meteorological data is adequate for characterizing current annual

conditions as well as some procedural methodology to ensure that potential facility changes impacting parameter values or new receptor locations are appropriately addressed.

Some concerns were raised during facility visits about whether potential progeny from radionuclides included in the usage survey were appropriately addressed (e.g., ^{241}Pu in the breached drum at TA 54-33 and ^{232}U in use at TA 48-1). Terp et al.[51] states "if a radionuclide had progeny, they were included in the source term, depending on equilibrium conditions." During interviews with ESH-17 personnel, it was indicated that progeny activity was generally considered to be equal to parent activity to eliminate the need to assume and justify appropriate ingrowth times. Progeny with half-lives 10 times or more larger than the half-lives of their parents were generally not included in the source term because of the significantly smaller resulting progeny activity by comparison to the parent activity (there are some exceptions to this, such as ^{241}Am from the decay of ^{241}Pu). Other factors, such as dose factors and branching ratios, were also considered when determining whether or not to include progeny. Again, the specific assumptions and methodology used for this process have not been thoroughly documented.

The suggested millirem per curie factor document should specify all assumptions and clearly describe the methodology used for the calculation of all millirem per curie factors. This is particularly evident considering the current reliance on these factors for regulatory compliance purposes. As a starting point and basis for determining important progeny, ESH-17 could refer to the atmospheric screening factors reported by NCRP,[52] which include all progeny contributing more than 10% of the dose of the parent.

STACK SAMPLING AND MONITORING EVALUATION

This chapter deals with point sources of radioactive releases to the atmosphere at the Los Alamos National Laboratory that are sampled or monitored. Unmonitored point sources were discussed in the previous chapter and non-point sources are discussed in the next chapter of this report.

Methods for monitoring, sampling, and analysis of effluents are specified in 40 CFR Part 61, § 61.93. Section 61.93 provides specific requirements that apply to monitoring or continuous representative sampling of discharges. Appendix B, Method 114, of 40 CFR Part 61 focuses on the requirements for sample collection, various types of analytical measurements made on collected samples, and real-time monitoring for radioactive gases discharged from stationary sources, such as stacks and building vents. The requirements of § 61.93 and Method 114 apply to the LANL effluent discharges that must be measured to comply with 40 CFR 61, Subpart H. Those discharges are measured, either continuously in real-time or by sequential collection and analysis of effluent samples throughout the year. This portion of the audit focused on evaluating the continuous effluent monitoring, sampling protocols, and analytical methods for locations that were estimated to be the main contributors to the offsite dose.

During 1999, the sampled and monitored stacks were relatively minor contributors to the estimated offsite dose. At the county landfill business office, where the estimated dose was greatest, the sampled and monitored stacks contributed about 3% of the estimated total of 0.32 mrem (3.2 μSv). Most of that contribution was due to releases of tritium from several facilities, and the remainder was due primarily to releases of transuranic nuclides from the Chemical and Metallurgical Research (CMR) facility. Because the estimation procedure likely yields a dose estimate that is too high, the contribution of the sampled and monitored stacks to the actual dose at that location would be greater than 3%. Releases from the TA-55 plutonium facility did not make a significant contribution to the estimated dose.

The East Gate site, north of the Los Alamos Neutron Science Center (LANSCE), has historically been the place where the highest offsite dose occurred. During 1999, the estimated dose for that location was 0.30 mrem (3 μSv), only slightly smaller than the dose estimated for the landfill site. Monitored releases from LANSCE contributed about 34% of the total estimated dose and most likely account for a larger proportion of the actual dose at the East Gate location. Radiation doses at the East Gate site have been due primarily to LANSCE releases of short-lived activation gases that are produced during accelerator operation.

Reliable estimates of the amounts of radionuclides released in effluents depend on knowledge of the effluent flow rate and the concentration of radionuclides in the effluent air. The quantity of radionuclides released is the product of its concentration in the airstream and the flow rate of the air out of the stack or vent. To measure some radionuclide concentrations properly, it is necessary to obtain a representative sample from the effluent stream, to collect the radionuclides present in the sample, and to measure the amounts of radioactivity collected. An alternative approach, used at the LANSCE facility, is to install instrumentation that can analyze the radionuclide concentrations and estimate releases in real time. In either case, estimation of the release is a multi-step process, and there are EPA requirements related to each of the steps involved.

The following sections discuss the requirements that are most generic and apply to all sampling locations. These are the procedures for effluent flow measurements, selection of

effluent sampling locations, extraction of effluent air samples, and transport of the sample to the collection device or measurement point. Subsequent sections address collection and measurement of radionuclide concentrations in effluent samples. Some measurement methods apply to more than one facility; such as the technique used to collect tritium from air samples and to quantify the amount collected. Each section includes a discussion of the applicable regulatory requirements, LANL methodology, an evaluation of the LANL approach, and any findings of this audit.

Effluent Flow Rate Measurements

Knowledge of the rate of discharge of effluent air is essential to accurately estimate radionuclide discharges. Because it is equally important for other pollutants regulated under the Clean Air Act, methods for measurements of the amount of air flowing in a stack or vent had been established by the EPA before the time that radionuclide releases were regulated. The EPA had published appropriate methods in Appendix A of 40 CFR 60. Different methods are used to measure effluent flow rates (a) in large stacks and vents and (b) in pipes and small vents.

Summary of LANL Methodology

LANL uses the methods specified by the EPA in 40 CFR 60, Appendix A, to measure effluent air flow. The procedures are described in detail in ESH-17-127, R1.[53] A contractor organization, Johnson Controls of Northern New Mexico, conducts the air flow measurements for the Laboratory. Stack flows are determined routinely on a quarterly schedule. Special measurements are made when there are major changes in ventilation systems or at other times, when requested by ESH-17.

Measured stack flow rates can differ from time to time because of changes in fan operation and effluent filtration units. For example, some stacks have both a primary exhaust fan and a back-up exhaust fan whose discharge flow rates may differ. To ensure that effluent releases are not underestimated, it has been LANL policy to use the highest flow rate measured during the previous three years in the release calculation.

Evaluation of LANL Methodology

The flow measurement techniques employed by LANL follow regulatory guidance established for the Clean Air Act. The approach is basically sound and the application of the flow measurement data is cautious. The policy of using the highest of the last twelve flow rate measurements leads to estimates of the amounts of radionuclides released that would nearly always exceed those that actually occurred.

A review, in 1999, of the details of the flow measurement process by a team from ESH-14 identified some deficiencies in the program.[54] The deficiencies were related to calibration frequencies for temperature gages and relative humidity measurement equipment and to incomplete documentation of the measurement process. The flow measurement calculations are relatively insensitive to these parameters, and it is not considered likely that the lower calibration frequencies led to any significant errors in the estimated flows. The deficiencies were rectified,

and the flow measurement procedure has been revised since the time of the review to address the deficiencies and observations made.

Findings

Additional Observations. Review of deficiency tracking system reports in connection with this topic indicates that the process of resolving deficiencies is often rather slow. We recommend that this area be given more attention and that a concerted effort be made to reduce the resolution time. The recent project performance report for 1998[55] also identifies deficiency resolution as an aspect of performance that could be improved, and CCNS (Appendix C, page C-31) also expressed concern about this issue.

Selection of Effluent Sampling Locations

Because it is essential that collected samples of the air being discharged represent the properties of that effluent, it is important that the location for the sample be chosen carefully. The EPA identified this issue when regulating other pollutants before establishing 40 CFR 61, Subpart H. Subpart H employs guidance that was established earlier. It specifies in § 61.93 (b) (2) that Reference Method 1 of 40 CFR 60, Appendix A (or other method for which EPA has given prior approval) be used to select sampling sites. Reference Method 1 relies upon a rule-of-thumb to avoid disturbances of the effluent flow that could cause samples to be non-representative; namely, that the location should be at least eight duct diameters downstream and at least two duct diameters upstream of a major flow disturbance.

Summary of LANL Methodology

The preferred method used by LANL is an alternative method that has received prior approval from the EPA. Beginning in 1993, DOE requested EPA approval of a method of sampling point selection for all DOE facilities based upon quantitative measurement rather than the rule of thumb.[56] It is known from measurements of trace gas concentration profiles that a sampling location chosen using the rule of thumb does not guarantee that the effluent will be well mixed. The goal of the proposed approach was to identify a location where the effluent is well mixed, to sample at that location using a single highly efficient sample extraction method (the shrouded probe) to collect the sample, and to transport the sample to the collector using an optimized line. The sample extraction and transport line aspects are discussed in a later section.

Following the agreement on the Clean Air Act Memorandum of Understanding[57] between the EPA and DOE in the fall of 1994, the EPA gave approval to use an alternative method for selecting sampling locations.[58] That approval letter and subsequent correspondence[59,60] established the conditions under which single-point sampling using a shrouded probe could be used. Those conditions are all listed in our first audit report.[61]

When single point sampling using a shrouded probe is not feasible at a location because conditions listed above or others given below are not met, the approach of Reference Method 1 is employed. Because needs for effluent monitoring were not given adequate attention during facility design, construction, and renovation, there are some stacks at LANL where application of Reference Method 1 is impractical. Sampling locations for those stacks are selected under the

provisions of § 61.93 (b) (3), which provides for prior EPA approval of documented procedures that will not significantly underestimate emissions.

Evaluation of LANL Methodology

The sampling location approach preferred at LANL that was approved by the EPA is part of the newly revised American National Standards Institute (ANSI) sampling guide[62] for releases of airborne radioactivity. The previous ANSI guide[63] is still incorporated by reference in the EPA regulations, but the agency has proposed incorporation of the new guidance in the 40 CFR 61, Subpart H regulation.

During 1999, the locations employed for sampling effluents from stacks and vents at LANL were the same as those used at the time of the first audit. Some sampling points are not definitely not ideal, but alternatives are limited by existing construction. The EPA has approved the sampling locations being used at LANL.

The Laboratory has identified new sampling locations for some stacks at the CMR facility, and equipment has been installed that would permit their use. The new sampling locations are currently being evaluated, but it seems likely that they will be found to provide improvements over current sampling points. Prior to use, the new locations will have to be approved by the EPA.

Selection of a sampling location where the effluent is well mixed is known to be satisfactory and is a clear improvement over the rule-of-thumb guidance that is part of Reference Method 1. For other stacks, the EPA-approved sampling locations are unlikely to lead to underestimates of the annual releases.

Sample Extraction Techniques

The requirement that the effluent sample represent the properties of the air being discharged also affects the method of withdrawal of the sample from the airstream. In § 61.93 (b), the requirement states:

> Representative samples of the effluent stream shall be withdrawn continuously from the sampling site following the guidance presented in American National Standards Institute (ANSI) N13.1-1969 'Guide to Sampling Airborne Radioactive Materials in Nuclear Facilities' (including the guidance presented in Appendix A of ANSI N13.1).

Appendix A of the ANSI guide deals specifically with sampling ducts and stacks. Briefly, the approach recommends sampling isokinetically at several points in the cross-section of the stack to ensure that the total sample collected is representative of a possibly non-uniform distribution of radionuclides in the air being discharged. Isokinetic sampling is achieved when the air velocity entering the probe is the same as the air velocity in the stack. As is the case for other methods presented in § 61.93 (b), alternative techniques may be used if prior approval is received from the EPA.

Summary of LANL Methodology

The preferred method used by LANL is an alternative method that has received prior approval from the EPA. As discussed above in the section on sampling location, the DOE requested and received prior approval for a technique that identifies a location where the effluent is well mixed and obtains samples using a single highly efficient sampling probe. This procedure employs a probe, called the shrouded probe, which intentionally avoids isokinetic sampling to reduce deposition of particles in the inlet of the sampling probe. The alternative method of sample extraction using a single shrouded probe was approved by the EPA in November 1994.[64] The approval letter includes conditions for the use of shrouded probes. Those conditions were enumerated in our report of the first audit,[65] which also includes details related to the approval by the EPA Regional Office.

When single-point sampling using a shrouded probe is not feasible at a location because either a sample location condition or a shrouded probe condition is not met, LANL employs an approach that utilizes multiple sample extraction probes in accord with current EPA guidance.[66] The sample extraction assembly with multiple probes installed is called a "sampling rake." LANL also uses ANSI sampling rakes with multiple probes to sample effluents from stacks for which Reference Method 1 cannot be used to select a sampling location.

In response to a recommendation from the first audit, LANL has selected a cautious correction factor for losses in rake sampling systems based on information for 5-µm aerodynamic diameter (AD)[d] aerosol particles.

Evaluation of LANL Methodology

During 1999, the sampling probes employed in stacks and vents at LANL were the same as those used at the time of the first audit. The shrouded probe that is preferred by LANL and was approved by the EPA is a superior approach and has been incorporated into the newly revised ANSI guide.[67] The EPA has also approved the use of multi-probe rakes in other sampling locations. The LANL sample extraction techniques meet the regulatory requirements.

The corrections for losses in sampling systems very probably overestimate actual losses because the expected aerodynamic equivalent diameter of the particles being sampled is substantially less than the 5-µm AD size that is assumed. Because aerosol filtration systems are installed, the particles being sampled are most likely to have ADs in the sub-micron range. Sampling losses for those particles are much lower than for 5-µm AD particles. The Laboratory's cautious approach is not likely to lead to dose estimates for particulate radionuclides that approach the 10-mrem (0.1 mSv) dose standard of 40 CFR 61, Subpart H. Nonetheless, the assumed correction factor must be remembered when making comparisons between concentrations of particulate radionuclides predicted using the estimated releases with the concentrations measured by the AIRNET stations.

