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Water Quality
Control Commission

Pamela Jones
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STATE OF NEW MEXICO
NEW MEXICO WATER QUALITY CONTROL COMMISSION

In the Matter of:
PROPOSED AMENDMENTS TO
STANDARDS FOR INTERSTATE AND
INTRASTATE WATERS,
20.6.4 NMAC

No. WQCC 20-51 (R)

THE BUCKMAN DIRECT DIVERSION BOARD'S NOTICE OF INTENT TO PRESENT REBUTTAL TESTIMONY

The Buckman Direct Diversion Board (BDD) hereby files its Notice of Intent to Present Rebuttal Testimony. Pursuant to 20.6.1.202.A NMAC and the November 9, 2020 Procedural Order in this matter the BDD provides the following information in this notice:

1. <u>Identify the person for whom the witness will testify</u>:

   The witness identified below, James P. Bearzi will testify on behalf of the Buckman Direct Diversion Board which is the governing board of directors of the Buckman Direct Diversion Project as established by the Joint Powers Agreement between the City of Santa Fe and the County of Santa Fe.

2. <u>Identify each technical witness the person intends to present, and state the qualifications of that witness, including a description of their educational and work background:</u>

   The BDD intends to present James P. Bearzi, Senior Environmental Geologist, Glorieta Geoscience, Inc. Mr. Bearzi's educational and work background is set forth in his resume, which is the BDD's Exhibit 2.

3. <u>Include a copy of the direct testimony of each technical witness in narrative form, and state the estimated duration of the direct oral testimony of that witness:</u>

   As set forth in the Procedural Order, the BDD submits the full written rebuttal testimony of Mr. Bearzi in Exhibit 1. Mr. Bearzi will limit his oral testimony at hearing to a summary of his written rebuttal testimony not to exceed 30 minutes.

4. Include the text of any recommended modifications to the proposed regulatory change:

The BDD does not propose any modifications to the proposed regulatory change and intends to present only rebuttal testimony related to the proposed regulatory changes submitted by other parties.

5. List and attach all exhibits anticipated to be offered by that person at the hearing:

Below is a list of all exhibits to be offered by the BDD in support of its rebuttal testimony, which are attached, and the page number in the PDF document for each exhibit. BDD reserves the right to offer sur-rebuttal exhibits.

Exhibit	**Description**	**Bates Number**
Ex. 1	Rebuttal Technical Testimony of James P. Bearzi	2020 TR BDD 0001 - 0011
Ex. 2	Resume of James P. Bearzi	0012 - 0013
Ex. 3	Map of Buckman Direct Diversion and its Early Notification System	0014
Ex. 4	Map of Los Alamos Canyon with Stormwater Monitoring/Sample Locations	0015
Ex. 5	Method 1668C; Chlorinated Biphenyl Congeners in Water, Soil, Sediment, Biosolids, and Tissue by HRGC/HRMS; April 2010	0016 - 0133
Ex. 6	State Certification Los Alamos National Laboratory Industrial Wastewater Permit No. NM0028355	0134 - 0146
Ex. 7	Federal Register Vol. 77, No. 97, Page 29763	0147
Ex. 8	2019 LANL Annual Site Environmental Report	0148 - 0483
Ex. 9	Map of PFAS Detections in Groundwater and Springs-Los Alamos National Laboratory	0484
Ex. 10	TREAT Raw Data v. 05312018	0485 - 0502

Respectfully submitted,

/s/ Luke Pierpont
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Certificate of Service

I certify that a copy of the foregoing pleading was emailed to the following counsel on June 22, 2021.

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/s/ Luke Pierpont

Exhibit 1

Rebuttal Technical Testimony of James P. Bearzi

2020 TR BDD 0001 - 0011

STATE OF NEW MEXICO
WATER QUALITY CONTROL COMMISSION

IN THE MATTER OF:

PROPOSED AMENDMENTS TO
STANDARDS FOR INTERSTATE AND
INTRASTATE SURFACE WATERS
20.6.4 NMAC **NO. WQCC 20-51(R)**

REBUTTAL TESTIMONY OF JAMES P. BEARZI ON BEHALF OF THE BUCKMAN DIRECT DIVERSION BOARD

JUNE 22, 2021

I. WORK EXPERIENCE AND BACKGROUND

I am James P. Bearzi and I am employed by Glorieta Geoscience, Inc. ("GGI") as a Senior Environmental Geologist. I am presenting this written rebuttal testimony (**Exhibit 1**) on behalf of the Buckman Direct Diversion ("BDD") Board (the "Board"), in the hearing regarding a petition filed by the New Mexico Environment Department ("NMED") with the New Mexico Water Quality Control Commission ("WQCC") to amend the Interstate and Intrastate Surface Water Quality Standards (the "Standards") at 20.6.4 NMAC (WQCC 20-51 (R)). My testimony is provided in rebuttal to Triad National Security, LLC ("Triad"), and the United States Department of Energy National Nuclear Security Administration (collectively, "DOE") Notice of Intent to Present Technical Testimony in the above-captioned matter.[1] The specific portions of DOE's direct testimony to which I provide rebuttal are discussed in Part III below.

GGI is a consulting firm specializing in groundwater and surface water resource evaluation, including vadose zone, saturated zone and surface water contaminant

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[1] Other parties to this proceeding have made proposals substantively similar to DOE's. For purposes of my testimony, reference to "DOE" includes reference to other parties where applicable.

characterization. I have held the position of Senior Environmental Geologist at GGI since 2014. I have a Master of Science degree in earth sciences from Montana State University, obtained in 1987, and a Bachelor of Science degree in geology and geography from Portland State University, obtained in 1985. In addition to my educational background, I have received and been provided training and continuing education over the years in various environmental topics including water quality and water rights, contaminant fate and transport, sampling, nature and extent studies, groundwater and vadose zone multi-phase transport, risk assessment, remediation technology, waste characterization and management, compliance, and regulation and policy. I also attended and completed *Strategic Management of Regulatory and Enforcement Agencies* at Harvard University's Kennedy School of Government. I have conducted, supervised, and reviewed numerous projects involving investigation and assessment of water quality, groundwater flow, contaminant source investigations, risk assessment, and contaminant transport in the saturated and vadose zones.

At GGI, I serve as Project Manager for a wide range of water resource, environmental, and other projects, many with complex regulatory and compliance issues. I am responsible for the assessment and evaluation of complex hydrologic, geologic, and ecological problems; federal and state law and regulatory compliance; waste profiling and characterization; evaluation of hydrologic models; and collection and evaluation of water quality and quantity data. I have authored numerous reports for clients and regulatory entities related to soil and groundwater contamination.

From 1989 to 2012 (except for 1990), I served in various technical, scientific, and leadership positions in the New Mexico Environment Department ("NMED"). I was a NMED Bureau Chief for 21 years, including a period as Surface Water Quality Bureau ("SWQB") Chief where I had overall responsibility for, and management of New Mexico's surface water quality protection programs, including those required by the federal Clean Water Act ("CWA"), the New Mexico Water Quality Act, and the Water Quality Standards for Interstate and Intrastate Surface Waters at 20.6.4 NMAC. In 2012, I provided direct testimony to the WQCC in support of NMED's petition to amend designated uses for the lower Dry Cimarron River, and to establish water quality standards for lakes. Prior to serving as SWQB Chief, I served for 12 years as Hazardous Waste Bureau Chief, where I had overall responsibility for New Mexico's hazardous waste management program, including regulation of cleanup and monitoring of Los Alamos National Laboratory ("LANL"). From 2012 to 2014 I served as technical staff and technical supervisor for the New Mexico Interstate Stream Commission. Throughout my service to the State of New Mexico, I had responsibilities similar to those as outlined above, and in addition provided testimony in litigation and administrative proceedings, and to legislative bodies; developed and implemented public policy, regulations, and statutes; and managed the technical and administrative aspects of large agency organizations.

A copy of my resume is attached and marked as **Exhibit 2**. It is accurate and up-to-date.

II. BUCKMAN DIRECT DIVERSION

The BDD is a municipal water supply project that is jointly operated by the City of Santa Fe and Santa Fe County to divert their San Juan-Chama and native Rio Grande water rights, and is managed by the Buckman Direct Diversion Board. The BDD treats diverted surface water to federal and state Safe Drinking Water Act standards to supply clean and safe water to the citizens of the City and County of Santa Fe. I provide this testimony on behalf of the Board to offer its unique perspective as a public water utility that diverts surface water that will be directly and adversely impacted by several of DOE's and other parties' proposed amendments to 20.4.6.4 NMAC (*see* footnote 1) introduced in their direct testimony.

The BDD is located west of the City of Santa Fe on the Rio Grande and downstream of several communities and NPDES permittees on the Rio Grande and its tributaries, including the community of Los Alamos, and LANL, which is owned by DOE and co-operated with DOE by Triad. **Exhibit 3** is a map showing these geographic relationships. LANL is located on the Pajarito Plateau, to the west of the Rio Grande, and includes watersheds with a number of perennial, intermittent, and ephemeral streams that are tributaries to the Rio Grande, at least two of which are upstream of the BDD intake structure. Numerous sites where pollutants from industrial outfalls and storm water discharge to tributaries of the Rio Grande are located at LANL or lands formerly occupied by LANL. Dozens of these sites are in the Los Alamos Canyon watershed, whose confluence with the Rio Grande is just below the Otowi Bridge approximately three miles upstream of the Buckman Direct Diversion Project intake structure. **Exhibit 4** is a map showing a portion of LANL and the Los Alamos Canyon watershed, and locations used by LANL to monitor run-on to and runoff from contaminated sites. As a result of these discharges, and other LANL operations that generated hazardous, mixed, and radioactive wastes, legacy contamination is entrained in sediments in the canyons and periodically migrates downcanyon with storm water in response to flood events.

The BDD Board has worked with LANL to establish an Early Notification System ("ENS") to alert BDD operators when a storm water event in Los Alamos Canyon is occurring (*see* **Exhibit 3**). The ENS is a group of strategically-placed storm water monitoring locations in Los Alamos Canyon that detects storm water flow and transmits real-time data that the BDD operators can use to determine if the BDD intake structure should be shut down to avoid diverting contaminated water. The ENS is one facet of the Board's efforts to mitigate the potential impacts of LANL legacy contamination on the BDD, and to instill public confidence in the BDD. The ENS provides critical information to the BDD operators, the Board, and the public on runoff in Los Alamos Canyon and its tributaries that could adversely affect the Rio Grande, the BDD's source water. Any potential for increase in contamination or sedimentation of the Rio Grande caused by LANL, or reduction or limitation of monitoring of the Rio Grande or its tributaries, is of keen interest to the Board and the public it serves. The water quality of the Rio Grande and its tributaries has a direct impact on the BDD's ability to divert and on the associated expense to treat this source water to federal and state drinking water standards.

The BDD relies on the New Mexico water quality standards at 20.6.4 NMAC to ensure that discharges to receiving waters in the BDD source area are appropriately regulated to protect human health and the environment, and is part of the statutory and regulatory framework that ensures cleanup of legacy pollution at LANL is accomplished to levels that maintain and preserve its source water quality. Any federal permit issued under the CWA by the U.S. Environmental Protection Agency ("EPA") in the State of New Mexico must be certified by NMED to ensure full compliance with the WQCC's surface water quality standards. Several of DOE's proposed amendments would undermine the WQCC's surface water quality standards and NMED's ability to certify that EPA-issued permits are protective of those standards, as explained in Part III below.

III. PROPOSED AMENDMENTS

The Board generally is supportive of NMED's Amended Petition. However, the Board has serious concerns with several of DOE's and NMED's proposals set forth in their Notices of Intent to Present Technical testimony. My testimony addresses the following issues:

- DOE's proposal to restrict analytical methods and compliance to those approved by the U.S. Environmental Protection Agency ("USEPA") under 40 CFR Part 136;

- DOE's proposal to limit the WQCC's definition of "toxic pollutants" to those listed by EPA, and NMED's proposal to include Contaminants of Emerging Concern ("CECs") as toxic pollutants; and
- DOE's and other parties' proposal to remove any reference to contaminants of emerging concern ("CECs").

A. Part 136 Methods

DOE proposes to limit analytical methods for purposes of compliance and enforcement of standards to those specified at 40 CFR Part 136 ("Part 136 Methods") in its proposed amendments to 20.6.4.12.E. NMAC (2020 TR LANL-00011). The WQCC has authority to establish a numeric water quality criterion at a concentration that is below the minimum quantification level of a Part 136 Method, so long as another method allowed by 20.6.4.14.A NMAC can achieve detection to the concentration in the criterion. In such cases, the water quality standard is enforceable at the minimum quantification level set forth in the allowed method (20.6.4.12.E NMAC). For example, the WQCC has established use-specific numeric criteria for polychlorinated biphenyl compounds ("PCBs") of 0.014 micrograms per liter ("µg/L") for Wildlife Habitat and Aquatic Life Chronic and 0.00064 µg/L for Aquatic Life Human Health-Organism Only (20.6.4.900.J(1) NMAC), which are less than the equivalent minimum quantification level of Part 136 Method 608.3. DOE does not challenge this in its direct testimony. The WQCC's current regulations account for the fact that Part 136 Methods may not be sufficiently sensitive to detect contaminants at the numeric limits set by the WQCC for certain contaminants, and so it has adopted a number of other acceptable sampling and analysis techniques for use by NMED (*see* 20.6.4.14.A. NMAC). Section 20.6.4.14.A(3) NMAC defines one such category of techniques or laboratory analysis of waste samples for monitoring and compliance purposes as "*Methods For Chemical Analysis Of Water And Waste*, and other methods published by EPA office of research and development or office of water." Under this provision, the NMED can require that monitoring and reporting of PCBs by LANL be performed in accordance with Method 1668C or later revisions. Method 1668C (EPA-820-R-10-005; **Exhibit 5**) was published in April 2010 by the EPA's Office of Water, and therefore is an allowable method under 20.6.4.14.A(3) NMAC.

Method 1668C is not only allowed under existing regulations, but is the only available method to detect PCBs at concentrations at or below the WQCC numerical standards discussed above. NMED has stated in its *State Certification Los Alamos National Laboratory Industrial Wastewater NPDES Permit No. NM0028355* (**Exhibit 6**) that "Method 1668C is a State approved method for testing surface wastewater discharges. Additionally, Method 1668C has a Minimum Quantification Level (MQL) set at or below the applicable and limiting State WQS found in 20.6.4.900(J)(1) NMAC. Further supporting this requirement is that Method 1668C is the only known and least restrictive and readily available laboratory wastewater sampling method that can reasonably assure that the proposed discharges do not exceed the WQS limits of 20.6.4.900(J)(1) NMAC." While EPA has not adopted Method 1668C as a new method under 40 CFR Part 136, it stated in its notice of deferral of action that it "…is still evaluating the large number of public comments and intends to make a determination on the approval of this method [1668C] at a later date…***This decision does not negate the merits of this method for the determination of PCB congeners in regulatory programs or for other purposes when analyses are performed by an experienced laboratory***." (**Exhibit 7**, emphasis added.)

In response to LANL's comment that "LANL is the only facility in New Mexico where use of the Congener Method 1668 is required to determine compliance with an NPDES permit limit," NMED stated that while LANL is the only facility for which Method 1668C is used for compliance, it also

> "…is the only facility whose discharge has been shown to have a reasonable potential to exceed State WQS for PCBs. The State also notes that LANL is not the only NPDES permittee in New Mexico subject to the specific use of USEPA Method 1668C (*see* **Exhibit 6**). For example, six other NPDES permits are required to use this method for monitoring and reporting only. These are discharges to waters where PCBs have been identified as a probable cause of a water quality impairment, but there was insufficient data to determine if the discharge had a reasonable potential to exceed State WQS or may contribute to a listed impairment. Therefore, based on these facts, use of Method 1668C is the least restrictive means known by the State to assure that the proposed activity will not exceed or contribute to the degradation of state water quality." (*see* **Exhibit 6).**

The practical effect of DOE's proposal to limit analytical methods to Part 136 Methods is that contaminants like PCBs in LANL surface and storm waters that are detectable and enforceable ***under current rules*** would be undetectable and unenforceable going forward. Ensuring compliance with the WQCC's numeric standards for PCBs is critical because some of the highest inventories of PCBs at contaminated sites on the Pajarito Plateau are in the Los Alamos Canyon watershed. Six of the 17 NPDES individual permit site monitoring areas where automated samplers collected compliance storm water samples in 2019 are in the Los Alamos Canyon watershed. In 2019 ***every*** storm water or base flow result for total PCBs measured by LANL exceeded the Human Health-Organism Only water quality standard (**Exhibit 8**; p. 6-25). DOE's proposal would make many of these exceedances invisible because the minimum detection limits or method limits for Part 136 Methods are not sufficiently sensitive.

Simply put, DOE's proposal would ***roll back current protections*** the BDD and the public rely upon to protect its source waters. The Board urges the Commission to reject DOE's proposal, and maintain the current regulations which provide authority for NMED to enforce the WQCC's water quality standards.

B. Toxic Pollutants

DOE proposes to limit the existing definition of "toxic pollutants" to those listed by EPA under CWA §307(a) in its proposed amendments to 20.6.4.7.T(2) NMAC (2020 TR LANL-00004). DOE's proposal would delete longstanding language from the WQCC's definition of toxic pollutants that protects the BDD's source water, and human health and the environment generally. Moreover, DOE proposes to eliminate existing language that defines toxic pollutants as including "…disease-causing agents, that after discharge and upon exposure, ingestion, inhalation or assimilation into any organism, either directly from the environment or indirectly by ingestion through food chains, will cause death, shortened life spans, disease, adverse behavioral changes, reproductive or physiological impairment or physical deformation in such organisms or their offspring" (2020 TR LANL-00147). Replacing this language with a definition that limits "toxic pollutants" to EPA's list of "toxic pollutants" would take away the State's authority to protect New Mexico waters from contaminants that have been well-established by the scientific community as "toxic," but that have not gone through the lengthy and laborious rulemaking process that EPA must undertake to add to its definition of "toxic pollutants." The State should have the flexibility and discretion, relying on reproducible data and transparent science, to protect the public and environment from contaminants that are toxic under the broader narrative definition in the current regulations. In combination with the general water quality criteria at 20.6.4.13.F(1) NMED, the existing definition of "toxic pollutants" ensures that New Mexico's waters are free of toxic pollutants as the WQCC and EPA have intended.

C. Contaminants of Emerging Concern

DOE proposes to remove any reference to contaminants of emerging concern ("CECs"), a category of pollutants that NMED proposes to add as a new term at 20.6.4.7.C(7) NMAC and in the general criteria at 20.6.4.13(F) NMAC. CECs include pharmaceuticals, personal care products, polyfluorinated alkylated substances ("PFAS"), and other chemicals that do not have regulatory standards but are suspected to have adverse ecological or human health effects. For many of these compounds, the technical basis of their deleterious effects on organisms, including humans, is evolving.

Nevertheless, some of these CECs, including three PFAS compounds, are listed as toxic pollutants at 20.6.2.7.T(2)(s) NMAC. PFAS have recently been detected in the groundwater beneath and in springs on the Pajarito Plateau (**Exhibit 9).** DOE's proposal would remove any authority NMED has to require further sampling for PFAS or any other CEC in either surface water or storm water. The BDD has conducted sampling of its source water for many of these CECs (**Exhibit 10**), and while it has confirmed that its treatment of source water is consistently able to supply safe drinking water to the public, ongoing and routine monitoring of CECs by permittees subject to the CWA and WQA will protect BDD's source water and to sustain public confidence in the BDD.

I agree with DOE that without clearly stated criteria, compliance with narrative water quality standards for CECs at this time could be unclear to permittees. However, DOE's proposed elimination of CEC's from the water quality standards is an overreaction. NMED's proposed inclusion of CECs as toxic pollutants under the general criteria is also problematic, as it would conflate CECs and toxic pollutants, inappropriately impose compliance requirements for toxic pollutants on CECs, and assume that all CECs are toxic pollutants where no such determination has been made. Instead of adopting either DOE's or NMED's proposal, the WQCC could protect surface water quality in the State and develop the evolving science behind the toxicity and deleterious effects of CECs by giving NMED the authority to include sampling and monitoring of CECs as a condition of an individual federal permit under CWA §401.

IV. CONCLUSION

For the foregoing reasons, limiting sampling methods for purposes of compliance to Part 136 Methods and limiting the definition of "toxic pollutants" to EPA's list of toxic pollutants would result in diminution of New Mexico's water quality, adversely affect the BDD's ability to provide safe and reliable drinking water to its customers, and undermine NMED's ability to monitor and enforce New Mexico's water quality standards, and should be rejected. Including CECs as toxic pollutants under the general criteria conflates CECs and toxic pollutants, imposes compliance requirements for toxic pollutants on CECs, and assumes that all CECs are toxic pollutants where no such determination has been made, and should also be rejected. NMED should be given authority to require monitoring of CECs as a condition of individual federal permits. This concludes my rebuttal testimony.

____
James P. Bearzi

Exhibit 2

Resume of James P. Bearzi

2020 TR BDD 0012 - 0013

NAME **JAMES P. BEARZI**

TITLE **Senior Environmental Geologist**

EXPERIENCE

Senior Environmental Geologist, Glorieta Geoscience, Inc. (2014 – present): Provide technical oversight and project-level management for a range of technical, environmental, regulatory, and water supply issues for private and governmental clients. Conduct wastewater, waste, and soil sampling, construction site stormwater inspections, and permitting and regulatory interface in federal, state, and local jurisdictions. Litigation support and expert witness testimony.

Senior Supervising Hydrogeologist, New Mexico Interstate Stream Commission (2012 – 2014): Responsible for assessment and evaluation of complex hydrologic, geologic, and ecologic problems that bear on New Mexico's obligations under interstate stream compacts, federal and state law, and other legal documents that define surface water delivery to downstream states. Manage projects and budgets that advance the Commission's charge to protect New Mexico's interests in managing the state's water resources. Evaluate hydrologic models, collect and evaluate water quality and quantity data, scrutinize consultant reports, and provide testimony in litigation.

Adjunct Instructor, University of New Mexico – Los Alamos (2008 – 2014): Instructor in environmental science, physical science, physical geography, physical geology, and American Studies. Most courses have laboratory component.

Bureau Chief, New Mexico Environment Department Surface Water Quality Bureau (2011 – 2012): Responsible for implementation of New Mexico's surface water quality protection program, including certification of federal permits, inspection, enforcement, and compliance programs; watershed protection and restoration; monitoring and assessment of water resources; utility operator certification; and standards development. Management of 51 FTE organization with $5 million operating budget from federal, general fund, and other state fund sources. Provide testimony in administrative hearings and legislative hearings.

Bureau Chief, New Mexico Environment Department Hazardous Waste Bureau (1999 – 2011): Responsible for implementation of New Mexico's hazardous waste regulatory program, including permitting, inspection, enforcement, and data management programs. Management of 58 FTE organization with $4.2 million operating budget from federal, general fund, and other state fund sources. Also responsible for Department spill and emergency response functions. Also conduct detailed technical review of corrective action documents, primarily focused on Los Alamos National Laboratory. Note – On special assignment to Governor's Office from July, 2003 to May, 2004 to participate in Governor Richardson's Performance Review of State Government (Phase 2). Also responsible for Radiation Protection Program that was within the Bureau until 2001. Provide expert witness testimony in federal and state court, administrative hearings, and legislative hearings.

District Manager, New Mexico Environment Department District II (1995 – 1999): Responsible for implementation of food safety, liquid waste disposal, pool and spa safety, subdivision review, and drinking water programs for NE New Mexico. Managed staff of 30 technical, financial, inspection, and support personnel in central and remote offices, with two general fund and three revenue-based budgets (approx. $1.6 million per year). Note – Performed “double duty” as Chief of NMED’s Community Services Bureau and Acting Manager of NMED’s Food Safety Program from mid-1998 to 1999. Oversaw development of Environmental and Public Health programs on a statewide basis and coordinated implementation in NMED’s four district offices. Serve a hearing officer of non-District II food and liquid waste hearings. Provide expert witness testimony in administrative and legislative hearings.

Chief of NMED’s Underground Storage Tank Bureau (1992 – 1995): Oversaw environmental programs involving prevention and cleanup of petroleum releases, with a staff of 65 in central and field locations. Oversaw two federal grants (approx. $1.5 million per year) and two fee programs (approx. $30 million per year). Provide expert witness testimony in federal and state court, and in administrative and legislative hearings.

President and Principle Investigator; Lassen Environmental Services, Inc. (1990 – 1996): Specialized in water availability, environmental assessment, and property transfer for private clients. Developed scopes of work and budgets for environmental restoration projects, managed projects, and ensured that work was performed within client-approved budgets. Conducted receivables and payables. Dissolved in 1996.

Scientist, Project Manager, and Front Line Supervisor in NMED’s Underground Storage Tank Bureau (1989 – 1992): Oversaw dozens of contaminated site investigations and cleanups. Responsible for ensuring robust scientific principles – geologic, geochemical, hydrologic, and biological – are adhered to in addressing groundwater and soil cleanups. Conducted sampling and surveying of domestic or public water supply well, and installation of monitoring wells. Employment interrupted from January, 1990 through February, 1991.

Hydrogeologist, Glorieta Geoscience, Inc. (1990): Conducted water availability and water resource studies for commercial and residential clients, environmental assessment for commercial interests, and property transfer for private clients. Conducted original hydrologic, geologic, and environmental studies. Developed budgets for environmental restoration projects, managed projects, and ensured that work was performed within client-approved budgets.

Hydrologist, U.S. Geological Survey – Water Resources Division (1988 – 1989): Assist in development of hydrologic and geologic models of groundwater flow; describe well cuttings for water wells; assess water resource potential in militarily sensitive areas in Central America and the Middle East; interpret geophysical logs of water wells.

EDUCATION

M.S. Earth Sciences, Montana State University, 1987, with specialty in fluvial geomorphology, natural hazard analysis, and soil science. Thesis – *Fluvial Geomorphology and Terrace Development, Lower Jack Creek, Southwestern Montana*

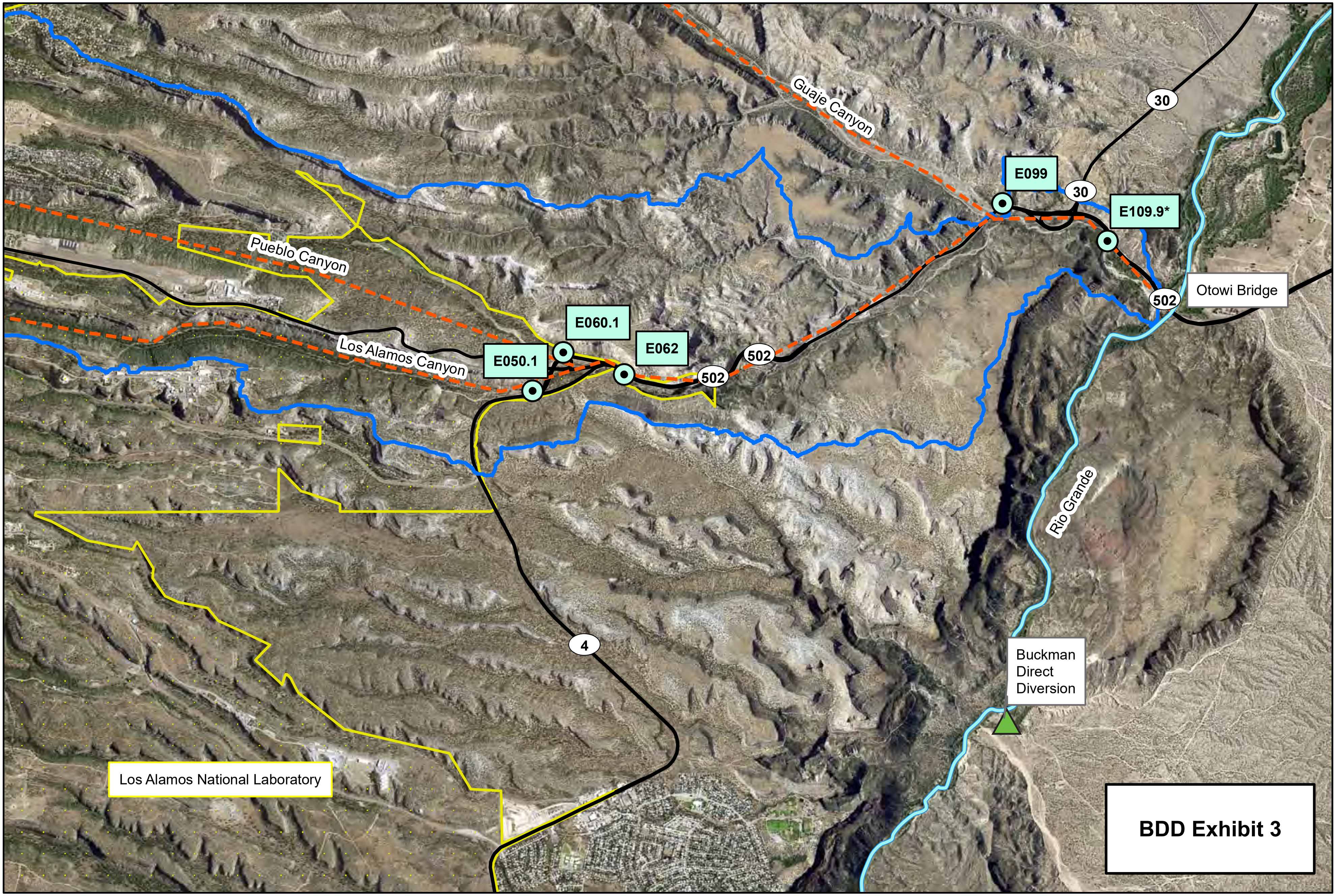
B.S. Geology and Geography (double major), Portland State University, 1985, *summa cum laude*

Strategic Management of Regulatory and Enforcement Agencies, 2002, Harvard University, Kennedy School of Government.

Exhibit 3

Map of Buckman Direct Diversion and its Early Notification System

2020 TR BDD 0014



Buckman Direct Diversion and its Early Notification System

◉ Early Notification Systems
▭ Los Alamos Canyon Watershed
▭ LANL Boundary
- - Canyons

*not functional since 2014

1 0.5 0 1 Miles

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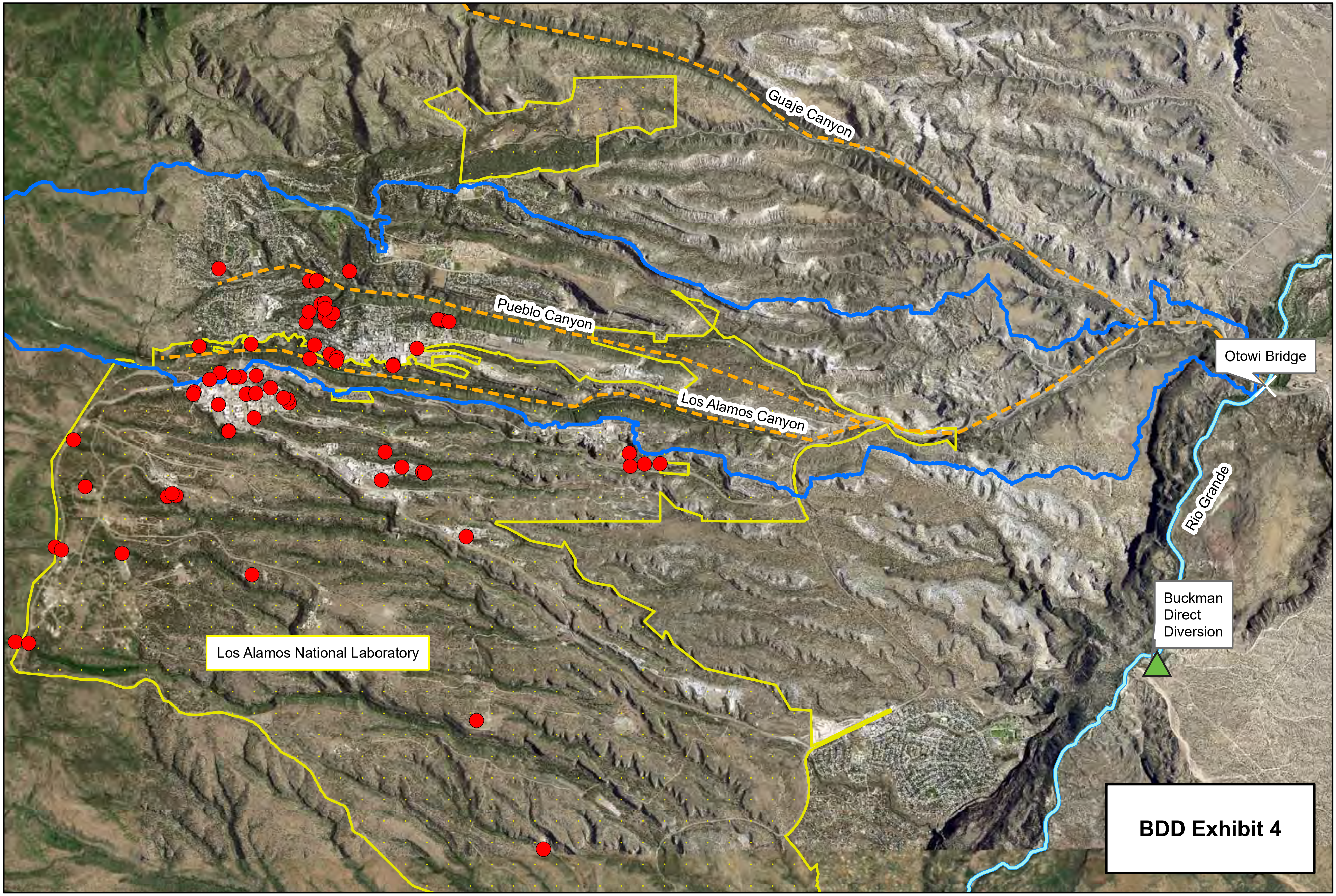
GLORIETA GEOSCIENCE, INC.

Exhibit 4

Map of Los Alamos Canyon with Stormwater Monitoring/Sample Locations

2020 TR BDD 0015

BDD Exhibit 4



Los Alamos National Laboratory Runon and Runoff Monitoring Locations

● Runon and Runoff Monitoring Locations
▭ Los Alamos Canyon Watershed
- - - Canyons
▭ LANL Boundary

GLORIETA GEOSCIENCE, INC.

Exhibit 5

Method 1668C; Chlorinated Biphenyl Congeners in Water, Soil, Sediment, Biosolids, and Tissue by HRGC/HRMS; April 2010

2020 TR BDD 0016 - 0133

United States
Environmental Protection
Agency

Method 1668C
Chlorinated Biphenyl Congeners in Water, Soil, Sediment, Biosolids, and Tissue by HRGC/HRMS

April 2010

U.S. Environmental Protection Agency
Office of Water
Office of Science and Technology
Engineering and Analysis Division (4303T)
1200 Pennsylvania Avenue, NW
Washington, DC 20460

EPA-820-R-10-005

Method 1668C Chlorinated Biphenyl Congeners in Water, Soil, Sediment, Biosolids, and Tissue by HRGC/HRMS April 2010

The Office of Science and Technology (OST) in EPA's Office of Water developed Method 1668C (Method 1668C; the "Method") for use in Clean Water Act (CWA) programs. EPA is publishing this Method for users who wish to measure PCBs as congeners now, and in 2010, EPA expects to publish a proposal in the *Federal Register* for public comment to add this Method to other CWA Methods published at 40 CFR Part 136.