A question about sampling rake efficiencies at TA-55 and the CMR facilities was raise by the IEER monitors (Appendix C, page C-9). In the first case, they point out that the efficiency of the TA-55 sampling rakes is low (~20%) for 10-µm AD particles and suggest that a deadline

[d] The aerodynamic diameter is the diameter of a unit density sphere that has the same terminal settling velocity in air as the particle of interest.

should be established for upgrading these rakes. The suggestion is related to the fact that EPA is currently considering revision of the regulation to reflect the newly revised ANSI guide.[68] The audit team notes that the particles that are normally present in TA-55 effluents are much smaller than 10 μm AD because the air being discharged has passed through multiple stages of HEPA filters. The cautious nature of the assumed correction factor, which considers 5-μm AD particles, was discussed above. We also note that off-normal conditions that could lead to releases of larger particles would be detected by operations and are not likely to have a substantial effect on estimates of annual releases that are obtained for compliance with 40 CFR 61. Inasmuch as modification of the effluent sampling systems at TA-55 would be a complex and expensive undertaking, it is our opinion that it should not be undertaken until both the need for change and the requirements of the new system are clear. The contribution of releases from TA-55 to the estimated maximum offsite dose for 1999 is difficult to estimate because both that contribution and the total were overestimated. It does not appear to have been more that about 0.01%.

In the second case (Appendix C, page C-9), IEER has raised questions about the continued use of sampling rakes whose efficiency has not been tested by particle challenge tests, even though the sampling systems have been approved by the EPA. They note that new sampling locations have been identified and equipment installed at the CMR facility, and suggest that a deadline be imposed upon completion of the work and use of the new sampling locations. As measured by the estimated contribution to the maximum offsite dose, the CMR releases are more important than those from TA-55, but are nonetheless a small fraction (1–2%) of the total. The audit team has also seen the evidence of installation of the new systems and understands that testing is underway. It is our expectation that the results will be positive and that a change to the new systems will be desirable; however, such a change will require EPA approval. External imposition of a deadline on the approval process is beyond the purview of the audit team.

Sample Transport Lines

Transport lines carry sampled air from the outlet of the sampling probe to the point of sample collection or location of a continuous monitoring system. Deposition on the walls and in bends of the line can lead to losses of particulate radionuclides from the sample. Therefore, transport lines should be kept as short as is feasible given the conditions at the sampling location. Appendix A of the ANSI guide,[69] which is included by reference in § 61.93 (b), deals specifically with sampling ducts and stacks. Appendix B of the same guide,[70] which discusses particle deposition in sampling lines, is not included by reference in § 61.93 (b).

Summary of LANL Methodology

As part of the DOE request[71] for EPA approval to use the alternative method, DOE proposed using the DEPOSITION computer code to optimize the transport line and to estimate transmission losses. This computer code was developed at Texas A & M University and had been accepted by the Nuclear Regulatory Commission for estimation of losses in transport lines. The EPA approved the proposed approach[72] under certain conditions, which are all given in the first audit report.[73]

For sampling locations that meet the requirements for use of the shrouded probe, LANL uses the DEPOSITION code to optimize the sampling line by selecting a line diameter that minimizes

deposition for the flow rate needed for sampling. For these lines, LANL also uses the DEPOSITION code to estimate transmission losses in the probe and sample transport line. In response to a finding from the first audit, sample losses during transmission have been determined for three lines and the relatively small (< 10%) corrections for those losses are applied.

Evaluation of LANL Methodology

The process of accounting for losses of particles in transmission lines has been improved since the time of the first audit. Corrections are now applied for losses in all lines. Some of the sampling lines have been optimized; others have low transmission losses as the result of good practice based upon practical experience.

Collection and Analysis of Tritium Samples from Stacks and Vents Located in TA-16, TA-21, TA-33, TA-41, and TA-55

The techniques used for collection and analysis of tritium in airborne effluents from stacks and vents at the TA-16, TA-21, TA-33, TA-41, and TA-55 locations are similar. For that reason, the tritium sample collection and analysis procedures for all these facilities are discussed together.

The requirements of 40 CFR 61, Appendix B, Method 114, Section 2.2.1 describes appropriate methods for collecting tritium from effluent samples. Section 2.2.1 also provides the method for oxidizing tritiated hydrogen gas, followed by collection of the resulting water vapor. Liquid scintillation counting, 40 CFR 61, Appendix B, Method B-5, is identified as a method that is most applicable to low-energy beta-emitters such as tritium.

Summary of LANL Methodology

Weekly samples of tritium in effluents are collected using ethylene glycol bubbler-type collectors. Three bubblers are used in series to collect tritium present as tritiated water vapor (symbolized by HTO) in the sampled air stream, which is trapped as the air bubbles through the ethylene glycol collectors. The second and third bubblers provide back-up capability to collect all the HTO in the sample. Tritium that is present as hydrogen gas (symbolized by HT) is not collected when the air passes through those three bubbler collectors. It is converted to HTO as the sampled air stream flows through a heated bed of palladium metal. The metal catalyzes the oxidation of the HT to HTO. The air stream that leaves the catalytic converter flows through a second series of three ethylene glycol bubbler collectors, which trap the HTO that contains tritium originally present as HT. The collected samples are analyzed by liquid scintillation counting and the results are used to estimate the releases of HTO and HT.

Periodically, LANL performs a test of the catalytic conversion process in the sampling system and the overall sample collection efficiency for HT. In this procedure, a known amount of HT is released into the stack over approximately a four-hour period. The ethylene glycol bubbler samples for HT are collected and analyzed. A second procedure then begins to measure the release of HT from the stack as the result of facility operations during most of the following day. Care is taken to detect any disturbances that would affect this measurement, which serves as a background release estimate for the test period. The HT concentration measured during the

background period is subtracted from the value measured during the test and the net response of the sampling system is compared with that expected from the known release. When the amount estimated by the sampling system is less than the expected value, estimated release of HT are corrected by an appropriate factor.

Duplicate aliquots of ethylene glycol are taken from the bubbler vials and analyzed by the Health Physics Analytical Laboratory (HPAL) together with a standard and blanks of unexposed ethylene glycol. Although there is normally little difference between the duplicate samples, the higher of the two is used to estimate releases. LANL uses the totals of the three highest estimates (one for each bubbler) for HTO and for HT to estimate the releases. As noted earlier, the highest flow during the previous three years is also used in the calculation. In the dose calculation, it is assumed that all of the tritium is present as HTO.

Evaluation of LANL Methodology

The techniques used by LANL to collect and analyze samples of tritium in airborne effluents are state-of-the-art and meet the requirements established by the EPA. All of the tritium sampling systems that we observed were functioning properly, and the records of sampling and measurement results that we examined indicate a high degree of reliability for these systems.

The analytical data that are obtained provide weekly demonstrations of the reliability of the ethylene glycol bubbler collection process. Results are available for the series of three collectors, and approximate collection efficiencies are readily calculated. The data that we examined show that there was no significant loss of tritium from the collectors. The decision by LANL to always use the highest of the twelve most recent flow rate measurements and the largest of the two duplicate results for each collection vial leads to overestimation of the actual releases.

Review of the sampling data files suggests that there is a small discrepancy in estimated release. It appears to have occurred because a spreadsheet calculation established for calibration releases was inadvertently applied to release estimates for other times. The calculational procedure was revised in 1999 and most of such overestimates were corrected.

We previously recommended[74] that, as a matter of good practice, LANL should provide heat tracing for those parts of the tritium sample transport lines that were outside and exposed to cold weather during the winter. This recommendation was made to avoid temporary losses of HTO from samples due to condensation in the lines and, in the extreme, the possibility of a sampling line being plugged by ice. All sampling lines except the one at TA-55 have heat tracing, and its installation at TA-55 has been requested.

A question raised by the IEER monitors is whether tritium sampling might also be required for both stacks at TA-55 (Appendix C, page C-9). We have examined this question and provide the following information. The ventilation systems for the two parts of the Plutonium Facility are isolated and exhausted separately through different stacks. The need (or lack of it) for tritium monitoring is based upon information about the operations in areas exhausted through the individual stacks and the building radionuclide inventory information. If a change in location of processing that involves tritium inventory were planned, ESH-17 would be notified and appropriate modifications of the sampling system would be made.

Another question from the IEER monitors (Appendix C, page C-21) deals with their comparison of the ESH-17 sampling results that meet the criteria established by the EPA with those from ionization chambers used to assess changes in effluent concentrations in real time for

operational purposes. The ion chambers are equipped with a summing circuit that multiplies the estimated concentration by a flow rate. The sum is normally recorded weekly as is the estimated background at the time. While noting that it is an apples-and-oranges type of comparison and that background subtraction is somewhat problematic, the IEER has tabulated their calculated and the recorded results from the ion chamber at TA-33 and compared them with the ESH-17 bubbler data. In general, the ion chamber (IC) estimates are lower (32% for the year) than the releases measured by the bubblers (B), and 42 of 51 ratios of weekly values (IC / B) are less than one. This rather consistent difference may be due to different choices of exhaust flow rates.

During the week ending August 3, 1999, when the exhaust fan failed, the summing circuit, which does not receive information about fan operation, estimated a release of 86 Ci (3.2 TBq), about eight times higher than the ESH-17 value. During this period, it can be expected that the concentration would build up to an equilibrium value, which will be higher than normal because the fan was not operating to remove tritium. High concentrations of HTO were measured by both systems. Review of the records revealed that it is not known how long the exhaust fan was operating during the week. The building is being decommissioned, and personnel make only weekly visits when no work is being performed. That was the case for the week in question. Thus, the exhaust flow could have been off nearly all week, or may have failed near the end of the week. It was also discovered on August 3 that the temperature of the catalytic converter was much lower (~100^{o}C) than the design operating temperature (475^{o}C). This is apparently the reason why the measured HT concentration was not elevated. The temperature controller for the converter was replaced. We have not investigated the cause of these failures, and it is not known to us if the two failures were related.

Releases of HTO and HT for the week were estimated using two assumptions. The first was that the releases would have been comparable to those during the preceding 5 weeks, which were also periods of no work involving tritium systems. The second assumption was that the exhaust fan operated throughout the week. The first assumption is reasonable; the second leads to a cautious overestimate of the releases. The assumed flow rate was the highest measured for that exhaust fan during the previous three years.

The audit team believes that the tritium sampling systems are reliable and that comparisons with other sampling or monitoring systems are not needed to bolster their standing. Likewise, it appears that the ion chamber systems are satisfactory for operational purposes and that there is no need for LANL to devote resources to their improvement or calibration, let alone to try to qualify them for use in the 40 CFR 61 compliance program.

A topic that was discussed during several facility tours and raised formally by IEER with regard to TA-55 (Appendix C, page C-9) is whether ESH-17 would be notified if a real-time monitor indicated that a significant release had occurred. The audit team agrees with the monitors that such notification is appropriate to permit ESH-17 staff to take appropriate action.

Collection and Analysis of Airborne Particles Released from the Chemical and Metallurgical Research Facility

Several radionuclides, primarily alpha-emitters, are released in the form of particles from 14 different stacks at the CMR Facility, TA-3-29. Particulate alpha-emitting radionuclides are also released from other facilities, such as the plutonium facility located in TA-55, but those releases did not contribute significantly to the offsite doses during 1999. Sample collection and analysis

methods and the procedure for estimating releases of alpha-emitters from these facilities are the same and are discussed together in this section.

The requirements of 40 CFR 61, Appendix B, Method 114, describe sample collection and analysis methods for radionuclides present in particulate form:

> The extracted effluent stream is passed through a filter media to remove the particulates. The filter must have a high efficiency for removal of sub-micron particles. The guidance in ANSI N13.1–1969 shall be followed in using filter media to collect particulates.

Summary of LANL Methodology

Weekly samples are collected downstream of effluent filtration systems in the several exhaust stacks using LB-5211 filters. The collection efficiency for 0.3-µm unit density particles by the LB-5211 filters has been measured. In six tests, the collection efficiencies ranged from 99.2 to 99.8%, and the mean value was 99.6%. As a screening procedure, these sample collection filters are analyzed by direct counting to determine total alpha radioactivity. Half of each filter is included in a quarterly composite sent to an offsite radiochemical laboratory for determination, by chemical separation and alpha spectrometry, of the alpha-emitting radionuclides present in the composite sample. LANL retains the other half of the filter.

The results of the alpha spectrometric analysis are used to estimate isotopic releases from the stacks. In the calculations, corrections (discussed earlier) for losses of particles during sampling collection and transport to the filter are applied. As for other releases, the maximum value among the last twelve quarterly flow rate measurements is used when calculating releases.

Evaluation of LANL Methodology

The methods used to estimate releases of alpha-emitters have changed since the time of the first audit. Analysis of composite samples using alpha spectrometry following chemical separation is a more reliable method for determining the effluent radionuclide concentrations. The current method has been used since the beginning of 1997.

Corrections for particle collection efficiency are not made; the difference between the assumed collection efficiency of one and the measured average of 0.996 is not significant. The collection efficiency measurements were made using particles that were in the size range (0.1–0.5 µm equivalent aerodynamic diameter) most likely to penetrate the filter medium. Particles that are either smaller or larger than those in this range are collected more efficiently. Thus, the collection efficiencies found for the 0.3-µm unit density particles can be applied broadly without fear of serious error. Conduct of some plant effluent measurements using two particulate filters in sequence could provide additional confidence in the collection efficiency of those filters under current field conditions.

The IEER monitors raised a question about the need for backup pump capability for sampling systems in the CMR facility (Appendix C, page C-9). They note that typical pump operating times substantially exceed the 85% requirement, but suggest that a higher standard may be appropriate.

The audit team observed that in some cases a single pump was used for two sampling systems and in others the building vacuum system was used to draw samples. Another relevant

observation is that the Laboratory has instituted a program of routine operational checks and preventative maintenance for the effluent air sampling pumps. Most of the carbon vane pumps used in the past have been replaced with better equipment. Both these changes help assure continuous operation of the effluent sampling systems. In view of the operational history, the equipment upgrade, and the new preventative maintenance program, the audit team does not believe that there is a problem with sampling system operability in the CMR or other facilities.

Analysis of Airborne Effluents from the Los Alamos Neutron Science Center (LANSCE)

The primary releases from the Los Alamos Neutron Science Center (LANSCE) are short-lived radioactive gases that are produced by operation of the linear accelerator. Lesser amounts of beta-gamma-emitters are released in particulate form or as vapors from the facility. Sections 2.2.3 and 2.2.4 of Method 114 in Appendix B of 40 CFR 61 apply to the short-lived gases.

> Radionuclides of argon, krypton, and xenon . . . are either measured directly by an in-live or off-line monitor, or are collected from the extracted sample by low temperature sorption techniques. Appropriate sorbers may include charcoal or metal zeolite.
> Radionuclides of oxygen, carbon, nitrogen, and radon . . . are measured directly using an in-line or off-line monitor. Radionuclides of carbon in the form of carbon dioxide may be collected by dissolution in caustic solutions.

An "in-line monitor" refers to a continuous measurement system in which the detector is placed directly in or adjacent to the effluent stream. An "off-line monitor" refers to a measurement system in which the detector is used to continuously measure an extracted sample of the effluent stream. Either may involve gross radioactivity measurements or specific radionuclide measurements.

The sampling protocol in Appendix B that is most appropriate for the reactive gases that are released from the facility is that for iodine, also a reactive gas. In both cases a collection medium such as impregnated charcoal or metal zeolite is used to trap the reactive forms (and less reactive forms that may exist in some exhausts). Particulate radionuclides are collected using filters as described earlier.

Summary of LANL Methodology

For the short-lived gas releases that are released through two stacks at LANSCE, LANL employs off-line monitors that employ Kanne flow through ion chambers and gamma spectrometers with high purity germanium (HPGe) detectors that are connected to multichannel analyzers. Each stack has a separate pair of off-line monitors. Outputs of the Kanne ion chamber and gamma spectrometry systems are processed and recorded automatically using a computer system. The two measurements are routinely compared and agreement within ± 10% is required. The ion chambers provide a gross measurement of total activity released, while the gamma spectrometer is used to identify the radionuclides that are released. Several of the radionuclides of interest (^{11}C, ^{10}C, ^{15}O, ^{14}O, ^{13}N) are positron-emitters. When positron annihilation occurs, two 511-keV photons are emitted and those gamma rays are characteristic of all these radionuclides.

Other nuclides (^{16}N, ^{41}Ar) that are released are beta-emitters, which also emit distinctive gamma rays.

Contributions of these radionuclides to the total release depend upon their production rates and half-lives. Typically, the longer-lived nuclides are most prominent in the discharge. For example, the half-life of ^{11}C, the predominant nuclide, is about 20 minutes, while the half-life of ^{10}C, a minor component of the mixture, is only about 9 seconds. The isotopic composition of the positron emitters is determined by observing the decay of the 511-keV peak using high-resolution gamma spectrometry.

Diffuse emissions of the radioactive activation gases leaking out of buildings, primarily near the main beam line, also occur are also estimated separately. Kanne ion chamber data within the facility are used to estimate concentrations of radioactive gases, which are multiplied by estimated volumes of air released from the area as the result of leakage.

Releases of radioactive particles and vapors are sampled continuously, with weekly sample exchanges. Shrouded probes are used to extract those samples, which are collected by sampling trains, each of which consists of a particulate filter followed by an impregnated charcoal cartridge. These samples are analyzed by high-resolution gamma spectrometry in the Health Physics Analytical Laboratory.

There are some releases of tritium from the LANSCE facility, but the amounts are too low to be detected using the normal tritium sampling arrangement. Instead, HTO in the stack effluents is collected using a bed of silica gel.

Evaluation of LANL Methodology

The methods for effluent sampling and diffuse emissions at LANSCE are described in older LANSCE facility procedures that are in the process of being converted to ESH-17 procedures. The available procedures are likely not completely up-to-date and will soon be superseded. Based upon those procedures and information obtained during the tours of the LANSCE facility, we conclude that the LANSCE methods meet the EPA requirements for effluent monitoring and sampling for 40 CFR 61.

The short-lived gas monitoring systems are state-of-the-art and the dual measurement approach provides for high reliability for monitoring these historically important release points. In fact, these release points were also important in 1999. The estimated dose at the East Gate site was only slightly lower than the maximum offsite dose location, and more that one third of the East Gate dose was due to LANSCE releases.

The procedure for estimating fugitive releases, which accounted for about 11% of the dose estimated for the East Gate site, is satisfactory and appears to follow the typical LANL approach of providing cautious estimates of releases. The Kanne ion chamber data that are used in those release calculations are considered quite reliable.

The sampling system for particles and vapors employs shrouded probes at locations where the effluents are well mixed. As noted earlier, this is a superior approach. The vaporous radionuclide collection by the impregnated charcoal cartridge is assumed to be 65% efficient. Testing, using two identical cartridges in sequence to collect these nuclides from the LANSCE effluent, has shown the efficiency for these cartridges to be higher (87–100%) than the assumed value.

These same sampling cartridges are used routinely at TA-48 and at TA-3-29. Because the chemical forms of the vaporous radionuclides may be different at these facilities, similar measurements of efficiency should be conducted there to check whether the assumed collection efficiency is appropriate for those locations. At the CMR facility, such measurements can only be conducted at some future time, if and when target processing occurs. At TA-48, concentrations are relatively low, but measurements might be coordinated with operations expected to produce higher effluent concentrations of the nuclides of interest. If the measurement sensitivity is adequate, values for the second cartridge that are below the detection limit may provide useful lower bounds for the collection efficiency.

NON-POINT SOURCE MONITORING EVALUATION

LANL has identified over 1500 potential sources for diffuse, or non-point, emissions within the boundaries of the LANL technical site. To meet the requirements of 40 CFR 61, Subpart H, releases from all sources that have the potential to release radionuclides must be kept below an annual dose limit of 10 mrem (0.1 mSv) to a maximally exposed individual (MEI). These releases include those from point sources as well as the 1500 diffuse sources onsite. Techniques for monitoring releases from point sources are specified in 40 CFR 61, Subpart H, but non-point sources are not explicitly addressed in the prescribed methods. Non-point sources include sources at LANL such as shallow land burials, surface impoundments, firing sites, unvented buildings, open burn sites, and tanks.

One method for assessing diffuse releases is to estimate the source term from each identified release site and model the dispersion of this source term through the atmosphere to the MEI. For example, these source areas might consist of soil areas or surface water contamination, but the endpoint of interest is the ambient air concentration of radionuclides at a downwind, maximally exposed location. The other method is to use environmental monitoring at the location of the MEI from which the dose can be inferred.

Within the FFCA Supplement 2a, which outlines LANL's proposed methodology for monitoring diffuse releases, LANL assesses the two alternate methods for establishing dose to a receptor for usability with the criteria of accuracy, completeness, and timeliness.[75]

The accuracy of a source term and dispersion calculation is affected not only by the errors involved in using resuspension and atmospheric dispersion modeling, but also in the ability to identify and quantify the source term. Techniques for modeling particle resuspension from area sources are not well established, and atmospheric dispersion modeling is extremely uncertain on rugged terrain such as that at LANL. The majority of atmospheric dispersion models are based on the assumption of flat terrain, which is certainly not exhibited at LANL. The site is located on the Pajarito Plateau, which consists of a series of finger-like mesas separated by deep canyons. This terrain complication makes the process of modeling the dose with any certainty a problem. LANL never actually modeled dose to a MEI from diffuse locations, but they subjectively estimated the uncertainty in modeling dose from these multiple locations based on their experience with conventional source to receptor models.

LANL places confidence in environmental monitoring based upon their ability to understand and control errors in environmental sampling that cannot be controlled in source term modeling. In the FFCA, LANL estimated the uncertainties in doses calculated from diffuse sources using modeling techniques to be greater than 30%. This estimate was not based on actual calculations but rather on professional judgment. In contrast, LANL assumes that the uncertainties in environmental monitoring measurements are much smaller since uncertain parameters are avoided and sampling error can be adjusted for and minimized through quality control.

LANL recognizes that by taking environmental measurements, they are essentially calculating dose from point sources twice: once with the effluent source and modeling techniques (includes both monitored and unmonitored sources) and once by measuring exposure at environmental locations that would also be affected by point sources. This conservatism is accepted by LANL in favor of more reliable environmental measurements.

It is difficult to calculate complete and timely dose estimates for diffuse sources using modeling techniques because of the sheer number of diffuse source locations at LANL. LANL

believes the source term estimates and modeling required to completely account for all diffuse sources would be more rigorous and time consuming and less complete than actually monitoring the ambient air. LANL applied this reasoning to support its decision for using environmental sampling to demonstrate compliance. Assuming that the samplers are properly placed, LANL postulated that the environmental measurements should provide a comprehensive assessment of contamination due to diffuse sources, as well as monitoring any unsuspected contamination. In LANL's judgment, the timeliness of sampling results would be at least as rapid, if not more so, than obtaining the results of modeling diffuse releases.

Because of constraints related to accuracy, timeliness, and completeness described above, LANL has chosen to use environmental monitoring techniques to assess releases from non-point sources instead of modeling.

During this second audit, we reexamined LANL's use of environmental sampling to show compliance with the dose limit for diffuse sources. Additionally, since the first audit, LANL has appended the FFCA sampler siting analysis to include more detailed information. To evaluate the Laboratory's compliance with 40 CFR 61, Subpart H, and the viability of LANL's diffuse source monitoring program, the audit team carefully examined the AIRNET program in its entirety once again, including a look at refinements and improvements that had been made since the time of the first audit.

The AIRNET System

AIRNET is a system of environmental air samplers located around the perimeter of LANL property and in other locations where monitoring the concentrations of radionuclides in air might be important. The AIRNET network has been in operation for over 20 years, long before LANL was legally bound to EPA and DOE requirements. The samplers are located between Laboratory facilities and potentially exposed members of the public or they encircle areas on the Laboratory property that have the potential to be major sources of diffuse emissions.

The compliance-related sampling network comprises only a small portion of the total AIRNET system. There are a number of AIRNET stations located at other onsite locations as well as a number of offsite locations that are not included in the compliance network. When the compliance sampler sites were being established, LANL tried to overlap existing AIRNET sites with compliance sites to avoid duplication. The sampler siting analysis is discussed in detail later in the report.

Sample Collection and Handling

Summary of LANL Methodology

Each AIRNET sampler station collects filter samples of airborne particles and silica gel samples of water vapor, including tritium vapor, from ambient air. The filter housing and airflow equipment configuration were designed by the Laboratory from commercially available parts. The filter housing is a weather-tight, louvered design containing a particulate filter assembly, two flow meters, a vacuum pump, various connecting hoses, and a power supply circuit. The silica gel water vapor absorber has been moved outside of the sampler housing to better represent the humidity in ambient air, as will be described later. An additional piece of equipment, a data

logger, has been added to the FFCA stations since the first audit. This data logger tracks the power supply to the station and alerts the AIRNET laboratory if a power failure occurs at a station. If a power failure is noted at an FFCA station, an AIRNET technician will go into the field and investigate the problem, fixing it immediately if possible, or collecting the appropriate equipment and returning to the field to resolve it. In the case of such a power failure, a note will be made in the laboratory technician's logbook and then transferred to the AIRNET logbook. Specifications for all parts of the sampling assembly are given in the sampling and analysis plan for AIRNET.[76]

Before placement in the field, filters and silica gels are prepared in the AIRNET laboratory.[77,78] The filter preparation involves cutting the filter paper using a cutting tool that stamps out filters with a uniform diameter. These filter papers are precut only in a quantity to fill the filter heads for the upcoming 2-week sampling period. The filter paper is handled with tweezers on a clean surface to avoid unnecessary contamination. The filter head assembly is cleaned of excess dust, the filter is placed within the filter head assembly, and a plastic cap is placed over the filter to again protect it from contamination. Each filter head is designated to a specific sampler, and each assembly is placed on its designated sampler every other 2-week period.

The filter head design for the samplers was chosen to reduce the possibility of filter contamination when the filters were removed and transferred to the AIRNET laboratory. The filter head is removable in its entirety from the airflow system by a quick disconnect fitting. During sample change-out, the old filter head, already marked with the sampler number, is removed from the airflow system and covered with the cap from the new filter head. This new filter head, also appropriately labeled, is then placed on the airflow system. Capping the filter reduces filter contamination during the change-out and keeps the collected sample in place on the filter. The filter heads and silica gel cartridges are color coded to represent each 2-week period. With this technique, when removing samples from the field, no confusion or misplaced sample occurs because of a field technician not being certain which is the old sample and which is the new.[79]

Silica gel containers are also prepared in the laboratory in the off-week during which samples are not changed out. First, a can of silica gel material is baked in an oven at approximately 150°C for at least 5 hours. This process removes any excess water from the silica gel, as such water would dilute the concentration of tritium collected in the sample. Under a fume hood, approximately 135 g of silica gel is placed into each sampler container. The container lid is replaced and the silica gel cartridge is then weighed. This weight is considered the starting weight and is tracked in the database, although the data are not directly used. In 1999, silica gel weights were hand-entered directly into the database, and no double checks of these weights were in place.

Silica gels are safe from contamination if the gel beads are not exposed to moisture before being sealed in the casing. Once the silica gel is connected to the airflow system, only moisture passing through the system during the 2-week sampling period will be collected by the gel. Gel weights have been selected based upon exposure duration and experience with these gels in the field. Silica gel cartridge holders include a mechanism that stops air flow and, thus, moisture flow, into the cartridge after it is removed from an airflow system. The change-out of silica gel cartridges proceeds similarly to the filter change-out. The importance of the color coding system

is even greater here, as there is no difference in appearance between the silica gels before and after placement in the field.[80]

During sampler change-out, important field information is entered into a palmtop computer. This information includes timer reading, filter flow before the filter head is removed, filter flow after the filter head is replaced, silica gel flow before and after removal and replacement of the cartridge, and any important information to describe conditions in the field that might affect sample readings, such as a power failure or a breaker that is off.