This Method determines chlorinated biphenyl congeners in environmental samples by isotope dilution and internal standard high-resolution gas chromatography/high-resolution mass spectrometry, HRGC/HRMS. EPA developed this Method for use in wastewater, surface water, soil, sediment, biosolids and tissue matrices. Other applications and matrices may be possible, which may or may not require modifications of sample preparation, chromatography, etc.

EPA used the results of an interlaboratory validation study of Method 1668A, a peer review of that study, user suggestions and additional interlaboratory data to write this version, 1668C, of Method 1668. Method 1668C, the validation study report, *Method1668A Interlaboratory Validation Study Report* (EPA-821-08-021), and the addendum describing the revised QC acceptance criteria, *Method 1668A Interlab Study Report Addendum*, are available at EPA's CWA methods website at www.epa.gov/waterscience/methods.

This "C" version of Method 1668 revises the quality control (QC) acceptance criteria in EPA Method 1668B to allow the upper recovery limit for some congeners to be above 100 percent, to revise the estimated method detection limits (EMDLs) and estimated minimum levels of quantitation (EMLs) to MDLs and MLs, and to makes other changes summarized below. The QC acceptance criteria developed in the interlaboratory method validation study of 1668A, and published in version B of the Method, did not allow the upper recovery limit for some congeners to be above 100 percent. The criteria have been revised based on data from the interlaboratory study and data from two laboratories with extensive experience in use of Method 1668A. TestAmerica, Knoxville, Tennessee and AXYS Analytical Services, Ltd., Sidney, British Columbia, Canada provided this new data. These two laboratories and Battelle-Columbus provided MDLs for the congeners and congener groups, which EPA pooled and used to replace the EMDLs and EMLs in Table 2 of Method 1668B with the MDLs and MLs in Method 1668C.

The detection limits and quantitation levels in this Method are usually dependent on the level of interferences and laboratory background levels rather than instrumental limitations. The method detection limits (MDLs) and minimum levels of quantitation (MLs) in Table 2 are concentrations at which a congener can be measured with no interferences present. In water, MDLs range from approximately 7 to 30 parts per quadrillion (picograms per liter, pg/L).

Interface, Inc. and CSC prepared this Method under EPA Contract EP-C-06-085. AXYS Analytical provided the single-lab data in Method 1668A that was later replaced by multi-lab data from laboratories that participated in EPA's inter-laboratory validation of 1668A (six labs for water and tissue, four for biosolids).

Summary of changes between EPA Method 1668B (January 2009) and 1668C (April 2010)

- Additional information on the concentration of extracts has been included in Section 4.2.
- The following note has been added to Section 10.1, "RTs, RRTs, and RRT limits may differ slightly from those in Table 2." This statement has also been added to the footnotes to Table 2.

- The note in Section 10.2.1 has been modified to inform the analyst that careful selection of the grade and purity of PFK may help minimize interferences with the dichlorobiphenyl secondary quantitation ion.

- The diluted combined 209 congener solution is now used for calibration verification, in place of the VER-3 solution. This allows all verification tests to be performed with a single solution.

- Section 17.2.1 has been changed to clarify that concentrations of native compounds other than those in the native toxics/LOC standard, in the labeled cleanup standard, and in the labeled injection internal standard (except for labeled CB 178) should be determined using the response factors from Section 10.5 or Section 15.4.2.3.

- Section 17.6.5 has been added to provide information on the use of optional data qualifier flags for reporting coeluting congeners.

- Based on data from the interlab validation study and data from two laboratories, the QC acceptance criteria in Table 6 have been revised to be consistent among tests for calibration verification (VER), initial precision and recovery (IPR), on-going precision and recovery (OPR), and labeled compound recovery from samples.

- Reference 22 has been added to cite the Addendum to the interlaboratory validation study report.

- Sections 1.3, 4.1, 4.6, 9.1.2.1, 9.5.2, 10.3.3, 17.6.1.4.1, 17.6.1.4.2, 17.6.1.4.3, and Table 2 been revised to change estimated method detection limits (EMDLs) and estimated minimum levels of quantitation (EMLs) to MDLs and MLs.

- Reference 23 has been added to cite the MDL data from AXYS, TestAmerica-Knoxville, and Battelle-Columbus, and to explain how these data were processed to produce the pooled MDLs in Table 2.

- A sentence was added to Section 11.4.2.1 to require weighing the sample bottle after emptying, and to determine the volume using the density of water.

- ML definition revised to cite the ML procedure.

- A note was added to Section 10.3.3 to state that MDLs and MLs lower than those in Table 2 may be established per Section 17.6.1.4.1.

- Section 17.6.1.4.1 expanded to state how MDLs and MLs lower than those in Table 2 may be established.

- A footnote was added to Table 2 to cite Reference 23.

Summary of changes between EPA Method 1668A (8-20-03) and 1668B (January 2009) (excluding typographical and grammatical error corrections, and section insertions or deletions necessitated by the following changes).

- Based on the interlaboratory validation study, single-laboratory QC acceptance criteria are replaced with interlaboratory criteria (Table 6). A new footnote 1 to Table 6 references the EPA interlaboratory study report, and the other footnote numbers are incremented.

- Section 1.5, the performance-based discussion, describes additional flexibility to modify CWA Methods that is allowed by 40 CFR Part 136.6.

- Section 2.5.2 now indicates that internal standards are the labeled congeners spiked into the sample.

- Section 2.5.3 now indicates that injection internal standards are labeled compounds spiked into the extract.

- Section 5.4 is an added section on biohazards.

- Section 7.8 notes that Method 1668A part numbers are valid for Method 1668B.

- Section 8.1 allows use of alternate sample collection techniques, if documented.

- Section 8.2 adds that one liter, or a larger or smaller volume of sample, may be collected.

- Section 12.3 adds a note to indicate that SDS extraction may cause loss of some mono- through trichloro congeners.

- Section 12.5.6 states that a macro concentration device is to be used to concentrate extracts, and deletes the requirement for collection of the extract in a round-bottom flask because any macro concentration device may be used.

- Section 16.2 requires an expert spectrometrist to determine analyte presence when an interference precludes meeting the signal-to-noise requirement for dichloro-CB congeners.

- Section 21 cites the validation studies, and that performance data are in the interlaboratory validation study report.

- Reference 1 was updated to the 2006 World Health Organization paper on toxicity equivalency factors.

- References 4 and 17 add titles to the papers in these references.

- Reference 21 cites the Method 1668A Interlaboratory Validation Study Report.

- Tables 2 and A-1 revised the elution order for congeners 107-109.

- Table 4 defines the solutions containing congeners 107, 108, and 109.

- Table 6 contains revised QC acceptance criteria for performance tests, and footnote 1 to Table 6 references the Method 1668A Interlaboratory Validation Study Report.

- Table 7 adds footnote 2 to require meeting the 10:1 signal-to-noise specification at the CS-2 calibration level.

Summary of corrections and changes to EPA Method 1668A as of August 20, 2003 (excluding typographical and grammatical error corrections, and section insertions or deletions necessitated by the following changes).

- Throughout: All references to IUPAC have been deleted. We have been informed that IUPAC does not assign congener numbers. Therefore, all references to congeners by number are to “congener number.” The congener naming system given by Guitart, *et al.* (Guitart R., Puig P., Gomez-Catalan J., Chemosphere 27 1451-1459, 1993) has been used in EPA Method 1668A since its inception and continues in this version.

- Sections 2.1.3, 12.4.2., 12.4.3, 12.4.5, and 12.4.9: Hexane has be deleted from the extraction solvent for fish and other tissue to preclude loss of the more volatile CBs.

- Section 7.7: A note has been added to reference the two known suppliers of labeled compounds.

- Section 7.15: A statement has been added to include certified reference materials (CRMs) from the National Resource Council of Canada.

- Sections 8.2.3, 8.3.2, and 8.4.2: The preservation temperature for shipment of samples has been changed to <6 °C to encompass the 4 ± 2 °C used by some organizations (e.g., USGS).

- Section 8.2.3: The requirement to preserve aqueous samples with sulfuric acid has been deleted because PCBs are stable in environmental samples, and the storage temperature for aqueous samples has been changed to <6 °C.

- Section 9.1.2.1: A statement has been added that a modification may be used routinely after it has been demonstrated to meet the QC acceptance criteria of the performance tests, so long as the other requirements in the Method are met (e.g., labeled compound recovery).

- Section 10.1.2.3: The word “approximately” has been inserted in the requirement to meet the retention times in Table 2 to reflect that slight changes in GC columns will produce slightly different retention times.

- Section 10.1.2.4: A statement has been added to indicate that the absolute and relative retention times in Table 2 were obtained under the GC conditions given in Section 10.1.1.

- Section 10.2.2: The text has been changed to clarify that the deviation between each monitored exact m/z and the theoretical m/z (Table 7) must be less than 5 ppm.

- Section 10.5: The text has been corrected to state that the diluted combined 209 congener solution (Section 7.10.2.2 and Table 5) is used for single-point calibration of the Native Toxics/LOC CBs.

- Section 12.4: A note has been added to allow use of a separate aliquot for percent lipid determination.

- Section 12.4.1: The minimum time required to dry the sample has been reduced from 12-24 hours to 30 minutes.

- Section 15.6: A requirement has been added to analyze one or more aliquots of solvent after the OPR if the CBs would be carried into the Method blank.

- Section 16.4: RRT QC limits may be based on the limits in Table 2 or limits developed from calibration data.

- Section 17.2.2: The units have been corrected to ng/mL

- Section 17.4: A multiplier of 1000 has been inserted in the equation to convert ng in extract to pg in sample.

- Section 18.5: A section has been added to suggest that the carbon column should be used if interferences preclude identification and/or quantitation of the Toxics.

- Table 2: The relative retention times have been changed to correct errors and reference each compound to the correct retention time and quantitation reference. The RT and RRT windows have been adjusted to attempt to unambiguously identify each congener in the presence of other congeners. Footnotes 7 and 8 have been revised to reflect this changes.

- Table 3: Units for the diluted combined 209 congener solution have been corrected to ng/mL as have the concentrations of the native compounds in the diluted combined 209 congener solution.

- Table 6: The lower QC acceptance criteria limit for the labeled monochloro- and dichloro-CBs has been lowered for the IPR, OPR, and recovery from samples to reflect that these compounds can be lost by evaporation.

- Table 7: Cl-3 scan descriptors have been added to Function 2 and the m/z types for the 13C12 Cl-4 PCBs have been corrected in Function 4.

- Table 8: The m/z's forming the ratio, the ratio, and the QC limits have been corrected for decachlorobiphenyl.

- Table A1: The header has been corrected to delete reference to EMDLs and EMLs.

Disclaimer

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Method 1668C
Chlorinated Biphenyl Congeners in Water, Soil, Sediment, Biosolids, and Tissue by HRGC/HRMS

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1.0 Scope and Application

1.1 Method 1668C (the Method) is for determination of chlorinated biphenyl congeners (CBs) in wastewater and other matrices by high-resolution gas chromatography/high resolution mass spectrometry (HRGC/HRMS).

1.1.1 The CBs that can be determined by this Method are the 12 polychlorinated biphenyls (PCBs) designated as toxic by the World Health Organization (WHO): congeners 77, 81, 105, 114, 118, 123, 126, 156, 157, 167, 169, and 189. The Method also determines the remaining 197 CBs, approximately 125 of which are resolved adequately on an SPB-octyl gas chromatographic column to be determined as individual congeners. The remaining approximately 70 congeners are determined as mixtures of isomers (co-elutions).

1.1.2 The 12 PCBs designated as toxic by WHO (the "Toxics"; also known as dioxin-like PCBs; DLPCBs), and the earliest and latest eluted congener at each level of chlorination are determined by the isotope dilution quantitation technique; the remaining congeners are determined by the internal standard quantitation technique.

1.1.3 This Method allows determination of the PCB toxicity equivalent (TEQ_{PCB}) for the Toxics in a sample using toxicity equivalency factors (TEFs; Reference 1) and allows unique determination of 19 of 21 CBs of interest to the National Oceanic and Atmospheric Administration (NOAA; Reference 2). A second-column option is provided for resolution of the two toxic PCB congeners (congener 156 and 157) that are not resolved on the SPB-octyl column and for resolution of other CB congeners.

1.1.4 This Method also allows estimation of homolog totals by level of chlorination (LOC) and estimation of total CBs in a sample by summation of the concentrations of the CB congeners and congener groups.

1.1.5 The list of 209 CBs (Table 1) identifies the Toxics, the CBs of interest to NOAA, and the LOC CBs.

1.2 EPA developed this Method for use in Clean Water Act (CWA) programs and for wastewater, surface water, soil, sediment, biosolids and tissue matrices. Other applications and matrices may be possible, which may or may not require modifications of sample preparation, chromatographic conditions, etc. Method 1668C is a revision of previous versions of Method 1668 all of which are based on a compilation of methods from the technical literature (References 3 and 4), and EPA's dioxins and furans Method, Method 1613.

1.3 The detection limits and quantitation levels in this Method are usually dependent on the level of interferences and laboratory background levels rather than instrumental limitations. The method detection limits (MDLs; 40 CFR 136, appendix B) and minimum levels of quantitation (MLs; 68 FR 11790) in Table 2 are the levels at which the CBs can be determined with no interferences present. The MDL for CB 126 in water is 16 pg/L (picograms-per-liter; parts-per-quadrillion).

1.4 The GC/MS portions of this Method are for use only by analysts experienced with HRGC/HRMS or under the close supervision of such qualified persons. Each laboratory that uses this Method must demonstrate the ability to generate acceptable results using the procedure in Section 9.2.

1.5 This Method is "performance-based," which means that you may make modifications without additional EPA review to improve performance (e.g., overcome interferences, or improve the sensitivity, accuracy or precision of the results) provided that you meet all performance criteria in this Method. Requirements for establishing equivalency are in Section 9.1.2, and include 9.1.2.2.3 – explaining the reason for your modifications. For CWA uses, additional flexibility is described at 40 CFR 136.6. You must document changes in performance, sensitivity, selectivity, precision, recovery, etc., that result from modifications within the scope of Part 136.6, and Section 9 of this Method, and how these modifications compare to the specifications in this Method. Changes outside the scope of Part 136.6 and Section 9 of this Method may require prior review or approval.

2.0 Summary of Method

Flow charts summarize procedures for sample preparation, extraction, and analysis for aqueous and solid samples, multi-phase samples, and tissue samples (Figures 1, 2 and 3, respectively.)

2.1 Extraction

2.1.1 Aqueous samples (samples containing less than one percent solids) – Stable isotopically labeled analogs of the Toxics and labeled LOC CBs are spiked into a 1-L sample. The sample is extracted using solid-phase extraction (SPE), separatory funnel extraction (SFE), or continuous liquid/liquid extraction (CLLE).

2.1.2 Solid, semi-solid, and multi-phase samples (excluding tissue) – The labeled compounds are spiked into a sample containing 10 g (dry weight) of solids. Samples containing multiple phases are pressure filtered and any aqueous liquid is discarded. Coarse solids are ground or homogenized. Any non-aqueous liquid from multi-phase samples is combined with the solids and extracted in a Soxhlet/Dean-Stark (SDS) extractor. The extract is concentrated for cleanup.

2.1.3 Fish and other tissue – A 20-g aliquot of sample is homogenized, and a 10-g aliquot is spiked with the labeled compounds. The sample is mixed with anhydrous sodium sulfate, allowed to dry for 12 - 24 hours, and extracted for 18-24 hours using methylene chloride in a Soxhlet extractor. The extract is evaporated to dryness, and the lipid content is determined.

2.2 After extraction, a labeled cleanup standard is spiked into the extract which is then cleaned up using back-extraction with sulfuric acid and/or base, and gel permeation, silica gel, or Florisil chromatography. Activated carbon and high-performance liquid chromatography (HPLC) can be used for further isolation of specific congener groups. Prior to the cleanup procedures cited above, tissue extracts are cleaned up using an anthropogenic isolation column.

2.3 After cleanup, the extract is concentrated to 20 µL. Immediately prior to injection, labeled injection internal standards are added to each extract and an aliquot of the extract is injected into the gas chromatograph (GC). The analytes are separated by the GC and detected by a high-resolution (≥10,000) mass spectrometer. Two exact m/z's are monitored at each level of chlorination (LOC) throughout a pre-determined retention time window.

2.4 An individual CB congener is identified by comparing the GC retention time and ion-abundance ratio of two exact m/z's with the corresponding retention time of an authentic standard and the theoretical or acquired ion-abundance ratio of the two exact m/z's. Isomer specificity for certain of the CB congeners is achieved using GC columns that resolve these congeners.

2.5 Quantitative analysis is performed in one of two ways using selected ion current profile (SICP) areas:

2.5.1 For the Toxics and the LOC CBs, the GC/MS is multi-point calibrated and the concentration is determined using the isotope dilution technique.

2.5.2 For all congeners other than the Toxics and LOC CBs, the GC/MS is calibrated at a single concentration and the concentrations are determined using the internal standard technique. The internal standards are the labeled congeners spiked into the sample, thus affording recovery correction for all congeners.

2.5.3 For the labeled Toxics, labeled LOC CBs, and the cleanup standards, the GC/MS is calibrated using replicates at a single concentration and the concentrations of these labeled compounds are determined using the internal standard technique. The labeled injection internal standards are determined using the internal standard technique.

2.6 The quality of the analysis is assured through reproducible calibration and testing of the extraction, cleanup, and HRGC/HRMS systems.

3.0 Definitions

Definitions are in the glossary at the end of this Method.

4.0 Contamination and interferences

4.1 Solvents, reagents, glassware, and other sample processing hardware may yield artifacts, elevated baselines, and/or lock-mass suppression causing misinterpretation of chromatograms. Specific selection of reagents and purification of solvents by distillation in all-glass systems may be required. Where possible, reagents are cleaned by extraction or solvent rinse. Environmentally abundant CBs have been shown to be very difficult to completely eliminate from the laboratory at levels lower than the MDLs in this Method (Table 2), and baking of glassware in a kiln or furnace at 450 - 500 ºC may be necessary to remove these and other contaminants.

4.2 Proper cleaning of glassware is extremely important, because glassware may not only contaminate the samples but may also remove the analytes of interest by adsorption on the glass surface.

4.2.1 Glassware should be rinsed with solvent and washed with a detergent solution as soon after use as is practical. Sonication of glassware containing a detergent solution for approximately 30 seconds may aid in cleaning. Glassware with removable parts, particularly separatory funnels with fluoropolymer stopcocks, must be disassembled prior to detergent washing.

4.2.2 After detergent washing, glassware should be rinsed immediately, first with methanol, then with hot tap water. The tap water rinse is followed by another methanol rinse, then acetone, and then methylene chloride.

4.2.3 Baking of glassware in a kiln or other high temperature furnace (300 - 500 ºC) may be warranted after particularly dirty samples are encountered. The kiln or furnace should be vented to prevent laboratory contamination by CB vapors. Baking should be minimized, as repeated baking of glassware may cause active sites on the glass surface that may irreversibly adsorb CBs.

4.2.4 Immediately prior to use, the Soxhlet apparatus should be pre-extracted with toluene for approximately 3 hours (see Sections 12.3.1-12.3.3). The extraction apparatus (Section 6.4) should be rinsed with methylene chloride/toluene (80/20 mixture).

4.2.5 A separate set of glassware may to necessary to effectively preclude contamination when low-level samples are analyzed.

4.2.6 Concentration of extracts by Kuderna-Danish (K-D) concentrator and/or final concentration using nitrogen evaporation may help reduce levels of background PCBs in samples.

4.3 All materials used in the analysis must be demonstrated to be free from interferences by running reference matrix Method blanks (Section 9.5) initially and with each sample batch (samples started through the extraction process on a given 12-hour shift, to a maximum of 20 samples).

4.3.1 The reference matrix must simulate, as closely as possible, the sample matrix under test. Ideally, the reference matrix should not contain the CBs in detectable amounts, but should contain potential interferents in the concentrations expected to be found in the samples to be analyzed.

4.3.2 When a reference matrix that simulates the sample matrix under test is not available, reagent water (Section 7.6.1) can be used to simulate water samples; playground sand (Section 7.6.2) or white quartz sand (Section 7.3.2) can be used to simulate soils; filter paper (Section 7.6.3) can be used to simulate papers and similar materials; and corn oil (Section 7.6.4) can be used to simulate tissues.

4.4 Interferences co-extracted from samples will vary considerably from source to source, depending on the diversity of the site being sampled. Interfering compounds may be present at concentrations several orders of magnitude higher than the CBs. The most frequently encountered interferences are chlorinated dioxins and dibenzofurans, methoxy biphenyls, hydroxydiphenyl ethers, benzylphenyl ethers, brominated diphenyl ethers, polynuclear aromatics, polychlorinated naphthalenes, and pesticides. Because very low levels of CBs are measured by this Method, elimination of interferences is essential. The cleanup steps given in Section 13 can be used to reduce or eliminate these interferences and thereby permit reliable determination of the CBs at the levels shown in Table 2.

4.5 Each piece of reusable glassware should be numbered to associate that glassware with the processing of a particular sample. This will assist the laboratory in tracking possible sources of contamination for individual samples, identifying glassware associated with highly contaminated samples that may require extra cleaning, and determining when glassware should be discarded.

4.6 Contamination of calibration solutions – The MDLs and MLs in Table 2 are the levels that can be achieved in the absence of laboratory backgrounds. Many of the MLs are greater than the equivalent concentrations of the calibration solutions. To prevent contamination, calibration solutions must be prepared in an area free from CB contamination using glassware free from contamination. If these requirements cannot be met or are difficult to meet in the laboratory, the laboratory should prepare the calibration solutions in a contamination-free facility or have a vendor prepare the calibration standards and guarantee freedom from contamination.

4.7 Cleanup of tissue – The natural lipid content of tissue can interfere in the analysis of tissue samples for the CBs. The lipid contents of different species and portions of tissue can vary widely. Lipids are soluble to varying degrees in various organic solvents and may be present in sufficient quantity to overwhelm the column chromatographic cleanup procedures used for cleanup of sample extracts. Lipids must be removed by the anthropogenic isolation column procedure in Section 13.6, followed by the gel permeation chromatography procedure in Section 13.2. Florisil (Section 13.7) is recommended as an additional cleanup step.

4.8 If the laboratory air is a potential source of CB contamination, samples, reagents, glassware, and other materials should be dried in a glove box or other area free from contamination.

5.0 Safety

5.1 The toxicity or carcinogenicity of each chemical used in this Method has not been precisely determined; however, each compound should be treated as a potential health hazard. Exposure to these compounds should be reduced to the lowest possible level.

5.1.1 PCBs have been tentatively classified as known or suspected human or mammalian carcinogens. On the basis of the available toxicological and physical properties of the CBs, pure standards should be handled only by highly trained personnel thoroughly familiar with handling and cautionary procedures and the associated risks.

5.1.2 It is recommended that the laboratory purchase dilute standard solutions of the analytes in this Method. However, if primary solutions are prepared, they must be prepared in a hood, and a NIOSH/MESA approved toxic gas respirator must be worn when high concentrations are handled.

5.2 The laboratory is responsible for maintaining a current awareness file of OSHA regulations regarding the safe handling of the chemicals specified in this Method. A reference file of material safety data sheets (MSDSs) should also be made available to all personnel involved in these analyses. It is also suggested that the laboratory perform personal hygiene monitoring of each analyst who uses this Method and that the results of this monitoring be made available to the analyst. Additional information on laboratory safety can be found in References 5-8. The references and bibliography at the end of Reference 7 are particularly comprehensive in dealing with the general subject of laboratory safety.

5.3 The pure CBs and samples suspected to contain these compounds are handled using essentially the same techniques employed in handling radioactive or infectious materials. Well-ventilated, controlled access laboratories are required. Assistance in evaluating the health hazards of particular laboratory conditions may be obtained from certain consulting laboratories and from State Departments of Health or Labor, many of which have an industrial health service. Each laboratory must develop a strict safety program for handling these compounds. The practices in Reference 9 for handling chlorinated dibenzo-*p*-dioxins and dibenzofurans (CDDs/CDFs) are also recommended for handling the CBs.

5.3.1 Facility – When finely divided samples (dusts, soils, dry chemicals) are handled, all operations (including removal of samples from sample containers, weighing, transferring, and mixing) should be performed in a glove box demonstrated to be leak tight or in a fume hood demonstrated to have adequate air flow. Gross losses to the laboratory ventilation system must not be allowed. Handling of the dilute solutions normally used in analytical and animal work presents no inhalation hazards except in the case of an accident.

5.3.2 Protective equipment – Disposable plastic gloves, apron or lab coat, safety glasses or mask, and a glove box or fume hood adequate for radioactive work should be used. During analytical operations that may give rise to aerosols or dusts, personnel should wear respirators equipped with activated carbon filters. Eye protection (preferably full face shields) must be worn while working with exposed samples or pure analytical standards. Latex gloves are commonly used to reduce exposure of the hands. When handling samples suspected or known to contain high concentrations of the CBs, an additional set of gloves can also be worn beneath the latex gloves.

5.3.3 Training – Workers must be trained in the proper method of removing contaminated gloves and clothing without contacting the exterior surfaces.

5.3.4 Personal hygiene – Hands and forearms should be washed thoroughly after each manipulation and before breaks (coffee, lunch, and shift).

5.3.5 Confinement – Isolated work areas posted with signs, segregated glassware and tools, and plastic absorbent paper on bench tops will aid in confining contamination.

5.3.6 Effluent vapors – The effluent of the sample splitter from the gas chromatograph (GC) and from roughing pumps on the mass spectrometer (MS) should pass through either a column of activated charcoal or be bubbled through a trap containing oil or high-boiling alcohols to condense CB vapors.

5.3.7 Waste Handling – Good technique includes minimizing contaminated waste. Plastic bag liners should be used in waste cans. Janitors and other personnel should be trained in the safe handling of waste.

5.3.8 Decontamination

5.3.8.1 Decontamination of personnel – Use any mild soap with plenty of scrubbing action.

5.3.8.2 Glassware, tools, and surfaces – Chlorothene NU Solvent is a less toxic solvent that should be effective in removing CBs. Satisfactory cleaning may be accomplished by rinsing with Chlorothene, then washing with any detergent and water. If glassware is first rinsed with solvent, the wash water may be disposed of in the sewer. Given the cost of disposal, it is prudent to minimize solvent wastes.

5.3.9 Laundry – Clothing known to be contaminated should be collected in plastic bags. Persons that convey the bags and launder the clothing should be advised of the hazard and trained in proper handling. The clothing may be put into a washer without contact if the launderer knows of the potential problem. The washer should be run through a cycle before being used again for other clothing.

5.3.10 Wipe tests – A useful method of determining cleanliness of work surfaces and tools is to perform a wipe test of the surface suspected of being contaminated.

5.3.10.1 Using a piece of filter paper moistened with Chlorothene or other solvent, wipe an area approximately 10 x 10 cm.

5.3.10.2 Extract and analyze the wipe by GC with an electron capture detector (ECD) or by this Method.

5.3.10.3 Using the area wiped (e.g., 10 x 10 cm = 0.01 m^2), calculate the concentration in µg/m2. A concentration less than 1 µg/m2 indicates acceptable cleanliness; anything higher warrants further cleaning. More than 100 µg/m^2 constitutes an acute hazard and requires prompt cleaning before further use of the equipment or work space, and indicates that unacceptable work practices have been employed.

5.4 Biosolids samples may contain high concentrations of biohazards, and must be handled with gloves and opened in a hood or biological safety cabinet to prevent exposure. Laboratory staff should know and observe the safety procedures required in a microbiology laboratory that handles pathogenic organisms when handling biosolids samples.

6.0 Apparatus and materials

Note: *Brand names, suppliers, and part numbers are for illustration purposes only and no endorsement is implied. Equivalent performance may be achieved using apparatus and materials other than those specified here. Meeting the performance requirements of this Method is the responsibility of the laboratory.*

6.1 Sampling equipment for discrete or composite sampling

6.1.1 Sample bottles and caps

6.1.1.1 Liquid samples (waters, sludges and similar materials containing 5 percent solids or less) – Sample bottle, amber glass, 1.1-L minimum, with screw cap.

6.1.1.2 Solid samples (soils, sediments, sludges, paper pulps, filter cake, compost, and similar materials that contain more than 5 percent solids) – Sample bottle, wide mouth, amber glass, 500-mL minimum.

6.1.1.3 If amber bottles are not available, samples must be protected from light.

6.1.1.4 Bottle caps – Threaded to fit sample bottles. Caps must be lined with fluoropolymer.

6.1.1.5 Cleaning

6.1.1.5.1 Bottles are detergent water washed, then solvent rinsed before use.

6.1.1.5.2 Liners are detergent water washed and rinsed with reagent water (Section 7.6.1).

6.1.2 Compositing equipment – Automatic or manual compositing system incorporating glass containers cleaned per bottle cleaning procedure above. Only glass or fluoropolymer tubing must be used. If the sampler uses a peristaltic pump, a minimum length of compressible silicone rubber tubing may be used in the pump only. Before use, the tubing must be thoroughly rinsed with methanol, followed by repeated rinsing with reagent water to minimize sample contamination. An integrating flow meter is used to collect proportional composite samples.

6.2 Equipment for glassware cleaning

Note: *If blanks from bottles or other glassware or with fewer cleaning steps than required above show no detectable CB contamination, unnecessary cleaning steps and equipment may be eliminated.*

6.2.1 Laboratory sink with overhead fume hood

6.2.2 Kiln – Capable of reaching 450 ºC within 2 hours and maintaining 450 - 500 ºC within ±10 ºC, with temperature controller and safety switch (Cress Manufacturing Co., Santa Fe Springs, CA, B31H, X31TS, or equivalent). See the precautions in Section 4.2.3.

6.3 Equipment for sample preparation

6.3.1 Laboratory fume hood of sufficient size to contain the sample preparation equipment listed below.

6.3.2 Glove box (optional)

6.3.3 Tissue homogenizer – VirTis Model 45 Macro homogenizer (American Scientific Products H-3515, or equivalent) with stainless steel Macro-shaft and Turbo-shear blade.

6.3.4 Meat grinder – Hobart, or equivalent, with 3- to 5-mm holes in inner plate.

6.3.5 Equipment for determining percent moisture

6.3.5.1 Oven – Capable of maintaining a temperature of 110 ±5 ºC

6.3.5.2 Desiccator

6.3.6 Balances

6.3.6.1 Analytical – Capable of weighing 0.1 mg

6.3.6.2 Top loading – Capable of weighing 10 mg

6.4 Extraction apparatus

6.4.1 Water samples

6.4.1.1 pH meter, with combination glass electrode

6.4.1.2 pH paper, wide range (Hydrion Papers, or equivalent)

6.4.1.3 Graduated cylinder, 1-L capacity

6.4.1.4 Liquid/liquid extraction – Separatory funnels, 250-, 500-, and 2000-mL, with fluoropolymer stopcocks

6.4.1.5 Solid-phase extraction

6.4.1.5.1 1-L filtration apparatus, including glass funnel, frit support, clamp, adapter, stopper, filtration flask, and vacuum tubing (Figure 4). For wastewater samples, the apparatus should accept 90 or 144 mm disks. For drinking water or other samples containing low solids, smaller disks may be used.

6.4.1.5.2 Vacuum source – Capable of maintaining 25 in. Hg, equipped with shutoff valve and vacuum gauge

6.4.1.5.3 Glass-fiber filter – Whatman GMF 150 (or equivalent), 1 micron pore size, to fit filtration apparatus in Section 6.4.1.5.1

6.4.1.5.4 Solid-phase extraction disk containing octadecyl (C_{18}) bonded silica uniformly enmeshed in an inert matrix – Fisher Scientific 14-378F (or equivalent), to fit filtration apparatus in Section 6.4.1.5.1

6.4.1.6 Continuous liquid/liquid extraction (CLLE) – Fluoropolymer or glass connecting joints and stopcocks without lubrication, 1.5-2 L capacity (Hershberg-Wolf Extractor, Cal-Glass, Costa Mesa, California, 1000 mL or 2000 mL, or equivalent).

6.4.2 Soxhlet/Dean-Stark (SDS) extractor (Figure 5 and Reference 10) for filters and solid/sludge samples

6.4.2.1 Soxhlet – 50-mm ID, 200-mL capacity with 500-mL flask (Cal-Glass LG-6900, or equivalent, except substitute 500-mL round-bottom flask for 300-mL flat-bottom flask)

6.4.2.2 Thimble – 43 × 123 to fit Soxhlet (Cal-Glass LG-6901-122, or equivalent)

6.4.2.3 Moisture trap – Dean Stark or Barret with fluoropolymer stopcock, to fit Soxhlet

6.4.2.4 Heating mantle – Hemispherical, to fit 500-mL round-bottom flask (Cal-Glass LG-8801-112, or equivalent)

6.4.2.5 Variable transformer – Powerstat (or equivalent), 110-volt, 10-amp

6.4.3 Beakers – 400- to 500-mL

6.4.4 Spatulas – Stainless steel

6.5 Filtration apparatus

6.5.1 Pyrex glass wool – Solvent-extracted using a Soxhlet or SDS extractor for 3 hours minimum

6.5.2 Glass funnel – 125- to 250-mL

6.5.3 Glass-fiber filter paper – Whatman GF/D (or equivalent), to fit glass funnel in Section 6.5.2.

6.5.4 Drying column – 15- to 20-mm ID Pyrex chromatographic column equipped with coarse-glass frit or glass-wool plug

6.5.5 Buchner funnel – 15-cm

6.5.6 Glass-fiber filter paper for Buchner funnel above

6.5.7 Filtration flasks – 1.5- to 2.0-L, with side arm

6.5.8 Pressure filtration apparatus – Millipore YT30 142 HW, or equivalent

6.6 Centrifuge apparatus

6.6.1 Centrifuge – Capable of rotating 500-mL centrifuge bottles or 15-mL centrifuge tubes at 5,000 rpm minimum

6.6.2 Centrifuge bottles – 500-mL, with screw-caps, to fit centrifuge

6.6.3 Centrifuge tubes – 12- to 15-mL, with screw-caps, to fit centrifuge

6.7 Cleanup apparatus

6.7.1 Automated gel permeation chromatograph (Analytical Biochemical Labs, Inc, Columbia, MO, Model GPC Autoprep 1002, or equivalent)

6.7.1.1 Column – 600-700 mm long × 25 mm ID glass, packed with 70 g of 200-400 mesh SX-3 Bio-beads (Bio-Rad Laboratories, Richmond, CA, or equivalent)

6.7.1.2 Syringe – 10-mL, with Luer fitting

6.7.1.3 Syringe filter holder – stainless steel, and glass-fiber or fluoropolymer filters (Gelman 4310, or equivalent)

6.7.1.4 UV detectors – 254-nm, preparative or semi-preparative flow cell (Isco, Inc., Type 6; Schmadzu, 5-mm path length; Beckman-Altex 152W, 8-µL micro-prep flow cell, 2-mm path; Pharmacia UV-1, 3-mm flow cell; LDC Milton-Roy UV-3, monitor #1203; or equivalent).