Once in from the field, contaminated filters are removed from the filter head assembly using tweezers. All of this is done on a clean surface to avoid unnecessary contamination. The filters are then placed in glassine envelopes that have been prelabeled to reflect the sampler number. During 1999, whole filters were face-front counted individually for gross alpha and gross beta, and counted in clumps for gross gamma by Wastren, Inc. in Grand Junction, Colorado. Wastren holds onto these whole filters and at each quarter's end, a representative from ESH-17 goes up to the analytical laboratory and splits each filter in half, adding each filter half to a quarterly filter composite for that sampler. One half filter composite is digested and analyzed for isotopes of uranium and plutonium and ^{241}Am. The other half composite is maintained at Wastren for a period of time stipulated in the contract with Wastren in case it is needed for a recount.

In 1999, silica gel was removed from the cartridge and the water vapor was distilled off of the gel and condensed. The water was then put into a small jar and measured for tritium content at Paragon Analytics of Fort Collins, Colorado.

Silica gel cartridges are checked for leaks every 6 months. The leak checking process involves putting 10 pounds per square inch (0.7 kilograms per square centimeter) of pressure using helium gas on the silica gel cartridge. A sensitive helium detector is then used to check for any leaks. Leaks are repaired and documented in the AIRNET log book.[81]

In addition to the samples placed in the field, several quality assurance samples are prepared and used as a check for cross-contamination. For filters, these quality assurance checks include filter trip blanks that go out on the filter placement loops with the field technicians and matrix blanks that stay in the AIRNET laboratory during the 2-week period. These help detect any contamination of filters in the field or in the laboratory. For the silica gels, water with undetectable amounts of tritium are sent to the analytical laboratory as blanks. This water is drawn from wells that sample the regional aquifer, where sensitive measurement techniques have been used to measure tritium concentrations that range from 1 to 2 pCi L^{-1} (0.037 to 0.074 Bq L^{-1}). These samples represent blanks for the AIRNET program, because the AIRNET detection limit is 500 pCi L^{-1} (18.5 Bq L^{-1}). Another blank sent to the laboratory contains silica gel that comes straight from the manufacturer's container, to which 10 g of deep well water is added. Spiked samples are prepared by another group onsite and sent to the laboratory for counting. In all, the filter program includes two different types of quality assurance samples, and the silica gel program includes three different types. The analytical laboratories also perform several quality assurance checks of their own to ensure that contamination is not introduced in their setting.

Evaluation of LANL Methodology

The audit team observed all aspects of the sample handling and preparation program described here. The techniques outlined in procedures were well followed in the laboratory. The audit team found the AIRNET sample collection process to be sound.

The addition of the data loggers to the compliance AIRNET stations marks a notable improvement in the completeness of the AIRNET data. During the prior audit, the field technicians visited the AIRNET stations during the off-week to ensure that the power was on and the station was running properly. Implementing the data loggers created an automated system for power maintenance that the audit team commends. Now, instead of having possibly a week of lost data, the AIRNET laboratory is notified within 2 days of a power failure. A recommendation related to these data loggers is noted in the Additional Observations section.

Another positive change in the system is in the silica gel collection process. In 1998, it was discovered that the location of the silica gel cartridge was likely having an impact on the collection efficiency of the silica gel.[82] Because of increased temperatures in the AIRNET housing relative to ambient temperatures, silica gel cartridges located within the housing had their sorption capacity reduced by more than half, reaching capacity in 6 days. As a result of this finding, the AIRNET staff moved the silica gel cartridges outside of the AIRNET housing, eliminating the temperature-related problem. They also discovered an issue related to the absolute humidity, which is discussed in the "Data Validation and Verification" section of the report.

In late 1999, the AIRNET staff was alerted to a possible contamination problem in their laboratory by Paragon Analytics, the laboratory that measures the tritium concentration. Paragon contacted the AIRNET staff about an unknown organic compound in the tritium samples whose luminescence was interfering with tritium analysis, done using scintillation counting. The luminescence was well above 5% and persisted for several weeks, causing ESH-17 to launch an investigation of what was causing the problem. After running several experiments to determine the probable cause, they discovered that a detergent used in cleaning the AIRNET laboratory had likely permeated the walls and contaminated all of the AIRNET equipment.[83] Distillation was discontinued in the AIRNET laboratory, and silica gels are now sent directly to Paragon for distillation and analysis. The samples contaminated at the end of 1999 were reanalyzed after the detergent luminescence had decayed away, providing usable samples for the end of 1999. The audit team commends the AIRNET staff for working together with the analytical laboratory to solve a problem and find a solution that resulted in important data being saved. The audit team does not feel that this compromised the tritium data; rather, it was an innovative solution that saved several weeks of environmental tritium data.

Throughout the last several years, AIRNET personnel have experimented with several different techniques for gross alpha and beta analyses. Filter face front counting versus filter digestion and plating is a discussion that has obviously gone through the group since the first audit, and the AIRNET staff has come full-circle. At the time of the first audit, AIRNET was using filter face front counting for gross alpha and gross beta measurements. Beginning in 1997, the group switched to cutting the filters in half and sending half for chemical treatment and plating before samples were analyzed for alpha and beta. The other half remained in the AIRNET laboratory for inclusion in the quarterly composite. Although switching to this technique may have revealed higher alpha and beta concentrations on the filters because no counts were lost to sample self-absorption, the staff instead found that readings at individual samplers remained very consistent, even with the change in methodology. It was hypothesized that filter loading was not great enough to cause a significantly thick layer of contamination on the filter to make sample self-absorption an issue. As a result, the AIRNET staff have switched back to analyzing gross alpha and beta using filter face-front counting. The difference in result was not significant enough to make it worth it for the staff to lose a half filter at every station in the event that recounting or

alternate analysis would need to be completed. While the audit team appreciated the half filter technique for alpha and beta during the first audit, we certainly understand the need for additional data options and believe that the AIRNET staff sufficiently examined the issue before making a decision, and we support their conclusions.

IEER raised an issue during this audit related to the distribution of ^{238}Pu and ^{241}Am activities in AIRNET samples (Appendix C, page C-13). They pointed out that a small quantity of each of these nuclides in the air would result in exceeding the compliance limit. They reviewed AIRNET data to see if such a situation appeared to be occurring. Their findings support the probability, but do not exclude the chance, that small numbers of particles with high specific activities do not exist in the LANL environment. If these particles did exist, it is possible that they would exist only on one-half of the filter. In such a case, the gross alpha analysis would likely show much higher than normal alpha counts. If one-half of the filter analysis did not reveal the source of this contamination, the other half would now be available for reanalysis. This is another important reason that we support LANL's choice to recommence filter face front counting for gross alpha and beta.

During one site visit, the audit team viewed a leak checking procedure on several silica gel cartridges. During the check, a leak was discovered on one cartridge. This leak was at the back end of the cartridge, or the end to which the air pump would normally be attached, with the other end being exposed to the environment. The leak essentially means that more air would be pulled through the volume of the silica gel without that additional air flow being measured by the AIRNET instrumentation. However, the calculated tritium concentration is independent of total air volume because tritium concentration is calculated using the total water vapor in the atmosphere, as described in the next section. The leak could also result in some loss of sample, as the silica gel will exchange somewhat with the ambient air. This constant sorption onto and off of the silica gel happens with or without this leak, and the sample will likely still provide a good representative sample for the 2-week period and certainly for the year over which tritium is measured.

It is difficult to assess the magnitude of the impact, if any, that this leak might have on the final sample concentration of tritium. During the semi-annual checks for leaks in the cartridges, about 10% of the cartridges are usually found to be leaking. Any environmental measurement program will experience problems of this sort, and it is not possible to remove all sources of random error from an environmental measurement program. We do not believe that the AIRNET program is compromised by the occasional leaking of silica gel cartridges. The frequency of leaks is too small and the checks occur often enough to ensure that this expected occurrence does not become a problem.

Quality assurance of the AIRNET samples and field data is maintained through several avenues. The numerous quality control samples sent to the analytical laboratory are ample evidence to show that the laboratory measures values correctly and that the AIRNET facilities or personnel are not inadvertently introducing additional contamination onto the filters and silica gels. The data loggers have increased the completeness of the AIRNET data, reducing downtime of the samplers. Two AIRNET personnel go out on nearly every station change-out loop for safety reasons and to create a built-in double check of field procedures. The palmtop computers, partially in place during the first audit, have built-in nominal values for the input parameters from the field, and alert personnel to any data points that are considerably out of range. The palmtops also print out a chain-of custody form, which the audit team observed to completely accompany

each AIRNET sample from AIRNET laboratory to field and back, to shipping and to the analytical laboratory. It was obvious to the audit team that the AIRNET group works as a team and is dedicated to good data quality. Constant improvements to the program are being made, mostly because of careful attention to the details and willingness to experiment and search for new and innovative ways to make the program better. Every quality assurance requirement is consistently well-documented in AIRNET procedures. The audit team considers quality assurance as it relates to sample handling and preparation to be complete in both documentation and application.

During the first audit, the audit team made several recommendations with regard to AIRNET sampler housing, filter flow rates, and other sampling parameters. Because environmental sampling is not regulated by the EPA in its application to air quality compliance, the Laboratory developed some parameters for sampling based on their experience. They did not research similar programs at other DOE facilities, and the audit team suggested that particularly in the area of filter flow rates, they might have something to learn from other facilities. Additionally, the audit team was not convinced that the AIRNET sampler housing design was sufficiently proven to collect particles in the respirable range. As a result, the audit team also recommended a wind tunnel study or side-by-side studies with EPA PM-10 monitors.

LANL followed through with both of these suggestions. In the process, ESH-17 collected considerable information about how their sampling program compares to others as well as how their air monitors collect respirable particles.

In the compilation and comparison of monitoring across the DOE complex[84], the Laboratory looked at filter types and sizes; filter flow rates; tritium collection methods; and minimum detection limits for alpha, beta, radioisotopes, and tritium. The filter flow rates used at LANL are quite comparable to those used at other sites where low flow rates are used. Some sites used larger filters and higher flow rates for particulate collection. LANL discovered that, like themselves, several other facilities have had to replace glass fiber filters with some other media because of the high uranium background in the filters. Silica gels with very similar flow rates are employed at many other laboratories. LANL compares quite favorably in the minimum detection limit category, where their detection limits for radioisotopes are consistently among the lowest at DOE facilities. This study was well done and very interesting, and we commend the Laboratory and the author for undertaking the work.

The wind tunnel experiment also proved very interesting and supports the AIRNET sampler collection capabilities. The experiment compared many different samplers, using the shrouded probe sampler as the standard against which all the samplers were compared because of the shrouded probe's near constant sampling efficiency over a wide range of wind speeds and particle size distributions. Several different particle sizes and wind speeds were examined. The particle size distributions centered on about 5, 10, and 30 μm and each particle size was explored at approximately 12, 15, and 17 m s^{-1}.

The AIRNET housings collected 5-μm particles with efficiency nearing 100% at all wind speeds, performing even better at higher wind speeds. Collection of 10-μm particles was near 80% at lower wind speeds and decreased to about 60% at higher wind speeds. The AIRNET sampler, however, overestimated concentrations of larger 30-μm particles by as much as 200–300% at all wind speeds. This phenomenon has been hypothesized to result from the impaction of larger particles through the louvers and into the sampler, creating an atmosphere that contains a higher concentration of large particles than the ambient air. This would skew the sampling results

to a higher concentration of these large particles. Additional studies of different orientations of the AIRNET sampler to the airflow in the wind tunnel seem to support this hypothesis[85].

This study shows that the AIRNET samplers perform favorably at respirable particle sizes. The audit team commends LANL for undertaking such an involved experiment, and we do feel that it proves the ability of the samplers to detect environmental concentrations of interest for compliance purposes.

Findings

The audit team identified several issues during our audit of the sample handling and preparation procedures that we wish to address in this section. These findings represent good laboratory practice, and their resolution is encouraged. We highlight three findings in this section, all under the category of additional observations.

Additional Observations. During 1999, silica gels were weighed by one person and data were entered directly into the AIRNET database. The weights were never double-checked, and this could have and probably did result in errors in the database. However, weight of the silica gel cartridges is not currently used in the calculation of concentration of tritium in air, so these errors would not have impacted environmental concentration calculations for 1999. We feel that this is an issue of good standard laboratory practice and recommend the use of these weights in a later section of the report, so we encourage double-checking of the silica gel weights in the future.

The data loggers placed into the AIRNET compliance stations have considerably increased the completeness of the environmental data, but the audit team discovered that this completeness could be further improved. The data loggers have a battery backup associated with them, and they are directly plugged into the station power supply. When power goes down to a station, the data logger can continue to run for 2 days on this auxiliary power supply before the data logger transmits a message to the AIRNET laboratory. We encourage finding a better way to implement these data loggers such that an alert goes out immediately and the 2-day lapse is eliminated.

When data logger information is sent to the AIRNET laboratory, any details about when and why the station stopped operating are recorded in the AIRNET log book. This information is not transferred to the AIRNET database with any consistency, as pointed out by a member of CCNS during the audit tours. We suggest that upon field data verification and validation, the AIRNET technician add any relevant information to the AIRNET database to make the database a complete listing of station operations during the year.

Changes since 1999

It is our understanding that silica gel weight double counting has been instituted during 2000. Additionally, a new software package was implemented in the AIRNET laboratory that connects the AIRNET database directly to the scale, eliminating the need for hand-entering the data. We find both of these to be improvements to the silica gel measurement program.

Because of the contamination issues in the AIRNET laboratory, all distillation of silica gels has been moved to an offsite laboratory. This has eliminated the existence of the fluorescence problem that was being experienced with the tritium samples. Although this process has been in place for over a year, we found no documentation of it in AIRNET procedural documents. We strongly encourage documentation to be updated to reflect this change.

Data Validation and Verification

Data validation and verification is the process of reviewing the data to ensure that information has been transferred correctly to electronic form and to identify any issues that might make a data point unusable. There are four types of data that go through the validation and verification process: field data, analytical chemistry data, meteorological data, and concentration data.