6.7.2 Reverse-phase high-performance liquid chromatograph (Reference 4)

6.7.2.1 Pump – Perkin-Elmer Series 410, or equivalent

6.7.2.2 Injector – Perkin-Elmer ISS-100 Autosampler, or equivalent

6.7.2.3 6-Port switching valve – Valco N60, or equivalent

6.7.2.4 Column – Hypercarb, 100 x 4.6 mm, 5 µm particle size, Keystone Scientific, or equivalent

6.7.2.5 Detector – Altex 110A (or equivalent) operated at 0.02 AUFS at 235 nm

6.7.2.6 Fraction collector – Isco Foxy II, or equivalent

6.7.3 Pipets

6.7.3.1 Disposable, Pasteur, 150-mm long x 5-mm ID (Fisher Scientific 13-678-6A, or equivalent)

6.7.3.2 Disposable, serological, 50-mL (8- to 10- mm ID)

6.7.4 Glass chromatographic columns

6.7.4.1 150-mm long x 8-mm ID, (Kontes K-420155, or equivalent) with coarse-glass frit or glass-wool plug and 250-mL reservoir

6.7.4.2 200-mm long x 15-mm ID, with coarse-glass frit or glass-wool plug and 250-mL reservoir

6.7.4.3 300-mm long x 22-mm ID, with coarse-glass frit, 300-mL reservoir, and glass or fluoropolymer stopcock

6.7.5 Oven – For baking and storage of adsorbents, capable of maintaining a constant temperature (± 5 ºC) in the range of 105-250 ºC

6.8 Concentration apparatus

6.8.1 Rotary evaporator – Buchi/Brinkman-American Scientific No. E5045-10 or equivalent, equipped with a variable temperature water bath

6.8.1.1 Vacuum source for rotary evaporator equipped with shutoff valve at the evaporator and vacuum gauge

6.8.1.2 A recirculating water pump and chiller are recommended, as use of tap water for cooling the evaporator wastes large volumes of water and can lead to inconsistent performance as water temperatures and pressures vary.

6.8.1.3 Round-bottom flask – 100-mL and 500-mL or larger, with ground-glass fitting compatible with the rotary evaporator

6.8.2 Kuderna-Danish (K-D) concentrator

6.8.2.1 Concentrator tube – 10-mL, graduated (Kontes K-570050-1025, or equivalent) with calibration verified. Ground-glass stopper (size 19/22 joint) is used to prevent evaporation of extracts.

6.8.2.2 Evaporation flask – 500-mL (Kontes K-570001-0500, or equivalent), attached to concentrator tube with springs (Kontes K-662750-0012 or equivalent)

6.8.2.3 Snyder column – Three-ball macro (Kontes K-503000-0232, or equivalent)

6.8.2.4 Boiling chips

6.8.2.4.1 Glass or silicon carbide – Approximately 10/40 mesh, extracted with methylene chloride and baked at 450 ºC for one hour minimum

6.8.2.4.2 Fluoropolymer (optional) – Extracted with methylene chloride

6.8.2.5 Water bath – Heated, with concentric ring cover, capable of maintaining a temperature within ± 2 ºC, installed in a fume hood

6.8.3 Nitrogen evaporation apparatus – Equipped with water bath controlled in the range of 30 - 60 ºC (N-Evap, Organomation Associates, Inc., South Berlin, MA, or equivalent), installed in a fume hood

6.8.4 Sample vials

6.8.4.1 Amber glass, 2- to 5-mL with fluoropolymer-lined screw-cap

6.8.4.2 Glass, 0.3-mL, conical, with fluoropolymer-lined screw or crimp cap

6.9 Gas chromatograph – Must have splitless or on-column injection port for capillary column, temperature program with isothermal hold, and must meet all of the performance specifications in Section 10.

6.9.1 GC column – Any GC column or column system (2 or more columns) that provides unique resolution and identification of the Toxics for determination of a TEQ_{PCB} using TEFs (Reference 1). Isomers may be unresolved so long as they have the same TEF and response factor and so long as these unresolved isomers are uniquely resolved from all other congeners. For example, the SPB-octyl column (Section 6.9.1.3) achieves unique GC resolution of all Toxics except congeners with congener numbers 156 and 157. This isomeric pair is uniquely resolved from all other congeners and these congeners have the same TEF and response factor.

6.9.1.1 If an SPB-octyl column is used, it must meet the specification in Section 6.9.1 and the following additional specifications:

6.9.1.1.1 The retention time for decachlorobiphenyl (DeCB; PCB 209) must be greater than 55 minutes.

6.9.1.1.2 The column must uniquely resolve congeners 34 from 23 and 187 from 182, and congeners 156 and 157 must co-elute within 2 seconds at the peak maximum. Unique resolution means a valley height less than 40 percent of the shorter of the two peaks that result when the Diluted combined 209 congener solution (Section 7.10.2.2) is analyzed (see Figures 6 and 7).

6.9.1.1.3 The column must be replaced when any of the criteria in Sections 6.9.1 - 6.9.1.1.2 are not met.

6.9.1.2 If a column or column system alternate to the SPB-octyl column is used, specifications similar to those for the SPB-octyl column (Sections 6.9.1 -

6.9.1.1.2) must be developed and be functionally equivalent to those specifications.

6.9.1.3 Suggested column – 30 ± 5-m long x 0.25 ± 0.02-mm ID; 0.25-µm film SPB-octyl (Supelco 2-4218, or equivalent). This column is capable of meeting the requirements in Sections 6.9.1 - 6.9.1.1.2.

Note: *The SPB-octyl column is subject to rapid degradation when exposed to oxygen. The analyst should exclude oxygen from the carrier gas, should eliminate air leaks, and should cool the injector, column, and transfer line before opening the column to the atmosphere. For further information on precluding oxidation, contact the column manufacturer.*

6.9.1.4 Column for resolution of additional congeners – See Appendix A for details on the DB-1 column. The DB-1 column is optional and is capable of uniquely resolving the congener pair with congener numbers 156 and 157. When used in combination with the SPB-octyl column (Section 6.9.1.3), the two-column system is capable of resolving a total of approximately 180 CB congeners.

6.10 Mass spectrometer – 28- to 40-eV electron impact ionization, must be capable of selectively monitoring a minimum of 22 exact m/z's minimum at high resolution (≥10,000) during a period less than 1.5 seconds, and must meet all of the performance specifications in Section 10.

6.11 GC/MS interface – The mass spectrometer (MS) must be interfaced to the GC such that the end of the capillary column terminates within 1 cm of the ion source but does not intercept the electron or ion beams.

6.12 Data system – Capable of collecting, recording, storing, and processing MS data

6.12.1 Data acquisition – The signal at each exact m/z must be collected repetitively throughout the monitoring period and stored on a mass storage device.

6.12.2 Response factors and multipoint calibrations – The data system must record and maintain lists of response factors (response ratios for isotope dilution) and multipoint calibrations. Computations of relative standard deviation (RSD) are be used to test calibration linearity. Statistics on initial (Section 9.4) and ongoing (Section 15.5.4) performance should be computed and maintained, either on the instrument data system, or on a separate computer system.

7.0 Reagents and standards

7.1 pH adjustment and back-extraction

7.1.1 Potassium hydroxide – Dissolve 20 g reagent grade KOH in 100 mL reagent water.

7.1.2 Sulfuric acid – Reagent grade (specific gravity 1.84)

7.1.3 Hydrochloric acid – Reagent grade, 6N

7.1.4 Sodium chloride – Reagent grade, prepare at 5% (w/v) solution in reagent water

7.2 Solution drying and evaporation

7.2.1 Solution drying – Sodium sulfate, reagent grade, granular, anhydrous (Baker 3375, or equivalent), rinsed with methylene chloride (20 mL/g), baked at 400 ºC for 1 hour minimum, cooled in a desiccator, and stored in a pre-cleaned glass bottle with screw-cap that prevents moisture from entering. If, after heating, the sodium sulfate develops a noticeable grayish cast (due to the presence of carbon in the crystal matrix), that batch of reagent is not suitable for use and should be discarded. Extraction with methylene chloride (as opposed to simple rinsing) and baking at a lower temperature may produce sodium sulfate that is suitable for use.

7.2.2 Tissue drying – Sodium sulfate, reagent grade, powdered, treated and stored as in Section 7.2.1

7.2.3 Prepurified nitrogen

7.3 Extraction

7.3.1 Solvents – Acetone, toluene, cyclohexane, hexane, methanol, methylene chloride, isooctane, and nonane; distilled in glass, pesticide quality, lot-certified to be free of interferences

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Note: *Some solvents; e.g., isooctane and nonane, may need to be re-distilled to eliminate CB backgrounds.*

7.3.2 White quartz sand, 60/70 mesh – For Soxhlet/Dean-Stark extraction (Aldrich Chemical, Cat. No. 27-437-9, or equivalent). Bake at 450 ºC for 4 hour minimum.

7.4 GPC calibration solution – Prepare a solution containing 2.5 mg/mL corn oil, 0.05 mg/mL bis(2-ethylhexyl) phthalate (BEHP), 0.01 mg/mL methoxychlor, 0.002 mg/mL perylene, and 0.008 mg/mL sulfur, or at concentrations appropriate to the response of the detector.

7.5 Adsorbents for sample cleanup

7.5.1 Silica gel

7.5.1.1 Activated silica gel – 100-200 mesh, Supelco 1-3651 (or equivalent), 100-200 mesh, rinsed with methylene chloride, baked at 180 ºC for a minimum of 1 hour, cooled in a desiccator, and stored in a precleaned glass bottle with screw-cap that prevents moisture from entering.

7.5.1.2 Acid silica gel (30% w/w) – Thoroughly mix 44 g of concentrated sulfuric acid with 100 g of activated silica gel in a clean container. Break up aggregates with a stirring rod until a uniform mixture is obtained. Store in a screw-capped bottle with fluoropolymer-lined cap.

7.5.1.3 Basic silica gel – Thoroughly mix 30 g of 1N sodium hydroxide with 100 g of activated silica gel in a clean container. Break up aggregates with a stirring rod until a uniform mixture is obtained. Store in a screw-capped bottle with fluoropolymer-lined cap.

7.5.1.4 Potassium silicate

7.5.1.4.1 Dissolve 56 g of high purity potassium hydroxide (Aldrich, or equivalent) in 300 mL of methanol in a 750- to 1000-mL flat-bottom flask.

7.5.1.4.2 Add 100 g of activated silica gel (Section 7.5.1.1) and a stirring bar, and stir on an explosion-proof hot plate at 60-70 ºC for 1-2 hours.

7.5.1.4.3 Decant the liquid and rinse the potassium silicate twice with 100-mL portions of methanol, followed by a single rinse with 100 mL of methylene chloride.

7.5.1.4.4 Spread the potassium silicate on solvent-rinsed aluminum foil and dry for 2-4 hours in a hood. Observe the precaution in Section 4.8.

7.5.1.4.5 Activate overnight at 200-250 ºC prior to use.

7.5.2 Carbon

7.5.2.1 Carbopak C – (Supelco 1-0258, or equivalent)

7.5.2.2 Celite 545 – (Supelco 2-0199, or equivalent)

7.5.2.3 Thoroughly mix 18.0 g Carbopak C and 18.0 g Celite 545 to produce a 50% w/w mixture. Activate the mixture at 130 ºC for a minimum of 6 hours. Store in a desiccator.

Note: *The carbon column has been included in this Method to allow separation of co-planar congeners 77, 126, and 169 from other congeners and interferences, should such separation be desired.*

7.5.3 Anthropogenic isolation column – Pack the column in Section 6.7.4.3 from bottom to top with the following:

7.5.3.1 2 g silica gel (Section 7.5.1.1)

7.5.3.2 2 g potassium silicate (Section 7.5.1.4)

7.5.3.3 2 g granular anhydrous sodium sulfate (Section 7.2.1)

7.5.3.4 10 g acid silica gel (Section 7.5.1.2)

7.5.3.5 2 g granular anhydrous sodium sulfate

7.5.4 Florisil column

7.5.4.1 Florisil – PR grade, 60-100 mesh (U.S. Silica Corp, Berkeley Springs, WV, or equivalent). Alternatively, prepacked Florisil columns may be used. Use the following procedure for Florisil activation and column packing.

7.5.4.1.1 Fill a clean 1- to 2-L bottle ½ to 2/3 full with Florisil and place in an oven at 130-150 ºC for a minimum of three days to activate the Florisil.

7.5.4.1.2 Immediately prior to use, dry pack a 300-mm x 22-mm ID glass column (Section 6.7.4.3) bottom to top with 0.5-1.0 cm of warm to hot anhydrous sodium sulfate (Section 7.2.1), 10-10.5 cm of warm to hot activated Florisil (Section 7.5.4.1.1), and 1-2 cm of warm to hot anhydrous sodium sulfate. Allow the column to cool and wet immediately with 100 mL of n-hexane to prevent water from entering.

7.5.4.2 Using the procedure in Section 13.7.3, establish the elution pattern for each carton of Florisil or each lot of Florisil columns received.

7.6 Reference matrices – Matrices in which the CBs and interfering compounds are not detected by this Method

7.6.1 Reagent water – Bottled water purchased locally, or prepared by passage through activated carbon

7.6.2 High-solids reference matrix – Playground sand or similar material. Prepared by extraction with methylene chloride and/or baking at 450 ºC for a minimum of 4 hours.

7.6.3 Paper reference matrix – Glass-fiber filter, Gelman type A, or equivalent. Cut paper to simulate the surface area of the paper sample being tested.

7.6.4 Tissue reference matrix – Corn or other vegetable oil.

7.6.5 Other matrices – This Method may be verified on any reference matrix by performing the tests in Section 9.2. Ideally, the matrix should be free of the CBs, but in no case must the background level of the CBs in the reference matrix exceed the minimum levels in Table 2. If low background levels of the CBs are present in the reference matrix, the spike level of the analytes used in Section 9.2 should be increased to provide a spike-to-background ratio of approximately 5 (Reference 11).

7.7 Standard solutions – Prepare from materials of known purity and composition or purchase as solutions or mixtures with certification to their purity, concentration, and authenticity. If the chemical purity is 98 % or greater, the weight may be used without correction to calculate the concentration of the standard. Observe the safety precautions in Section 5 and the recommendation in Section 5.1.2.

Note: *Native PCB standards are available from several suppliers.* $^{13}C_{12}$*-labeled congeners are available from Cambridge Isotope Laboratories and Wellington Laboratories, and may be available from other suppliers. Listing of these suppliers does not constitute a recommendation or endorsement for use. Part numbers are for reference only.*

7.7.1 For preparation of stock solutions from neat materials, dissolve an appropriate amount of assayed reference material in solvent. For example, weigh 10 to 20 mg of PCB 126 to three significant figures in a 10-mL ground-glass-stoppered volumetric flask and fill to the mark with nonane. After the compound is completely dissolved, transfer the solution to a clean 15-mL vial with fluoropolymer-lined cap.

7.7.2 When not being used, store standard solutions in the dark at room temperature in screw-capped vials with fluoropolymer-lined caps. Place a mark on the vial at the level of the solution so that solvent loss by evaporation can be detected. Replace the solution if solvent loss has occurred.

7.8 Native (unlabeled) stock solutions

Note: *Some of the part numbers for solutions described below contain the identifier "1668A." These part numbers remain valid for Method 1668C.*

7.8.1 Native Toxics/LOC stock solution – Prepare to contain the native Toxics and LOC CBs at the concentrations shown in Table 3, or purchase Accu-Standard M1668A-C-NT-LOC-WD-GCPC, or equivalent. If additional CBs are to be determined by isotope dilution (e.g., 170 and 180), include the additional native compounds in this stock solution.

7.8.2 Native 209 CB congener stock solutions – Solutions containing CB congeners to calibrate the SPB-octyl column.

Note: *If a column other than the SPB-octyl column is used, solutions that will allow separation of all 209 congeners on that column must be prepared.*

7.8.2.1 Native congener mix stock solutions for separation of individual congeners on the SPB-octyl column – Prepare the five solutions with the congeners listed in Table 4 at the concentrations shown in Table 3 or purchase Accu-Standard M-1668A-1, M-1668A-2, M-1668A-3, M-1668-4, and M-1668-5, or equivalent.

7.8.2.2 Combined 209 congener stock solution – Combine equal volumes of the standards in Section 7.8.2.1 to form a stock solution containing all CB congeners. This solution will be at 1/5 the concentration of the 5 individual solutions.

7.8.3 Stock solutions should be checked for signs of degradation prior to preparation of calibration or performance test standards. Reference standards that can be used to determine the accuracy of standard solutions are available from several vendors.

7.9 Labeled compound stock solutions (Table 3)

7.9.1 Labeled Toxics/LOC/window-defining stock solution – Prepare in isooctane or nonane at the concentrations in Table 3 or purchase Cambridge Isotope Laboratories (CIL) EC-4977, or equivalent. If additional CBs are to be determined by isotope dilution (e.g., 170 and 180), include the additional labeled compounds in this stock solution.

7.9.2 Labeled cleanup standard stock solution – Prepare labeled CBs 28, 111, and 178 in iso-octane or nonane at the concentration shown in Table 3 or purchase CIL EC-4978, or equivalent.

7.9.3 Labeled injection internal standard stock solution – Prepare labeled CBs 9, 52, 101, 138, and 194 in nonane or isooctane at the concentrations shown in Table 3, or purchase CIL EC-4979, or equivalent.

7.10 Calibration standards

7.10.1 Calibration standards – Combine and dilute the solutions in Sections 7.8.1 and 7.9 to produce the calibration solutions in Table 5 or purchase CIL EC-4976, or equivalent, for the CS-1 to CS-5 set of calibration solutions. If a 6-point calibration is used, prepare the CS-0.2 solution or purchase CIL EC-4976-0.2, or equivalent. These solutions permit the relative response (labeled to native) and response factor to be measured as a function of concentration. The CS-3 standard (CIL EC-4976-3, or equivalent) is used for calibration verification (VER).

7.10.2 Solutions of congener mixes

7.10.2.1 Diluted individual solutions

7.10.2.1.1 The 5 individual solutions, when analyzed individually, allow resolution of all 209 congeners on the SPB-octyl column, and are used for establishing retention time and other data for each congener. The elution order of the congeners present in each of the 5 solutions (Section 7.8.2.1) is given in Table 4.

7.10.2.1.2 Individually combine an aliquot of each individual mix stock solution (Section 7.8.2.1) with an aliquot of the Labeled Toxics/LOC/window-defining stock solution (Section 7.9.1), the Labeled cleanup standard stock solution (Section 7.9.2), and the Labeled injection internal standard stock solution (7.9.3) to produce concentrations of 100 ng/mL for the labeled compounds and 25, 50, and 75 ng/mL for the MoCB-TrCB, TeCB-HpCB, and OcCB-DeCB congeners, respectively, as shown in Table 3.

7.10.2.2 Diluted combined 209 congener solution

7.10.2.2.1 This solution combines the 5 individual mixes with the labeled compounds to allow single-point calibration of the congeners not included in the multi-point calibration, and establishes an average response factor for the co-eluting isomeric congeners.

7.10.2.2.2 Combine an aliquot of the combined 209 congener solution (Section 7.8.2.2) with an aliquot of the Labeled Toxics/LOC/window-defining stock solution (Section 7.9.1), the Labeled cleanup standard stock solution (Section 7.9.2), and the Labeled injection internal standard stock solution (7.9.3) to produce the same concentrations as in the diluted individual mix solutions (Section 7.10.2.1.2 and Table 3).

7.11 Native Toxics/LOC standard spiking solution – Used for determining initial precision and recovery (IPR; Section 9.2) and ongoing precision and recovery (OPR; Section 15.5). Dilute the Native Toxics/LOC stock solution (Section 7.8.1) with acetone to produce a concentration of the Toxics at 1 ng/mL, as shown in Table 3. When 1 mL of this solution spiked into the IPR (Section 9.2.1) or OPR (Section 15.5) and concentrated to a final volume of 20 µL, the concentration in the final volume will be 50 ng/mL (50 pg/µL). Prepare only the amount necessary for each reference matrix with each sample batch.

7.12 Labeled Toxics/LOC/window-defining standard spiking solution – This solution is spiked into each sample (Section 9.3) and into the IPR (Section 9.2.1), OPR (Section 15.5), and blank (Section 9.5) to measure recovery. Dilute the Labeled Toxics/LOC/window-defining stock solution (Section 7.9.1) with acetone to produce a concentration of the labeled compounds at 2 ng/mL, as shown in Table 3. When 1 mL of this solution is spiked into an IPR, OPR, blank, or sample and concentrated to a final extract volume of 20 µL, the concentration in the final extract volume will be 100 ng/mL (100 pg/µL). Prepare only the amount necessary for each reference matrix with each sample batch.

7.13 Labeled cleanup standard spiking solution – This solution is spiked into each extract prior to cleanup to measure the efficiency of the cleanup process. Dilute the Labeled cleanup standard stock solution (Section 7.9.2) in methylene chloride to produce a concentration of the cleanup standards at 2 ng/mL, as shown in Table 3. When 1 mL of this solution is spiked into a sample extract and concentrated to a final volume of 20 µL, the concentration in the final volume will be 100 ng/mL (100 pg/µL).

7.14 Labeled injection internal standard spiking solution – This solution is added to each concentrated extract prior to injection into the HRGC/HRMS. Dilute the Labeled injection internal standard stock solution (Section 7.9.3) in nonane to produce a concentration of the injection internal standards at 1000 ng/mL, as shown in Table 3. When 2 µL of this solution is spiked into a 20 µL extract, the concentration of each injection internal standard will be nominally 100 ng/mL (100 pg/µL).

Note: *The addition of 2 µL of the Labeled injection internal standard spiking solution to a 20-µL final extract has the effect of diluting the concentration of the components in the extract by 10%. Provided all calibration solutions and all extracts undergo this dilution as a result of adding the Labeled injection internal standard spiking solution, the effect of the 10% solution is compensated, and correction for this dilution should not be made.*

7.15 QC Check Sample – A QC Check Sample should be obtained from a source independent of the calibration standards. Ideally, this check sample would be a certified Standard Reference Material (SRM) containing the CBs in known concentrations in a sample matrix similar to the matrix under test. The National Institute of Standards and Technology (NIST) in Gaithersburg, Maryland has SRMs, and the Institute for National Measurement Standards of the National Research Council of Canada in Ottawa has certified reference materials (CRMs) for CBs in various matrices.

7.16 Stability of solutions – Standard solutions used for quantitative purposes (Sections 7.9 through 7.14) should be assayed periodically (e.g., every 6 months) against SRMs from NIST (if available), or certified reference materials from a source that will attest to the authenticity and concentration, to assure that the composition and concentrations have not changed.

8.0 Sample collection, preservation, storage, and holding times

8.1 Collect samples in amber glass containers following conventional sampling practices (Reference 12). Other sample collection techniques, or sample volumes may be used, if documented.

8.2 Aqueous samples

8.2.1 Samples that flow freely are collected as grab samples or in refrigerated bottles using automatic sampling equipment. Collect one liter (or a larger or smaller volume) of sample sufficient to meet project needs.

8.2.2 If residual chlorine is present, add 80 mg sodium thiosulfate per liter of water. EPA Methods 330.4 and 330.5 may be used to measure residual chlorine (Reference 13).

8.2.3 Maintain aqueous samples in the dark at less than 6 ºC from the time of collection until receipt at the laboratory. If the sample will be frozen, allow room for expansion. Store in the dark at less than 6 ºC.

8.3 Solid, mixed-phase, semi-solid, and oily samples, excluding tissue.

8.3.1 Collect samples as grab samples using wide-mouth jars.

8.3.2 Maintain solid, semi-solid, oily, and mixed-phase samples in the dark at less than 6 ºC from the time of collection until receipt at the laboratory. Store solid, semi-solid, oily, and mixed-phase samples in the dark at less than -10 ºC.

8.4 Fish and other tissue samples

8.4.1 Fish may be cleaned, filleted, or processed in other ways in the field, such that the laboratory may expect to receive whole fish, fish fillets, or other tissues for analysis.

8.4.2 Collect fish, wrap in aluminum foil, and maintain at less than 6 ºC from the time of collection until receipt at the laboratory, to a maximum time of 24 hours. If a longer transport time is necessary, freeze the sample. Ideally, fish should be frozen upon collection and shipped to the laboratory on dry ice.

8.4.3 Freeze tissue samples upon receipt at the laboratory and maintain them in the dark at less than -10 ºC until prepared. Maintain unused sample in the dark at less than -10 ºC.

8.5 Holding times

8.5.1 There are no demonstrated maximum holding times associated with the CBs in aqueous, solid, semi-solid, tissue, or other sample matrices. If stored in the dark at less than 6 ºC, aqueous samples may be stored for up to one year. Similarly, if stored in the dark at less than -10 ºC, solid, semi-solid, multi-phase, and tissue samples may be stored for up to one year.

8.5.2 Store sample extracts in the dark at less than -10 ºC until analyzed. If stored in the dark at less than -10 ºC, sample extracts may be stored for one year.

9.0 Quality assurance/quality control

9.1 Each laboratory that uses this Method is required to operate a formal quality assurance program (Reference 14). The minimum requirements of this program consist of an initial demonstration of laboratory capability, analysis of samples spiked with labeled compounds to evaluate and document data quality, and analysis of standards and blanks as tests of continued performance. Laboratory performance is compared to established performance criteria to determine if the results of analyses meet the performance characteristics of the Method.

If the Method is to be applied to sample matrix other than water (e.g., soils, filter cake, compost, tissue) the most appropriate alternate reference matrix (Sections 7.6.2 - 7.6.5 and 7.15) is substituted for the reagent water matrix (Section 7.6.1) in all performance tests.

9.1.1 The laboratory must make an initial demonstration of the ability to generate acceptable precision and recovery with this Method. This demonstration is given in Section 9.2.

9.1.2 In recognition of advances that are occurring in analytical technology, and to overcome matrix interferences, the laboratory is permitted certain options to improve separations or lower the costs of measurements. These options include alternate extraction, concentration, and cleanup procedures, and changes in sample volumes, columns and detectors. Alternate determinative techniques, such as substitution of spectroscopic or immunoassay techniques for HRGC/HRMS technology, and changes that degrade Method performance, are not allowed without prior review and approval. If an analytical technique other than the techniques specified in this Method is used, that technique must have a specificity equal to or greater than the specificity of the techniques in this Method for the analytes of interest. (Note: For additional flexibility to make modifications without prior EPA review see 40 CFR Part 136.6.)

9.1.2.1 Each time a modification is made to this Method, the laboratory is required to repeat the procedure in Section 9.2. If MDLs would be affected by the change, the laboratory is required to demonstrate that the MDLs (40 CFR Part 136, Appendix B) are lower than one-third the regulatory compliance level or lower than five times the MDLs in this Method, whichever are greater. If calibration will be affected by the change, the instrument must be recalibrated per Section 10. Once the modification is demonstrated to produce results equivalent or superior to results produced by this Method as written, that modification may be used routinely thereafter, so long as the other requirements in this Method are met (e.g., labeled compound recovery).

9.1.2.2 The laboratory is required to maintain records of modifications made to this Method. These records include the following, at a minimum:

9.1.2.2.1 The names, titles, addresses, and telephone numbers of the analyst(s) that performed the analyses and modification, and of the quality control officer that witnessed and will verify the analyses and modifications.

9.1.2.2.2 A listing of pollutant(s) measured, by name and CAS Registry number.

9.1.2.2.3 A narrative stating reason(s) for the modifications (see Section 1.5).

9.1.2.2.4 Results from all quality control (QC) tests comparing the modified method to this Method, including:

a) Calibration (Section 10).
b) Calibration verification (Section 15.3).
c) Initial precision and recovery (Section 9.2).
d) Labeled compound recovery (Section 9.3).
e) Analysis of blanks (Section 9.5).
f) Accuracy assessment (Section 9.4).

9.1.2.2.5 Data that will allow an independent reviewer to validate each determination by tracing the instrument output (peak height, area, or other signal) to the final result. These data are to include:

a) Sample numbers and other identifiers.
b) Extraction dates.
c) Analysis dates and times.
d) Analysis sequence/run chronology.
e) Sample weight or volume (Section 11).
f) Extract volume prior to each cleanup step (Section 13).
g) Extract volume after each cleanup step (Section 13).
h) Final extract volume prior to injection (Section 14).
i) Injection volume (Section 14.3).
j) Dilution data, differentiating between dilution of a sample or extract (Section 17.5).
k) Instrument and operating conditions.
l) Column (dimensions, liquid phase, solid support, film thickness, etc).
m) Operating conditions (temperatures, temperature program, flow rates).
n) Detector (type, operating conditions, etc).
o) Chromatograms, printer tapes, and other recordings of raw data.
p) Quantitation reports, data system outputs, and other data to link the raw data to the results reported.

9.1.2.3 Alternate HRGC columns and column systems – See Sections 6.9.1. If a column or column system alternate to those specified in this Method is used, that column or column system must meet the requirements in Section 6.9.1 - 6.9.1.1.3.

9.1.3 Analyses of Method blanks are required to demonstrate freedom from contamination (Section 4.3). The procedures and criteria for analysis of a Method blank are described in Sections 9.5 and 15.6.

9.1.4 The laboratory must spike all samples with labeled compounds to monitor Method performance. This test is described in Section 9.3. When results of these spikes indicate atypical Method performance for samples, the samples are diluted to bring Method performance within acceptable limits. Procedures for dilution are given in Section 17.5.

9.1.5 The laboratory must, on an ongoing basis, demonstrate through calibration verification and the analysis of the ongoing precision and recovery standard (OPR) and blanks that the analytical system is in control. These procedures are given in Sections 15.1 through 15.6.

9.1.6 The laboratory should maintain records to define the quality of data generated. Development of accuracy statements is described in Section 9.4.

9.2 Initial precision and recovery (IPR) – To establish the ability to generate acceptable precision and recovery, the laboratory must perform the following operations.

9.2.1 For low solids (aqueous) samples, extract, concentrate, and analyze four 1-L aliquots of reagent water spiked with 1 mL each of the Native Toxics/LOC spiking solution (Section 7.11), the Labeled Toxics/LOC/window-defining standard spiking solution (Section 7.12), and the Labeled cleanup standard spiking solution (Section 7.13), according to the procedures in Sections 11 through 18. For an alternative sample matrix, four aliquots of the alternative reference matrix (Section 7.6) are used. All sample processing steps that are to be used for processing samples, including preparation (Section 11), extraction (Section 12), and cleanup (Section 13), must be included in this test.

9.2.2 Using results of the set of four analyses, compute the average percent recovery (X) of the extracts and the relative standard deviation (RSD) of the concentration for each compound, by isotope dilution for CBs with a labeled analog, and by internal standard for CBs without a labeled analog and for the labeled compounds.

9.2.3 For each CB and labeled compound, compare RSD and X with the corresponding limits for initial precision and recovery in Table 6. If RSD and X for all compounds meet the acceptance criteria, system performance is acceptable and analysis of blanks and samples may begin. If, however, any individual RSD exceeds the precision limit or any individual X falls outside the range for recovery, system performance is unacceptable for that compound. Correct the problem and repeat the test (Section 9.2).

9.3 To assess Method performance on the sample matrix, the laboratory must spike all samples with the Labeled Toxics/LOC/window-defining standard spiking solution (Section 7.12) and all sample extracts with the Labeled cleanup standard spiking solution (Section 7.13).

9.3.1 Analyze each sample according to the procedures in Sections 11 through 18.

9.3.2 Compute the percent recovery of the labeled Toxics/LOC/window-defining congeners and the labeled cleanup congeners using the internal standard method (Section 17.2).

9.3.3 The recovery of each labeled compound must be within the limits in Table 6. If the recovery of any compound falls outside of these limits, Method performance is unacceptable for that compound in that sample. Additional cleanup procedures must then be employed to attempt to bring the recovery within the normal range. If the recovery cannot be brought within the normal range after all cleanup procedures have been employed, water samples are diluted and smaller amounts of soils, sludges, sediments, and other matrices are analyzed per Section 18.

9.4 It is suggested, but not required, that recovery of labeled compounds from samples be assessed and records maintained.

9.4.1 After the analysis of 30 samples of a given matrix type (water, soil, sludge, pulp, etc.) for which the labeled compounds pass the tests in Section 9.3, compute the average percent recovery (R) and the standard deviation of the percent recovery (S_R) for the labeled compounds only. Express the assessment as a percent recovery interval from R - $2S_R$ to R + $2S_R$ for each matrix. For example, if R = 90% and S_R = 10% for five analyses of pulp, the recovery interval is expressed as 70 to 110%.

9.4.2 Update the accuracy assessment for each labeled compound in each matrix on a regular basis (e.g., after each five to ten new measurements).

9.5 Method blanks – A reference matrix Method blank is analyzed with each sample batch (Section 4.3) to demonstrate freedom from contamination. The matrix for the Method blank must be similar to the sample matrix for the batch, e.g., a 1-L reagent water blank (Section 7.6.1), high-solids reference matrix blank (Section 7.6.2), paper matrix blank (Section 7.6.3); tissue blank (Section 7.6.4), or alternative reference matrix blank (Section 7.6.5).

9.5.1 Spike 1.0 mL each of the Labeled Toxics/LOC/window-defining standard spiking solution (Section 7.12), and the Labeled cleanup standard spiking solution (Section 7.13) into the Method blank, according to the procedures in Sections 11 through 18. Prepare, extract, clean up, and concentrate the Method blank. Analyze the blank immediately after analysis of the OPR (Section 15.5) to demonstrate freedom from contamination.

9.5.2 If any CB (Table 1) is found in the blank at greater than two times the minimum level (Table 2) or one-third the regulatory compliance limit, whichever is greater; or if any potentially interfering compound is found in the blank at the minimum level for each CB given in Table 2 (assuming a response factor of 1 relative to the quantitation reference in Table 2 at that level of chlorination for a potentially interfering compound; i.e., a compound not listed in this Method), analysis of samples must be halted until the sample batch is re-extracted and the extracts re-analyzed, and the blank associated with the sample batch shows no evidence of contamination at these levels. All samples must be associated with an uncontaminated Method blank before the results for those samples may be reported or used for permitting or regulatory compliance purposes.

9.6 QC Check Sample – Analyze the QC Check Sample (Section 7.15) periodically to assure the accuracy of calibration standards and the overall reliability of the analytical process. It is suggested that the QC Check Sample be analyzed at least quarterly.

9.7 The specifications contained in this Method can be met if the apparatus used is calibrated properly and then maintained in a calibrated state. The standards used for calibration (Section 10), calibration verification (Section 15.3), and for initial (Section 9.2) and ongoing (Section 15.5) precision and recovery should be identical, so that the most precise results will be obtained. A GC/MS instrument will provide the most reproducible results if dedicated to the settings and conditions required for determination of CBs by this Method.

9.8 Depending on specific program requirements, field replicates may be collected to determine the precision of the sampling technique, and spiked samples may be required to determine the accuracy of the analysis when the internal standard method is used.

10.0 Calibration

10.1 Establish the operating conditions necessary to meet the retention times (RTs) and relative retention times (RRTs) for the CBs in Table 2.

Note: *RTs, RRTs, and RRT limits may differ slightly from those in Table 2.*

10.1.1 Suggested GC operating conditions:

Injector temperature:	270 ºC
Interface temperature:	290 ºC
Initial temperature:	75 ºC
Initial time:	2 minutes
Temperature program:	75-150 ºC at 15 ºC/minute 150-290 ºC at 2.5 ºC/minute
Final time:	1 minute

Note: *All portions of the column that connect the GC to the ion source should remain at or above the interface temperature specified above during analysis to preclude condensation of less volatile compounds.*

The GC conditions may be optimized for compound separation and sensitivity. Once optimized, the same GC conditions must be used for the analysis of all standards, blanks, IPR and OPR standards, and samples.

10.1.2 Retention time calibration for the CB congeners

10.1.2.1 Separately inject each of the diluted individual congener solutions (Section 7.10.2.1.2). Establish the beginning and ending retention times for the scan descriptors in Table 7. Scan descriptors other than those listed in Table 7 may be used provided the MLs in Table 2 are met. Store the retention time (RT) and relative retention time (RRT) for each congener in the data system.

10.1.2.2 The absolute retention time of CB 209 must exceed 55 minutes on the SPB-octyl column; otherwise, the GC temperature program must be adjusted and this test repeated until the minimum retention time criterion is met. If a GC column or column system alternate to the SPB-octyl column is used, a similar minimum retention time specification must be established for the alternate column or column systems so that interferences that may be encountered in environmental samples will be resolved from the analytes of interest. This specification is deemed to be met if the retention time of CB 209 is greater than 55 minutes on such alternate column.

10.1.2.3 Inject the Diluted combined 209 congener solution (Section 7.10.2.2). Adjust the chromatographic conditions and scan descriptors until the RT and RRT for all congeners are approximately within the windows in Table 2 and the column performance specifications in Sections 6.9.1 - 6.9.1.2 are met. If an alternate column is used, adjust the conditions for that column. If column performance is unacceptable, optimize the analysis conditions or replace the column and repeat the performance tests. Confirm that the scan descriptor changes at times when CBs do not elute.

10.1.2.4 After the column performance tests are passed (Section 10.1.2.2 - 10.1.2.3), calculate and store the RT and RRT for the resolved congeners and the RT and RRT for the isomeric congeners that co-elute. The windows in Table 2 were developed based on the GC conditions given in Section 10.1.1.

10.2 Mass spectrometer (MS) resolution

10.2.1 Using perfluorokerosene (PFK) (or other reference substance) and a molecular leak, tune the instrument to meet the minimum required resolving power of 10,000 (10% valley) at m/z 330.9792 or any other significant PFK fragment in the range of 300 to 350. For each descriptor (Table 7), monitor and record the resolution and exact m/z's of three to five reference peaks covering the mass range of the descriptor. The level of PFK (or other reference substance) metered into the HRMS during analyses should be adjusted so that the amplitude of the most intense selected lock-mass m/z signal (regardless of the descriptor number) does not exceed 10% of the full-scale deflection for a given set of detector parameters. Under those conditions, sensitivity changes that might occur during the analysis can be more effectively monitored.

Note: *Different lots and types of PFK can contain varying levels of contamination, and excessive PFK (or other reference substance) may cause noise problems and contamination of the ion source necessitating increased frequency of source cleaning. A minor PFK mass (223.9872) is known to interfere with dichlorobiphenyl secondary quantitation ion (M+2). Careful selection of the grade and purity of PFK and minimization of the amount of PFK bled into the HRMS has been shown to correct this problem.*

10.2.2 The analysis time for CBs may exceed the long-term mass stability of the mass spectrometer. Because the instrument is operated in the high-resolution mode, mass drifts of a few ppm (e.g., 5 ppm in mass) can have serious adverse effects on instrument performance. Therefore, mass-drift correction is mandatory and a lock-mass m/z from PFK or other reference substance is used for drift correction. The lock-mass m/z is dependent on the exact m/z's monitored within each descriptor, as shown in Table 7. The deviation between each monitored exact m/z and the theoretical m/z (Table 7) must be less than 5 ppm.

10.2.3 Obtain a selected ion current profile (SICP) at the two exact m/z's specified in Table 7 and at ≥10,000 resolving power at each LOC for the native congeners and congener groups and for the labeled congeners. Because of the extensive mass range covered in each function, it may not be possible to maintain 10,000 resolution throughout the mass range during the function. Therefore, resolution must be ≥8,000 throughout the mass range and must be ≥10,000 in the center of the mass range for each function.

10.2.4 If the HRMS has the capability to monitor resolution during the analysis, it is acceptable to terminate the analysis when the resolution falls below the minimum (Section 10.2.3) to save re-analysis time.

10.3 Ion abundance ratios, minimum levels, and signal-to-noise ratios. Choose an injection volume of either 1 or 2 µL, consistent with the capability of the HRGC/HRMS instrument. Inject a 1 or 2 µL aliquot of the CS-1 calibration solution (Table 5) using the GC conditions in Section 10.1.1.

10.3.1 Measure the SICP areas for each congener or congener group, and compute the ion abundance ratios at the exact m/z's specified in Table 7. Compare the computed ratio to the theoretical ratio given in Table 8.

10.3.1.1 The exact m/z's to be monitored in each descriptor are shown in Table 7. Each group or descriptor must be monitored in succession as a function of GC retention time to ensure that the CBs of interest are detected. Additional m/z's may be monitored in each descriptor, and the m/z's may be divided among more than the descriptors listed in Table 7, provided that the laboratory is able to monitor the m/z's of all CBs that may elute from the GC in a given LOC window. The laboratory must also monitor exact m/z's for congeners at higher levels of chlorination to determine if fragments will compromise measurement of congeners at lower levels of chlorination.

10.3.1.2 The mass spectrometer must be operated in a mass-drift correction mode, using PFK (or other reference substance) to provide lock m/z's. The lock mass for each group of m/z's is shown in Table 7. Each lock mass must be monitored and must not vary by more than ± 20% throughout its respective retention time window. Variations of lock mass by more than 20% indicate the presence of co-eluting interferences that raise the source pressure and may significantly reduce the sensitivity of the mass spectrometer. Re-injection of another aliquot of the sample extract may not resolve the problem and additional cleanup of the extract may be required to remove the interference. A lock mass interference or suppression in a retention time region in which CBs and labeled compounds do not elute may be ignored.

10.3.2 All CBs and labeled compounds in the CS-1 standard must be within the QC limits in Table 8 for their respective ion abundance ratios; otherwise, the mass spectrometer must be adjusted and this test repeated until the m/z ratios fall within the limits specified. If the adjustment alters the resolution of the mass spectrometer, resolution must be verified (Section 10.2.3) prior to repeat of the test.

10.3.3 Verify that the HRGC/HRMS instrument achieves a minimum level (ML) for each congener no greater than 2 times the MLs in Table 2. The peaks representing the CBs and labeled compounds in the CS-1 calibration standard must have signal-to-noise ratios (S/N) ≥ 10; otherwise, the mass spectrometer must be adjusted and this test repeated until the minimum levels in Table 2 are met.

***Note:** The MDLs and MLs in Table 2 are based on the levels of contamination normally found in laboratories. Lower levels may be readily achievable if segregation and extensive cleaning of glassware are employed. If lower levels are achievable, these lower levels must be established as described in Section 17.6.1.4.1.*

10.4 Calibration by isotope dilution – Isotope dilution is used for calibration of the Toxics/LOC CBs. The reference compound for each native compound its labeled analog, as listed in Table 2. A 5- or 6-point calibration encompassing the concentration range is prepared for each native congener.

10.4.1 For the Toxics/LOC CBs determined by isotope dilution, the relative response (RR) (labeled to native) vs. concentration in the calibration solutions (Table 5) is computed over the calibration range according to the procedures described below. Five calibration points are employed for less-sensitive HRMS instruments (e.g., VG 70); five or six points may be employed for more-sensitive instruments (e.g., Micromass Autospec Ultima).

10.4.2 The response of each Toxics/LOC CB relative to its labeled analog is determined using the area responses of both the primary and secondary exact m/z's specified in Table 7, for each calibration standard, as follows:

$$RR = \frac{(A1_n + A2_n)\,C_l}{(A1_l + A2_l)\,C_n}$$

where:

$A1_n$ and $A2_n$ = The measured areas at the primary and secondary m/z's for the PCB

$A1_l$ and $A2_l$ = The measured areas at the primary and secondary m/z's for the labeled compound

C_l = The concentration of the labeled compound in the calibration standard (Table 4)

C_n = The concentration of the native compound in the calibration standard (Table 4)

10.4.3 To calibrate the analytical system by isotope dilution, inject calibration standards CS-1 through CS-5 (Section 7.10 and Table 5) for a less sensitive instrument or CS-0.2 through CS-5 for a more sensitive instrument. Use a volume identical to the volume chosen in Section 10.3, the procedure in Section 14, and the conditions in Section 10.1.1. Compute and store the relative response (RR) for each Native Toxics/LOC CB at each concentration. Compute the average (mean) RR and the RSD of the 5 (or 6) RRs.

10.4.4 Linearity – If the RR for any Native Toxics/LOC CB is constant (less than 20% RSD), the average RR may be used for that congener; otherwise, the complete calibration curve for that congener must be used over the calibration range.

10.5 Calibration by internal standard – Internal standard calibration is applied to determination of the native CBs for which a labeled compound is not available, determination of the Labeled Toxics/LOC/window-defining congeners and Labeled cleanup congeners for performance tests and intra-laboratory statistics (Sections 9.4 and 15.5.4), and determination of the Labeled injection internal standards except for CB 178. The reference compound for each compound is listed in Table 2. For the native congeners (other than the Native Toxics/LOC CBs), calibration is performed at a single point using the Diluted combined 209 congener solution (Section 7.10.2.2 and Table 5). For the labeled compounds, calibration is performed using data from the 5 (or 6) points in the calibration for the Native Toxics/LOC CBs (Section 10.4).

10.5.1 Response factors – Internal standard calibration requires the determination of response factors (RF) defined by the following equation:

$$RF = \frac{(A1_s + A2_s)\, C_{is}}{(A1_{is} + A2_{is})\, C_s}$$

where:

$A1_s$ and $A2_s$ = The measured areas at the primary and secondary m/z’s for the PCB

$A1_{is}$ and $A2_{is}$ = The measured areas at the primary and secondary m/z’s for the internal standard

C_{is} = The concentration of the internal standard (Table 5)

C_s = The concentration of the compound in the calibration standard (Table 5)

10.5.2 To single-concentration calibrate the analytical system for native CBs other than the Native Toxics/LOC CBs by internal standard, inject the Diluted combined 209 congener solution (Section 7.10.2.2 and Table 3). Use a volume identical to the volume chosen in Section 10.3, the procedure in Section 14, and the conditions in Section 10.1.1.

10.5.3 Compute and store the response factor (RF) for all native CBs except the Native Toxics/LOC CBs. Use the average (mean) response of the labeled compounds at each level of chlorination (LOC) as the quantitation reference, to a maximum of 5 labeled congeners, as shown in Table 2. For the combinations of isomeric congeners that co-elute, compute a combined RF for the co-eluted group. For example, for congener 122, the areas at the two exact m/z’s for 104L, 105L, 114L, 118L, and 123L are summed and the total area is divided by 5 (because there are 5 congeners in the quantitation reference).

Note: *All labeled congeners at each LOC are used as reference to reduce the effect of an interference if a single congener is used as reference. Other quantitation references and procedures may be used provided that the results produced are as accurate as results produced by the quantitation references and procedures described in this Section.*

10.5.4 Compute and store the response factor (RF) for the labeled compounds, except CB 138. For the Labeled Toxics/LOC/window-defining compounds and the Labeled cleanup standards, use the nearest eluted Labeled injection internal standard as the quantitation reference, as given in Table 2. The Labeled injection internal standards are referenced to CB 138, as shown in Table 2.

11.0 Sample preparation

11.1 Sample preparation involves modifying the physical form of the sample so that the CBs can be extracted efficiently. In general, the samples must be in a liquid form or in the form of finely divided solids in order for efficient extraction to take place. Table 9 lists the phases and suggested quantities for extraction of various sample matrices.

For samples known or expected to contain high levels of the CBs, the smallest sample size representative of the entire sample should be used (see Section 18). For all samples, the blank and IPR/OPR aliquots must be processed through the same steps as the sample to check for contamination and losses in the preparation processes.

11.1.1 For samples that contain particles, percent solids and particle size are determined using the procedures in Sections 11.2 and 11.3, respectively.

11.1.2 Aqueous samples – Because CBs may be bound to suspended particles, the preparation of aqueous samples is dependent on the solids content of the sample.

11.1.2.1 Aqueous samples containing one percent solids or less are prepared per Section 11.4 and extracted directly using one of the extraction techniques in Section 12.2.

11.1.2.2 For aqueous samples containing greater than one percent solids, a sample aliquot sufficient to provide 10 g of dry solids is used, as described in Section 11.5.

11.1.3 Solid samples are prepared using the procedure described in Section 11.5 followed by extraction using the SDS procedure in Section 12.3.

11.1.4 Multi-phase samples – The phase(s) containing the CBs is separated from the non-CB phase using pressure filtration and centrifugation, as described in Section 11.6. The CBs will be in the organic phase in a multi-phase sample in which an organic phase exists.

11.1.5 Procedures for grinding, homogenization, and blending of various sample phases are given in Section 11.7.

11.1.6 Tissue samples – Preparation procedures for fish and other tissues are given in Section 11.8.

11.2 Determination of percent suspended solids

Note: *This aliquot is used for determining solids content of the sample, not for determination of CBs.*

11.2.1 Aqueous liquids and multi-phase samples consisting of mainly an aqueous phase

11.2.1.1 Desiccate and weigh a GF/D filter (Section 6.5.3) to three significant figures.

11.2.1.2 Filter 10.0 ± 0.02 mL of well-mixed sample through the filter.

11.2.1.3 Dry the filter a minimum of 12 hours at 110 ±5 ºC and cool in a desiccator.

11.2.1.4 Calculate percent solids as follows:

$$\%\text{ solids} = \frac{\text{weight of sample aliquot after drying (g) - weight of filter (g)}}{10\text{ g}} \text{ x } 100$$

11.2.2 Non-aqueous liquids, solids, semi-solid samples, and multi-phase samples in which the main phase is not aqueous; but not tissues

11.2.2.1 Weigh 5 to 10 g of sample to three significant figures in a tared beaker.

11.2.2.2 Dry a minimum of 12 hours at 110 ± 5 ºC, and cool in a desiccator.

11.2.2.3 Calculate percent solids as follows:

$$\%\text{ solids} = \frac{\text{weight of sample aliquot after drying (g)}}{\text{weight of sample aliquot before drying (g)}} \text{ x } 100$$

11.3 Estimation of particle size

11.3.1 Spread the dried sample from Section 11.2.2.2 on a piece of filter paper or aluminum foil in a fume hood or glove box.

11.3.2 Estimate the size of the particles in the sample. If the size of the largest particles is greater than 1 mm, the particle size must be reduced to 1 mm or less prior to extraction using the procedures in Section 11.7.

11.4 Preparation of aqueous samples containing one percent suspended solids or less

11.4.1 Aqueous samples containing one percent suspended solids or less are prepared using the procedure below and extracted using the one of the extraction techniques in Section 12.2.

11.4.2 Preparation of sample and QC aliquots

11.4.2.1 Mark the original level of the sample on the sample bottle for reference. Weigh the sample plus bottle to ± 1 g. After extraction (Section 12.2), re-weigh the sample bottle and convert the weight to volume assuming a density of 1.00 g/mL.

11.4.2.2 Spike 1.0 mL of the Labeled Toxics/LOC/window-defining standard spiking solution (Section 7.12) into the sample bottle. Cap the bottle and mix the sample by careful shaking. Allow the sample to equilibrate for 1 to 2 hours, with occasional shaking.

11.4.2.3 For each sample or sample batch (to a maximum of 20 samples) to be extracted during the same 12-hour shift, place two 1.0-L aliquots of reagent water in clean sample bottles or flasks.

11.4.2.4 Spike 1.0 mL of the Labeled Toxics/LOC/window-defining standard spiking solution (Section 7.12) into both reagent water aliquots. One of these aliquots will serve as the Method blank.

11.4.2.5 Spike 1.0 mL of the Native Toxics/LOC standard spiking solution (Section 7.11) into the remaining reagent water aliquot. This aliquot will serve as the OPR (Section 15.5).

11.4.2.6 For extraction using SPE, add 5 mL of methanol to the sample and QC aliquots. Cap and shake the sample and QC aliquots to mix thoroughly, and proceed to Section 12.2 for extraction.

11.5 Preparation of samples containing greater than one percent solids

11.5.1 Weigh a well-mixed aliquot of each sample (of the same matrix type) sufficient to provide 10 g of dry solids (based on the solids determination in Section 11.2) into a clean beaker or glass jar.

11.5.2 Spike 1.0 mL of the Labeled Toxics/LOC/window-defining standard spiking solution (Section 7.12) into the sample.

11.5.3 For each sample or sample batch (to a maximum of 20 samples) to be extracted during the same 12 hour shift, weigh two 10-g aliquots of the appropriate reference matrix (Section 7.6) into clean beakers or glass jars.

11.5.4 Spike 1.0 mL of the Labeled Toxics/LOC/window-defining standard spiking solution (Section 7.12) into both reference matrix aliquots. Spike 1.0 mL of the Native Toxics/LOC standard spiking solution (Section 7.11) into one reference matrix aliquot. This aliquot will serve as the OPR (Section 15.5). The other aliquot will serve as the Method blank.

11.5.5 Stir or tumble and equilibrate the aliquots for 1 to 2 hours.

11.5.6 Decant excess water. If necessary to remove water, filter the sample through a glass-fiber filter and discard the aqueous liquid.

11.5.7 If particles >1 mm are present in the sample (as determined in Section 11.3.2), spread the sample on clean aluminum foil in a hood. After the sample is dry, grind to reduce the particle size (Section 11.7).

11.5.8 Extract the sample and QC aliquots using the SDS procedure in Section 12.3.

11.6 Multi-phase samples

11.6.1 Using the percent solids determined in Section 11.2.1 or 11.2.2, determine the volume of sample that will provide 10 g of solids, up to 1 L of sample.

11.6.2 Spike 1.0 mL of the Labeled Toxics/LOC/window-defining standard spiking solution (Section 7.12) into the amount of sample determined in Section 11.6.1, and into the OPR and blank. Spike 1.0 mL of the Native Toxics/LOC standard spiking solution (Section 7.11) into the OPR. Pressure filter the sample, blank, and OPR through Whatman GF/D glass-fiber filter paper (Section 6.5.3). If necessary to separate the phases and/or settle the solids, centrifuge these aliquots prior to filtration.

11.6.3 Discard any aqueous phase (if present). Remove any non-aqueous liquid present and reserve the maximum amount filtered from the sample (Section 11.6.1) or 10 g, whichever is less, for combination with the solid phase (Section 12.3.5).

11.6.4 If particles >1 mm are present in the sample (as determined in Section 11.3.2) and the sample is capable of being dried, spread the sample and QC aliquots on clean aluminum foil in a hood. Observe the precaution in Section 4.8.

11.6.5 After the aliquots are dry or if the sample cannot be dried, reduce the particle size using the procedures in Section 11.7 and extract the reduced-size particles using the SDS procedure in Section 12.3. If particles >1 mm are not present, extract the particles and filter in the sample and QC aliquots directly using the SDS procedure in Section 12.3.

11.7 Sample grinding, homogenization, or blending – Samples with particle sizes greater than 1 mm (as determined in Section 11.3.2) are subjected to grinding, homogenization, or blending. The method of reducing particle size to less than 1 mm is matrix-dependent. In general, hard particles can be reduced by grinding with a mortar and pestle. Softer particles can be reduced by grinding in a Wiley mill or meat grinder, by homogenization, or in a blender.

11.7.1 Each size-reducing preparation procedure on each matrix must be verified by running the tests in Section 9.2 before the procedure is employed routinely.

11.7.2 The grinding, homogenization, or blending procedures must be carried out in a glove box or fume hood to prevent particles from contaminating the work environment.

11.7.3 Grinding – Certain papers and pulps, slurries, and amorphous solids can be ground in a Wiley mill or heavy duty meat grinder. In some cases, reducing the temperature of the sample to freezing or to dry ice or liquid nitrogen temperatures can aid in the grinding process. Grind the sample aliquots from Sections 11.5.7 or 11.6.5 in a clean grinder. Do not allow the sample temperature to exceed 50 ºC. Grind the blank and reference matrix aliquots using a clean grinder.

11.7.4 Homogenization or blending – Particles that are not ground effectively, or particles greater than 1 mm in size after grinding, can often be reduced in size by high speed homogenization or blending. Homogenize and/or blend the particles or filter from Sections 11.5.7 or 11.6.5 for the sample, blank, and OPR aliquots.

11.7.5 Extract the aliquots using the SDS procedure in Section 12.3.

11.8 Fish and other tissues – Prior to processing tissue samples, the laboratory must determine the exact tissue to be analyzed. Common requests for analysis of fish tissue include whole fish-skin on, whole fish-skin removed, edible fish fillets (filleted in the field or by the laboratory), specific organs, and other portions. Once the appropriate tissue has been determined, the sample must be homogenized.

11.8.1 Homogenization

11.8.1.1 Samples are homogenized while still frozen, where practical. If the laboratory must dissect the whole fish to obtain the appropriate tissue for analysis, the unused tissues may be rapidly refrozen and stored in a clean glass jar for subsequent use.

11.8.1.2 Each analysis requires 10 g of tissue (wet weight). Therefore, the laboratory should homogenize at least 20 g of tissue to allow for re-extraction of a second aliquot of the same homogenized sample, if re-analysis is required. When whole fish analysis is necessary, the entire fish is homogenized.

11.8.1.3 Homogenize the sample in a tissue homogenizer (Section 6.3.3) or grind in a meat grinder (Section 6.3.4). Cut tissue that is too large to feed into the grinder into smaller pieces. To assure homogeneity, grind three times.

11.8.1.4 Transfer approximately 10 g (wet weight) of homogenized tissue to a clean, tared, 400- to 500-mL beaker.

11.8.1.5 Transfer the remaining homogenized tissue to a clean jar with a fluoropolymer-lined lid. Seal the jar and store the tissue at less than -10 ºC. Return any tissue that was not homogenized to its original container and store at less than -10 ºC.

11.8.2 QC aliquots

11.8.2.1 Prepare a Method blank by adding approximately 1-2 g of the oily liquid reference matrix (Section 7.6.4) to a 400- to 500-mL beaker.

11.8.2.2 Prepare a precision and recovery aliquot by adding 1-2 g of the oily liquid reference matrix (Section 7.6.4) to a separate 400- to 500-mL beaker. Record the weight to the nearest 10 mg. If the initial precision and recovery test is to be performed, use four aliquots; if the ongoing precision and recovery test is to be performed, use a single aliquot.

11.8.3 Spiking

11.8.3.1 Spike 1.0 mL of the Labeled Toxics/LOC/window-defining standard spiking solution (Section 7.12) into the sample, blank, and OPR aliquot.

11.8.3.2 Spike 1.0 mL of the Native Toxics/LOC standard spiking solution (Section 7.11) into the OPR aliquot.

11.8.4 Extract the aliquots using the procedures in Section 12.4.

12.0 Extraction and concentration

12.1 Extraction procedures include: solid-phase (Section 12.2.1), separatory funnel (Section 12.2.2), and continuous liquid/liquid (Section 12.2.3) for aqueous liquids; Soxhlet/Dean-Stark (Section 12.3) for solids and filters; and Soxhlet extraction (Section 12.4) for tissues. Acid/base back-extraction (Section 12.5) is used for initial cleanup of extracts.

Macro-concentration procedures include: rotary evaporation (Section 12.6.1), heating mantle (Section 12.6.2), and Kuderna-Danish (K-D) evaporation (Section 12.6.3). Micro-concentration uses nitrogen evaporation (Section 12.7).

12.2 Extraction of aqueous liquids

12.2.1 Solid-phase extraction of samples containing less than one percent solids

12.2.1.1 Disk preparation

12.2.1.1.1 Remove the test tube from the suction flask (Figure 4). Place an SPE disk on the base of the filter holder and wet with methylene chloride. While holding a GMF 150 filter above the SPE disk with tweezers, wet the filter with methylene chloride and lay the filter on the SPE disk, making sure that air is not trapped between the filter and disk. Clamp the filter and SPE disk between the 1-L glass reservoir and the vacuum filtration flask.

12.2.1.1.2 Rinse the sides of the reservoir with approx 15 mL of methylene chloride using a squeeze bottle or pipet. Apply vacuum momentarily until a few drops appear at the drip tip. Release the vacuum and allow the filter/disk to soak for approx one minute. Apply vacuum and draw all of the methylene chloride through the filter/disk. Repeat the wash step with approx 15 mL of acetone and allow the filter/disk to air dry.

12.2.1.2 Sample extraction

12.2.1.2.1 Pre-wet the disk by adding approx 20 mL of methanol to the reservoir. Pull most of the methanol through the filter/disk, retaining a layer of methanol approx 2 mm thick on the filter. Do not allow the filter/disk to go dry from this point until the extraction is completed.

12.2.1.2.2 Add approx 20 mL of reagent water to the reservoir and pull most through, leaving a layer approx 2 mm thick on the filter/disk.

12.2.1.2.3 Allow the sample (Section 11.4.2.6) to stand for 1-2 hours, if necessary, to settle the suspended particles. Decant the clear layer of the sample, the blank (Section 11.4.2.4), or IPR/OPR aliquot (Section 11.4.2.5) into its respective reservoir and turn on the vacuum to begin the extraction. Adjust the vacuum to complete the extraction in no less than 10 minutes. For samples containing a high concentration of particles (suspended solids), the extraction time may be an hour or longer.

12.2.1.2.4 Before all of the sample has been pulled through the filter/disk, add approx 50 mL of reagent water to the sample bottle, swirl to suspend the solids (if present), and pour into the reservoir. Pull through the filter/disk. Use additional reagent water rinses until all solids are removed.

12.2.1.2.5 Before all of the sample and rinses have been pulled through the filter/disk, rinse the sides of the reservoir with small portions of reagent water.

12.2.1.2.6 Partially dry the filter/disk under vacuum for approx 3 minutes.

12.2.1.3 Elution of the filter/disk

12.2.1.3.1 Release the vacuum, remove the entire filter/disk/reservoir assembly from the vacuum flask, and empty the flask. Insert a test tube for eluant collection into the flask. The test tube should have sufficient capacity to contain the total volume of the elution solvent (approx 50 mL) and should fit around the drip tip. The drip tip should protrude into the test tube to preclude loss of sample from spattering when vacuum is applied. Reassemble the filter/disk/reservoir assembly on the vacuum flask.

12.2.1.3.2 Wet the filter/disk with 4-5 mL of acetone. Allow the acetone to spread evenly across the disk and soak for 15-20 seconds. Pull the acetone through the disk, releasing the vacuum when approx 1 mm thickness remains on the filter.

12.2.1.3.3 Rinse the sample bottle with approx 20 mL of methylene chloride and transfer to the reservoir. Pull approx half of the solvent through the filter/disk and release the vacuum. Allow the filter/disk to soak for approx 1 minute. Pull all of the solvent through the disk. Repeat the bottle rinsing and elution step with another 20 mL of methylene chloride. Pull all of the solvent through the disk.

12.2.1.3.4 Release the vacuum, remove the filter/disk/reservoir assembly, and remove the test tube containing the sample solution. Quantitatively transfer the solution to a 250-mL separatory funnel and proceed to Section 12.5 for back-extraction.

12.2.2 Separatory funnel extraction

12.2.2.1 Pour the spiked sample (Section 11.4.2.2) into a 2-L separatory funnel. Rinse the bottle or flask twice with 5 mL of reagent water and add these rinses to the separatory funnel.

12.2.2.2 Add 60 mL methylene chloride to the empty sample bottle. Seal the bottle and shake 60 seconds to rinse the inner surface. Transfer the solvent to the separatory funnel, and extract the sample by shaking the funnel for 2 minutes with periodic venting. Allow the organic layer to separate from the aqueous phase for a minimum of 10 minutes. If an emulsion forms and is more than one-third the volume of the solvent layer, employ mechanical techniques to complete the phase separation (see note below). Drain the methylene chloride extract through a solvent-rinsed glass funnel approximately one-half full of granular anhydrous sodium sulfate (Section 7.2.1) supported on clean glass-fiber paper into a solvent-rinsed concentration device (Section 12.6).

Note: *If an emulsion forms, the laboratory must employ mechanical techniques to complete the phase separation. The optimum technique depends upon the sample, but may include stirring, filtration through glass wool, use of phase separation paper, centrifugation, use of an ultrasonic bath with ice, addition of NaCl, or other physical methods. Alternatively, solid-phase (Section 12.2.1), CLLE (Section 12.2.3), or other extraction techniques may be used to prevent emulsion formation. Any alternative technique is acceptable so long as the requirements in Section 9.2 are met.*

12.2.2.3 Extract the water sample two more times with 60-mL portions of methylene chloride. Drain each portion through the sodium sulfate into the concentrator. After the third extraction, rinse the separatory funnel with at least 20 mL of methylene chloride, and drain this rinse through the sodium sulfate into the concentrator. Repeat this rinse at least twice.

12.2.2.4 Concentrate the extract using one of the macro-concentration procedures in Section 12.6 and proceed to back extraction in Section 12.5. Set aside the concentration device for use after back extraction or other cleanup.

12.2.3 Continuous liquid/liquid extraction

12.2.3.1 Place 100-150 mL methylene chloride in each continuous extractor and 200-300 mL in each distilling flask.

12.2.3.2 Pour the sample(s), blank, and QC aliquots into the extractors. Rinse the sample containers with 50-100 mL methylene chloride and add to the respective extractors. Include all solids in the extraction process.

12.2.3.3 Begin the extraction by heating the flask until the methylene chloride is boiling. When properly adjusted, 1-2 drops of methylene chloride per second will fall from the condenser tip into the water. Extract for 16-24 hours.

12.2.3.4 Remove the distilling flask, estimate and record the volume of extract (to the nearest 100 mL), and pour the contents through a drying column containing 7 to 10 cm of granular anhydrous sodium sulfate into a 500-mL K-D evaporator flask equipped with a 10-mL concentrator tube. Rinse the distilling flask with 30-50 mL of methylene chloride and pour through the drying column. Concentrate and exchange to hexane per Section 12.6 and back extract per Section 12.5. Set aside the concentration device for use after back extraction or other cleanup.

12.3 SDS extraction of samples containing particles

Note: *SDS extraction with toluene may cause loss of some of the mono- through tri- CB congeners. If this loss is excessive, use Soxhlet extraction with methylene chloride (Section 12.4) and increase the amount of powdered, anhydrous sodium sulfate as necessary to provide a free-flowing mixture.*

12.3.1 Charge a clean extraction thimble (Section 6.4.2.2) with 5.0 g of 100/200 mesh silica (Section 7.5.1.1) topped with 100 g of quartz sand (Section 7.3.2).

Note: *Do not disturb the silica layer throughout the extraction process.*

12.3.2 Place the thimble in a clean extractor. Place 30 to 40 mL of toluene in the receiver and 200 to 250 mL of toluene in the flask.

12.3.3 Pre-extract the glassware by heating the flask until the toluene is boiling. When properly adjusted, 1 to 2 drops of toluene will fall per second from the condenser tip into the receiver. Extract the apparatus for a minimum of 3 hours.

12.3.4 After pre-extraction, cool and disassemble the apparatus. Rinse the thimble with toluene and allow to air dry.

12.3.5 Load the wet sample and/or filter from Sections 11.5.8, 11.6.5, or 11.7.5 and any non-aqueous liquid from Section 11.6.3 into the thimble and manually mix into the sand layer with a clean metal spatula, carefully breaking up any large lumps of sample.

12.3.6 Reassemble the pre-extracted SDS apparatus, and add a fresh charge of toluene to the receiver and reflux flask. Apply power to the heating mantle to begin re-fluxing. Adjust the reflux rate to match the rate of percolation through the sand and silica beds until water removal lessens the restriction to toluene flow. Frequently check the apparatus for foaming during the first 2 hours of extraction. If foaming occurs, reduce the reflux rate until foaming subsides.

12.3.7 Drain the water from the receiver at 1-2 hours and 8-9 hours, or sooner if the receiver fills with water. Reflux the sample for a total of 16-24 hours. Cool and disassemble the apparatus. Record the total volume of water collected.

12.3.8 Remove the distilling flask. Drain the water from the Dean-Stark receiver and add any toluene in the receiver to the extract in the flask.

12.3.9 Concentrate the extracts from particles to approximately 10 mL using the rotary evaporator (Section 12.6.1) or heating mantle (Section 12.6.2), transfer to a 250-mL separatory funnel, and proceed with back-extraction (Section 12.5). Set aside the concentration device for use after back-extraction or other cleanup.

12.4 Soxhlet extraction of tissue (References 3 and 15)

Note: *This procedure includes determination of the lipid content of the sample (Sections 12.4.8 - 12.4.9), using the same sample extract that is analyzed by GC/MS. Alternatively, a separate sample aliquot may be used for the lipid determination. If a separate aliquot is used, use nitrogen to evaporate the main portion of the sample extract only to the extent necessary to effect the solvent exchange to n-hexane, so that loss of low molecular weight CBs is avoided, i.e., it is not necessary to dry the main portion of the sample to constant weight (Section 12.4.8).*

12.4.1 Add 30 to 40 g of powdered anhydrous sodium sulfate (Section 7.2.2) to each of the beakers (Section 11.8.4) and mix thoroughly. Cover the beakers with aluminum foil and dry until the mixture becomes a free-flowing powder (30 minutes minimum). Remix prior to extraction to prevent clumping.

12.4.2 Assemble and pre-extract the Soxhlet apparatus per Sections 12.3.1-12.3.4, except use methylene chloride for the pre-extraction and rinsing and omit the quartz sand.

12.4.3 Reassemble the pre-extracted Soxhlet apparatus and add a fresh charge of methylene chloride to the reflux flask.

12.4.4 Transfer the sample/sodium sulfate mixture (Section 12.4.1) to the Soxhlet thimble, and install the thimble in the Soxhlet apparatus.