Summary of LANL Methodology

The process of data validation and verification includes checking the data to make sure that transfer from one form to another is complete and accurate and initially separating the data into three categories: accepted, qualified, or rejected. The validation and verification process then involves looking at the data included in each of these three categories to ensure that it does, in fact, belong in that category or to provide evidence to suggest that a qualified or rejected point may actually be useful.

First, field data are verified and validated. Data that go through field validation and verification include collection date and time, sampler number, timer reading, beginning and ending filter flow rates, beginning and ending silica gel flow rates, beginning and ending silica gel masses, moisture distillation volume, and comments. Field data are transferred from the palmtop computers to the AIRNET database, and then 100% of the data are checked for accuracy. Any additional comments may be added at this time.

There are certain nominal ranges that field data are expected to fall within. If the data do not fall within these ranges, this could be evidence to suggest either qualifying or rejecting that data point. For instance, if a pump fails, the filter and silica gel data would be qualified, and it would take further review to determine if those data points were valid and could be used in the annual calculations.[86]

Once the analytical chemistry data are received from the analytical laboratory, these data are electronically transferred to the AIRNET database. The biweekly data are 10% verified for accurate transfer, and the quarterly data are 100% verified. The quarterly data contain the isotopic information and are considered by the analytical chemistry coordinator to be too important to not verify at 100%, even though only 10% is required by LANL procedures. The analytical chemistry point person also checks to ensure that the chain of custody form is complete.

A number of calculations are made at this stage of the data analysis. Concentrations of alpha and beta are calculated for biweekly data packages, as well as run time and sample completeness. An analysis of the success of the analytical laboratory with the quality assurance samples sent with the data package is also made at this time. For quarterly data packages, isotopic concentrations are calculated.

The analytical data also go through the qualification, acceptance, or rejection process. Data are qualified or rejected based on analysis of expected ranges given historical data and professional knowledge and judgment. In addition, concentration values that are above the action or investigation levels are tagged. A memo documenting this entire analysis is included in the AIRNET data package and sent to the AIRNET managers and to the next step of the analysis. This analysis must be done within 3 weeks of receipt of the data package from the analytical laboratory.[87]

One important function of data validation and verification from an analytical standpoint is ensuring that the analytical laboratory is meeting the data quality objectives set out in the statement of work. Audits of the analytical chemistry laboratories are done by ESH-17 annually. This is an important quality assurance step in data validation and verification.

The meteorological data are used for calculating 15-minute absolute humidity concentrations. These 15-minute concentrations are averaged over the 2 weeks that span the sampling period. These data are validated to ensure that they are within expected humidity levels for that time of year. An AIRNET staff member checks these data and would question the meteorologists if something appeared to be out of line.

Tritium concentrations in 1999 were calculated using a new methodology that incorporated absolute humidity data. In early 1998, AIRNET personnel discovered that silica gel collection efficiency was much lower than they originally assumed.[88] After running a number of experiments, they discovered that the temperature inside the louvered housing was high enough to reduce collection capacity of the silica gel significantly. It was also discovered the capacity varied with absolute humidity. It was decided to move the silica gel cartridges outside of the louvered housing, making the conditions that the gel is exposed to consistent with ambient conditions. Additionally, tritium concentrations were calculated using the absolute humidity, which represents the total concentration of water in the air, instead of using the total volume of air flowing through the sampler. Making these changes has increased the measured and calculated concentration of tritium in the atmosphere, making the measurements more realistic.

Finally, air concentration data undergo a validation and verification along with a health physics review and check. During this process, any data points that exceed the action levels are assessed, and qualified and rejected data points are reviewed for possible acceptance. This process must be completed within 30 days of the completion of the field and analytical chemistry data verification.

Occasionally, an AIRNET station will suffer some partial loss of data during the 2-week sampling period. These cases may result from a power loss, a breaker being thrown, a pump failure, etc. In these cases, the AIRNET data are usually qualified and require review during this part of data validation and verification. Because some data from during the 2-week period is better than no data during the 2-week period, AIRNET staff research the data to see if they might be useable. For filters, beta concentration can be a good indicator. Beta concentrations vary seasonally, but at any given time of the year, they are quite consistent across stations. If the beta concentration is consistent with other stations, the data from that station can still be used.[89]

Concentrations that exceed action levels are also reviewed during this process to determine whether they are consistent with historical measurements, contemporaneous measurements, or known releases. There are two types of action levels: investigation and alert. Investigation levels are based on historical data, and alert levels are calculated as the concentration that would result in a dose of 0.1 mrem (1 μSv). In every case, the technical memo that is drafted as a result of this process contains information about values that exceed an action level and the cause.

Run-time and completeness are evaluated annually. The FFCA requires 95% run-time of stations and 80% completeness of samples throughout the year. The completeness requirement corresponds to no more than five individual samples being lost, rejected, or not analyzed during a calendar year.

Quality assurance for the verification and validation process, in addition to auditing the analytical laboratories, involves having another individual check and sign his/her approval of

each step outlined here. This also applies for review of the database, in which case the database tracks when a review was completed and which individual completed it.

Evaluation of LANL Methodology

We found the data validation and verification process to be well managed and complete. Each individual is very familiar with the role they play in the validation and verification process, and we are confident that data are handled appropriately.

We reviewed half of all the data packages for 1999. We found chain of custody to be complete and promptness of data review to be satisfactory. When data were qualified or rejected, the reviewers did an excellent job of evaluating these data and including data points that may have otherwise been discarded. We also found the methodologies used to accept qualified or rejected data points to be sound.

Calculations of concentration for both gross counts and isotopes were reviewed and found to be sound. The audit team commends the AIRNET group for reviewing the tritium collection issue and taking such important steps toward providing better tritium concentration data.

Comparison of concentrations to action levels is an important part of the data validation and verification process. Occasionally, exceeding an investigation level can be related to a known release. Often the values are consistent with historical data, and they reflect some seasonal change for which the action levels do not account. Tritium data in 1999 had consistently been exceeding the investigation levels because of the new concentration calculation methodology that incorporates the absolute humidity measurements. Development of new investigation levels based on recalculated tritium concentrations for past years will eliminate that problem. Nearly all investigation levels were recalculated during 1999 using a new methodology that reduced the impact of outliers and accounted more for natural variation. The audit team reviewed these calculations and found them to be adequate. AIRNET personnel still review all of the alpha and beta concentration data points, whether they exceed action levels or not, to ensure that no values are unusually high or low.

The audit team also reviewed implementation of quality assurance and discovered it to be complete in all cases. We reviewed the audit reports that ESH-17 completed after visiting the analytical laboratories.[90,91] The laboratories are carefully scrutinized by ESH-17 annually, and suggestions are made for improvement. Additionally, it is important for ESH-17 to know how the analytical laboratories score in nationwide measurement comparisons. The analytical laboratories used by the AIRNET project scored favorably in 1999.

One issue raised by IEER during the course of the audit related to how total water vapor collected in the atmosphere on silica gels is measured and how tritium concentration is calculated using this information (Appendix C, page C-17). Because of the chance for human error in the weighing of silica gel cartridges before and after placement in the field, LANL has used the weight of the distillate as the mass in which the tritium measured in the water sample is calculated to be concentrated. Silica gel naturally retains some small amount of water that even baking the gel cannot remove, but it is likely removed from the gel in the distillation process. IEER postulates that this water may dilute the tritium concentration, but it is difficult to show that trend in 1999 because of inconsistencies and errors in the silica gel cartridge weight data. IEER has suggested a conservative method for calculating tritium concentrations using either weight difference or distillate weight, depending on the ratio between the two. The audit team believes

this to be a sound and conservative approach to calculating total weight of water vapor collected, but we also believe that a valid analysis of the bias introduced by using distillate weight vs. reported weight difference using more reliable weight data is important. We make such a recommendation in the findings section below.

Findings

Additional Observations. Because of the potential for bias in the tritium weight introduced by residual water on the silica gel, the audit teams recommends that LANL explore this issue using current data and take steps to correct it. As discovered by IEER during the course of the audit, the total tritium collected in the environmental water vapor sample could be diluted by residual water that cannot be baked off the silica gel. It was difficult to assess the magnitude of this dilution for 1999, however, because of errors in the weighing process that should be corrected by procedures currently in place. We suggest that LANL review the data for silica gel for the year 2000. Given changes to the procedure used to weigh the silica gels, weight difference data should be much more reliable and easily compared to weight of the distillate. The distribution of the ratios of these two quantities would be of interest in determining the range of the potential error introduced in the tritium concentration.

Given this evaluation of the potential error, it is appropriate to use the information that would result in the most conservative assessment of the tritium concentration, as suggested by IEER. Since all values needed for both types of calculations are already included in the AIRNET database, it would be easy to calculate the ratio of distillate weight to reported weight difference. If this ratio is greater than one, the reported weight difference should be used to calculate tritium concentration. If the ratio is less than one, the distillate weight should be used. This would result in the most conservative calculation of the tritium concentration based on the available weight information.

Sampler Siting Analysis

During the first audit, we thoroughly reviewed the sampler siting analysis documented in the FFCA. We found the siting analysis to be unsatisfactory and recommended that some further justification of the sampler locations be completed. To date, AIRNET staff have made some enhancements to the sampler siting analysis, but they have not addressed the core issue that we raised in the first audit. We provide a brief description of the siting analysis here and discuss our recommendations below.

Summary of LANL Methodology

A complete description of LANL's sampler siting analysis can be found in the FFCA and the first audit report.[92,93] We will not offer as complete a description here, but instead only summarize the analysis.

In the FFCA, LANL defined a methodology for using environmental sampling as a means of demonstrating compliance for releases from diffuse sources. Because the AIRNET system was already in place for environmental surveillance at the time that the FFCA was drafted, LANL wished to use as many of the existing stations as possible for compliance purposes.

Sampler locations to the north of the site were evaluated using a 16-sector grid, with minimum and maximum source-to-receptor distances defined based upon the existing spacing of the AIRNET stations. One sector of the grid was laid over each sampler location and remaining sectors were evaluated for existence of a sampler. For sampler locations in the White Rock area, a different methodology was used that looked at diffuse source locations and evaluated the existence of a sampler within each sector of the 16-sector grid based on the diffuse source location and not on the existing location of the samplers.

In 2000, LANL suggested enhancements to the FFCA siting criteria[94] to address diffuse sources close to the LANL boundary, samplers in sectors adjacent to the primary sampling sector, and samplers that need to be moved to meet micro siting criteria, as defined in ESH-17-207.[95]

For diffuse sources close to the Laboratory boundary, ESH-17 will rely on the New Source Review process to help identify any new or modified non-point sources within 1700 meters of the LANL boundary. A single location with the highest dose potential will be determined, and estimated dose will be calculated. If the dose exceeds 0.1 mrem (1 μSv), a sampler will be placed in that location. If dose in an adjacent sector is more than 50% of the dose in the primary sector and the calculations would place the sampler in the adjacent sector more than 100 meters from the primary station, a station would also be placed in the adjacent sector.

For relocated AIRNET stations, the station can maintain its original identity if it is moved no more than 500 yards (460 meters) in any given direction, even if that move would place it in a different sector. For a move of greater distance than this, the sampler may no longer be representative of concentrations at the original sampler location and would need to be given a new identity.

Evaluation of LANL Methodology

During the first audit, we were not convinced that the methodology used to determine whether samplers were in the appropriate locations for collecting emissions from diffuse sources was technically credible. Using the existing sampler locations to define the sector grid and to evaluate other sampler locations to the north of the facility necessarily produced a biased result. We were disappointed that LANL did nothing to respond to this finding before the second audit commenced. A finding associated with this issue is related in the following section. It is important to point out that this relates only to the samplers to the north of the facility, as we believe samplers in the White Rock area were identified using an appropriate methodology.

The enhancements to the FFCA suggested by the Laboratory are mostly sound, with one exception. We reviewed the New Source Review process and extensively reviewed one New Source Review that was completed in 1999 for the In-Situ Vitrification Pilot Plant. We were impressed with the completeness of this process and the evaluation of dose at offsite locations. We are convinced that this process would help identify any new or modified non-point sources and that the review of them would lead to the appropriate conclusion about the placement of a new sampler. Our only concern with this methodology is the definition of 1700 meters as the distance that is close enough to the site boundary to require this analysis. The 1700 meter value comes from the original sampler siting analysis and is based on the minimum source-to-receptor distance defined by the smallest distance between two existing samplers. Because we believe the development of this value to be inherently flawed, we felt it was necessary to note that here. However, we feel confident that evaluation of sources within this distance from the site boundary

will accurately identify any new samplers that need to be sited. We found the remainder of the new recommendations for enhancements to the sampler siting to be good.

During the first audit, we pointed out the need to consider the placement of a sampler at the ski hill or on the San Ildefonso Pueblo lands. The need for a sampler at the ski hill was explored, and calculations showed that with the current sources of environmental release at LANL, a potential MEI could never exist at the ski hill.[96] We believe that the use of the new source review process would identify any new sources that might make a receptor in this location necessary, and we encourage LANL to continue to review sources and possible potential receptor locations. We understand that AIRNET staff continue to pursue potential placement of a sampler on the Pueblo lands. We encourage this continued communication, but we strongly recommend that this effort be undertaken with the recognition of the government to government relationship that exists between the Pueblos and DOE.

Findings

Technical or Scientific Deficiencies. The audit team believes that additional criteria for sampler siting to the north of the Laboratory are necessary to make the siting technically sound. We believe this to be a deficiency in the program that should be resolved. We offer a suggestion for a methodology that might resolve this issue.

To start assessing the feasibility of the AIRNET sampler locations, LANL might compare facility MEI locations with AIRNET sampler locations. If an AIRNET sampler were present at each facility MEI location, it would prove that AIRNET is capable of detecting environmental contamination from the stack releases. Compliance monitoring through AIRNET is not intended to measure stack emissions; rather, it was designed to measure diffuse sources of airborne materials.