12.4.5 Rinse the beaker with several portions of solvent and add to the thimble. Fill the thimble/receiver with solvent. Extract for 18-24 hours.

12.4.6 After extraction, cool and disassemble the apparatus.

12.4.7 Quantitatively transfer the extract to a macro-concentration device (Section 12.6), and concentrate to near dryness. Set aside the concentration apparatus for re-use.

12.4.8 Complete the removal of the solvent using the nitrogen blow evaporation procedure (Section 12.7) and a water bath temperature of 60 ºC. Weigh the receiver, record the weight, and return the receiver to the blowdown apparatus, concentrating the residue until a constant weight is obtained.

12.4.9 Percent lipid determination

12.4.9.1 Redissolve the residue in the receiver in hexane and spike 1.0 mL of the Labeled cleanup standard spiking solution (Section 7.13) into the solution.

12.4.9.2 Transfer the residue/hexane to the anthropogenic isolation column (Section 13.6), retaining the boiling chips in the concentration apparatus. Use several rinses to assure that all material is transferred. If necessary, sonicate or heat the receiver slightly to assure that all material is re-dissolved. Allow the receiver to dry. Weigh the receiver and boiling chips.

12.4.9.3 Calculate the lipid content to the nearest three significant figures as follows:

$$\%\ \text{lipid} = \frac{\text{weight of residue (g)}}{\text{weight of tissue (g)}}\ \text{x}\ 100$$

12.4.9.4 The laboratory should determine the lipid content of the blank, IPR, and OPR to assure that the extraction system is working effectively.

12.5 Back-extraction with base and acid

12.5.1 Back-extraction may not be necessary for some samples. For some samples, the presence of color in the extract may indicate that back-extraction is necessary. If back-extraction is not necessary, spike 1.0 mL of the Labeled cleanup standard spiking solution (Section 7.13) into the extract and concentrate the extract for cleanup or analysis (Sections 12.6 and 12.7). If back-extraction is necessary, spike 1.0 mL of the Labeled cleanup standard spiking solution (Section 7.13) into the separatory funnels containing the sample and QC extracts from Section 12.2.3.4 or 12.3.9.

12.5.2 Partition the extract against 50 mL of potassium hydroxide solution (Section 7.1.1). Shake for 2 minutes with periodic venting into a hood. Remove and discard the aqueous layer. Repeat the base washing until no color is visible in the aqueous layer, to a maximum of four washings. Minimize contact time between the extract and the base to prevent degradation of the CBs. Stronger potassium hydroxide solutions may be employed for back-extraction, provided that the laboratory meets the specifications for labeled compound recovery and demonstrates acceptable performance using the procedure in Section 9.2.

12.5.3 Partition the extract against 50 mL of sodium chloride solution (Section 7.1.4) in the same way as with base. Discard the aqueous layer.

12.5.4 Partition the extract against 50 mL of sulfuric acid (Section 7.1.2) in the same way as with base. Repeat the acid washing until no color is visible in the aqueous layer, to a maximum of four washings.

12.5.5 Repeat the partitioning against sodium chloride solution and discard the aqueous layer.

12.5.6 Pour each extract through a drying column containing 7 to 10 cm of granular anhydrous sodium sulfate (Section 7.2.1) into a macro-concentration device (Section 12.6). If a concentration device was set aside from extraction, that concentration device may be re-used. Rinse the separatory funnel with 30 to 50 mL of solvent, and pour through the drying column. Re-concentrate the sample and QC aliquots per Sections 12.6-12.7, and clean up the samples and QC aliquots per Section 13.

12.6 Macro-concentration – Extracts in toluene are concentrated using a rotary evaporator or a heating mantle; extracts in methylene chloride or hexane are concentrated using a rotary evaporator, heating mantle, or Kuderna-Danish apparatus.

Note: *In the concentration procedures below, the extract must not be allowed to concentrate to dryness because the mono- through tri-chlorobiphenyls may be totally or partially lost.*

12.6.1 Rotary evaporation – Concentrate the extracts in separate round-bottom flasks.

12.6.1.1 Assemble the rotary evaporator according to manufacturer's instructions, and warm the water bath to 45 ºC. On a daily basis, pre-clean the rotary evaporator by concentrating 100 mL of clean extraction solvent through the system. Archive both the concentrated solvent and the solvent in the catch flask for a contamination check if necessary. Between samples, three 2- to 3- mL aliquots of solvent should be rinsed down the feed tube into a waste beaker.

12.6.1.2 Attach the round-bottom flask containing the sample extract to the rotary evaporator. Slowly apply vacuum to the system, and begin rotating the sample flask.

12.6.1.3 Lower the flask into the water bath, and adjust the speed of rotation and the temperature as required to complete concentration in 15 to 20 minutes. At the proper rate of concentration, the flow of solvent into the receiving flask will be steady, but no bumping or visible boiling of the extract will occur.

Note: *If the rate of concentration is too fast, analyte loss may occur.*

12.6.1.4 When the liquid in the concentration flask has reached an apparent volume of approximately 2 mL, remove the flask from the water bath and stop the rotation. Slowly and carefully admit air into the system. Be sure not to open the valve so quickly that the sample is blown out of the flask. Rinse the feed tube with approximately 2 mL of solvent.

12.6.1.5 Proceed to Section 12.6.4 for preparation for back-extraction or micro-concentration and solvent exchange.

12.6.2 Heating mantle – Concentrate the extracts in separate round-bottom flasks.

12.6.2.1 Add one or two clean boiling chips to the round-bottom flask, and attach a three-ball macro Snyder column. Prewet the column by adding approximately 1 mL of solvent through the top. Place the round-bottom flask in a heating mantle, and apply heat as required to complete the concentration in 15 to 20 minutes. At the proper rate of distillation, the balls of the column will actively chatter, but the chambers will not flood.

12.6.2.2 When the liquid has reached an apparent volume of approximately 10 mL, remove the round-bottom flask from the heating mantle and allow the solvent to drain and cool for at least 10 minutes. Remove the Snyder column and rinse the glass joint into the receiver with small portions of solvent.

12.6.2.3 Proceed to Section 12.6.4 for preparation for back-extraction or micro-concentration and solvent exchange.

12.6.3 Kuderna-Danish (K-D) – Concentrate the extracts in separate 500-mL K-D flasks equipped with 10-mL concentrator tubes. The K-D technique is used for solvents such as methylene chloride and hexane. Toluene is difficult to concentrate using the K-D technique unless a water bath fed by a steam generator is used.

12.6.3.1 Add 1 to 2 clean boiling chips to the receiver. Attach a three-ball macro Snyder column. Prewet the column by adding approximately 1 mL of solvent through the top. Place the K-D apparatus in a hot water bath so that the entire lower rounded surface of the flask is bathed with steam.

12.6.3.2 Adjust the vertical position of the apparatus and the water temperature as required to complete the concentration in 15 to 20 minutes. At the proper rate of distillation, the balls of the column will actively chatter but the chambers will not flood.

12.6.3.3 When the liquid has reached an apparent volume of 1 mL, remove the K-D apparatus from the bath and allow the solvent to drain and cool for at least 10 minutes. Remove the Snyder column and rinse the flask and its lower joint into the concentrator tube with 1 to 2 mL of solvent. A 5-mL syringe is recommended for this operation.

12.6.3.4 Remove the three-ball Snyder column, add a fresh boiling chip, and attach a two ball micro Snyder column to the concentrator tube. Prewet the column by adding approximately 0.5 mL of solvent through the top. Place the apparatus in the hot water bath.

12.6.3.5 Adjust the vertical position and the water temperature as required to complete the concentration in 5 to 10 minutes. At the proper rate of distillation, the balls of the column will actively chatter but the chambers will not flood.

12.6.3.6 When the liquid reaches an apparent volume of 0.5 mL, remove the apparatus from the water bath and allow to drain and cool for at least 10 minutes.

12.6.3.7 Proceed to 12.6.4 for preparation for back-extraction or micro-concentration and solvent exchange.

12.6.4 Preparation for back-extraction or micro-concentration and solvent exchange

12.6.4.1 For back-extraction (Section 12.5), transfer the extract to a 250-mL separatory funnel. Rinse the concentration vessel with small portions of hexane, adjust the hexane volume in the separatory funnel to 10 to 20 mL, and proceed to back-extraction (Section 12.5).

12.6.4.2 For determination of the weight of residue in the extract, or for clean-up procedures other than back-extraction, transfer the extract to a blowdown vial using 2-3 rinses of solvent. Proceed with micro-concentration and solvent exchange (Section 12.7).

12.7 Micro-concentration and solvent exchange

12.7.1 Extracts to be subjected to GPC cleanup are exchanged into methylene chloride. Extracts to be cleaned up using silica gel, carbon, Florisil, and/or HPLC are exchanged into hexane.

12.7.2 Transfer the vial containing the sample extract to a nitrogen evaporation device. Adjust the flow of nitrogen so that the surface of the solvent is just visibly disturbed.

Note: *A large vortex in the solvent may cause analyte loss.*

12.7.3 Lower the vial into a 45 ºC water bath and continue concentrating.

12.7.3.1 If the extract or an aliquot of the extract is to be concentrated to dryness for weight determination (Sections 12.4.8 and 13.6.4), blow dry until a constant weight is obtained.

12.7.3.2 If the extract is to be concentrated for injection into the GC/MS or the solvent is to be exchanged for extract cleanup, proceed as follows:

12.7.4 When the volume of the liquid is approximately 100 µL, add 2 to 3 mL of the desired solvent (methylene chloride for GPC and HPLC, or hexane for the other cleanups) and continue concentration to approximately 100 µL. Repeat the addition of solvent and concentrate once more.

12.7.5 If the extract is to be cleaned up by GPC, adjust the volume of the extract to 5.0 mL with methylene chloride. If the extract is to be cleaned up by HPLC, concentrate the extract to 1.0 mL. Proceed with GPC or HPLC cleanup (Section 13.2 or 13.5, respectively).

12.7.6 If the extract is to be cleaned up by column chromatography (silica gel, Carbopak/Celite, or Florisil), bring the final volume to 1.0 mL with hexane. Proceed with column cleanup (Sections 13.3, 13.4, or 13.7).

12.7.7 If the extract is to be concentrated for injection into the GC/MS (Section 14), quantitatively transfer the extract to a 0.3-mL conical vial for final concentration, rinsing the larger vial with hexane and adding the rinse to the conical vial. Reduce the volume to approximately 100 µL. Add 20 µL of nonane to the vial, and evaporate the solvent to the level of the nonane. Seal the vial and label with the sample number. Store in the dark at room temperature until ready for GC/MS analysis. If GC/MS analysis will not be performed on the same day, store the vial at less than -10 ºC.

13.0 Extract cleanup

13.1 Cleanup may not be necessary for relatively clean samples (e.g., treated effluents, groundwater, drinking water). If particular circumstances require the use of a cleanup procedure, the laboratory may use any or all of the procedures below or any other appropriate procedure. Before using a cleanup procedure, the laboratory must demonstrate that the requirements of Section 9.2 can be met using the cleanup procedure.

13.1.1 Gel permeation chromatography (Section 13.2) removes high molecular weight interferences that cause GC column performance to degrade. It should be used for all soil and sediment extracts. It may be used for water extracts that are expected to contain high molecular weight organic compounds (e.g., polymeric materials, humic acids). It should also be used for tissue extracts after initial cleanup on the anthropogenic isolation column (Section 13.6).

13.1.2 Acid, neutral, and basic silica gel (Section 13.3) and Florisil (Section 13.7) are used to remove non-polar and polar interferences.

13.1.3 Carbopak/Celite (Section 13.4) can be used to separate CBs 77, 126, and 169 from the mono- and di- ortho-substituted CBs, if desired.

13.1.4 HPLC (Section 13.5) is used to provide specificity for certain congeners and congener groups.

13.1.5 The anthropogenic isolation column (Section 13.6) is used for removal of lipids from tissue samples.

13.2 Gel permeation chromatography (GPC)

13.2.1 Column packing

13.2.1.1 Place 70 to 75 g of SX-3 Bio-beads (Section 6.7.1.1) in a 400- to 500-mL beaker.

13.2.1.2 Cover the beads with methylene chloride and allow to swell overnight (a minimum of 12 hours).

13.2.1.3 Transfer the swelled beads to the column (Section 6.7.1.1) and pump solvent through the column, from bottom to top, at 4.5 to 5.5 mL/minute prior to connecting the column to the detector.

13.2.1.4 After purging the column with solvent for 1 to 2 hours, adjust the column head pressure to 7 to 10 psig and purge for 4 to 5 hours to remove air. Maintain a head pressure of 7 to 10 psig. Connect the column to the detector (Section 6.7.1.4).

13.2.2 Column calibration

13.2.2.1 Load 5 mL of the GPC calibration solution (Section 7.4) into the sample loop.

13.2.2.2 Inject the GPC calibration solution and record the signal from the detector. The elution pattern will be corn oil, BEHP, methoxychlor, perylene, and sulfur.

13.2.2.3 Set the "dump time" to allow >85% removal of BEHP and >85% collection of methoxychlor.

13.2.2.4 Set the "collect time" to the time of the sulfur peak maximum.

13.2.2.5 Verify calibration with the GPC calibration solution after every 20 extracts. Calibration is verified if the recovery of the methoxychlor is greater than 85%. If calibration is not verified, the system must be recalibrated using the GPC calibration solution, and the previous sample batch must be re-extracted and cleaned up using the calibrated GPC system.

13.2.3 Extract cleanup – GPC requires that the column not be overloaded. The column specified in this Method is designed to handle a maximum of 0.5 g of material from an aqueous, soil, or mixed-phase sample in a 5-mL extract, and has been shown to handle 1.5 g of lipid from a tissue sample in a 5-mL extract. If the extract is known or expected to contain more than these amounts, the extract is split into aliquots for GPC, and the aliquots are combined after elution from the column. The residue content of the extract may be obtained gravimetrically by evaporating the solvent from a 50-µL aliquot.

13.2.3.1 Filter the extract or load through the filter holder (Section 6.7.1.3) to remove particles. Load the 5.0-mL extract onto the column.

13.2.3.2 Elute the extract using the calibration data determined in Section 13.2.2. Collect the eluate in a clean 400- to 500-mL beaker. Allow the system to rinse for additional 10 minutes before injecting the next sample.

13.2.3.3 Rinse the sample loading tube thoroughly with methylene chloride between extracts to prepare for the next sample.

13.2.3.4 If an extract is encountered that could overload the GPC column to the extent that carry-over could occur, a 5.0-mL methylene chloride blank must be run through the system to check for carry-over.

13.2.3.5 Concentrate the eluate per Sections 12.6 and 12.7 for further cleanup or injection into the GC/MS.

13.3 Silica gel cleanup

13.3.1 Place a glass-wool plug in a 15-mm ID chromatography column (Section 6.7.4.2). Pack the column bottom to top with: 1 g silica gel (Section 7.5.1.1), 4 g basic silica gel (Section 7.5.1.3), 1 g silica gel, 8 g acid silica gel (Section 7.5.1.2), 2 g silica gel, and 4 g granular anhydrous sodium sulfate (Section 7.2.1). Tap the column to settle the adsorbents.

13.3.2 Pre-elute the column with 50 to 100 mL of hexane. Close the stopcock when the hexane is within 1 mm of the sodium sulfate. Discard the eluate. Check the column for channeling. If channeling is present, discard the column and prepare another.

13.3.3 Apply the concentrated extract to the column. Open the stopcock until the extract is within 1 mm of the sodium sulfate.

13.3.4 Rinse the receiver twice with 1-mL portions of hexane, and apply separately to the column. Elute the CBs with 25 mL of hexane and collect the eluate.

13.3.5 Concentrate the eluate per Section 12.6 and 12.7 for further cleanup or injection into the HPLC or GC/MS.

13.3.6 For extracts of samples known to contain large quantities of other organic compounds, it may be advisable to increase the capacity of the silica gel column. This may be accomplished by increasing the strengths of the acid and basic silica gels. The acid silica gel (Section 7.5.1.2) may be increased in strength to as much as 40% w/w (6.7 g sulfuric acid added to 10 g silica gel). The basic silica gel (Section 7.5.1.3) may be increased in strength to as much as 33% w/w (50 mL 1N NaOH added to 100 g silica gel), or the potassium silicate (Section 7.5.1.4) may be used.

Note: *The use of stronger acid silica gel (44% w/w) may lead to charring of organic compounds in some extracts. The charred material may retain some of the analytes and lead to lower recoveries of the CBs. Increasing the strengths of the acid and basic silica gel may also require different volumes of hexane than those specified above to elute the analytes from the column. The performance of the Method after such modifications must be verified by the procedure in Section 9.2.*

13.4 Carbon column (Reference 16)

13.4.1 Cut both ends from a 50-mL disposable serological pipet (Section 6.7.3.2) to produce a 20-cm column. Fire-polish both ends and flare both ends if desired. Insert a glass-wool plug at one end, and pack the column with 3.6 g of Carbopak/Celite (Section 7.5.2.3) to form an adsorbent bed 20 cm long. Insert a glass-wool plug on top of the bed to hold the adsorbent in place.

13.4.2 Pre-elute the column with 20 mL each in succession of toluene, methylene chloride, and hexane.

13.4.3 When the solvent is within 1 mm of the column packing, apply the n-hexane sample extract to the column. Rinse the sample container twice with 1-mL portions of hexane and apply separately to the column. Apply 2 mL of hexane to complete the transfer.

13.4.4 Elute the column with 25 mL of n-hexane and collect the eluate. This fraction will contain the mono- and di-ortho CBs. If carbon particles are present in the eluate, filter through glass-fiber filter paper.

13.4.5 Elute the column with 15 mL of methanol and discard the eluate. The fraction discarded will contain residual lipids and other potential interferents, if present.

13.4.6 Elute the column with 15 mL of toluene and collect the eluate. This fraction will contain CBs 77, 126, and 169. If carbon particles are present in the eluate, filter through glass-fiber filter paper.

13.4.7 Concentrate the fractions per Section 12.6 and 12.7 for further cleanup or injection into the HPLC or GC/MS.

13.5 HPLC (References 4 and 17)

13.5.1 Column calibration

13.5.1.1 Prepare a calibration standard containing the Toxics and other congeners of interest at the concentrations of the stock solution in Table 3, or at a concentration appropriate to the response of the detector.

13.5.1.2 Inject the calibration standard into the HPLC and record the signal from the detector. Collect the eluant for reuse. Elution will be in the order of the di-ortho, mono-ortho, and non-ortho congeners.

13.5.1.3 Establish the collection time for the congeners of interest. Following calibration, flush the injection system with solvent to ensure that residual CBs are removed from the system.

13.5.1.4 Verify the calibration with the calibration solution after every 20 extracts. Calibration is verified if the recovery of the CBs is 75 to 125% compared to the calibration (Section 13.5.1.1). If calibration is not verified, the system must be recalibrated using the calibration solution, and the previous 20 samples must be re-extracted and cleaned up using the calibrated system.

13.5.2 Extract cleanup – HPLC requires that the column not be overloaded. The column specified in this Method is designed to handle a maximum of 5-50 µg of a given CB, depending on the congener (Reference 17). If the amount of material in the extract will overload the column, split the extract into fractions and combine the fractions after elution from the column.

13.5.2.1 Rinse the sides of the vial containing the sample and adjust to the volume required for the sample loop for injection.

13.5.2.2 Inject the sample extract into the HPLC.

13.5.2.3 Elute the extract using the calibration data determined in Section 13.5.1. Collect the fraction(s) in clean 20-mL concentrator tubes.

13.5.2.4 If an extract containing greater than 500 µg of total CBs is encountered, a blank must be run through the system to check for carry-over.

13.5.2.5 Concentrate the eluate per Section 12.7 for injection into the GC/MS.

13.6 Anthropogenic isolation column (Reference 3) – Used for removal of lipids from tissue extracts

13.6.1 Prepare the column as given in Section 7.5.3.

13.6.2 Pre-elute the column with 100 mL of hexane. Drain the hexane layer to the top of the column, but do not expose the sodium sulfate.

13.6.3 Load the sample and rinses (Section 12.4.9.2) onto the column by draining each portion to the top of the bed. Elute the CBs from the column into the apparatus used for concentration (Section 12.4.7) using 200 mL of hexane.

13.6.4 Remove a small portion (e.g., 50 µL) of the extract for determination of residue content. Estimate the percent of the total that this portion represents. Concentrate the small portion to constant weight per Section 12.7.3.1. Calculate the total amount of residue in the extract. If more than 500 mg of material remains, repeat the cleanup using a fresh anthropogenic isolation column.

13.6.5 If necessary, exchange the extract to a solvent suitable for the additional cleanups to be used (Section 13.2-13.5 and 13.7).

13.6.6 Clean up the extract using the procedures in Sections 13.2-13.5 and 13.7. GPC (Section 13.2) and Florisil (Section 13.7) are recommended as minimum additional cleanup steps.

13.6.7 Following cleanup, concentrate the extract to 20 µL as described in Section 12.7 and proceed with the analysis in Section 14.

13.7 Florisil cleanup (Reference 18)

13.7.1 Begin to drain the n-hexane from the column (Section 7.5.4.1.2). Adjust the flow rate of eluant to 4.5-5.0 mL/min.

13.7.2 When the n-hexane is within 1 mm of the sodium sulfate, apply the sample extract (in hexane) to the column. Rinse the sample container twice with 1-mL portions of hexane and apply to the column.

13.7.3 Elute the mono-ortho and di-ortho CBs with approx 165 mL of n-hexane and collect the eluate. Elute the non-ortho co-planar CBs with approx 100 mL of 6% ether:hexane and collect the eluate. The exact volumes of solvents will need to be determined for each batch of Florisil. If the mono/di-ortho CBs are not to be separated from the non-ortho co-planar CBs, elute all CBs with 6% ether:hexane.

13.7.4 Concentrate the eluate(s) per Sections 12.6-12.7 for further cleanup or for injection into the HPLC or GC/MS.

14.0 HRGC/HRMS analysis

14.1 Establish the operating conditions given in Section 10.1.

14.2 Add 2 µL of the labeled injection internal standard spiking solution (Section 7.14) to the 20 µL sample extract immediately prior to injection to minimize the possibility of loss by evaporation, adsorption, or reaction. If an extract is to be reanalyzed and evaporation has occurred, do not add more labeled injection internal standard spiking solution. Rather, bring the extract back to its previous volume (e.g., 19 µL) with pure nonane (18 µL if 2 µL injections are used).

14.3 Inject 1.0 or 2.0 µL of the concentrated extract containing the Labeled injection internal standards using on-column or splitless injection. The volume injected must be identical to the volume used for calibration (Section 10.3).

14.3.1 Start the GC column initial isothermal hold upon injection. Start MS data collection after the solvent peak elutes.

14.3.2 Monitor the exact m/z's at each LOC throughout the LOC retention time window. Where warranted, monitor m/z's associated with congeners at higher levels of chlorination to assure that fragments are not interfering with the m/z's for congeners at lower levels of chlorination. Also where warranted, monitor m/z's associated with interferents expected to be present.

14.3.3 Stop data collection after $^{13}C_{12}$-DeCB has eluted. Return the column to the initial temperature for analysis of the next extract or standard.

15.0 System and laboratory performance

15.1 At the beginning of each 12-hour shift during which analyses are performed, GC/MS system performance and calibration are verified for all native CBs and labeled compounds. For these tests, analyze the diluted combined 209 congener solution (Section 7.10.2.2) to verify all performance criteria. Adjustment and/or recalibration (Section 10) must be performed until all performance criteria are met. Only after all performance criteria are met may samples, blanks, IPRs, and OPRs be analyzed.

15.2 MS resolution – Static resolving power checks must be performed at the beginning and at the end of each shift per Section 10.2.1. If analyses are performed on successive shifts, only the beginning of shift static resolving power check is required. If the requirement in Section 10.2.1 cannot be met, the problem must be corrected before analyses can proceed. If any of the samples in the previous shift may be affected by poor resolution, those samples must be re-analyzed.

15.3 Calibration verification

15.3.1 Inject and analyze the Diluted combined 209 congener solution (Section 7.10.2.2.2) using the procedure in Section 14.

15.3.2 The m/z abundance ratios for each native CB and labeled compound in the VER standard must be within the limits in Table 8; otherwise, the mass spectrometer must be adjusted until the m/z abundance ratios fall within the limits specified when the verification test is be repeated. If the adjustment alters the resolution of the mass spectrometer, resolution must be verified (Section 10.2.1) prior to repeat of the verification test.

15.3.3 The GC peak representing each native CB and labeled compound in the VER standard must be present with a S/N of at least 10; otherwise, the mass spectrometer must be adjusted and the verification test repeated.

15.3.4 Compute the recovery of the Toxics/LOC CBs by isotope dilution (Section 17.1) and the labeled compounds by internal standard (17.2). These recoveries are computed based on the calibration data in Section 10.

15.3.5 For each compound, compare the recovery with the calibration verification limit in Table 6. If all compounds meet the acceptance criteria, calibration has been verified and analysis of standards and sample extracts may proceed. If, however, any compound fails its respective limit, the measurement system is not performing properly. In this event, prepare a fresh calibration standard or correct the problem and repeat the resolution (Section 15.2) and verification (Section 15.3) tests, or recalibrate (Section 10). If recalibration is required, recalibration for the 209 congeners (Section 10.5) must also be performed.

15.4 Retention times and GC resolution

15.4.1 Retention times

15.4.1.1 Absolute – The absolute retention times of the Labeled Toxics/LOC/window defining standard congeners (Section 7.12) in the verification test (Section 15.3) must be within ± 15 seconds of the respective retention times in the calibration or, if an alternate column or column system is employed, within ± 15 seconds of the respective retention times in the calibration for the alternate column or column system (Section 6.9.1.2).

15.4.1.2 Relative – The relative retention times of native CBs and labeled compounds in the verification test (Section 15.3) must be within their respective RRT limits in Table 2 or, if an alternate column or column system is employed, within their respective RRT limits for the alternate column or column system (Section 6.9.1.2).

15.4.1.3 If the absolute or relative retention time of any compound is not within the limits specified, the GC is not performing properly. In this event, adjust the GC and repeat the verification test (Section 15.3) or recalibrate (Section 10), or replace the GC column and either verify calibration or recalibrate.

15.4.2 GC resolution and minimum analysis time

15.4.2.1 As a final step in calibration verification, GC resolution and minimum analysis time are verified and response factors for congeners other than the Toxics and LOC CBs are updated.

15.4.2.2 The resolution and minimum analysis time specifications in Sections 6.9.1.1.2 and 6.9.1.1.1, respectively, must be met for the SPB-octyl column or, if an alternate column or column system is employed, must be met as specified for the alternate column or column system (Section 6.9.1.2). If these specifications are not met, the GC analysis conditions must be adjusted until the specifications are met, or the column must be replaced and the calibration verification tests repeated Sections 15.4.1 through 15.4.2.2), or the system must be recalibrated (Section 10).

15.4.2.3 After the resolution and minimum analysis time specifications are met, update the retention times and relative retention times for all congeners, and response factors for all congeners except the Toxics and LOC CBs. For the Toxics and LOC CBs, the multi-point calibration data must be used (Section 10.4) and verified (Section 15.3.4).

15.5 Ongoing precision and recovery

15.5.1 Analyze the extract of the ongoing precision and recovery (OPR) aliquot (Section 11.4.2.5, 11.5.4, 11.6.2, or 11.8.3.2) prior to analysis of samples from the same batch.

15.5.2 Compute the percent recovery of the Toxics/LOC CBs by isotope dilution (Section 10.4). Compute the percent recovery of each labeled compound by the internal standard method (Section 10.5).

15.5.3 For the Toxics/LOC CBs and labeled compounds, compare the recovery to the OPR limits given in Table 6. If all compounds meet the acceptance criteria, system performance is acceptable and analysis of blanks and samples may proceed. If, however, any individual concentration falls outside of the range given, the extraction/concentration processes are not being performed properly for that compound. In this event, correct the problem, re-prepare, extract, and clean up the sample batch and repeat the ongoing precision and recovery test (Section 15.5).

15.5.4 If desired, add results that pass the specifications in Section 15.5.3 to initial and previous ongoing data for each compound in each matrix. Update QC charts to form a graphic representation of continued laboratory performance. Develop a statement of laboratory accuracy for each congener in each matrix type by calculating the average percent recovery (R) and the standard deviation of percent recovery (S_R). Express the accuracy as a recovery interval from $R - 2S_R$ to $R + 2S_R$. For example, if $R = 95\%$ and $S_R = 5\%$, the accuracy is 85 to 105%.

15.6 Blank – Analyze the Method blank extracted with each sample batch immediately following analysis of the OPR aliquot to demonstrate freedom from contamination and freedom from carryover from the OPR analysis. If CBs will be carried from the OPR into the Method blank, analyze one or more aliquots of solvent between the OPR and the Method blank. The results of the analysis of the blank must meet the specifications in Section 9.5.2 before sample analyses may proceed.

16.0 Qualitative determination

A CB or labeled compound is identified in a standard, blank, or sample when all of the criteria in Sections 16.1 through 16.4 are met.

16.1 The signals for the two exact m/z's in Table 7 must be present and must maximize within the same two scans.

16.2 The signal-to-noise ratio (S/N) for the GC peak at each exact m/z must be greater than or equal to 2.5 for each CB detected in a sample extract, and greater than or equal to 10 for all CBs in the calibration and verification standards (Sections 10.3.3 and 15.3.3).

Note: *An interference between DiCB m/z 223.9974 and PFK m/z 223.9872 may preclude meeting the S/N requirement for the DiCB congeners. If identification is ambiguous, an experienced spectrometrist (Section 1.4) must determine the presence or absence of the congener.*

16.3 The ratio of the integrated areas of the two exact m/z's specified in Table 7 must be within the limit in Table 8, or within ± 15 percent of the ratio in the midpoint (CS-3) calibration or calibration verification (VER), whichever is most recent.

16.4 The relative retention time of the peak for a CB must be within the RRT QC limits specified in Table 2 or within similar limits developed from calibration data (Section 10.1.2). If an alternate column or column system is employed, the RRT for the CB must be within its respective RRT QC limits for the alternate column or column system (Section 6.9.1.2).

Note: *For native CBs determined by internal standard quantitation, a given CB congener may fall within more than one RT window and be mis-identified unless the RRT windows are made very narrow, as in Table 2. Therefore, consistency of the RT and RRT with other congeners and the labeled compounds may be required for rigorous congener identification. Retention time regression analysis may aid in this identification.*

16.5 Because of congener overlap and the potential for interfering substances, it is possible that all of the identification criteria (Sections 16.1-16.4) may not be met. It is also possible that loss of one or more chlorines from a highly chlorinated congener may inflate or produce a false concentration for a less-chlorinated congener that elutes at the same retention time (see Section 18.5). If identification is ambiguous, an experienced spectrometrist (Section 1.4) must determine the presence or absence of the congener.

16.6 If the criteria for identification in Sections 16.1-16.5 are not met, the CB has not been identified and the result for that congener may not be reported or used for permitting or regulatory compliance purposes. If interferences preclude identification, a new aliquot of sample must be extracted, further cleaned up, and analyzed.

17.0 Quantitative determination

17.1 Isotope dilution quantitation

17.1.1 By adding a known amount of the Labeled Toxics/LOC/window-defining compounds to every sample prior to extraction, correction for recovery of the CBs can be made because the native compound and its labeled analog exhibit similar effects upon extraction, concentration, and gas chromatography. Relative responses (RRs) are used in conjunction with the calibration data in Section 10.4 to determine concentrations in the final extract, so long as labeled compound spiking levels are constant.

17.1.2 Compute the concentrations in the extract of the Native Toxics/LOC CBs using the RRs from the calibration data (Section 10.4) and following equation:

$$C_{ex}\ (\text{ng/mL}) = \frac{(A1_n + A2_n)\ C_l}{(A1_l + A2_l)\ RR}$$

where:

C_{ex} = concentration of the PCB in the extract (ng/mL) and the other terms are as defined in Section 10.5.1

17.2 Internal standard quantitation and labeled compound recovery

17.2.1 Compute the concentrations in the extract of the labeled compounds (except labeled CB 178) and of the native compounds other than those in the Native Toxics/LOC standard using the response factors determined from calibration (Section 10.5) or calibration verification (Section 15.4.2.3) and the following equation:

$$C_{ex}\ (\text{ng/mL}) = \frac{(A1_s + A2_s)\ C_{is}}{(A1_{is} + A2_{is})\ RF}$$

where:

C_{ex} = concentration of the native or labeled compound in the extract (ng/mL) and the other terms are as defined in Section 10.5.1

17.2.2 Using the concentration in the extract determined above, compute the percent recovery of the Labeled Toxics/LOC/window-defining CBs and the Labeled cleanup standard CBs using the following equation:

$$\text{Recovery}\,(\%) = \frac{\text{Concentration found (ng/mL)}}{\text{Concentration spiked (ng/mL)}}\ \text{x}\ 100$$

17.3 The concentration of a native CB in the solid phase of the sample is computed using the concentration of the compound in the extract and the weight of the solids (Section 11.2.2.3), as follows:

$$\text{Concentration in solid sample (ng/kg)} = \frac{C_{ex}\ V_{ex}}{W_s}$$

where:

C_{ex} = The concentration of the compound in the extract (ng/mL).
V_{ex} = The extract volume in mL.
W_s = The sample weight (dry weight) in kg.

17.4 The concentration of a native CB in the aqueous phase of the sample is computed using the concentration of the compound in the extract and the volume of water extracted (Section 11.4.2.1), as follows:

$$\text{Concentration in aqueous sample (ng/L)} = \frac{C_{ex}\ V_{ex}}{V_s}\ \text{x}\ 1000$$

where:

C_{ex} = The concentration of the compound in the extract (pg/mL).
V_{ex} = The extract volume in mL.
V_s = The sample volume in liters.

17.5 If the SICP area at either quantitation m/z for any congener exceeds the calibration range of the system, dilute the sample extract by the factor necessary to bring the concentration within the calibration range, adjust the concentration of the Labeled injection internal standard to 100 pg/µL in the extract, and analyze an aliquot of this diluted extract. If the CBs cannot be measured reliably by isotope dilution, dilute and analyze an aqueous sample or analyze a smaller portion of a soil, tissue, or mixed-phase sample. Adjust the CB congener concentrations, detection limits, and minimum levels to account for the dilution.

17.6 Reporting of results – Results are reported to three significant figures for the CBs and labeled compounds found in all standards, blanks, and samples.

17.6.1 Reporting units and levels

17.6.1.1 Aqueous samples – Report results in pg/L (parts-per-quadrillion).

17.6.1.2 Samples containing greater than 1% solids (soils, sediments, filter cake, compost) – Report results in ng/kg based on the dry weight of the sample. Report the percent solids so that the result may be converted to aqueous units.

17.6.1.3 Tissues – Report results in ng/kg of wet tissue, not on the basis of the lipid content of the tissue. Report the percent lipid content, so that the data user can calculate the concentration on a lipid basis if desired.

17.6.1.4 Reporting level

17.6.1.4.1 Report the result for each congener at or above the minimum level of quantitation (ML; Table 2) for analyses of blanks, standards, and samples. The MLs in Table 2 are the levels that can be achieved in the presence of common laboratory contamination. A laboratory may establish an ML for a CB congener lower than the MLs in Table 2. MLs may be established as low as the lowest calibration point (Table 5) provided that the concentration of the congener in a minimum of 10 blanks for a sample medium (e.g., water, soil, sludge, tissue) is significantly below the ML in Table 2. “Significant” means that the ML for the congener is no less than 2 standard deviations above the mean (average) level in the minimum of 10 blanks (Reference 19). The blanks must be analyzed during the same period that samples are analyzed, ideally over an approximately 1-month period.

17.6.1.4.2 Standards (VER, IPR, OPR) and samples – Report the result for each congener at or above the ML (Table 2) to 3 significant figures. Report results below the ML as <ML (where ML is the concentration at the ML) or as required by the regulatory authority or permit.

17.6.1.4.3 Blanks – Report the result for each congener above the ML to 3 significant figures. Report a result below the ML but above the MDL to 2 significant figures. Report a result below the MDL as <MDL (where MDL is the concentration at the MDL) or as required by the regulatory authority or permit.

17.6.1.4.4 Blank correction – Blank-corrected results may be reported in addition to reporting of separate results for samples (Section 17.6.1.4.1) and blanks (Section 17.6.1.4.2). The recommended procedure for blank correction (Reference 19) is that a result is significantly above the blank level, and the level in the blank may be subtracted, if the result is 2 standard deviations above the mean (average) of results of analyses of 10 or more blanks for a sample medium.

17.6.2 Results for a CB in a sample that has been diluted are reported at the least dilute level at which the area at the quantitation m/z is within the calibration range (Section 17.5).

17.6.3 For a CB having a labeled analog, report results at the least dilute level at which the area at the quantitation m/z is within the calibration range (Section 17.5) and the labeled compound recovery is within the normal range for the Method (Section 9.3 and Table 6).

17.6.4 If requested, the total concentration of all congeners at a given level of chlorination (homolog; i.e., total TrCB, total PeCB, total HxCB) may be reported by summing the concentrations of all congeners identified at that LOC, including both the Toxics and other congeners. Also if requested, total CBs may be reported by summing all congeners identified at all LOCs.

17.6.5 Reporting of coeluting PCB congeners–Optionally, Delaware River Basin Commission (DRBC) data qualifier flags and conventions for reporting coeluting congeners (see http://www.state.nj.us/drbc/PCB_info.htm), or other reporting convention agreed upon between the laboratory and the discharger/permittee or regulatory/control authority, may be used.

18.0 Analysis of complex samples

18.1 Some samples may contain high levels (>10 ng/L; >1000 ng/kg) of the compounds of interest, interfering compounds, and/or polymeric materials. Some extracts may not concentrate to 20 µL (Section 12.7.7); others may overload the GC column and/or mass spectrometer. Fragment ions from congeners at higher levels of chlorination may interfere with determination of congeners at lower levels of chlorination.

18.2 Analyze a smaller aliquot of the sample (Section 17.5) when the extract will not concentrate to 20 µL after all cleanup procedures have been exhausted. If a smaller aliquot of soils or mixed-phase samples is analyzed, attempt to assure that the sample is representative.

18.3 Perform integration of peak areas and calculate concentrations manually when interferences preclude computerized calculations.

18.4 Several laboratories have reported that backgrounds of many of the CB congeners are difficult to eliminate, and that these backgrounds can interfere with the determination of the CBs in environmental samples. Backgrounds of Toxics with congener numbers 105, 114, 118, 123, 156, 157, and 167 are common. The effects of contamination on results for these congeners should be understood in order to make a reliable determination.

18.5 Interferences may pose a problem in the determination of congeners 81, 123, 126, and 169 in some environmental samples. Loss of one or more chlorines from a highly chlorinated congener may inflate or produce a false concentration for a less-chlorinated congener that elutes at the same retention time. If, upon inspection of the chromatogram, the possibility of interferences is evident (e.g., high concentrations of fragments from loss of one or two chlorines from higher chlorinated closely eluting congeners), carbon column fractionation (Section 13.4) and analysis is recommended.

18.6 Recovery of labeled compounds – In most samples, recoveries of the labeled compounds will be similar to those from reagent water or from the alternate matrix (Section 7.6).

18.6.1 If the recovery of any of the labeled compounds is outside of the normal range (Table 6), a diluted sample must be analyzed (Section 17.5).

18.6.2 If the recovery of any of the labeled compounds in the diluted sample is outside of normal range, the Diluted combined 209 congener solution (Section 7.10.2.2.2) must be analyzed and calibration verified (Section 15.3).

18.6.3 If the calibration cannot be verified, a new calibration must be performed and the original sample extract reanalyzed.

18.6.4 If calibration is verified and the diluted sample does not meet the limits for labeled compound recovery, the Method does not apply to the sample being analyzed and the result may not be reported or used for permitting or regulatory compliance purposes. In this case, alternate extraction and cleanup procedures in this Method or an alternate GC column must be employed to resolve the interference. If all cleanup procedures in this Method and an alternate GC column have been employed and labeled compound recovery remains outside of the normal range, extraction and/or cleanup procedures that are beyond this scope of this Method will be required to analyze the sample.

19.0 Pollution prevention

19.1 Pollution prevention encompasses any technique that reduces or eliminates the quantity or toxicity of waste at the point of generation. Many opportunities for pollution prevention exist in laboratory operation. EPA has established a preferred hierarchy of environmental management techniques that places pollution prevention as the management option of first choice. Whenever feasible, laboratory personnel should use pollution prevention techniques to address waste generation. When wastes cannot be reduced feasibly at the source, the Agency recommends recycling as the next best option.

19.2 The CBs in this Method are used in extremely small amounts and pose little threat to the environment when managed properly. Standards should be prepared in volumes consistent with laboratory use to minimize the disposal of excess volumes of expired standards.

19.3 For information about pollution prevention that may be applied to laboratories and research institutions, consult *Less is Better: Laboratory Chemical Management for Waste Reduction*, available from the American Chemical Society's Department of Governmental Relations and Science Policy, 1155 16th Street NW, Washington DC 20036, 202/872-4477.

20.0 Waste management

20.1 The laboratory is responsible for complying with all Federal, State, and local regulations governing waste management, particularly the hazardous waste identification rules and land disposal restrictions, and to protect the air, water, and land by minimizing and controlling all releases from fume hoods and bench operations. Compliance is also required with any sewage discharge permits and regulations. An overview of requirements can be found in *Environmental Management Guide for Small Laboratories* (EPA 233-B-98-001).

20.2 Samples containing HCl or H_2SO_4 to pH <2 are hazardous and must be neutralized before being poured down a drain or must be handled as hazardous waste.

20.3 The CBs decompose above 800 ºC. Low-level waste such as absorbent paper, tissues, animal remains, and plastic gloves may be burned in an appropriate incinerator. Gross quantities (milligrams) should be packaged securely and disposed of through commercial or governmental channels that are capable of handling extremely toxic wastes.

20.4 Liquid or soluble waste should be dissolved in methanol or ethanol and irradiated with ultraviolet light with a wavelength shorter than 290 nm for several days. Use F40 BL or equivalent lamps. Analyze liquid wastes, and dispose of the solutions when the CBs can no longer be detected.

20.5 For further information on waste management, consult *The Waste Management Manual for Laboratory Personnel* and *Less is Better-Laboratory Chemical Management for Waste Reduction*, available from the American Chemical Society's Department of Government Relations and Science Policy, 1155 16th Street NW, Washington, DC 20036.

21.0 Method performance

The original version of Method 1668 was validated in single-laboratory studies at Pacific Analytical, Inc., Carlsbad, California and AXYS Analytical Services, Ltd., Sidney, British Columbia, Canada. The next version, Method 1668A, was validated and data were collected at AXYS Analytical (Reference 20). Method 1668A was subjected to peer review in 1999, and published in 2000. In 2003-2004, EPA conducted an interlaboratory method validation study of Method 1668A (Reference 21), subjected the study to a peer review, and subsequently published interlaboratory performance data in Method 1668B.

After release of Method 1668B, it was reported to EPA that some of the QC acceptance criteria in Method 1668B did not allow excursions above 100 percent. As a result, the QC acceptance criteria were re-developed using data from the interlaboratory study and data from AXYS Analytical and TestAmerica-Knoxville, Tennessee. The revised QC acceptance criteria were published in addendum to the Interlaboratory Study Report (Reference 22).

Subsequent to development of the revised QC acceptance criteria, AXYS Analytical, TestAmerica-Knoxville, and Battelle-Columbus provided method detection limit (MDL) data to EPA. These data were combined to produced pooled MDLs and MLs (Reference 23). Method 1668B was revised to Method 1668C to incorporate the revised QC acceptance criteria and revised MDLs and MLs.

Figure 8 is a chromatogram showing method performance at each level of chlorination.

22.0 References

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23.0 Tables and Figures

Table 1. Names, Congener Numbers, and CAS Registry Numbers for Native and Labeled Chlorinated Biphenyl (CB) Congeners Determined by Isotope Dilution and Internal Standard HRGC/HRMS

CB congener name[1]	Congener number	CAS Registry number	Labeled analog name	Labeled analog congener number	CAS Registry number
2-MoCB	1	2051-60-7	$^{13}C_{12}$-2-MoCB[2]	1L	234432-85-0
3-MoCB	2	2051-61-8			
4-MoCB	3	2051-62-9	$^{13}C_{12}$-4-MoCB[2]	3L	208263-77-8
2,2'-DiCB	4	13029-08-8	$^{13}C_{12}$-2,2'-DiCB[2]	4L	234432-86-1
2,3-DiCB	5	16605-91-7			
2,3'-DiCB	6	25569-80-6			
2,4-DiCB	7	33284-50-3			
2,4'-DiCB[3]	8	34883-43-7			
2,5-DiCB	9	34883-39-1	$^{13}C_{12}$-2,5-DiCB[4]	9L	250694-89-4
2,6-DiCB	10	33146-45-1			
3,3'-DiCB	11	2050-67-1			
3,4-DiCB	12	2974-92-7			
3,4'-DiCB	13	2974-90-5			
3,5-DiCB	14	34883-41-5			
4,4'-DiCB	15	2050-68-2	$^{13}C_{12}$-4,4'-DiCB[2]	15L	208263-67-6
2,2',3-TrCB	16	38444-78-9			
2,2',4-TrCB	17	37680-66-3			
2,2',5-TrCB[3]	18	37680-65-2			
2,2',6-TrCB	19	38444-73-4	$^{13}C_{12}$-2,2',6-TrCB[2]	19L	234432-87-2
2,3,3'-TrCB	20	38444-84-7			
2,3,4-TrCB	21	55702-46-0			
2,3,4'-TrCB	22	38444-85-8			
2,3,5-TrCB	23	55720-44-0			
2,3,6-TrCB	24	55702-45-9			
2,3',4-TrCB	25	55712-37-3			
2,3',5-TrCB	26	38444-81-4			
2,3',6-TrCB	27	38444-76-7			
2,4,4'-TrCB[3]	28	7012-37-5	$^{13}C_{12}$-2,4,4'-TriCB[5]	28L	208263-76-7
2,4,5-TrCB	29	15862-07-4			
2,4,6-TrCB	30	35693-92-6			
2,4',5-TrCB	31	16606-02-3			
2,4',6-TrCB	32	38444-77-8			
2',3,4-TrCB	33	38444-86-9			
2',3,5-TrCB	34	37680-68-5			
3,3',4-TrCB	35	37680-69-6			
3,3',5-TrCB	36	38444-87-0			
3,4,4'-TrCB	37	38444-90-5	$^{13}C_{12}$-3,4,4'-TrCB[2]	37L	208263-79-0
3,4,5-TrCB	38	53555-66-1			
3,4',5-TrCB	39	38444-88-1			
2,2',3,3'-TeCB	40	38444-93-8			
2,2',3,4-TeCB	41	52663-59-9			
2,2',3,4'-TeCB	42	36559-22-5			
2,2',3,5-TeCB	43	70362-46-8			
2,2',3,5'-TeCB[3]	44	41464-39-5			

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CB congener name[1]	Congener number	CAS Registry number	Labeled analog name	Labeled analog congener number	CAS Registry number
2,2',3,6-TeCB	45	70362-45-7			
2,2',3,6'-TeCB	46	41464-47-5			
2,2',4,4'-TeCB	47	2437-79-8			
2,2',4,5-TeCB	48	70362-47-9			
2,2',4,5'-TeCB	49	41464-40-8			
2,2',4,6-TeCB	50	62796-65-0			
2,2',4,6'-TeCB	51	68194-04-7			
2,2',5,5'-TeCB[3]	52	35693-99-3	$^{13}C_{12}$-2,2',5,5'-TeCB[4]	52L	208263-80-3
2,2',5,6'-TeCB	53	41464-41-9			
2,2',6,6'-TeCB	54	15968-05-5	$^{13}C_{12}$-2,2',6,6'-TeCB[2]	54L	234432-88-3
2,3,3',4'-TeCB	55	74338-24-2			
2,3,3',4'-TeCB	56	41464-43-1			
2,3,3',5-TeCB	57	70424-67-8			
2,3,3',5'-TeCB	58	41464-49-7			
2,3,3',6-TeCB	59	74472-33-6			
2,3,4,4'-TeCB	60	33025-41-1			
2,3,4,5-TeCB	61	33284-53-6			
2,3,4,6-TeCB	62	54230-22-7			
2,3,4',5-TeCB	63	74472-34-7			
2,3,4',6-TeCB	64	52663-58-8			
2,3,5,6-TeCB	65	33284-54-7			
2,3',4,4'-TeCB[3]	66	32598-10-0			
2,3',4,5-TeCB	67	73575-53-8			
2,3',4,5'-TeCB	68	73575-52-7			
2,3',4,6-TeCB	69	60233-24-1			
2,3',4',5-TeCB	70	32598-11-1			
2,3',4',6-TeCB	71	41464-46-4			
2,3',5,5'-TeCB	72	41464-42-0			
2,3',5',6-TeCB	73	74338-23-1			
2,4,4',5-TeCB	74	32690-93-0			
2,4,4',6-TeCB	75	32598-12-2			
2',3,4,5-TeCB	76	70362-48-0			
3,3',4,4'-TeCB[3,6]	77	32598-13-3	$^{13}C_{12}$-3,3',4,4'-TeCB[2,7]	77L	105600-23-5
3,3',4,5-TeCB	78	70362-49-1			
3,3',4,5'-TeCB	79	41464-48-6			
3,3',5,5'-TeCB	80	33284-52-5			
3,4,4',5-TeCB[6]	81	70362-50-4	$^{13}C_{12}$-3,4,4',5-TeCB[7]	81L	208461-24-9
2,2',3,3',4-PeCB	82	52663-62-4			
2,2',3,3',5-PeCB	83	60145-20-2			
2,2',3,3',6-PeCB	84	52663-60-2			
2,2',3,4,4'-PeCB	85	65510-45-4			
2,2',3,4,5-PeCB	86	55312-69-1			
2,2',3,4,5'-PeCB	87	38380-02-8			
2,2',3,4,6-PeCB	88	55215-17-3			
2,2',3,4,6'-PeCB	89	73575-57-2			
2,2',3,4',5-PeCB	90	68194-07-0			

Table 1. Names, Congener Numbers, and CAS Registry Numbers for Native and Labeled Chlorinated Biphenyl (CB) Congeners Determined by Isotope Dilution and Internal Standard HRGC/HRMS

CB congener name[1]	Congener number	CAS Registry number	Labeled analog name	Labeled analog congener number	CAS Registry number
2,2',3,4',6-PeCB	91	68194-05-8			
2,2',3,5,5'-PeCB	92	52663-61-3			
2,2',3,5,6-PeCB	93	73575-56-1			
2,2',3,5,6'-PeCB	94	73575-55-0			
2,2',3,5',6-PeCB	95	38379-99-6			
2,2',3,6,6'-PeCB	96	73575-54-9			
2,2',3',4,5-PeCB	97	41464-51-1			
2,2',3',4,6-PeCB	98	60233-25-2			
2,2',4,4',5-PeCB	99	38380-01-7			
2,2',4,4',6-PeCB	100	39485-83-1			
2,2',4,5,5'-PeCB[3]	101	37680-73-2	$^{13}C_{12}$-2,2',4,5,5'-PeCB[4]	101L	104130-39-4
2,2',4,5,6'-PeCB	102	68194-06-9			
2,2',4,5,'6-PeCB	103	60145-21-3			
2,2',4,6,6'-PeCB	104	56558-16-8	$^{13}C_{12}$-2,2',4,6,6'-PeCB[2]	104L	234432-89-4
2,3,3',4,4'-PeCB[3,6]	105	32598-14-4	$^{13}C_{12}$-2,3,3',4,4'-PeCB[7]	105L	208263-62-1
2,3,3',4,5-PeCB	106	70424-69-0			
2,3,3',4',5-PeCB	107	70424-68-9			
2,3,3',4,5'-PeCB	108	70362-41-3			
2,3,3',4,6-PeCB	109	74472-35-8			
2,3,3',4',6-PeCB	110	38380-03-9			
2,3,3',5,5'-PeCB	111	39635-32-0	$^{13}C_{12}$-2,3,3',5,5'-PeCB[5]	111 L	235416-29-2
2,3,3',5,6-PeCB	112	74472-36-9			
2,3,3',5',6-PeCB	113	68194-10-5			
2,3,4,4',5-PeCB[6]	114	74472-37-0	$^{13}C_{12}$-2,3,4,4',5-PeCB[7]	114 L	208263-63-2
2,3,4,4',6-PeCB	115	74472-38-1			
2,3,4,5,6-PeCB	116	18259-05-7			
2,3,4',5,6-PeCB	117	68194-11-6			
2,3',4,4',5-PeCB[3,6]	118	31508-00-6	$^{13}C_{12}$-2,3',4,4',5-PeCB[7]	118 L	104130-40-7
2,3',4,4',6-PeCB	119	56558-17-9			
2,3',4,5,5'-PeCB	120	68194-12-7			
2,3',4,5,'6-PeCB	121	56558-18-0			
2',3,3',4,5-PeCB	122	76842-07-4			
2',3,4,4',5-PeCB[6]	123	65510-44-3	$^{13}C_{12}$-2',3,4,4',5-PeCB[7]	123L	208263-64-3
2',3,4,5,5'-PeCB	124	70424-70-3			
2',3,4,5,6'-PeCB	125	74472-39-2			
3,3',4,4',5-PeCB[3,6]	126	57465-28-8	$^{13}C_{12}$-3,3',4,4',5-PeCB[2,7]	126L	208263-65-4
3,3',4,5,5'-PeCB	127	39635-33-1			
2,2',3,3',4,4'-HxCB[3]	128	38380-07-3			
2,2',3,3',4,5-HxCB	129	55215-18-4			
2,2',3,3',4,5'-HxCB	130	52663-66-8			
2,2',3,3',4,6-HxCB	131	61798-70-7			
2,2',3,3',4,6'-HxCB	132	38380-05-1			
2,2',3,3',5,5'-HxCB	133	35694-04-3			
2,2',3,3',5,6-HxCB	134	52704-70-8			
2,2',3,3',5,6'-HxCB	135	52744-13-5			
2,2',3,3',6,6'-HxCB	136	38411-22-2			

Table 1. Names, Congener Numbers, and CAS Registry Numbers for Native and Labeled Chlorinated Biphenyl (CB) Congeners Determined by Isotope Dilution and Internal Standard HRGC/HRMS

CB congener name[1]	Congener number	CAS Registry number	Labeled analog name	Labeled analog congener number	CAS Registry number
2,2',3,4,4',5-HxCB	137	35694-06-5			
2,2',3,4,4',5'-HxCB[3]	138	35065-28-2	$^{13}C_{12}$-2,2',3,4,4',5'-HxCB[4]	138L	208263-66-5
2,2',3,4,4',6-HxCB	139	56030-56-9			
2,2',3,4,4',6'-HxCB	140	59291-64-4			
2,2',3,4,5,5'-HxCB	141	52712-04-6			
2,2',3,4,5,6-HxCB	142	41411-61-4			
2,2',3,4,5,6'-HxCB	143	68194-15-0			
2,2',3,4,5',6-HxCB	144	68194-14-9			
2,2',3,4,6,6'-HxCB	145	74472-40-5			
2,2',3,4',5,5'-HxCB	146	51908-16-8			
2,2',3,4',5,6-HxCB	147	68194-13-8			
2,2',3,4',5,6'-HxCB	148	74472-41-6			
2,2',3,4',5',6-HxCB	149	38380-04-0			
2,2',3,4',6,6'-HxCB	150	68194-08-1			
2,2',3,5,5',6-HxCB	151	52663-63-5			
2,2',3,5,6,6'-HxCB	152	68194-09-2			
2,2',4,4',5,5'-HxCB[3]	153	35065-27-1			
2,2',4,4',5',6-HxCB	154	60145-22-4			
2,2',4,4',6,6'-HxCB	155	33979-03-2	$^{13}C_{12}$-2,2',4,4',6,6'-HxCB[2]	155L	234432-90-7
2,3,3',4,4',5-HxCB[6]	156	38380-08-4	$^{13}C_{12}$-2,3,3',4,4',5-HxCB[7]	156L	208263-68-7
2,3,3',4,4',5'-HxCB[6]	157	69782-90-7	$^{13}C_{12}$-2,3,3',4,4',5'-HxCB[7]	157L	235416-30-5
2,3,3',4,4',6-HxCB	158	74472-42-7			
2,3,3',4,5,5'-HxCB	159	39635-35-3			
2,3,3',4,5,6-HxCB	160	41411-62-5			
2,3,3',4,5',6-HxCB	161	74472-43-8			
2,3,3',4',5,5'-HxCB	162	39635-34-2			
2,3,3',4',5,6-HxCB	163	74472-44-9			
2,3,3',4',5',6-HxCB	164	74472-45-0			
2,3,3',5,5',6-HxCB	165	74472-46-1			
2,3,4,4',5,6-HxCB	166	41411-63-6			
2,3',4,4',5,5'-HxCB[6]	167	52663-72-6	$^{13}C_{12}$-2,3',4,4',5,5'-HxCB[7]	167L	208263-69-8
2,3',4,4',5',6-HxCB	168	59291-65-5			
3,3',4,4',5,5'-HxCB[3,6]	169	32774-16-6	$^{13}C_{12}$-3,3',4,4',5,5'-HxCB[2,7]	169L	208263-70-1
2,2',3,3',4,4',5-HpCB[3]	170	35065-30-6	$^{13}C_{12}$-2,2',3,3',4,4',5-HpCB	170L	160901-80-4
2,2'3,3',4,4',6-HpCB	171	52663-71-5			
2,2',3,3',4,5,5'-HpCB	172	52663-74-8			
2,2',3,3',4,5,6-HpCB	173	68194-16-1			
2,2',3,3',4,5,6'-HpCB	174	38411-25-5			
2,2',3,3',4,5',6-HpCB	175	40186-70-7			
2,2',3,3',4,6,6'-HpCB	176	52663-65-7			
2,2',3,3',4',5,6-HpCB	177	52663-70-4			
2,2',3,3',5,5',6-HpCB	178	52663-67-9	$^{13}C_{12}$-2,2',3,3',5,5',6-HpCB[5]	178L	232919-67-4
2,2',3,3',5,6,6'-HpCB	179	52663-64-6			
2,2',3,4,4',5,5'-HpCB[3]	180	35065-29-3	$^{13}C_{12}$-2,2',3,4,4',5,5'-HpCB	180L	160901-82-6
2,2',3,4,4',5,6-HpCB	181	74472-47-2			
2,2',3,4,4',5,6'-HpCB	182	60145-23-5			

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CB congener name[1]	Congener number	CAS Registry number	Labeled analog name	Labeled analog congener number	CAS Registry number
2,2',3,4,4',5',6-HpCB	183	52663-69-1			
2,2',3,4,4',6,6'-HpCB	184	74472-48-3			
2,2',3,4,5,5',6-HpCB	185	52712-05-7			
2,2',3,4,5,6,6'-HpCB	186	74472-49-4			
2,2',3,4',5,5',6-HpCB[3]	187	52663-68-0			
2,2',3,4',5,6,6'-HpCB	188	74487-85-7	$^{13}C_{12}$-2,2',3,4',5,6,6'-HpCB[2]	188L	234432-91-8
2,3,3',4,4',5,5'-HpCB[6]	189	39635-31-9	$^{13}C_{12}$-2,3,3',4,4',5,5'-HpCB[2,7]	189L	208263-73-4
2,3,3',4,4',5,6-HpCB	190	41411-64-7			
2,3,3',4,4',5',6-HpCB	191	74472-50-7			
2,3,3',4,5,5',6-HpCB	192	74472-51-8			
2,3,3',4',5,5',6-HpCB	193	69782-91-8			
2,2',3,3',4,4',5,5'-OcCB	194	35694-08-7	$^{13}C_{12}$-2,2',3,3',4,4',5,5'-OcCB[4]	194L	208263-74-5
2,2',3,3',4,4',5,6-OcCB[3]	195	52663-78-2			
2,2',3,3',4,4',5,6'-OcCB	196	42740-50-1			
2,2',3,3',4,4',6,6'-OcCB	197	33091-17-7			
2,2',3,3',4,5,5',6-OcCB	198	68194-17-2			
2,2',3,3',4,5,5',6'-OcCB	199	52663-75-9			
2,2',3,3',4,5,6,6'-OcCB	200	52663-73-7			
2,2',3,3',4,5',6,6'-OcCB	201	40186-71-8			
2,2',3,3',5,5',6,6'-OcCB	202	2136-99-4	$^{13}C_{12}$-2,2',3,3',5,5',6,6'-OcCB[2]	202L	105600-26-8
2,2',3,4,4',5,5',6-OcCB	203	52663-76-0			
2,2',3,4,4',5,6,6'-OcCB	204	74472-52-9			
2,3,3',4,4',5,5',6-OcCB	205	74472-53-0	$^{13}C_{12}$-2,3,3',4,4',5,5',6-OcCB[2]	205L	234446-64-1
2,2',3,3',4,4',5,5',6-NoCB[3]	206	40186-72-9	$^{13}C_{12}$-2,2',3,3',4,4',5,5',6-NoCB[2]	206L	208263-75-6
2,2',3,3',4,4',5,6,6'-NoCB	207	52663-79-3			
2,2',3,3',4,5,5',6,6'-NoCB	208	52663-77-1	$^{13}C_{12}$-2,2',3,3',4,5,5',6,6'-NoCB[2]	208L	234432-92-9
DeCB[3]	209	2051-24-3	$^{13}C_{12}$-DeCB[2]	209L	105600-27-9

1. Abbreviations for chlorination levels

MoCB	monochlorobiphenyl	HxCB	hexachlorobiphenyl
DiCB	dichlorobiphenyl	HpCB	heptachlorobiphenyl
TrCB	trichlorobiphenyl	OcCB	octachlorobiphenyl
TeCB	tetrachlorobiphenyl	NoCB	nonachlorobiphenyl
PeCB	pentachlorobiphenyl	DeCB	decachlorobiphenyl

2. Labeled level of chlorination (LOC) window-defining congener
3. National Oceanic and Atmospheric Administration (NOAA) congener of interest
4. Labeled injection internal standard
5. Labeled clean-up standard
6. World Health Organization (WHO) toxic congener
7. Labeled analog of WHO toxic congener

Table 2. Retention times (RT), RT references, relative retention times (RRTs), method detection limits (MDLs), and minimum levels of quantitation (MLs) for the 209 CB congeners on SPB-octyl.

Cl No.[1]	Congener No.[2,3]	RT Ref[4]	RT[5]	RRT[6]	RRT limits[7]	Window (sec)[8]	Quantitation reference[9]	Detection limits and minimum levels - Matrix and concentration[10]				
								Water (pg/L)		Other (ng/kg)		Extract (pg/µL)
								MDL	ML	MDL	ML	ML
Compounds using 9L ($^{13}C_{12}$-2,5-DiCB) as Labeled injection internal standard												
CB congener												
Monochlorobiphenyls												
1	1	1L	13:44	1.0012	0.9988-1.0036	-1+3	1L	10	20	1.0	2	1
1	2	3L	16:08	0.9878	0.9847-0.9908	6	1L/3L	7	20	0.7	2	1
1	3	3L	16:21	1.0010	0.9990-1.0031	-1+3	3L	11	50	1.1	5	2.5
Dichlorobiphenyls												
2	4	4L	16:40	1.0010	0.9990-1.0030	-1+3	4L	13	50	1.3	5	2.5
2	10	4L	16:53	1.0140	1.0110-1.0170	6	4L/15L	13	50	1.3	5	2.5
2	9	4L	18:55	1.1361	1.1331-1.1391	6	4L/15L	7	20	0.7	2	1
2	7	4L	19:07	1.1481	1.1451-1.1512	6	4L/15L	8	20	0.8	2	1
2	6	4L	19:26	1.1672	1.1642-1.1702	6	4L/15L	7	20	0.7	2	1
2	5	4L	19:48	1.1892	1.1862-1.1922	6	4L/15L	8	20	0.8	2	1
2	8	4L	19:56	1.1972	1.1942-1.2002	6	4L/15L	15	50	1.5	5	2.5
2	14	15L	21:42	0.9267	0.9246-0.9288	6	4L/15L	8	20	0.8	2	1
2	11	15L	22:42	0.9694	0.9673-0.9715	6	4L/15L	34	100	3.4	10	5
2	13	15L	23:03	0.9843	0.9822-0.9865	6	4L/15L	19	50	1.9	5	2.5
2	12	15L	23:06	0.9865	0.9843-0.9886	6	4L/15L					
2	13/12	15L	23:04	0.9851	0.9829-0.9872	6	4L/15L					
2	15	15L	23:26	1.0007	0.9993-1.0021	-1+3	15L	16	50	1.6	5	2.5
Trichlorobiphenyls												
3	19	19L	20:19	1.0008	0.9992-1.0025	-1+3	19L	8	20	0.8	2	1
3	30	19L	22:15	1.0961	1.0936-1.0985	6	19L/37L	16	50	1.6	5	2.5
3	18	19L	22:23	1.1026	1.1002-1.1051	6	19L/37L					

								Detection limits and minimum levels - Matrix and concentration[10]				
								Water (pg/L)		Other (ng/kg)		Extract (pg/µL)
Cl No.[1]	Congener No.[2,3]	RT Ref[4]	RT[5]	RRT[6]	RRT limits[7]	Window (sec)[8]	Quantitation reference[9]	MDL	ML	MDL	ML	ML
3	30/18	19L	22:19	1.0993	1.0969-1.1018	6	19L/37L					
3	17	19L	22:49	1.1240	1.1215-1.1264	6	19L/37L	9	20	0.9	2	1
3	27	19L	23:06	1.1379	1.1355-1.1404	6	19L/37L	8	20	0.8	2	1
3	24	19L	23:14	1.1445	1.1420-1.1470	6	19L/37L	10	20	1.0	2	1
3	16	19L	23:25	1.1535	1.1511-1.1560	6	19L/37L	9	20	0.9	2	1
3	32	19L	24:57	1.2291	1.2266-1.2315	6	19L/37L	8	20	0.8	2	1
3	34	19L	25:17	1.2455	1.2430-1.2479	6	19L/37L	7	20	0.7	2	1
3	23	19L	25:26	1.2529	1.2504-1.2553	6	19L/37L	7	20	0.7	2	1
3	29	19L	25:47	1.2701	1.2660-1.2742	10	19L/37L	12	50	1.2	5	2.5
3	26	19L	25:48	1.2709	1.2668-1.2750	10	19L/37L					
3	29/26	19L	25:48	1.2709	1.2668-1.2750	10	19L/37L					
3	25	37L	26:04	0.8364	0.8348-0.8380	6	19L/37L	8	20	0.8	2	1
3	31	37L	26:25	0.8476	0.8460-0.8492	6	19L/37L	18	50	1.8	5	2.5
3	28	37L	26:44	0.8578	0.8551-0.8604	10	19L/37L	22	50	2.2	5	2.5
3	20	37L	26:49	0.8604	0.8578-0.8631	10	19L/37L					
3	28/20	37L	26:47	0.8594	0.8567-0.8620	10	19L/37L					
3	21	37L	26:58	0.8652	0.8626-0.8679	10	19L/37L	21	50	2.1	5	2.5
3	33	37L	27:01	0.8668	0.8642-0.8695	10	19L/37L					
3	21/33	37L	26:59	0.8658	0.8631-0.8684	10	19L/37L					
3	22	37L	27:29	0.8818	0.8802-0.8834	6	19L/37L	9	20	0.9	2	1
3	36	37L	29:05	0.9332	0.9316-0.9348	6	19L/37L	8	20	0.8	2	1
3	39	37L	29:30	0.9465	0.9449-0.9481	6	19L/37L	8	20	0.8	2	1
3	38	37L	30:10	0.9679	0.9663-0.9695	6	19L/37L	7	20	0.7	2	1
3	35	37L	30:42	0.9850	0.9834-0.9866	6	19L/37L	9	20	0.9	2	1
3	37	37L	31:11	1.0005	0.9995-1.0011	-1+3	37L	10	20	1.0	2	1
	Labeled Compounds											
1	1L	9L	13:43	0.7257	0.7125-0.7390	30	9L					
1	3L	9L	16:20	0.8642	0.8510-0.8774	30	9L					
2	4L	9L	16:39	0.8810	0.8677-0.8942	30	9L					
2	15L	9L	23:25	1.2390	1.2302-1.2478	20	9L					
3	19L	9L	20:18	1.0741	1.0608-1.0873	30	9L					
3	37L	52L	31:10	1.0841	1.0754-1.0928	30	52L					