To extend this methodology to the diffuse sources, then, it would be reasonable to determine (using diffuse source location, the appropriate meteorological data, and a unit release quantity) the maximally exposed locations to the north of the Laboratory resulting from diffuse sources. Using CAP-88, the area source solution is essentially a point source with some extra distance added onto it to account for the initial dispersion from the diffuse source emissions. Generally, a point source, since the release is at ground level, would be a more conservative assessment, assuming the source releases the same mass per unit time. The most appropriate solution may be to evaluate the diffuse source locations as point sources, with the location defined as the closest distance within the area source to the nearest receptor. Going through a process similar to this would be a quantitative method for confirming that AIRNET locations are sufficient to capture releases from diffuse sources. It would also provide good confirmation to the public that the environmental samplers are appropriately located and would detect any unexpected releases from the site.

Precision and Accuracy of Environmental Samples

Summary of LANL Methodology

Because of requirements laid out in 40 CFR 61, Appendix B, Method 114, LANL is required to document the required precision, accuracy, and completeness of the emission measurement

data, including a description of the procedures used to assess these parameters. Accuracy is the degree of agreement of a measurement with a true of known value. Precision is a measure of the agreement among individual measurements of the same parameters under similar conditions. Completeness is a measure of the amount of valid data obtained compared to the amount expected under normal conditions. We discussed completeness in the context of the "Data Validation and Verification" section of this report. Precision and accuracy are laid out by LANL in the Sampling and Analysis Plan for AIRNET.[97]

Evaluation of LANL Methodology

As we noted in the first audit report, the discussion of precision and accuracy as they relate to AIRNET is extremely confusing and very difficult to follow (pages 12-15 of the Sampling and Analysis Plan for AIRNET).[98] We recommended in the last audit report that LANL look at rewriting some sections of this discussion. We make that same recommendation again.

Findings

Additional Observations. The discussion of precision and accuracy in the Sampling and Analysis Plan for AIRNET is altogether difficult to read and understand. The discussion of minimum and target precision includes virtually no support for the conclusions drawn. The comparison of sampler measurements for the two sets of paired AIRNET stations could be significantly improved with more background material and explanation of the information contained in the table. Precision is continuously defined within the document in terms of millirem, but the table goes on to give precision in units of attocuries per cubic meter. Conversion of the values to comparable measures would be instructive.

Accuracy is defined and then it is indicated that true accuracy cannot be determined. An explanation of why this statement is true would be informative. More detail about the uncertainty calculations could readily be included in this section of the Sampling and Analysis Plan. This increased level of detail, if appropriately explained, would increase the clarity of this description and make it clear why uncertainty is assessed for 10 mrem (0.1 mSv) equivalent concentrations and not for actual environmental concentrations.

We strongly urge LANL to make such changes to the Sampling and Analysis Plan. Based on the discussion included therein, it is not entirely possible to ascertain that they meet the requirements of 40 CFR 61, although a detailed review by the audit team indicates that the calculations are acceptable.

DOSE ASSESSMENT EVALUATION

40 CFR 61, Subpart H, contains relatively few requirements for performing the dose assessments that are required for demonstrating compliance. For example, EPA-approved computer codes must be used. 40 CFR 61.93 specifically allows the use of CAP-88[e], AIRDOS-PC, and COMPLY. The EPA has also granted approval for the computer codes CAP88-PC and MICROAIRDOS. In addition, other computer codes or procedures could be used with prior approval by the EPA.

40 CFR 61, Subpart H, requires that doses are to be estimated at offsite points where there is a residence, school, business, or office. The highest dose to a member of the public at these locations is used to demonstrate compliance with the 10 mrem yr^{-1} (0.1 mSv yr^{-1}) standard contained in § 61.92. This person is referred to as the site-wide MEI. It should be noted that 40 CFR 61, Subpart H, is not an unrestricted area standard. This means that doses are to be estimated at fixed locations where members of the public are actually located and doses do not have to be estimated at locations such as roads to which members of the public merely have access for short periods of time. Short-term, episodic releases must be included in the inventory of releases for the year and modeled using an EPA-approved computer code such as CAP-88 and annual average meteorological conditions.[99] A comparison is being undertaken by the audit team between air concentrations calculated by CAP-88 and an air dispersion model that takes into account the complex terrain around LANL. It has been suggested by IEER that the CAP-88 Gaussian dispersion model may not be conservative for the Los Alamos area and may underestimate doses. This is discussed more in the next section of the report.

40 CFR 61.94 also contains reporting requirements. For example, the distances to the nearest residence, school, business, or office and the distances to the nearest farms producing vegetables, milk, and meat are to be included in the annual report submitted to the EPA. All user-supplied input data and the source of these data also are to be included in the annual report.

Locating Receptors and Identifying the MEI

In order to start the dose calculation process, the first step that must be taken is to locate possible receptors and identify the site-wide MEI. The methodology used to accomplish this for 1999 contains significant improvements over what we saw during the first audit.

Summary of LANL Methodology

For each facility at LANL that has a radioactive effluent plume released from a stack, possible receptors for that stack and the stack (or facility) MEI are located. Additionally, MEI locations are identified for the entire site. These receptors may be the same from year to year, or they may change during the course of a year, as new construction develops. A site tour was instituted in 1999 to look for new potential receptors.

The individual at ESH-17 in charge of dose calculations obtains maps from the geographic information system and tours the site. During this tour, a prescribed route is followed and

[e] Throughout this section, the term CAP-88 is used to refer to the mainframe version of the computer code CAP-88 used by LANL.

particular attention is given to any new construction that is not already built into the site's geographic information system. It is then determined from the nature of the construction whether it qualifies as a new potential MEI. The new buildings are added into the geographic information system network at their approximate coordinates.

Once this tour is completed and all potential receptors for each facility are identified, a facility MEI is determined for each facility. Doses for several potential receptors at each facility are calculated using CAP-88, and the receptor subject to the highest dose from that facility is identified as the MEI for that facility.

The site-wide MEI was determined for 1999 using this facility MEI information as well as using public comment and interaction. Without LANSCE as the dominant source of releases, the site-wide MEI was not as immediately obvious as it had been in the past. LANL looked at the facility MEI doses and selected several possible candidates for the site-wide MEI. Additionally, they gave several presentations at the Citizen's Advisory Board meetings where they allowed members of the panel to select additional possible receptors for MEI analysis. All of these candidates for the MEI were evaluated using CAP-88 modeling. After years of the East Gate receptor being the site-wide MEI, the dose at the County Landfill Office exceeded the East Gate dose and became the site-wide MEI for 1999.

Evaluation of LANL Methodology

During the first audit, LANL was cited for not exploring more than one possible location for an MEI for the entire site. We are pleased with their new process of evaluating and calculating dose for several possible site-wide MEIs and believe that it has produced more meaningful and more defensible results for the annual dose calculation. Seeking public input as a means to determine possible MEI locations is an excellent idea, and we strongly encourage this process to be continued and expanded, as it not only strengthens the validity of the site-wide MEI, but it also strengthens the relationship between the Laboratory and the community.

The addition of the annual tour to identify new receptors is also supported by the audit team. This tour should certainly be continued, and it might even be worthwhile to expand the tour to include an exploration of the frequency of use of public buildings and facilities. This information might encourage the group to calculate dose at some additional locations that may not turn out to be the MEI, but further validates the actual location of the site-wide MEI.

In the first audit, we questioned the exclusion of the ski hill as a possible receptor, primarily for purposes of environmental monitoring, but this is also an important question for dose calculations. ESH-17 explored the ski hill as a possible MEI, calculating doses for a hypothetical emissions scenario and showing that samplers in adjacent sectors always exhibit a higher dose.[100] We encourage LANL to use the site tour process to continue to evaluate the ski hill should emissions at LANL change in the future.

Without the operation of LANSCE, the site-wide MEI for LANL could easily change again. We encourage continued use of this methodology to determine receptor locations and the site-wide MEI, and we commend LANL for their resolution of this issue raised in the first audit.

Approval of Database Modifications

During the first audit, we noted that LANL had not received prior approval for additions of radionuclides to the CAP-88 database. Since then, approval has been sought and gained for these changes.[101,102]

Dose Calculations

The dose calculations completed with CAP-88 have undergone several significant changes since the first audit, all of which served to improve the program significantly. Each improvement is a direct answer to findings noted in the first audit, and we are pleased to see that LANL and the individual in charge of dose calculations made such a significant commitment to quality.

Summary of LANL Methodology

LANL has a large number of effluent sources and potential receptors for which dose calculations have to be made, which makes this aspect of the program especially challenging. A number of significant improvements have been implemented that not only enhance the program, but make it easier to complete the calculations and confirm their correctness.

A set of input files is unique for each release point. Meteorological data are obtained from the Laboratory's Weather Machine. This computerized data producer will take the data from the four different meteorological towers around the site and produce annual average STAR (Stability Array) data files for direct input into CAP-88. The meteorological tower closest to each release point is used to provide the data for the calculations for that release point. Population files are created for each release point from census data and updated annually. Since each release point uses a different population file, it is important to ensure that the correct population file is used in each calculation. Source term data input files are created from the stack emissions database. These input files are created electronically using a short program written for that specific purpose.

At the beginning of a day of CAP-88 runs, the operator runs the EPA test case for CAP-88 to make sure that installation and operation of the program are good. This verification test is appended to the output files for that day's runs. All of the input files that combine to produce each output file are also appended to the output file. This confirmation of input files and EPA test run has been implemented as a result of the first audit.

For site MEI calculations, a different run is made for each release point. Each of these output files undergoes a preparer review, a technical review, and a management review. All of these procedures and the reviews are outlined in the dose calculation procedure and use a checklist contained in that procedure.[103] The preparer review is done by the person who completed the dose calculations. This person checks to make sure that all the input files and data are correct and appended to the output files. For the technical review, an individual who understands CAP-88 and has access to review sheets that show the correct input values essentially double checks the preparer's work and review. The management review finally just checks to make sure that the technical review is done and complete. Each person signs and dates the checklist to verify that the review has been completed. These peer review checks are also new since the first audit.

Evaluation of LANL Methodology

We reviewed all of the dose calculation output files located in the Dose Assessment files at ESH-17. The quality assurance reviews done are quite complete and a significant improvement since the last audit when no peer review was visible. Reviews are signed and dated as an affirmation that the review was completed. We also obtained the review sheets used by the technical reviewer. These sheets appeared to cover every input value that needed to be checked in the output files including source term quantity and radionuclides, stack parameters, distance and direction to the receptor, meteorological file use, population file use, and dose to the receptor. The only review that is not done is an actual review of the meteorological data downloaded from the Weather Machine to ensure that the annual average weather file reflects the continuous data collected from the towers throughout the year. Given the form of the input file to CAP-88, it is not reasonable to expect this type of review to occur. The dose calculation preparer indicated that he does review the annual average meteorological data file, and with meteorological patterns that are similar from year to year, he would expect to notice if something were incorrect or inappropriate about the data sets. Weather Machine software that was written to produce the CAP-88 input files and other requested data forms were quality reviewed at the time of their production. Meteorological staff also do frequent QA checks on the towers to ensure they are measuring and collecting data that are representative of the actual conditions at each site. The audit team is satisfied with the review of the dose calculations.

The verification of installation of CAP-88 at the start of each day's runs as well as the appendage of that information in the output file is a vast improvement. Inclusion of the input files in the output file was suggested during the last audit, and we were pleased to see this improvement in the program. This is an important confirmation of the calculations now being completed.

The audit team also obtained the input and output files for the CAP-88 runs done for 1999 and confirmed the calculation of dose by running the files ourselves. The average absolute value of the percent difference was 0.3%, which shows extremely good agreement. See Table 2 for the details. The input files were very clean and the audit team found no deficiencies in the runs.

Table 2. Comparison of Audit Team CAP-88 Run Results to LANL Run Results

Release Point	LANL Dose (mrem yr^{-1})[a]	CAP88-PC Dose (mrem yr^{-1})	Percent Difference[b]
03002914	1.59×10^{-6}	1.59×10^{-6}	0
03002915	2.52×10^{-6}	2.52×10^{-6}	0
03002919	2.99×10^{-3}	2.99×10^{-3}	0
03002920	1.10×10^{-4}	1.10×10^{-4}	0
03002923	1.60×10^{-4}	1.65×10^{-4}	3.13
03002924	1.95×10^{-4}	1.95×10^{-4}	0
03002928	4.81×10^{-6}	4.81×10^{-6}	0
03002929	3.84×10^{-5}	3.84×10^{-5}	0
03002933	8.56×10^{-7}	8.56×10^{-7}	0
03002937	4.62×10^{-8}	4.62×10^{-8}	0
03002944	1.14×10^{-6}	1.14×10^{-6}	0
03002946	9.06×10^{-7}	9.05×10^{-7}	-0.11
03003501	1.42×10^{-4}	1.42×10^{-4}	0
03010222	2.63×10^{-5}	2.63×10^{-5}	0
16020504	1.34×10^{-3}	1.33×10^{-3}	-0.75
21015505	3.04×10^{-4}	3.04×10^{-4}	0
21020901	1.85×10^{-3}	1.85×10^{-3}	0
33008606	1.74×10^{-3}	1.74×10^{-3}	0
41000417	1.15×10^{-4}	1.16×10^{-4}	0.87
48000160	7.71×10^{-9}	7.68×10^{-9}	-0.39
50000102	2.23×10^{-6}	2.24×10^{-6}	0.45
50003701	8.52×10^{-8}	8.51×10^{-8}	-0.12
50006903	1.22×10^{-9}	1.21×10^{-9}	-0.82
53000303	1.22×10^{-5}	1.22×10^{-5}	0
53000702	4.16×10^{-4}	4.16×10^{-4}	0
55000415	2.13×10^{-6}	2.12×10^{-6}	-0.47
55000416	1.25×10^{-5}	1.25×10^{-5}	0
LANSCE switch yard	3.18×10^{-5}	3.15×10^{-5}	-0.94
TA-18 diffuse	1.47×10^{-6}	1.47×10^{-6}	0

[a]Divide each value in the table by 100 to get values in units of mSv yr^{-1}
[b]Average percent difference = 0.3% (absolute value).

Findings

We have only one finding related to this section, which is a recommendation for improvement.

Additional Observations. When we requested the output files for the 1999 CAP-88 runs, we discovered that the runs had to be reproduced because the hard copy in the ESH-17 files becomes the official copy. With the storage capacity available on CDs, we strongly recommend that all input and output data files are copied onto a CD for permanent storage. This will not only eliminate the need to reproduce files for audits, it could also facilitate information that may be sent to the regulatory agency so they can also confirm the calculations.

Calculating Dose from Non-CAP-88 Radionuclides

LANL has devised three different methods of calculating dose from non-CAP-88 radionuclides, as described in ESH-17-511.[104] LANL has notified EPA of this method of calculating dose from these nuclides.[105] These three methods are the EPA Table 2 Method, the Federal Guidance Report Method, and the Raw Data Method.

Summary of LANL Methodology

Although not all of the radionuclides that might be encountered at a nuclear facility such as LANL are included in the CAP-88 database, many additional dose factors are included in Appendix E to 40 CFR 61, Subpart H. Appendix E, Table 2 lists dose conversion values in units of Ci m^{-3} per 10 mrem yr^{-1}. CAP-88 produces air concentration values in units of pCi m^{-3}, and these Appendix E dose conversion values, with some units conversion applied, are used to determine the annual dose in mrem (converted to mSv by dividing by 100).

For radionuclides that are not included in Appendix E, one of two methodologies must be applied to calculate dose. EPA Federal Guidance Reports contain internal and external dose factors for 838 radionuclides. For remaining radionuclides, raw data must be used to calculate dose.

The Federal Guidance Report Method involves obtaining the dose factors for air immersion, contaminated ground surface, inhalation, and ingestion from EPA reports. Dose calculation personnel have written a code that takes these values and the half-life of the radioisotope and converts them into EPA Appendix E, Table 2 comparable values. Then the dose can again be calculated using the CAP-88 output and this information.

The Raw Data Method is required when there are no published or readily available dose conversion data for the released radionuclides. To date, LANL has identified over 25 of these radionuclides. The nuclear information for these nuclides is downloaded from tables on the internet. This information on decays and energies is processed by a program written by ESH-17 staff, which creates input files to the EPA's DOSFACTOR code. The DOSFACTOR code produces the two external dose factors for input into the federal guidance report program described above. Inhalation and ingestion dose factors are produced using a combination of an EPA program called SEECAL and ESH-17 produced codes. This process also uses the nuclear information and extracts the appropriate information needed to use the International Council on Radiation Protection Publication 30 lung model and the International Council on Radiation Protection Publication 30 gastrointestinal tract model in producing dose factors. These four dose factors are combined to produce an EPA Appendix E comparable value. The Raw Data Method is extremely involved and arduous.

Evaluation of LANL Methodology

The audit team reviewed two files of non-CAP-88 nuclide dose factor calculations for sulfur and gold.[106] Each file included the calculations for several isotopes of the nuclides, showing both the Federal Guidance Method and the Raw Data Method. Gold has a large number of nuclear transformations that make up its decay scheme, so this set of calculations was particularly involved. The calculations were entirely reviewed by the preparer and signed and dated to

indicate that the calculations are complete. Peer review of these calculations is done using a checklist. The reviewer certifies that the preparer's checklist is complete, test data were included, correct nuclear data were used, and that all dose factors were cross-checked and verified. The audit team believes the techniques used to determine dose factors for non-CAP-88 radionuclides are sound and that quality assurance of these calculations is complete.

Rad-NESHAP Annual Report

Summary of LANL Methodology

Each year, LANL is required to report the dose to a site-wide MEI via all pathways due to releases to air. The formal reporting of this dose is in the Rad-NESHAP report. This report must also contain

- The results of monitoring and dose calculations
- The name and location of the facility
- A list of radioactive materials used at the facility
- A description of the handling and processing that the radioactive materials undergo at the facility
- A list of the stacks or vents or other points where radioactive materials are released to the atmosphere
- A description of the effluent controls that are used on each stack, vent, or other release point and an estimate of the efficiency of each control device
- Distances from the points of release to the nearest residence, school, business, or office and the nearest farms producing vegetables, milk, and meat
- The values of all other user-supplied input parameters for the computer models and the source of these data
- A brief description of all construction and modifications that were completed in the calendar year.

According to the 1999 report,[107] the effective dose equivalent for the site-wide MEI located at the County Landfill was 0.32 mrem (3.2 μSv). This dose is significantly lower than it has been in recent years as a result of LANSCE not being operational during 1999. The location of the site-wide MEI has also changed.

Evaluation of LANL Methodology

We reviewed a portion of the source term emission data in the ESH-17 files to ensure that the ESH-17 files matched the source term database. We then verified that the database values matched those reported in the annual report and the annual report values matched those shown in the input files for the dose calculations. There was complete agreement, which is probably attributable to the use of a code to transfer data from the database output into a form useable by CAP-88. The data are no longer manually entered, which reduces the errors significantly. Additionally, quality assurance checks would ensure that any errors were corrected.

We find the 1999 Annual Report to be complete and to meet all regulatory requirements. We make a few suggestions for improvement below.

Findings

Our findings in this section are suggestions for further improvement in the program.

Additional Observations. We believe that each population file should be reported in the annual report to meet regulatory requirements. However, this is a large amount of information, and we appreciate the need to use an example file instead. We do feel, however, that this is an area in which something needs to be done. We refer again to the idea of copying all of the input and output files to a CD. This could be part of the package presented to the regulatory authority, and it would contain all of the relevant information, including all of the population files used in the calculations.

We believe that it would be helpful to the readers of this report, as well as the regulators, to include information about which meteorological data set are used for each release point. This would provide a more complete picture of how the meteorological information in used in the calculations.

Finally, we appreciate that the structure of the Annual Report has been standardized and that EPA likely knows exactly where to go to get the information they are looking for to determine compliance. However, the audit team feels that the format not easy for a layperson to use. It is difficult for a member of the public to gain any useful knowledge from it because it is so cumbersome to read. We suggest that a technical summary be included in the front of the report or a fact sheet be produced to accompany the report. This summary or fact sheet should be very easy to read and should relay a summary of the relevant information contained in the report.

Overall Dose Calculation Management

It is clear that ESH-17 has dedicated a significantly larger level of resources toward the dose calculation program, and that the enhancements we witnessed during this audit were accomplished because of the ability of one individual to focus more energy to these ends. We are concerned that the management, calculations, and procedural drafting within the dose calculation program is done and understood by only one individual.

Findings

Additional Observations. Our main concern is that this program is largely run and understood only by one individual. While the procedures that accompany the program are greatly improved and list step-by-step instructions, it is not clear that there is any well-defined back-up person involved. We strongly encourage ESH-17 to dedicate more resources and to identify an individual who can assist with dose calculations. This is partly to reduce the burden on a single individual but also because there is no obvious other person with the training required to run this program should such a necessity arise.

ISSUES PERIPHERAL TO THE SCOPE OF THE AUDIT

During the course of the audit, a number of issues were raised that were peripheral to the scope of the audit; that is, they do not impact LANL's compliance status. The audit team agreed to look at these issues and comment on them. These issues relate to the Neighborhood Environmental Watch Network (NEWNET), neutrons, and complex terrain modeling comparisons.

The Neighborhood Environmental Watch Network

NEWNET is a set of environmental measurement stations located primarily in and around Los Alamos. The operation of NEWNET is currently funded by LANL in accordance with the Consent Decree. Issues about the quality of NEWNET data were raised during the course of the second audit, and the audit team agreed to consider these issues and make some recommendations about NEWNET. We felt that it was important to take this step not because of the Consent Decree but because the concept of NEWNET is so important and has so much to offer to the citizens of New Mexico and LANL.

NEWNET was originally funded as an environmental network at the Nevada Test Site as a means for the public to understand and appreciate environmental exposure from weapons testing. The goal of this network was principally educational in nature, but the network was also seen as a good source of unprocessed environmental measurement data for members of the public. The NEWNET stations provide data on wind speed, direction, humidity, barometric pressure, and the external radiation exposure rate at the measurement location. These data are summarized as 15-minute averages and distributed via the internet. Although NEWNET was developed at and for the residents in the area of the Nevada Test Site, it was developed with a vision of taking the program nationwide and worldwide as a tool to educate people about environmental radiation.[108]

The NEWNET concept for the Nevada Test Site was made obsolete by the implementation of the nuclear test ban treaty. The guiding philosophy and goal of NEWNET, however, were unchanged by this treaty, so the network was moved to the LANL area. Because LANL was already partially supporting the program, the move was a relatively simple one and one that made sense.

The events that resulted in our discussion of the NEWNET program and data quality are briefly summarized as follows. Discussion of the NEWNET program was based upon an observation of IEER. In looking at the NEWNET data during the first audit, IEER noted that the station at East Gate showed a spike in exposure rate when LANSCE was operational. This spike was evident when winds blew generally from the south (Appendix C, page C-3 and C-25). There was also a small spike when winds blew from the north, and this was hypothesized to be due to LANSCE as well. However, during the second audit, IEER again looked at the NEWNET data for periods when LANSCE did not operate, and noted that a spike correlated with north winds still existed. IEER questioned the reason for the spike. After much discussion, ESH-17 staff discovered that the spike was due to instrument noise. It was in this context that our discussion of NEWNET and data quality began.

Based on our review of the program and our meetings about NEWNET, it is our observation that the data quality program associated with NEWNET is not adequate to ensure that the data posted on the web are good and reliable. We believe that this is because NEWNET was designed

primarily to be an independent and community-driven educational tool and sufficient emphasis was not given to providing highly reliable environmental data. We firmly believe that NEWNET can provide both of these things, without compromising either the mission of NEWNET or the quality of the data, as long as the NEWNET capabilities and scope are understood.

Capabilities of NEWNET

It is important for the public to understand NEWNET's capabilities and not believe that NEWNET can tell them something about LANL releases of which it is not capable. When NEWNET was originally developed, it was intended to provide real-time data on local meteorological conditions and environmental radiation fields. Ionization chambers were chosen as the measurement tool for environmental radiation. Ionization chambers measure charged particles created by gamma rays as they pass through the walls of the chamber and the pressurized gas inside. The charged particles produce an electric signal proportional to the gamma-ray exposure and that signal is recorded.

At the time that NEWNET was moved to LANL, the primary source of offsite radiation exposure was the operation of the LANSCE facility. Short-lived radioactive gases released from LANSCE stacks are a source of external radiation exposure in nearby areas. The NEWNET radiation detectors are well suited to measuring these radiation exposures. As noted earlier in this report, LANSCE operations were not the primary source of exposure during 1999. The most important radionuclide during the audit year was tritium, which emits only low-energy beta particles that cannot be detected by NEWNET's ionization chambers. Other radionuclides released from LANL also emit primarily alpha and beta particles, to which the ionization chambers are insensitive. Releases of these radionuclides are measured by the AIRNET samplers located around LANL.

Although the main beam line of LANSCE is not currently operational and the LANSCE releases are smaller than they have been in the past, NEWNET is an important way to measure and communicate radiation exposure levels due to these releases. We do not intend to imply that it is necessary to add additional sensors to NEWNET; instead, we believe that it is critical that the public should be aware of the power and limitations of NEWNET.

We reviewed the NEWNET web page briefly, and information about the form and source of the gamma radiation data provided by this network is not readily available. We suggest that the web page be the first step at communicating more effectively with the public. The revision of the web site would be best accomplished as a cooperative effort among interested members of the public and Laboratory staff.

Additionally, we believe the concept of community NEWNET station managers to be a good one, provided that those individuals are in a position to share information in an effective way. Teachers, Laboratory scientists, environmental groups, and other informed and interested parties would make excellent station managers, and we encourage continued training and education of these individuals. Their ability to educate the public would be an invaluable tool for spreading the word about NEWNET.

Scope of NEWNET

We suggest that although the goal of NEWNET is an important one, "The goal of this program is to promote better understanding of the environment through collaboration between the public, government, educational institutions, and industry"(www.newnet.lanl.gov/goal.asp), that goal is almost certainly not being met. In the case of NEWNET, it appears that the goal went global before the local problems were resolved. NEWNET will only have power if the data are reliable and meaningful. We see this as a scope problem. The magnitude of the NEWNET station network is taking up resources that should be dedicated to improving the quality of the NEWNET data to a level consistent with that of the other environmental monitoring data at LANL. It may be appropriate to revisit how the stations are assembled to pinpoint where electronic noise is being introduced. It also appears that an examination of the data review process is needed. We suggest that one simple way to do this would be to give less attention to the stations that are not in the immediate LANL environment until some data quality objectives can be evaluated and met. Steps such as these might eliminate concerns like those raised by IEER during this audit.

Summary

We believe the concept of NEWNET to be important; a community-managed environmental monitoring network to provide data and educate the public about environmental radiation is certainly something for which to strive. For the goal to be achieved, the system and data quality must be improved. It is our understanding that management of the NEWNET system is being transferred to the ESH-17 program. We believe that although ESH-17 will be giving up these data as an independent source, this move will be positive, particularly with respect to the data quality issue. ESH-17 has experience in establishing and meeting data quality objectives that will be beneficial to the process of improving the NEWNET system.

Community involvement will be a critical force in making NEWNET last beyond the boundaries of the Consent Decree and we encourage this type of involvement. However, it will be important for the public to fully understand both the capabilities and limitations NEWNET for community involvement to be effective.

Neutrons

The issues of public exposure to neutrons and neutron monitoring have been raised in both the first audit and this second audit. Because the 40 CFR 61, Subpart H regulation excludes exposure from neutrons, such exposure is not a part of Rad-NESHAP compliance. We agree that the regulation could be written more clearly with regard to this issue, and we have forwarded such a comment to the EPA for consideration in their current review of 40 CFR 61, Subpart H (Appendix D).