Cl No.[1]	Congener No.[2,3]	RT Ref[4]	RT[5]	RRT[6]	RRT limits[7]	Window (sec)[8]	Quantitation reference[9]	Detection limits and minimum levels - Matrix and concentration[10]				
								Water (pg/L)		Other (ng/kg)		Extract (pg/µL)
								MDL	ML	MDL	ML	ML
Compounds using 52L ($^{13}C_{12}$-2,2',5,5'-TeCB) as Labeled injection internal standard												
	CB congener											
	Tetrachlorobiphenyls											
4	54	54L	23:51	1.0007	0.9993-1.0021	-1+3	54L	14	50	1.4	5	2.5
4	50	54L	26:07	1.0958	1.0923-1.0993	10	54L/81L/77L	25	100	2.5	10	5
4	53	54L	26:09	1.0972	1.0937-1.1007	10	54L/81L/77L					
4	50/53	54L	26:08	1.0965	1.0930-1.1000	10	54L/81L/77L					
4	45	54L	26:55	1.1294	1.1259-1.1329	10	54L/81L/77L	22	50	2.2	5	2.5
4	51	54L	26:58	1.1315	1.1280-1.1350	10	54L/81L/77L					
4	45/51	54L	26:57	1.1308	1.1273-1.1343	10	54L/81L/77L					
4	46	54L	27:18	1.1455	1.1434-1.1476	6	54L/81L/77L	10	20	1.0	2	1
4	52	54L	28:45	1.2063	1.2042-1.2084	6	54L/81L/77L	15	50	1.5	5	2.5
4	73	54L	28:52	1.2112	1.2091-1.2133	6	54L/81L/77L	14	50	1.4	5	2.5
4	43	54L	28:58	1.2154	1.2133-1.2175	6	54L/81L/77L	14	50	1.4	5	2.5
4	69	54L	29:08	1.2224	1.2189-1.2259	10	54L/81L/77L	26	100	2.6	10	5
4	49	54L	29:16	1.2280	1.2245-1.2315	10	54L/81L/77L					
4	69/49	54L	29:12	1.2252	1.2217-1.2287	10	54L/81L/77L					
4	48	54L	29:33	1.2399	1.2378-1.2420	6	54L/81L/77L	14	50	1.4	5	2.5
4	65	54L	29:49	1.2510	1.2476-1.2545	10	54L/81L/77L	40	100	4.0	10	5
4	47	54L	29:50	1.2517	1.2483-1.2552	10	54L/81L/77L					
4	44	54L	29:53	1.2538	1.2503-1.2573	10	54L/81L/77L					
4	65/47/44	54L	29:50	1.2517	1.2483-1.2552	10	54L/81L/77L					
4	62	54L	30:06	1.2629	1.2594-1.2664	10	54L/81L/77L	37	100	3.7	10	5
4	75	54L	30:08	1.2643	1.2608-1.2678	10	54L/81L/77L					
4	59	54L	30:12	1.2671	1.2636-1.2706	10	54L/81L/77L					
4	62/75/59	54L	30:09	1.2650	1.2615-1.2685	10	54L/81L/77L					
4	42	54L	30:26	1.2769	1.2748-1.2790	6	54L/81L/77L	16	50	1.6	5	2.5
4	41	54L	30:52	1.2951	1.2916-1.2986	10	54L/81L/77L	42	100	4.2	10	5
4	71	54L	30:58	1.2993	1.2958-1.3028	10	54L/81L/77L					
4	40	54L	31:01	1.3014	1.2979-1.3049	10	54L/81L/77L					
4	41/71/40	54L	30:58	1.2993	1.2958-1.3028	10	54L/81L/77L					
4	64	54L	31:12	1.3091	1.3070-1.3112	6	54L/81L/77L	13	50	1.3	5	2.5

Cl No.[1]	Congener No.[2,3]	RT Ref[4]	RT[5]	RRT[6]	RRT limits[7]	Window (sec)[8]	Quantitation reference[9]	Detection limits and minimum levels - Matrix and concentration[10]				
								Water (pg/L)		Other (ng/kg)		Extract (pg/µL)
								MDL	ML	MDL	ML	ML
4	72	81L	31:59	0.8336	0.8323-0.8349	6	54L/81L/77L	13	50	1.3	5	2.5
4	68	81L	32:18	0.8419	0.8406-0.8432	6	54L/81L/77L	14	50	1.4	5	2.5
4	57	81L	32:46	0.8540	0.8527-0.8553	6	54L/81L/77L	11	50	1.1	5	2.5
4	58	81L	33:05	0.8623	0.8610-0.8636	6	54L/81L/77L	14	50	1.4	5	2.5
4	67	81L	33:13	0.8658	0.8645-0.8671	6	54L/81L/77L	12	50	1.2	5	2.5
4	63	81L	33:30	0.8732	0.8719-0.8745	6	54L/81L/77L	12	50	1.2	5	2.5
4	61	81L	33:46	0.8801	0.8775-0.8827	12	54L/81L/77L	59	200	5.9	20	10
4	70	81L	33:53	0.8831	0.8805-0.8858	12	54L/81L/77L					
4	76	81L	33:55	0.8840	0.8814-0.8866	12	54L/81L/77L					
4	74	81L	33:57	0.8849	0.8827-0.8871	10	54L/81L/77L					
4	61/70/76/74	81L	33:55	0.8840	0.8814-0.8866	12	54L/81L/77L					
4	66	81L	34:15	0.8927	0.8914-0.8940	6	54L/81L/77L	17	50	1.7	5	2.5
4	55	81L	34:28	0.8983	0.8970-0.8997	6	54L/81L/77L	12	50	1.2	5	2.5
4	56	81L	35:03	0.9136	0.9123-0.9149	6	54L/81L/77L	15	50	1.5	5	2.5
4	60	81L	35:16	0.9192	0.9179-0.9205	6	54L/81L/77L	14	50	1.4	5	2.5
4	80	81L	35:32	0.9262	0.9248-0.9275	6	54L/81L/77L	11	50	1.1	5	2.5
4	79	81L	37:16	0.9713	0.9700-0.9726	6	54L/81L/77L	13	50	1.3	5	2.5
4	78	81L	37:52	0.9870	0.9857-0.9883	6	54L/81L/77L	16	50	1.6	5	2.5
4	81	81L	38:23	1.0004	0.9996-1.0013	-1+3	81L	18	50	1.8	5	2.5
4	77	77L	39:02	1.0004	0.9996-1.0013	-1+3	77L	14	50	1.4	5	2.5
	Labeled compounds											
4	54L	52L	23:50	0.8290	0.8232-0.8348	20	52L					
4	81L	52L	38:22	1.3345	1.3287-1.3403	20	52L					
4	77L	52L	39:01	1.3571	1.3513-1.3629	20	52L					
Compounds using 101L ($^{13}C_{12}$-2,2',4,5,5'-PeCB) as Labeled injection internal standard												
	CB congener											
	Pentachlorobiphenyls											
5	104	104L	29:46	1.0000	0.9994-1.0017	-1+3	104L	14	50	1.4	5	2.5
5	96	104L	30:17	1.0174	1.0146-1.0202	10	104L/123L/114L/118L/105L	15	50	1.5	5	2.5
5	103	104L	32:11	1.0812	1.0795-1.0829	6	104L/123L/114L/118L/105L	11	50	1.1	5	2.5
5	94	104L	32:29	1.0913	1.0896-1.0929	6	104L/123L/114L/118L/105L	13	50	1.3	5	2.5
5	95	104L	33:00	1.1086	1.1058-1.1114	10	104L/123L/114L/118L/105L	77	200	7.7	20	10

								Detection limits and minimum levels - Matrix and concentration[10]				
								Water (pg/L)		Other (ng/kg)		Extract (pg/μL)
Cl No. [1]	Congener No. [2,3]	RT Ref[4]	RT[5]	RRT[6]	RRT limits[7]	Window (sec) [8]	Quantitation reference[9]	MDL	ML	MDL	ML	ML
5	100	104L	33:06	1.1120	1.1092-1.1148	10	104L/123L/114L/118L/105L					
5	93	104L	33:14	1.1165	1.1137-1.1193	10	104L/123L/114L/118L/105L					
5	102	104L	33:21	1.1204	1.1176-1.1232	10	104L/123L/114L/118L/105L					
5	98	104L	33:26	1.1232	1.1204-1.1260	10	104L/123L/114L/118L/105L					
5	95/100/93/102/98	104L	33:13	1.1159	1.1131-1.1187	15	104L/123L/114L/118L/105L					
5	88	104L	33:48	1.1355	1.1321-1.1389	12	104L/123L/114L/118L/105L	22	50	2.2	5	2.5
5	91	104L	33:55	1.1394	1.1366-1.1422	10	104L/123L/114L/118L/105L					
5	88/91	104L	33:52	1.1377	1.1344-1.1411	12	104L/123L/114L/118L/105L					
5	84	104L	34:14	1.1501	1.1484-1.1517	6	104L/123L/114L/118L/105L	11	20	1.1	2	1
5	89	104L	34:44	1.1669	1.1652-1.1685	6	104L/123L/114L/118L/105L	13	50	1.3	5	2.5
5	121	104L	34:57	1.1741	1.1725-1.1758	6	104L/123L/114L/118L/105L	12	50	1.2	5	2.5
5	92	123L	35:26	0.8639	0.8627-0.8651	6	104L/123L/114L/118L/105L	13	50	1.3	5	2.5
5	113	123L	36:01	0.8781	0.8761-0.8801	10	104L/123L/114L/118L/105L	47	200	4.7	20	10
5	90	123L	36:03	0.8789	0.8769-0.8809	10	104L/123L/114L/118L/105L					
5	101	123L	36:04	0.8793	0.8773-0.8813	10	104L/123L/114L/118L/105L					
5	113/90/101	123L	36:03	0.8789	0.8769-0.8809	10	104L/123L/114L/118L/105L					
5	83	123L	36:39	0.8935	0.8911-0.8960	12	104L/123L/114L/118L/105L	29	100	2.9	10	5
5	99	123L	36:41	0.8944	0.8923-0.8964	10	104L/123L/114L/118L/105L					
5	83/99	123L	36:40	0.8939	0.8915-0.8964	12	104L/123L/114L/118L/105L					
5	112	123L	36:51	0.8984	0.8972-0.8996	6	104L/123L/114L/118L/105L	14	50	1.4	5	2.5
5	119	123L	37:12	0.9069	0.9037-0.9102	16	104L/123L/114L/118L/105L	74	200	7.4	20	10
5	109	123L	37:12	0.9069	0.9037-0.9102	16	104L/123L/114L/118L/105L					
5	86	123L	37:17	0.9090	0.9057-0.9122	16	104L/123L/114L/118L/105L					
5	97	123L	37:17	0.9090	0.9057-0.9122	16	104L/123L/114L/118L/105L					
5	125	123L	37:21	0.9106	0.9074-0.9139	16	104L/123L/114L/118L/105L					
5	87	123L	37:25	0.9122	0.9102-0.9143	10	104L/123L/114L/118L/105L					
5	119/109/86/97/125/87	123L	37:19	0.9098	0.9065-0.9130	16	104L/123L/114L/118L/105L					
5	117	123L	37:57	0.9252	0.9228-0.9277	12	104L/123L/114L/118L/105L	38	100	3.8	10	5
5	116	123L	38:02	0.9273	0.9248-0.9297	12	104L/123L/114L/118L/105L					
5	85	123L	38:05	0.9285	0.9265-0.9305	10	104L/123L/114L/118L/105L					
5	117/116/85	123L	38:00	0.9265	0.9240-0.9289	12	104L/123L/114L/118L/105L					
5	110	123L	38:16	0.9330	0.9309-0.9350	10	104L/123L/114L/118L/105L	39	100	3.9	10	5

								Detection limits and minimum levels - Matrix and concentration[10]				
								Water (pg/L)		**Other (ng/kg)**		**Extract (pg/µL)**
Cl No.[1]	**Congener No.**[2,3]	**RT Ref**[4]	**RT**[5]	**RRT**[6]	**RRT limits**[7]	**Window (sec)**[8]	**Quantitation reference**[9]	**MDL**	**ML**	**MDL**	**ML**	**ML**
5	115	123L	38:18	0.9338	0.9317-0.9358	10	104L/123L/114L/118L/105L					
5	110/115	123L	38:17	0.9334	0.9313-0.9354	10	104L/123L/114L/118L/105L					
5	82	123L	38:40	0.9427	0.9415-0.9439	6	104L/123L/114L/118L/105L	15	50	1.5	5	2.5
5	111	123L	38:52	0.9476	0.9464-0.9488	6	104L/123L/114L/118L/105L	14	50	1.4	5	2.5
5	120	123L	39:21	0.9594	0.9581-0.9606	6	104L/123L/114L/118L/105L	13	50	1.3	5	2.5
5	108	123L	40:39	0.9911	0.9890-0.9931	10	104L/123L/114L/118L/105L	29	100	2.9	10	5
5	124	123L	40:40	0.9915	0.9894-0.9935	10	104L/123L/114L/118L/105L					
5	108/124	123L	40:39	0.9911	0.9890-0.9931	10	104L/123L/114L/118L/105L					
5	107	123L	40:54	0.9972	0.9959-0.9984	6	104L/123L/114L/118L/105L	17	50	1.7	5	2.5
5	123	123L	41:02	1.0004	0.9996-1.0012	-1+3	123L	17	50	1.7	5	2.5
5	106	123L	41:10	1.0037	1.0024-1.0049	6	104L/123L/114L/118L/105L	17	50	1.7	5	2.5
5	118	118L	41:22	1.0004	0.9996-1.0012	-1+3	118L	30	100	3.0	10	5
5	122	118L	41:49	1.0113	1.0101-1.0125	6	104L/123L/114L/118L/105L	12	50	1.2	5	2.5
5	114	114L	41:58	1.0004	0.9999-1.0012	-1+3	114L	15	50	1.5	5	2.5
5	105	105L	42:43	0.9996	0.9996-1.0012	-2+3	105L	17	50	1.7	5	2.5
5	127	105L	44:09	1.0332	1.0320-1.0343	6	104L/123L/114L/118L/105L	14	50	1.4	5	2.5
5	126	126L	45:58	1.0004	0.9996-1.0011	-1+3	126L	16	50	1.6	5	2.5
	Labeled compounds											
5	104L	101L	29:46	0.8257	0.8211-0.8303	20	101L					
5	123L	101L	41:01	1.1378	1.1331-1.1424	20	101L					
5	118L	101L	41:21	1.1470	1.1424-1.1516	20	101L					
5	114L	101L	41:57	1.1637	1.1590-1.1683	20	101L					
5	105L	101L	42:44	1.1854	1.1808-1.1900	20	101L					
5	126L	101L	45:57	1.2746	1.2700-1.2792	20	101L					
Compounds using 138L ($^{13}C_{12}$-2,2',3,4,4',5'-HxCB) as Labeled injection internal standard												
	CB congener											
	Hexachlorobiphenyls											
6	155	155L	35:44	1.0000	0.9995-1.0014	-1+3	155L	14	50	1.4	5	2.5
6	152	155L	36:07	1.0107	1.0093-1.0121	6	155L/156L/157L/167L/169L	14	50	1.4	5	2.5
6	150	155L	36:15	1.0145	1.0131-1.0159	6	155L/156L/157L/167L/169L	15	50	1.5	5	2.5
6	136	155L	36:44	1.0280	1.0266-1.0294	6	155L/156L/157L/167L/169L	16	50	1.6	5	2.5
6	145	155L	37:00	1.0354	1.0340-1.0368	6	155L/156L/157L/167L/169L	16	50	1.6	5	2.5

Cl No.[1]	Congener No.[2,3]	RT Ref[4]	RT[5]	RRT[6]	RRT limits[7]	Window (sec)[8]	Quantitation reference[9]	Detection limits and minimum levels - Matrix and concentration[10]				
								Water (pg/L)		Other (ng/kg)		Extract (pg/µL)
								MDL	ML	MDL	ML	ML
6	148	155L	34:26	1.0756	1.0742-1.0770	6	155L/156L/157L/167L/169L	14	50	1.4	5	2.5
6	151	155L	39:10	1.0961	1.0938-1.0984	10	155L/156L/157L/167L/169L	46	100	4.6	10	5
6	135	155L	39:17	1.0993	1.0970-1.1017	10	155L/156L/157L/167L/169L					
6	154	155L	39:21	1.1012	1.0989-1.1035	10	155L/156L/157L/167L/169L					
6	151/135/154	155L	39:15	1.0984	1.0961-1.1007	10	155L/156L/157L/167L/169L					
6	144	155L	39:47	1.1133	1.1119-1.1147	6	155L/156L/157L/167L/169L	15	50	1.5	5	2.5
6	147	155L	40:09	1.1236	1.1213-1.1259	10	155L/156L/157L/167L/169L	35	100	3.5	10	5
6	149	155L	40:12	1.1250	1.1227-1.1273	10	155L/156L/157L/167L/169L					
6	147/149	155L	40:10	1.1241	1.1217-1.1264	10	155L/156L/157L/167L/169L					
6	134	155L	40:27	1.1320	1.1297-1.1343	10	155L/156L/157L/167L/169L	33	100	3.3	10	5
6	143	155L	40:30	1.1334	1.1311-1.1357	10	155L/156L/157L/167L/169L					
6	134/143	155L	40:29	1.1329	1.1306-1.1353	10	155L/156L/157L/167L/169L					
6	139	155L	40:47	1.1413	1.1390-1.1437	10	155L/156L/157L/167L/169L	29	100	2.9	10	5
6	140	155L	40:48	1.1418	1.1395-1.1441	10	155L/156L/157L/167L/169L					
6	139/140	155L	40:47	1.1413	1.1390-1.1437	10	155L/156L/157L/167L/169L					
6	131	155L	41:03	1.1488	1.1474-1.1502	6	155L/156L/157L/167L/169L	17	50	1.7	5	2.5
6	142	155L	41:13	1.1535	1.1521-1.1549	6	155L/156L/157L/167L/169L	17	50	1.7	5	2.5
6	132	155L	41:36	1.1642	1.1618-1.1665	10	155L/156L/157L/167L/169L	16	50	1.6	5	2.5
6	133	155L	41:57	1.1740	1.1726-1.1754	6	155L/156L/157L/167L/169L	12	50	1.2	5	2.5
6	165	167L	42:23	0.8864	0.8853-0.8874	6	155L/156L/157L/167L/169L	13	50	1.3	5	2.5
6	146	167L	42:38	0.8916	0.8906-0.8926	6	155L/156L/157L/167L/169L	14	50	1.4	5	2.5
6	161	167L	42:47	0.8947	0.8937-0.8958	6	155L/156L/157L/167L/169L	13	50	1.3	5	2.5
6	153	167L	43:17	0.9052	0.9035-0.9069	10	155L/156L/157L/167L/169L	30	100	3.0	10	5
6	168	167L	43:21	0.9066	0.9048-0.9083	10	155L/156L/157L/167L/169L					
6	153/168	167L	43:19	0.9059	0.9041-0.9076	10	155L/156L/157L/167L/169L					
6	141	167L	43:34	0.9111	0.9101-0.9122	6	155L/156L/157L/167L/169L	17	50	1.7	5	2.5
6	130	167L	44:01	0.9205	0.9195-0.9216	6	155L/156L/157L/167L/169L	13	50	1.3	5	2.5
6	137	167L	44:14	0.9251	0.9240-0.9261	6	155L/156L/157L/167L/169L	15	50	1.5	5	2.5
6	164	167L	44:22	0.9278	0.9268-0.9289	6	155L/156L/157L/167L/169L	15	50	1.5	5	2.5
6	138	167L	44:42	0.9348	0.9324-0.9373	14	155L/156L/157L/167L/169L	63	200	6.3	20	10
6	163	167L	44:42	0.9348	0.9324-0.9373	14	155L/156L/157L/167L/169L					
6	129	167L	44:47	0.9366	0.9341-0.9390	14	155L/156L/157L/167L/169L					

								Detection limits and minimum levels - Matrix and concentration[10]				
								Water (pg/L)		**Other (ng/kg)**		**Extract (pg/µL)**
Cl No.[1]	**Congener No.[2,3]**	**RT Ref[4]**	**RT[5]**	**RRT[6]**	**RRT limits[7]**	**Window (sec)[8]**	**Quantitation reference[9]**	**MDL**	**ML**	**MDL**	**ML**	**ML**
6	160	167L	44:53	0.9387	0.9369-0.9404	10	155L/156L/157L/167L/169L					
6	138/163/129/160	167L	44:47	0.9366	0.9341-0.9390	14	155L/156L/157L/167L/169L					
6	158	167L	45:05	0.9428	0.9418-0.9439	6	155L/156L/157L/167L/169L	16	50	1.6	5	2.5
6	166	167L	45:59	0.9617	0.9599-0.9634	10	155L/156L/157L/167L/169L	29	100	2.9	10	5
6	128	167L	46:09	0.9651	0.9634-0.9669	10	155L/156L/157L/167L/169L					
6	128/166	167L	46:04	0.9634	0.9617-0.9651	10	155L/156L/157L/167L/169L					
6	159	167L	46:59	0.9826	0.9815-0.9836	6	155L/156L/157L/167L/169L	14	50	1.4	5	2.5
6	162	167L	47:18	0.9892	0.9881-0.9902	6	155L/156L/157L/167L/169L	13	50	1.3	5	2.5
6	167	167L	47:49	1.0000	0.9997-1.0010	-1+3	167L	13	50	1.3	5	2.5
6	156	156L/157L	49:05	0.9993	0.9983-1.0003	6	156L/157L	23	100	2.3	10	5
6	157	156L/157L	49:09	1.0007	0.9990-1.0024	10	156L/157L					
6	156/157	156L/157L	49:07	1.0000	0.9990-1.1010	6	156L/157L					
6	169	169L	52:31	1.0003	0.9997-1.0010	-1+3	169L	15	50	1.5	5	2.5
	Labeled compounds											
6	155L	138L	35:44	0.7997	0.7960-0.8034	20	138L					
6	167L	138L	47:49	1.0701	1.0664-1.0739	20	138L					
6	156L	138L	49:05	1.0985	1.0974-1.0996	20	138L					
6	157L	138L	49:08	1.0996	1.0959-1.1033	20	138L					
6	156L/157L	138L	49:07	1.0992	1.0981-1.1003	20	138L					
6	169L	138L	52:30	1.1749	1.1738-1.1761	20	138L					
Compounds using 194L($^{13}C_{12}$-2,2',3,3',4,4',5,5'-OcCB) as Labeled injection internal standard												
	CB congener											
	Heptachlorobiphenyls											
7	188	188L	41:51	1.0000	0.9996-1.0012	-1+3	188L	15	50	1.5	5	2.5
7	179	188L	42:19	1.0112	1.0100-1.0123	6	188L/189L	14	50	1.4	5	2.5
7	184	188L	42:45	1.0215	1.0203-1.0227	6	188L/189L	14	50	1.4	5	2.5
7	176	188L	43:15	1.0335	1.0323-1.0346	6	188L/189L	12	50	1.2	5	2.5
7	186	188L	43:45	1.0454	1.0442-1.0466	6	188L/189L	15	50	1.5	5	2.5
7	178	188L	45:06	1.0777	1.0765-1.0789	6	188L/189L	14	50	1.4	5	2.5
7	175	188L	45:46	1.0936	1.0924-1.0948	6	188L/189L	14	50	1.4	5	2.5
7	187	188L	46:02	1.1000	1.0988-1.1012	6	188L/189L	17	50	1.7	5	2.5
7	182	188L	46:14	1.1047	1.1035-1.1059	6	188L/189L	13	50	1.3	5	2.5

Cl No.[1]	Congener No.[2,3]	RT Ref[4]	RT[5]	RRT[6]	RRT limits[7]	Window (sec)[8]	Quantitation reference[9]	Detection limits and minimum levels - Matrix and concentration[10]				
								Water (pg/L)		Other (ng/kg)		Extract (pg/µL)
								MDL	ML	MDL	ML	ML
7	183	188L	46:42	1.1159	1.1147-1.1171	6	188L/189L	28	100	2.8	10	5
7	185	188L	46:53	1.1203	1.1191-1.1215	6	188L/189L					
7	183/185	188L	46:47	1.1179	1.1167-1.1191	6	188L/189L					
7	174	188L	47:02	1.1239	1.1227-1.1251	6	188L/189L	15	50	1.5	5	2.5
7	177	188L	47:30	1.1350	1.1338-1.1362	6	188L/189L	11	50	1.1	5	2.5
7	181	188L	47:52	1.1438	1.1426-1.1450	6	188L/189L	13	50	1.3	5	2.5
7	171	188L	48:10	1.1509	1.1489-1.1529	10	188L/189L	30	100	3.0	10	5
7	173	188L	48:11	1.1513	1.1501-1.1525	6	188L/189L					
7	171/173	188L	48:10	1.1509	1.1489-1.1529	6	188L/189L					
7	172	189L	49:47	0.9035	0.9026-0.9044	6	188L/189L	13	50	1.3	5	2.5
7	192	189L	50:06	0.9093	0.9083-0.9102	6	188L/189L	13	50	1.3	5	2.5
7	193	189L	50:26	0.9153	0.9144-0.9162	6	188L/189L	30	100	3.0	10	5
7	180	189L[11]	50:27	0.9156	0.9147-0.9165	6	188L/189L[11]					
7	193/180	189L	50:26	0.9153	0.9144-0.9162	6	188L/189L					
7	191	189L	50:51	0.9229	0.9220-0.9238	6	188L/189L	13	50	1.3	5	2.5
7	170	189L[11]	51:54	0.9419	0.9410-0.9428	6	188L/189L[11]	12	50	1.2	5	2.5
7	190	189L	52:26	0.9516	0.9507-0.9525	6	188L/189L	14	50	1.4	5	2.5
7	189	189L	55:07	1.0003	0.9997-1.0009	-1+3	189L	13	50	1.3	5	2.5
	Octachlorobiphenyls											
8	202	202L	47:32	1.0004	0.9996-1.0011	-1+3	202L	24	100	2.4	10	5
8	201	202L	48:31	1.0210	1.0193-1.0228	10	202L/205L	20	50	2.0	5	2.5
8	204	202L	49:11	1.0351	1.0340-1.0361	6	202L/205L	21	50	2.1	5	2.5
8	197	202L	49:27	1.0407	1.0396-1.0417	6	202L/205L	43	100	4.3	10	5
8	200	202L	49:40	1.0452	1.0442-1.0463	6	202L/205L					
8	197/200	202L	49:33	1.0428	1.0417-1.0438	6	202L/205L					
8	198	202L	52:30	1.1049	1.1031-1.1066	10	202L/205L	37	100	3.7	10	5
8	199	202L	52:32	1.1056	1.1045-1.1066	6	202L/205L					
8	198/199	202L	52:31	1.1052	1.1035-1.1070	10	202L/205L					
8	196	205L	53:13	0.9207	0.9198-0.9216	6	202L/205L	20	50	2.0	5	2.5
8	203	205L	53:26	0.9245	0.9236-0.9253	6	202L/205L	18	50	1.8	5	2.5
8	195	205L	54:55	0.9501	0.9493-0.9510	6	202L/205L	22	50	2.2	5	2.5
8	194	205L	57:19	0.9916	0.9908-0.9925	6	202L/205L	18	50	1.8	5	2.5

								Detection limits and minimum levels - Matrix and concentration[10]				
								Water (pg/L)		**Other (ng/kg)**		**Extract (pg/µL)**
Cl No. [1]	**Congener No.** [2,3]	**RT Ref**[4]	**RT**[5]	**RRT**[6]	**RRT limits**[7]	**Window (sec)** [8]	**Quantitation reference**[9]	**MDL**	**ML**	**MDL**	**ML**	**ML**
8	205	205L	57:49	1.0003	0.9997-1.0009	-1+3	205L	15	50	1.5	5	2.5
	Nonachlorobiphenyls											
9	208	208L	54:33	1.0003	0.9997-1.0009	-1+3	208L	16	50	1.6	5	2.5
9	207	208L	55:32	1.0183	1.0174-1.0193	6	208L/206L	19	50	1.9	5	2.5
9	206	206L	59:37	1.0003	0.9997-1.0008	-1+3	206L	16	50	1.6	5	2.5
	Decachlorobiphenyl											
10	209	209L	61:15	1.0003	0.9997-1.0008	-1+3	209L	16	50	1.6	5	2.5
	Labeled compounds											
7	188L	194L	41:51	0.7304	0.7275-0.7333	20	194L					
7	180L	194L	50:27	0.8805	0.8775-0.8834	20	194L					
7	170L	194L	51:53	0.9055	0.9026-0.9084	20	194L					
7	189L	194L	55:06	0.9616	0.9587-0.9645	20	194L					
8	202L	194L	47:31	0.8293	0.8264-0.8322	20	194L					
8	205L	194L	57:48	1.0087	1.0044-1.0131	30	194L					
9	208L	194L	54:32	0.9517	0.9488-0.9546	20	194L					
9	206L	194L	59:36	1.0401	1.0358-1.0445	30	194L					
10	209L	194L	61:14	1.0686	1.0643-1.0730	30	194L					
Labeled clean-up standards												
3	28L	52L	26:44	0.9266	0.9209-0.9324	20	52L					
5	111L	101L	38:51	1.0777	1.0730-1.0823	20	101L					
7	178L	138L	45:05	1.0090	1.0052-1.0127	20	138L					
Labeled injection internal standards												
2	9L	138L	18:54	0.4230	0.4183-0.4276	25	138L					
4	52L	138L	28:45	0.6434	0.6388-0.6481	25	138L					
5	101L	138L	36:03	0.8068	0.8021-0.8115	25	138L					
6	138L	138L	44:41	1.0000	0.9996-1.0011	100	138L					
8	194L	138L	57:18	1.2824	1.2777-1.2870	25	138L					

1. Number of chlorines on congener.
2. Suffix “L” indicates labeled compound.
3. Multiple congeners in a box indicates congeners that co-elute or may not be adequately resolved on a 30-m SPB-octyl column.
4. Retention time (RT) reference used to locate target congener.
5. Retention time of target congener.

6. Relative retention time (RRT) between the RT for the congener and RT for the reference.
7. RRT limits based on RT window. RTs, RRTs, and RRT limits may differ slightly from those in Table 2.
8. RT window width necessary to attempt to unambiguously identify the congener in the presence of other congeners.
9. Labeled congeners that form the quantitation reference. Areas from the exact m/z’s of the congeners listed in the quantitation reference are summed, and divided by the number of congeners in the quantitation reference. For example, for congener 10, the areas at the exact m/z’s for 4L and 15L are summed and the sum is divided by 2 (because there are 2 congeners in the quantitation reference).
10. MDLs for water pooled from data from AXYS Analytical, TestAmerica-Knoxville, and Battelle-Columbus (see Reference 24). MLs for water per ML procedure at 68 FR 11790. MDLs and MLs for “Other” and “Extract” calculated from sample amount and extract volume.
11. If congeners 170L and 180L are included in the calibration and spiking solutions, these congeners should be used as RT and quantitation references.

Table 3. Concentrations of Native and Labeled Chlorinated Biphenyls in Stock Solutions Spiking Solutions

CB Congener	Solution Concentrations		
	Stock (µg/mL)	**Spiking (ng/mL)**	**Extract (ng/mL)**
Native toxics/LOC[1]			
1	20	1.0	50
3	20	1.0	50
4	20	1.0	50
15	20	1.0	50
19	20	1.0	50
37	20	1.0	50
54	20	1.0	50
77	20	1.0	50
81	20	1.0	50
104	20	1.0	50
105	20	1.0	50
114	20	1.0	50
118	20	1.0	50
123	20	1.0	50
126	20	1.0	50
155	20	1.0	50
156	20	1.0	50
157	20	1.0	50
167	20	1.0	50
169	20	1.0	50
188	20	1.0	50
189	20	1.0	50
202	20	1.0	50
205	20	1.0	50
206	20	1.0	50
208	20	1.0	50
209	20	1.0	50
Native congener mix stock solutions[2]			
MoCB thru TrCB	2.5		
TeCB thru HpCB	5.0		
OcCB thru DeCB	7.5		
Labeled toxics/LOC/window-defining[3]			
1L	1.0	2.0	100
3L	1.0	2.0	100
4L	1.0	2.0	100
15L	1.0	2.0	100
19L	1.0	2.0	100
37L	1.0	2.0	100
54L	1.0	2.0	100
77L	1.0	2.0	100
81L	1.0	2.0	100
104L	1.0	2.0	100
105L	1.0	2.0	100

Table 3. Concentrations of Native and Labeled Chlorinated Biphenyls in Stock Solutions Spiking Solutions

CB Congener	Solution Concentrations		
	Stock (µg/mL)	Spiking (ng/mL)	Extract (ng/mL)
114L	1.0	2.0	100
118L	1.0	2.0	100
123L	1.0	2.0	100
126L	1.0	2.0	100
155L	1.0	2.0	100
156L	1.0	2.0	100
157L	1.0	2.0	100
167L	1.0	2.0	100
169L	1.0	2.0	100
188L	1.0	2.0	100
189L	1.0	2.0	100
202L	1.0	.2.0	100
205L	1.0	2.0	100
206L	1.0	2.0	100
208L	1.0	2.0	100
209L	1.0	2.0	100
Labeled clean-up[4]			
28L	1.0	2.0	100
111L	1.0	2.0	100
178L	1.0	2.0	100
Labeled injection internal[5]			
9L	5.0	1000	100
52L	5.0	1000	100
101L	5.0	1000	100
138L	5.0	1000	100
194L	5.0	1000	100

Diluted combined 209 congener[6]	Solution Concentration (ng/mL)	
Standard	**Native**	**Labeled**
Native congeners		
MoCB thru TrCB	25	
TeCB thru HpCB	50	
OcCB thru DeCB	75	
Labeled toxics/LOC/window-defining		100
Labeled cleanup		100
Labeled injection internal		100

1. Stock solution: Section 7.8.1; Spiking solution: Section 7.11
2. Section 7.8.2.1
3. Stock solution: Section 7.9.1; Spiking solution: Section 7.12
4. Stock solution: Section 7.9.2; Spiking solution: Section 7.13
5. Stock solution: Section 7.9.3; Spiking solution: Section 7.14
6. Section 7.10.2.2.2

Table 4. Composition of Individual Native CB Congener Solutions[1]

Solution Identifier				
A2	**B2**	**C2**	**D2**	**E2**
Accu-Standard part number				
M-1668A-1	**M-1668A-2**	**M-1668A-3**	**M-1668A-4**	**M-1668A-5**
2	7	13	25	1
10	5	17	21	3
9	12	29	69	4
6	18	20	47	15
8	24	46	42	19
14	23	65	a64	16
11	28	59	70	37
30	22	40	102	54
27	39	67	97	43
32	53	76	115	44
34	51	80	123	74
26	73	93	134	56
31	48	84	131	77
33	62	101	163	104
36	71	112	180	98
38	68	86		125
35	58	116		110
50	61	107		126
45	55	154		155
52	60	147		138
49	94	140		169
75	100	146		188
41	91	141		189
72	121	164		202
57	90	158		205
63	99	182		208
66	109	174		206
79	117	173		209
78	111	193		
81	108			
96	118			
103	114			
95	150			
88	145			
89	135			
92	149			
113	139			
83	132			
119	165			
87	168			
85	137			
82	160			
120	128			
124	162			
106	157			

Table 4. Composition of Individual Native CB Congener Solutions[1]

Solution Identifier				
A2	B2	C2	D2	E2
Accu-Standard part number				
M-1668A-1	M-1668A-2	M-1668A-3	M-1668A-4	M-1668A-5
122	184			
105	186			
127	187			
152	185			
136	181			
148	192			
151	197			
144	199/201			
143	203			
142				
133				
161				
153				
130				
129				
166				
159				
167				
156				
179				
176				
178				
175				
183				
177				
171				
172				
191				
170				
190				
201/200				
204				
200/199				
198				
196				
195				
194				
207				
Total number of congeners				
83	54	29	15	28

1. Congeners present in each standard solution are listed in elution order for each level of chlorination. Congener number (Table 1) listed first; BZ number listed second, where ambiguous. See Table 3 for concentrations of congeners in stock solutions and Table 5 for concentrations in calibration standards.