LANL operates an extensive thermoluminescent dosimeter network whose measurements are used to calculate and report neutron dose annually. This information is available in the Annual Environmental Surveillance Report as well as on the web site for the Air Quality Group. A number of stations were added as a result of the Consent Decree at various locations where public access is not restricted. These data are also available on the web (http://drambuie.lanl.gov/~AirQuality/Albedo-TLD.htm). We did have some discussions about

neutron doses at these locations. Although the locations are publicly accessible, they are not likely to be locations where a person would likely be present for considerable periods during any day. The doses, therefore, are less instructive as an actual neutron dose and more helpful for indicating a possible, but not probable, upper bound for the neutron dose. Because neutron doses are not regulated under the 40 CFR 61, Subpart H regulation, the 10-mrem (0.1 mSv) limit of that regulation does not apply.

Complex Terrain Modeling Comparisons

The issue of complex terrain modeling was raised in the first audit, and we forwarded a question to the EPA regarding the issue. The EPA responded that although LANL is required to use CAP-88 or a similar model based on the language of the regulation, its location suggests that a model more suitable to complex terrain should be considered. The application of a complex terrain model is the responsibility of the facility, and prior approval must be granted by EPA to apply such a model.

As a means of exploring this issue, the audit team looked at a comparison of the dispersion parameters predicted by CAP-88 and CALPUFF,[109] a complex terrain model that explicitly models spatial variability in terrain and wind vectors. The dispersion parameter (χ/Q) is the ratio of the downwind air concentration to the release rate.

A plot of annual average CALPUFF χ/Q values versus annual average CAP-88 χ/Q values (Figure 2) shows CAP-88 generally has higher χ/Q values compared to those of CALPUFF. Higher χ/Q values indicate less plume spreading and consequently, higher pollutant concentrations. On average, CAP-88 χ/Q values are a factor of 2.75 higher than CALPUFF. Approximately 6% of the CALPUFF χ/Q values were higher than the corresponding CAP-88 χ/Q values. Of these χ/Q values, only 5 values were a factor of 2 or more greater than the corresponding CAP-88 values. Differences in CAP-88 and CALPUFF χ/Q values as a function of distance and azimuth from the source are shown in Figure 3. The CAP-88 results show the effect of plume lofting over the nearest receptor (100 m). The CALPUFF results generally do not show plume lofting effects. However, it is strongly suspected that the CALPUFF modeling grid was too coarse to resolve plume lofting effects close to the sources. Difficulty in resolving close-in receptors may have contributed to some CALPUFF χ/Q values being higher than CAP-88 χ/Q values close to the source. Almost all cases in which CALPUFF χ/Q values exceeded those of CAP-88 were for receptors close to the source (~100 m). A more complete description of the calculations done for this comparison appears as Appendix E to this report.

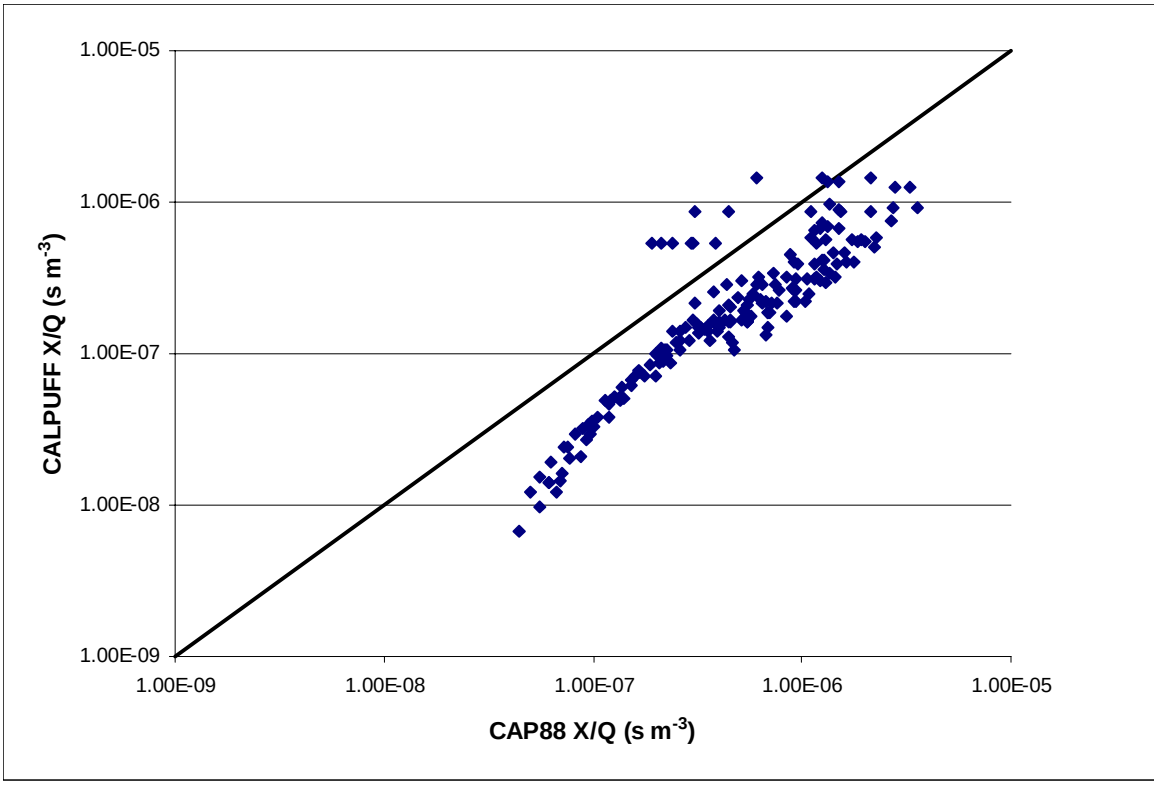

Figure 2. Comparison of CAP-88 χ/Q values and CALPUFF χ/Q values. The black line indicates exact correlation between CALPUFF and CAP-88. CALPUFF χ/Q values exceed those of CAP-88 for the points that lie above the line.

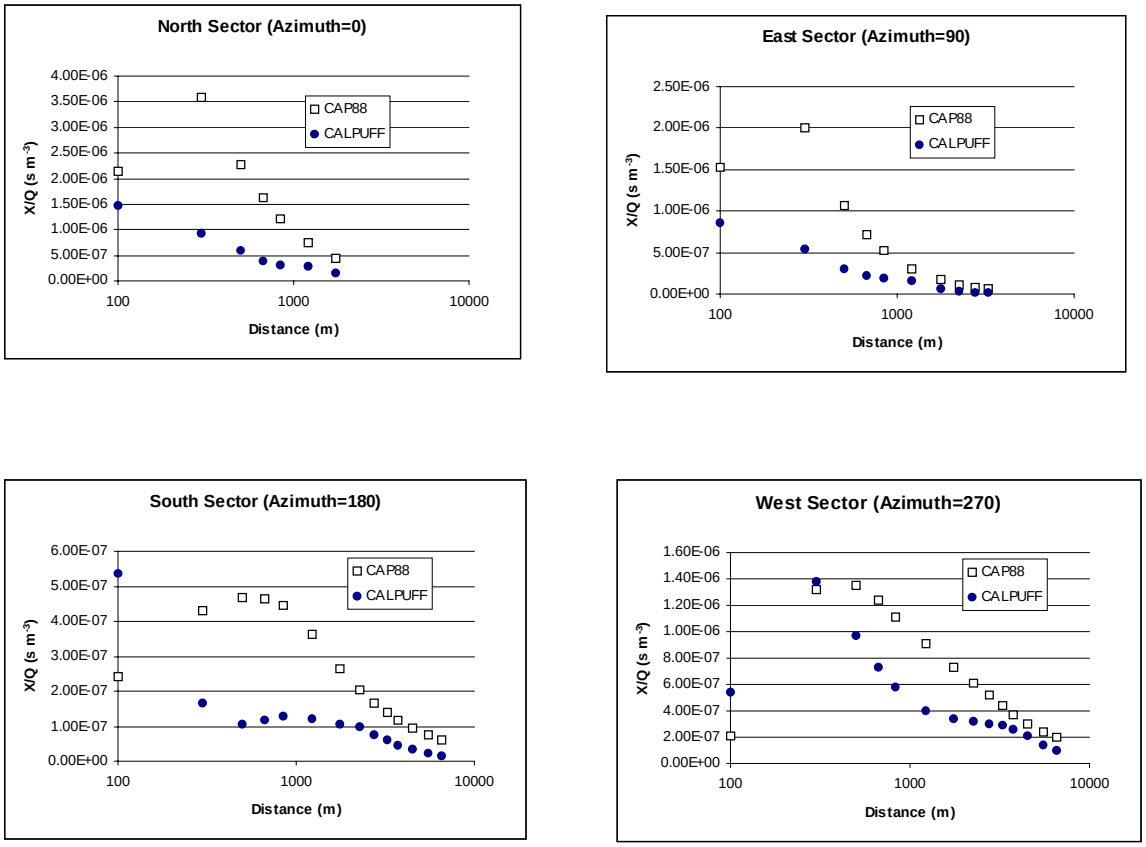

Figure 3. Comparison of CAP-88 and CALPUFF χ/Q values as a function of distance from the source in four different azimuth directions.

Use of the Word "Kiva" at Los Alamos

During the course of the audit tours, we visited the AIRNET laboratory. This laboratory, built into the side of a mountain, is referred to as a "Kiva" by LANL personnel. It was brought to our attention by the Governor of Picuris Pueblo that this naming convention at the Laboratory is not only disrespectful to Native American people, but it violates their cultural belief of what is represented by a "Kiva" (Appendix C, page C-41). We respect how sacred this word is to the Native American people and everything it represents. Therefore, the audit team recommends, with the support of the Governor of Picuris Pueblo, that LANL discontinue use of this word at their facilities. Although not verified, the audit team has been informed that LANL is currently addressing this issue.

A Precautionary Note about Future Emissions

It is evident that one reason for the site MEI dose being less in 1999 than in previous years is the lack of operations at the LANSCE facility. In future years, should operations at LANSCE increase, careful attention will need to be given to emissions from this facility. This would normally be done in the course of determining compliance; however, we note this as a precaution for the future.

Additionally, the audit team urges careful attention be given to decommissioning of facilities at LANL because of potential emissions of radionuclides during decommissioning. We visited a number of facilities that are no longer operating and scheduled to be decommissioned. Some of these have the potential for releasing radionuclides during decommissioning, which must be considered when evaluating compliance in the future.

CONCLUSIONS

This report documents the results of the second independent audit of the LANL performed by *RAC*. The audit focused on the Laboratory's compliance with 40 CFR 61, Subpart H, for the year 1999. The audit was conducted as part of a settlement agreement and Consent Decree that resolved a lawsuit filed against the DOE and LANL Director, Siegfried S. Hecker, by CCNS and Patrick Jerome Chavez. The audit team divided its work into four areas that addressed the major elements of the regulation. These elements comprise the primary portion of this audit report. The audit team focused on the following four areas:

- Evaluating the radionuclide survey for unmonitored point sources
- Effluent monitoring of major release points to air
- Environmental compliance sampling for non-point sources
- Dose calculation

The audit team also evaluated other areas as it assessed compliance with the regulations. These included traceability of data to their original source, documentation supporting compliance, technical competence, quality assurance, and overall confidence of the audit team in the compliance program.

This audit concludes that LANL is in compliance with 40 CFR 61, Subpart H for the year 1999. The audit team commends LANL for their implementation of recommendations provided in the first audit and also the exemplary spirit of cooperation they have shown during this audit to make it an open, thorough, and responsive process. Furthermore, the Rad-NESHAP compliance program at LANL and this audit process could be considered as a model for other DOE facilities. Credit for this achievement is also due to CCNS, who, as a citizens' organization and plaintiff in a lawsuit against DOE, helped to initiate the audit and designed its format.

The audit team did still identify some areas for improvement. These findings are detailed in Appendix A to this report. The findings are listed chronologically as they appear in the report by finding type.

It is noteworthy that this audit was conducted under unusually difficult circumstances created by the Cerro Grande Fire that occurred in May of 2000 and important issues with regard to security at LANL throughout this year. The audit's success is a direct reflection of the professionalism and dedication to this process by all parties who participated. The audit team expresses its appreciation for the spirit of cooperation that made this audit possible.

This is the second audit of its type. The audit team completed an audit that covered compliance for the year 1996. Many of the improvements made in the program and outlined in this report resulted from that first audit. The Consent Decree indicates that the audit may be repeated in the year 2002 and cover compliance for the year 2001. The audit team has evaluated the need for a third audit in consultation with all parties involved and has determined that a third audit will be conducted.

The audit team believed that the public's role in the compliance process was critical. The positive interaction between the audit team, LANL, IEER, and the public confirmed that where regulations related to public exposures are being evaluated, the public can play an important role. The audit team also believed that IEER's role to monitor and verify the audit process was valuable in maintaining this atmosphere of openness. IEER challenged the audit team to conduct

a thorough and fair evaluation of compliance and with the public raised a number of questions regarding important issues. These issues are detailed in Appendix C and are treated within the text of this report. The audit team also noted several instances where the regulation is not clear with regard to what is required to achieve compliance. These issues were forwarded to the EPA for clarification in future revisions to the regulation. The correspondence with the EPA is shown in Appendix D.

This was the second audit of 40 CFR 61, Subpart H, to be conducted by an independent audit team working under the auspices of the U.S. Department of Justice. This arrangement was critical to guarantee the independence of the audit team. The audit team learned much from the process used in the first audit, and used these lessons to complete this audit much more efficiently. This audit should serve as a model for similar reviews at other sites.

It is emphasized that this audit was more rigorous and broader in scope than previous audits conducted for compliance with 40 CFR 61, Subpart H, at LANL and at other DOE sites. The degree of cooperation received from all parties involved was exemplary. The audit team especially commends the Air Quality Group of the Environmental, Safety, and Health Division at Los Alamos National Laboratory because supporting the audit process has required extraordinary effort on their part. The audit team also thanks and commends DOE, LANL, CCNS and IEER for their active involvement and support.

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