Table 5. Concentration of Congeners in Calibration and Calibration Verification Standards

Congener Name	Congener No.[1]	Solution Concentration (ng/mL)					
		CS-0.2 (Hi sens)[2]	CS-1	CS-2	CS-3 (VER)	CS-4	CS-5
Native toxics/LOC							
2-MoCB	1	0.20	1.0	5.0	50	400	2000
4-MoCB	3	0.20	1.0	5.0	50	400	2000
2,2'-DiCB	4	0.20	1.0	5.0	50	400	2000
4,4'-DiCB	15	0.20	1.0	5.0	50	400	2000
2,2',6'-TrCB	19	0.20	1.0	5.0	50	400	2000
3,4,4'-TrCB	37	0.20	1.0	5.0	50	400	2000
2,2',6,6'-TeCB	54	0.20	1.0	5.0	50	400	2000
3,3',4,4'-TeCB	77	0.20	1.0	5.0	50	400	2000
3,4,4',5-TeCB	81	0.20	1.0	5.0	50	400	2000
2,2',4,6,6'-PeCB	104	0.20	1.0	5.0	50	400	2000
2,3,3',4,4'-PeCB	105	0.20	1.0	5.0	50	400	2000
2,3,4,4',5-PeCB	114	0.20	1.0	5.0	50	400	2000
2,3',4,4',5-PeCB	118	0.20	1.0	5.0	50	400	2000
2',3,4,4',5-PeCB	123	0.20	1.0	5.0	50	400	2000
3,3',4,4',5-PeCB	126	0.20	1.0	5.0	50	400	2000
2,2',4,4',6,6'-HxCB	155	0.20	1.0	5.0	50	400	2000
2,3,3',4,4',5-HxCB	156	0.20	1.0	5.0	50	400	2000
2,3,3',4,4',5'-HxCB	157	0.20	1.0	5.0	50	400	2000
2,3',4,4',5,5'-HxCB	167	0.20	1.0	5.0	50	400	2000
3,3',4,4',5,5'-HxCB	169	0.20	1.0	5.0	50	400	2000
2,2',3,4',5,6,6'-HpCB	188	0.20	1.0	5.0	50	400	2000
2,3,3',4,4',5,5'-HpCB	189	0.20	1.0	5.0	50	400	2000
2,2',3,3',5,5',6,6'-OcCB	202	0.20	1.0	5.0	50	400	2000
2,3,3',4,4',5,5',6-OcCB	205	0.20	1.0	5.0	50	400	2000
2,2',3,3',4,4',5,5',6-NoCB	206	0.20	1.0	5.0	50	400	2000
2,2',3,3',4',5,5',6,6'-NoCB	208	0.20	1.0	5.0	50	400	2000
DeCB	209	0.20	1.0	5.0	50	400	2000
Labeled toxics/LOC/window-defining							
$^{13}C_{12}$-2-MoCB	1L	100	100	100	100	100	100
$^{13}C_{12}$-4-MoCB	3L	100	100	100	100	100	100
$^{13}C_{12}$-2,2'-DiCB	4L	100	100	100	100	100	100
$^{13}C_{12}$-4,4'-DiCB	15L	100	100	100	100	100	100
$^{13}C_{12}$-2,2',6'-TrCB	19L	100	100	100	100	100	100
$^{13}C_{12}$-3,4,4'-TrCB	37L	100	100	100	100	100	100
$^{13}C_{12}$-2,2',6,6'-TeCB	54L	100	100	100	100	100	100
$^{13}C_{12}$-3,3',4,4'-TeCB	77L	100	100	100	100	100	100
$^{13}C_{12}$-3,4,4',5-TeCB	81L	100	100	100	100	100	100
$^{13}C_{12}$-2,2',4,6,6'-PeCB	104L	100	100	100	100	100	100
$^{13}C_{12}$-2,3,3',4,4'-PeCB	105L	100	100	100	100	100	100
$^{13}C_{12}$-2,3,4,4',5-PeCB	114L	100	100	100	100	100	100
$^{13}C_{12}$-2,3',4,4',5-PeCB	118L	100	100	100	100	100	100
$^{13}C_{12}$-2',3,4,4',5-PeCB	123L	100	100	100	100	100	100
$^{13}C_{12}$-3,3',4,4',5-PeCB	126L	100	100	100	100	100	100
$^{13}C_{12}$-2,2',4,4',6,6'-HxCB	155L	100	100	100	100	100	100
$^{13}C_{12}$-2,3,3',4,4',5-HxCB	156L	100	100	100	100	100	100
$^{13}C_{12}$-2,3,3',4,4',5'-HxCB	157L	100	100	100	100	100	100
$^{13}C_{12}$-2,3',4,4',5,5'-HxCB	167L	100	100	100	100	100	100
$^{13}C_{12}$-3,3',4,4',5,5'-HxCB	169L	100	100	100	100	100	100

Table 5. Concentration of Congeners in Calibration and Calibration Verification Standards

Congener Name	Congener No.[1]	Solution Concentration (ng/mL)					
		CS-0.2 (Hi sens)[2]	**CS-1**	**CS-2**	**CS-3 (VER)**	**CS-4**	**CS-5**
$^{13}C_{12}$-2,2',3,4',5,6,6'-HpCB	188L	100	100	100	100	100	100
$^{13}C_{12}$-2,3,3',4,4',5,5'-HpCB	189L	100	100	100	100	100	100
$^{13}C_{12}$-2,2',3,3',5,5',6,6'-OcCB	202L	100	100	100	100	100	100
$^{13}C_{12}$-2,3,3',4,4',5,5',6-OcCB	205L	100	100	100	100	100	100
$^{13}C_{12}$-2,2',3,3',4,4',5,5',6-NoCB	206L	100	100	100	100	100	100
$^{13}C_{12}$-2,2',3,3',4',5,5',6,6'-NoCB	208L	100	100	100	100	100	100
$^{13}C_{12}$-DeCB	209L	100	100	100	100	100	100
Labeled clean-up							
$^{13}C_{12}$-2,4,4'-TrCB	28L	100	100	100	100	100	100
$^{13}C_{12}$-2,3,3',5,5'-PeCB	111L	100	100	100	100	100	100
$^{13}C_{12}$-2,2',3,3',5,5',6-HpCB	178L	100	100	100	100	100	100
Labeled injection internal							
$^{13}C_{12}$-2,5-DiCB	9L	100	100	100	100	100	100
$^{13}C_{12}$-2,2',5,5'-TeCB	52L	100	100	100	100	100	100
$^{13}C_{12}$-2,2',4',5,5'-PeCB	101L	100	100	100	100	100	100
$^{13}C_{12}$-2,2',3',4,4',5'-HxCB	138L	100	100	100	100	100	100
$^{13}C_{12}$-2,2',3,3',4,4',5,5'-OcCB	194L	100	100	100	100	100	100

1. Suffix “L” indicates labeled compound.
2. Additional concentration used for calibration of high sensitivity HRGC/HRMS systems. If the ion abundance ratio (Table 8) cannot be achieved at this level (see Section 10.3.3), a calibration point at 0.4 or 0.5 ng/mL may be used.

Table 6. QC Acceptance Criteria for VER, IPR, OPR, and Labeled Compounds in Samples[1,2]

Congener Name	Congener No.[3]	Test Conc. (ng/mL)[4]	VER (%)[5]	IPR		OPR Recovery (%)	Labeled Compound Recovery in Samples (%)
				RSD (%)	Mean Recovery (%)		
2-MoCB	1	50	75 - 125	25	70 - 130	60 - 135	NA
4-MoCB	3	50	75 - 125	25	70 - 130	60 - 135	
2,2'-DiCB	4	50	75 - 125	25	70 - 130	60 - 135	
4,4'-DiCB	15	50	75 - 125	25	70 - 130	60 - 135	
2,2'6-TrCB	19	50	75 - 125	25	70 - 130	60 - 135	
3,4,4'-TrCB	37	50	75 - 125	25	70 - 130	60 - 135	
2,2'6,6'TeCB	54	50	75 - 125	25	70 - 130	60 - 135	
3,3',4,4'-TeCB	77	50	75 - 125	25	70 - 130	60 - 135	
3,4,4',5-TeCB	81	50	75 - 125	25	70 - 130	60 - 135	
2,2',4,6,6'-PeCB	104	50	75 - 125	25	70 - 130	60 - 135	
2,3,3',4,4'-PeCB	105	50	75 - 125	25	70 - 130	60 - 135	
2,3,4,4',5-PeCB	114	50	75 - 125	25	70 - 130	60 - 135	
2,3',4,4',5-PeCB	118	50	75 - 125	25	70 - 130	60 - 135	
2',3,4,4',5-PeCB	123	50	75 - 125	25	70 - 130	60 - 135	
3,3',4,4',5-PeCB	126	50	75 - 125	25	70 - 130	60 - 135	
2,2',4,4',6,6'-HxCB	155	50	75 - 125	25	70 - 130	60 - 135	
2,3,3',4,4',5-HxCB [6]	156	50	75 - 125	25	70 - 130	60 - 135	
2,3,3',4,4',5'-HxCB [6]	157	50	75 - 125	25	70 - 130	60 - 135	
2,3',4,4',5,5'-HxCB	167	50	75 - 125	25	70 - 130	60 - 135	
3,3',4,4',5,5'-HxCB	169	50	75 - 125	25	70 - 130	60 - 135	
2,2',3,4',5,6,6'-HpCB	188	50	75 - 125	25	70 - 130	60 - 135	
2,3,3',4,4',5,5'-HpCB	189	50	75 - 125	25	70 - 130	60 - 135	
2,2',3,3',5,5',6,6'-OcCB	202	50	75 - 125	25	70 - 130	60 - 135	
2,3,3',4,4',5,5',6-OcCB	205	50	75 - 125	25	70 - 130	60 - 135	
2,2',3,3',4,4',5,5',6-NoCB	206	50	75 - 125	25	70 - 130	60 - 135	
2,2',3,3,'4,5,5',6,6'-NoCB	208	50	75 - 125	25	70 - 130	60 - 135	
DeCB	209	50	75 - 125	25	70 - 130	60 - 135	
$^{13}C_{12}$-2-MoCB	1L	100	50 - 145	70	20 - 135	15 - 145	5 - 145
$^{13}C_{12}$-4-MoCB	3L	100	50 - 145	70	20 - 135	15 - 145	5 - 145
$^{13}C_{12}$-2,2'-DiCB	4L	100	50 - 145	70	20 - 135	15 - 145	5 - 145
$^{13}C_{12}$-4,4'-DiCB	15L	100	50 - 145	70	20 - 135	15 - 145	5 - 145
$^{13}C_{12}$-2,2',6-TrCB	19L	100	50 - 145	70	20 - 135	15 - 145	5 - 145
$^{13}C_{12}$-3,4,4'-TrCB	37L	100	50 - 145	70	20 - 135	15 - 145	5 - 145
$^{13}C_{12}$-2,2',6,6'-TeCB	54L	100	50 - 145	70	20 - 135	15 - 145	5 - 145

Table 6. QC Acceptance Criteria for VER, IPR, OPR, and Labeled Compounds in Samples[1,2]

Congener Name	Congener No.[3]	Test Conc. (ng/mL)[4]	VER (%)[5]	IPR		OPR Recovery (%)	Labeled Compound Recovery in Samples (%)
				RSD (%)	Mean Recovery (%)		
$^{13}C_{12}$-3,3',4,4'-TeCB	77L	100	50 - 145	50	45 - 135	40 - 145	10 - 145
$^{13}C_{12}$-3,4,4',5-TeCB	81L	100	50 - 145	50	45 - 135	40 - 145	10 - 145
$^{13}C_{12}$-2,2',4,6,6'-PeCB	104L	100	50 - 145	50	45 - 135	40 - 145	10 - 145
$^{13}C_{12}$-2,3,3',4,4'-PeCB	105L	100	50 - 145	50	45 - 135	40 - 145	10 - 145
$^{13}C_{12}$-2,3,4,4',5-PeCB	114L	100	50 - 145	50	45 - 135	40 - 145	10 - 145
$^{13}C_{12}$-2,3',4,4',5-PeCB	118L	100	50 - 145	50	45 - 135	40 - 145	10 - 145
$^{13}C_{12}$-2',3,4,4',5-PeCB	123L	100	50 - 145	50	45 - 135	40 - 145	10 - 145
$^{13}C_{12}$-3,3',4,4',5-PeCB	126L	100	50 - 145	50	45 - 135	40 - 145	10 - 145
$^{13}C_{12}$-2,2',4,4',6,6'-HxCB	155L	100	50 - 145	50	45 - 135	40 - 145	10 - 145
$^{13}C_{12}$-2,3,3',4,4',5 -HxCB [6]	156L	100	50 - 145	50	45 - 135	40 - 145	10 - 145
$^{13}C_{12}$-2,3,3',4,4',5'-HxCB [6]	157L	100	50 - 145	50	45 - 135	40 - 145	10 - 145
$^{13}C_{12}$-2,3',4,4',5,5'-HxCB	167L	100	50 - 145	50	45 - 135	40 - 145	10 - 145
$^{13}C_{12}$-3,3',4,4',5,5'-HxCB	169L	100	50 - 145	50	45 - 135	40 - 145	10 - 145
$^{13}C_{12}$-2,2',3,4',5,6,6'-HpCB	188L	100	50 - 145	50	45 - 135	40 - 145	10 - 145
$^{13}C_{12}$-2',3,3',4,4',5,5'-HpCB	189L	100	50 - 145	50	45 - 135	40 - 145	10 - 145
$^{13}C_{12}$-2,2',3,3',5,5',6,6'-OcCB	202L	100	50 - 145	50	45 - 135	40 - 145	10 - 145
$^{13}C_{12}$-2,3,3',4,4',5,5',6-OcCB	205L	100	50 - 145	50	45 - 135	40 - 145	10 - 145
$^{13}C_{12}$-2,2',3,3',4,4',5,5',6-NoCB	206L	100	50 - 145	50	45 - 135	40 - 145	10 - 145
$^{13}C_{12}$-2,2',3,3',4,5,5',6,6'-NoCB	208L	100	50 - 145	50	45 - 135	40 - 145	10 - 145
$^{13}C_{12}$-2,2',3,3',4,4',5,5',6,6'-DeCB	209L	100	50 - 145	50	45 - 135	40 - 145	10 - 145
Cleanup standards							
$^{13}C_{12}$-2,4,4'-TrCB	28L	100	65 - 135	70	20 - 135	15 - 145	5 - 145
$^{13}C_{12}$-2,3,3',5,5'-PeCB	111L	100	75 - 125	50	45 - 135	40 - 145	10 - 145
$^{13}C_{12}$-2,2',3,3',5,5',6-HpCB	178L	100	75 - 125	50	45 - 135	40 - 145	10 - 145

1. Reference 22 describes how interlaboratory results were pooled from analyses of wastewater, biosolids, and fish tissue samples.
2. QC acceptance criteria for IPR, OPR, and samples based on a 20-µL extract final volume
3. Suffix “L” indicates labeled compound.
4. See Table 5.
5. Section 15.3.
6. CBs 156/157 and 156L/157L are tested as the sum of the two congeners

NA = Not applicable

Table 7. Scan Descriptors, Levels of Chlorination, m/z Information, and Substances Monitored by HRGC/HRMS

Function and Chlorine Level	m/z[1]	m/z Type	m/z Formula	Substance
Fn-1; Cl-1	188.0393	M	$^{12}C_{12}H_{9}{}^{35}Cl$	Cl-1 CB
	190.0363	M+2	$^{12}C_{12}H_{9}{}^{37}Cl$	Cl-1 CB
	200.0795	M	$^{13}C_{12}H_{9}{}^{35}Cl$	$^{13}C_{12}$ Cl-1 CB
	202.0766	M+2	$^{13}C_{12}H_{9}{}^{37}Cl$	$^{13}C_{12}$ Cl-1 CB
	218.9856	lock	C_4F_9	PFK
Fn-2; Cl-2, 3	222.0003	M	$^{12}C_{12}H_{8}{}^{35}Cl_2$	Cl-2 PCB
	223.9974 (2)	M+2	$^{12}C_{12}H_{8}{}^{35}Cl{}^{37}Cl$	Cl-2 PCB
	225.9944	M+4	$^{12}C_{12}H_{8}{}^{37}Cl_2$	Cl-2 PCB
	234.0406	M	$^{13}C_{12}H_{8}{}^{35}Cl_2$	$^{13}C_{12}$ Cl-2 PCB
	236.0376	M+2	$^{13}C_{12}H_{8}{}^{35}Cl{}^{37}Cl$	$^{13}C_{12}$ Cl-2 PCB
	242.9856	lock	C_6F_9	PFK
	255.9613	M	$^{12}C_{12}H_{7}{}^{35}Cl_3$	Cl-3 PCB
	257.9584	M+2	$^{12}C_{12}H_{7}{}^{35}Cl_2{}^{37}Cl$	Cl-3 PCB
	268.0016	M	$^{13}C_{12}H_{7}{}^{35}Cl_3$	$^{13}C_{12}$ Cl-3 PCB
	269.9986	M+2	$^{13}C_{12}H_{7}{}^{35}Cl_2{}^{37}Cl$	$^{13}C_{12}$ Cl-3 PCB
Fn-3; Cl-3, 4, 5	255.9613	M	$^{12}C_{12}H_{7}{}^{35}Cl_3$	Cl-3 PCB
	257.9584	M+2	$^{12}C_{12}H_{7}{}^{35}Cl_2{}^{37}Cl$	Cl-3 PCB
	259.9554	M+4	$^{12}C_{12}H_{7}{}^{35}Cl{}^{37}Cl_2$	Cl-3 PCB
	268.0016	M	$^{13}C_{12}H_{7}{}^{35}Cl_3$	$^{13}C_{12}$ Cl-3 PCB
	269.9986	M+2	$^{13}C_{12}H_{7}{}^{35}Cl_2{}^{37}Cl$	$^{13}C_{12}$ Cl-3 PCB
	280.9825	lock	C_6F_{11}	PFK
	289.9224	M	$^{12}C_{12}H_{6}{}^{35}Cl_4$	Cl-4 PCB
	291.9194	M+2	$^{12}C_{12}H_{6}{}^{35}Cl_3{}^{37}Cl$	Cl-4 PCB
	293.9165	M+4	$^{12}C_{12}H_{6}{}^{35}Cl_2{}^{37}Cl_2$	Cl-4 PCB
	301.9626	M	$^{13}C_{12}H_{6}{}^{35}Cl_4$	$^{13}C_{12}$ Cl-4 PCB
	303.9597	M+2	$^{13}C_{12}H_{6}{}^{35}Cl_3{}^{37}Cl$	$^{13}C_{12}$ Cl-4 PCB
	323.8834	M	$^{13}C_{12}$ H5 $^{35}Cl_5$	Cl-5 PCB
	325.8804	M+2	$^{12}C_{12}$ H5 $^{35}Cl_4{}^{37}Cl$	Cl-5 PCB
	327.8775	M+4	$^{12}C_{12}$ H5 $^{35}Cl_3{}^{37}Cl_2$	Cl-5 PCB
	337.9207	M+2	$^{13}C_{12}$ H5 $^{35}Cl_4{}^{37}Cl$	$^{13}C_{12}$ Cl-5 PCB
	339.9178	M+4	$^{13}C_{12}$ H5 $^{35}Cl_3{}^{37}Cl_2$	$^{13}C_{12}$ Cl-5 PCB
Fn-4; Cl-4, 5, 6	289.9224	M	$^{12}C_{12}H_{6}{}^{35}Cl_4$	Cl-4 PCB
	291.9194	M+2	$^{12}C_{12}H_{6}{}^{35}Cl_3{}^{37}Cl$	Cl-4 PCB
	293.9165	M+4	$^{12}C_{12}H_{6}{}^{35}Cl_2{}^{37}Cl_2$	Cl-4 PCB
	301.9626	M	$^{13}C_{12}H_{6}{}^{35}Cl_3{}^{37}Cl$	$^{13}C_{12}$ Cl-4 PCB
	303.9597	M+2	$^{13}C_{12}H_{6}{}^{35}Cl_2{}^{37}Cl_2$	$^{13}C_{12}$ Cl-4 PCB
	323.8834	M	$^{12}C_{12}H_{5}{}^{35}Cl_5$	Cl-5 PCB
	325.8804	M+2	$^{12}C_{12}H_{5}{}^{35}Cl_4{}^{37}Cl$	Cl-5 PCB
	327.8775	M+4	$^{12}C_{12}H_{5}{}^{35}Cl_3{}^{37}Cl_2$	Cl-5 PCB
	330.9792	lock	C_7F_{15}	PFK
	337.9207	M+2	$^{13}C_{12}H_{5}{}^{35}Cl_4{}^{37}Cl$	$^{13}C_{12}$ Cl-5 PCB
	339.9178	M+4	$^{13}C_{12}H_{5}{}^{35}Cl_3{}^{37}Cl_2$	$^{13}C_{12}$ Cl-5 PCB

Table 7. Scan Descriptors, Levels of Chlorination, m/z Information, and Substances Monitored by HRGC/HRMS

Function and Chlorine Level	m/z[1]	m/z Type	m/z Formula	Substance
Fn-4; Cl-4, 5, 6	359.8415	M+2	$^{12}C_{12}\,H_4\,^{35}Cl_5\,^{37}Cl$	Cl-6 PCB
	361.8385	M+4	$^{12}C_{12}\,H_4\,^{35}Cl_4\,^{37}Cl_2$	Cl-6 PCB
	363.8356	M+6	$^{12}C_{12}\,H_4\,^{35}Cl_3\,^{37}Cl_3$	Cl-6 PCB
	371.8817	M+2	$^{13}C_{12}\,H_4\,^{35}Cl_5\,^{37}Cl$	$^{13}C_{12}$ Cl-6 PCB
	373.8788	M+4	$^{13}C_{12}\,H_4\,^{35}Cl_4\,^{37}Cl_2$	$^{13}C_{12}$ Cl-6 PCB
Fn-5; Cl-5, 6, 7	323.8834	M	$^{12}C_{12}\,H_5\,^{35}Cl_5$	Cl-5 PCB
	325.8804	M+2	$^{12}C_{12}\,H_5\,^{35}Cl_4\,^{37}Cl$	Cl-5 PCB
	327.8775	M+4	$^{12}C_{12}\,H_5\,^{35}Cl_3\,^{37}Cl_2$	Cl-5 PCB
	337.9207	M+2	$^{13}C_{12}\,H_5\,^{35}Cl_4\,^{37}Cl$	$^{13}C_{12}$ Cl-5 PCB
	339.9178	M+4	$^{13}C_{12}\,H_5\,^{35}Cl_3\,^{37}Cl_2$	$^{13}C_{12}$ Cl-5 PCB
	354.9792	lock	$C_9\,F_{13}$	PFK
	359.8415	M+2	$^{12}C_{12}\,H_4\,^{35}Cl_5\,^{37}Cl$	Cl-6 PCB
	361.8385	M+4	$^{12}C_{12}\,H_4\,^{35}Cl_4\,^{37}Cl_2$	Cl-6 PCB
	363.8356	M+6	$^{12}C_{12}\,H_4\,^{35}Cl_3\,^{37}Cl_3$	Cl-6 PCB
	371.8817	M+2	$^{13}C_{12}\,H_4\,^{35}Cl_5\,^{37}Cl$	$^{13}C_{12}$ Cl-6 PCB
	373.8788	M+4	$^{13}C_{12}\,H_4\,^{35}Cl_4\,^{37}Cl_2$	$^{13}C_{12}$ Cl-6 PCB
	393.8025	M+2	$^{12}C_{12}\,H_3\,^{35}Cl_6\,^{37}Cl$	Cl-7 PCB
	395.7995	M+4	$^{12}C_{12}\,H_3\,^{35}Cl_5\,^{37}Cl_2$	Cl-7 PCB
	397.7966	M+6	$^{12}C_{12}\,H_3\,^{35}Cl_4\,^{37}Cl_3$	Cl-7 PCB
	405.8428	M+2	$^{13}C_{12}\,H_3\,^{35}Cl_6\,^{37}Cl$	$^{13}C_{12}$ Cl-7 PCB
	407.8398	M+4	$^{13}C_{12}\,H_3\,^{35}Cl_5\,^{37}Cl_2$	$^{13}C_{12}$ Cl-7 PCB
	454.9728	QC	$C_{11}\,F_{17}$	PFK
Fn-6; Cl-7, 8, 9, 10	393.8025	M+2	$^{12}C_{12}\,H_3\,^{35}Cl_6\,^{37}Cl$	Cl-7 PCB
	395.7995	M+4	$^{12}C_{12}\,H_3\,^{35}Cl_5\,^{37}Cl_2$	Cl-7 PCB
	397.7966	M+6	$^{12}C_{12}\,H_3\,^{35}Cl_4\,^{37}Cl_3$	Cl-7 PCB
	405.8428	M+2	$^{13}C_{12}\,H_3\,^{35}Cl_6\,^{37}Cl$	$^{13}C_{12}$ Cl-7 PCB
	407.8398	M+4	$^{13}C_{12}\,H_3\,^{35}Cl_5\,^{37}Cl_2$	$^{13}C_{12}$ Cl-7 PCB
	427.7635	M+2	$^{12}C_{12}\,H_2\,^{35}Cl_7\,^{37}Cl$	Cl-8 PCB
	429.7606	M+4	$^{12}C_{12}\,H_2\,^{35}Cl_6\,^{37}Cl_2$	Cl-8 PCB
	431.7576	M+6	$^{12}C_{12}\,H_2\,^{35}Cl_5\,^{37}Cl_3$	Cl-8 PCB
	439.8038	M+2	$^{13}C_{12}\,H_2\,^{35}Cl_7\,^{37}Cl$	$^{13}C_{12}$ Cl-8 PCB
	441.8008	M+4	$^{13}C_{12}\,H_2\,^{35}Cl_6\,^{37}Cl_2$	$^{13}C_{12}$ Cl-8 PCB
	442.9728	QC	$C_{10}\,F_{13}$	PFK
	454.9728	lock	$C_{11}\,F_{13}$	PFK
	461.7246	M+2	$^{12}C_{12}\,H_1\,^{35}Cl_8\,^{37}Cl$	Cl-9 PCB
	463.7216	M+4	$^{12}C_{12}\,H_1\,^{35}Cl_7\,^{37}Cl_2$	Cl-9 PCB
	465.7187	M+6	$^{12}C_{12}\,H_1\,^{35}Cl_6\,^{37}Cl_3$	Cl-9 PCB
	473.7648	M+2	$^{13}C_{12}\,H_1\,^{35}Cl_8\,^{37}Cl$	$^{13}C_{12}$ Cl-9 PCB
	475.7619	M+4	$^{13}C_{12}\,H_1\,^{35}Cl_7\,^{37}Cl_2$	$^{13}C_{12}$ Cl-9 PCB
	495.6856	M+2	$^{12}C_{12}\,H_4\,^{35}Cl_9\,^{37}Cl$	Cl-10 PCB
	497.6826	M+4	$^{12}C_{12}\,^{35}Cl_8\,^{37}Cl_2$	Cl-10 PCB
	499.6797	M+6	$^{12}C_{12}\,^{35}Cl_7\,^{37}Cl_3$	Cl-10 PCB

Table 7. Scan Descriptors, Levels of Chlorination, m/z Information, and Substances Monitored by HRGC/HRMS

Function and Chlorine Level	m/z[1]	m/z Type	m/z Formula	Substance
Fn-6; Cl-7, 8, 9, 10	507.7258	M+2	$^{13}C_{12}\ ^{35}Cl_9\ ^{37}Cl$	$^{13}C_{12}$ Cl-10 PCB
	509.7229	M+4	$^{13}C_{12}\ ^{35}Cl_8\ ^{37}Cl_2$	$^{13}C_{12}$ Cl-10 PCB
	511.7199	M+6	$^{13}C_{12}\ ^{35}Cl_7\ ^{37}Cl_3$	$^{13}C_{12}$ Cl-10 PCB

1. Isotopic masses used for accurate mass calculation

^{1}H	1.0078
^{12}C	12.0000
^{13}C	13.0034
^{35}Cl	34.9689
^{37}Cl	36.9659
^{19}F	18.9984

2. An interference with PFK m/z 223.9872 may preclude meeting 10:1 S/N for the DiCB congeners at the CS-0.2 and CS-1 calibration levels (Section 10.3.3 and Table 5). If this interferences occurs, 10:1 S/N must be met at the CS-2 level. See the note at Section 10.2.1 for information on how to minimize this interference.

Table 8. Theoretical Ion Abundance Ratios and QC Limits

Chlorine Atoms	m/z's Forming Ratio	Theoretical Ratio	Lower QC Limit	Upper QC Limit
1	M/(M+2)	3.13	2.66	3.60
2	M/(M+2)	1.56	1.33	1.79
3	M/(M+2)	1.04	0.88	1.20
4	M/(M+2)	0.77	0.65	0.89
5	(M+2)/(M+4)	1.55	1.32	1.78
6	(M+2)/(M+4)	1.24	1.05	1.43
7	(M+2)/(M+4)	1.05	0.89	1.21
8	(M+2)/(M+4)	0.89	0.76	1.02
9	(M+2)/(M+4)	0.77	0.65	0.89
10	(M+4)(M+6)	1.16	0.99	1.33

Table 9. Suggested Sample Quantities to be Extracted for Various Matrices[1]

Sample Matrix[2]	Example	Percent Solids	Phase	Quantity Extracted
Single-phase				
Aqueous	Drinking water Groundwater Treated wastewater	<1	–[3]	1000 mL
Solid	Dry soil Compost Ash	>20	Solid	10 g
Organic	Waste solvent Waste oil Organic polymer	<1	Organic	10 g
Tissue	Fish Human adipose	–	Organic	10 g
Multi-phase - Liquid/Solid				
Aqueous/Solid	Wet soil Untreated effluent Digested municipal sludge Filter cake Paper pulp	1-30	Solid	10 g
Organic/solid	Industrial sludge Oily waste	1-100	Both	10 g
Multi-phase - Liquid/Liquid				
Aqueous/organic	In-process effluent Untreated effluent Drum waste	<1	Organic	10 g
Multi-phase - Liquid/Liquid/Solid				
Aqueous/organic/solid	Untreated effluent Drum waste	>1	Organic and solid	10 g

1. The quantity of sample to be extracted is adjusted to provide 10 g of solids (dry weight). One liter of aqueous samples containing one percent solids will contain 10 grams of solids. For aqueous samples containing greater than one percent solids, a lesser volume is used so that 10 grams of solids (dry weight) will be extracted. Other sample volumes may be used to meet project needs.

2. The sample matrix may be amorphous for some samples. In general, when the CBs are in contact with a multi-phase system in which one of the phases is water, they will be preferentially dispersed in or adsorbed on the alternate phase because of their low solubility in water.

3. Aqueous samples are filtered after spiking with the labeled compounds. The filtrate and the materials trapped on the filter are extracted separately, and the extracts are combined for cleanup and analysis.

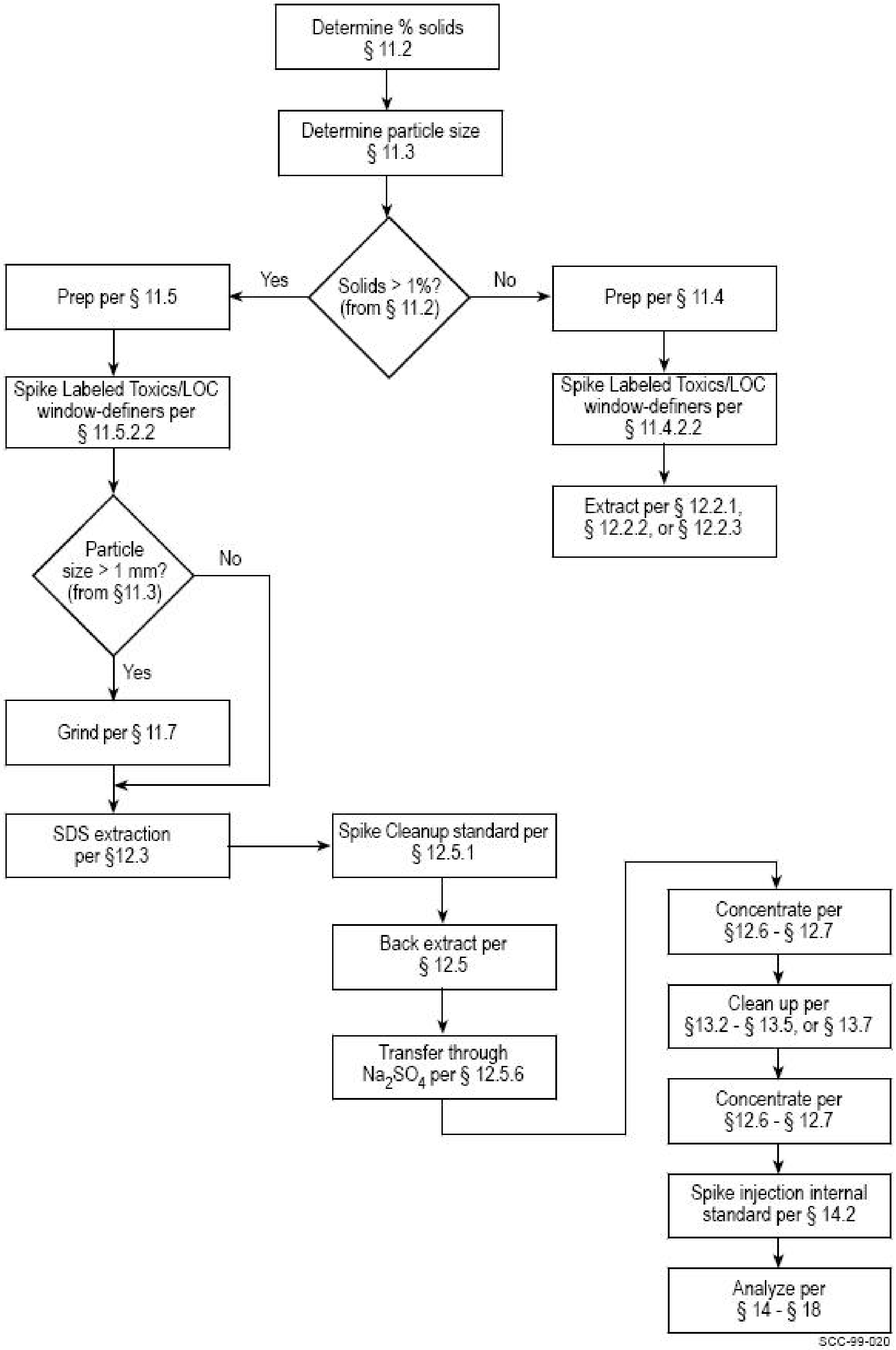

Figure 1 Flow Chart for Analysis of Aqueous and Solid Samples

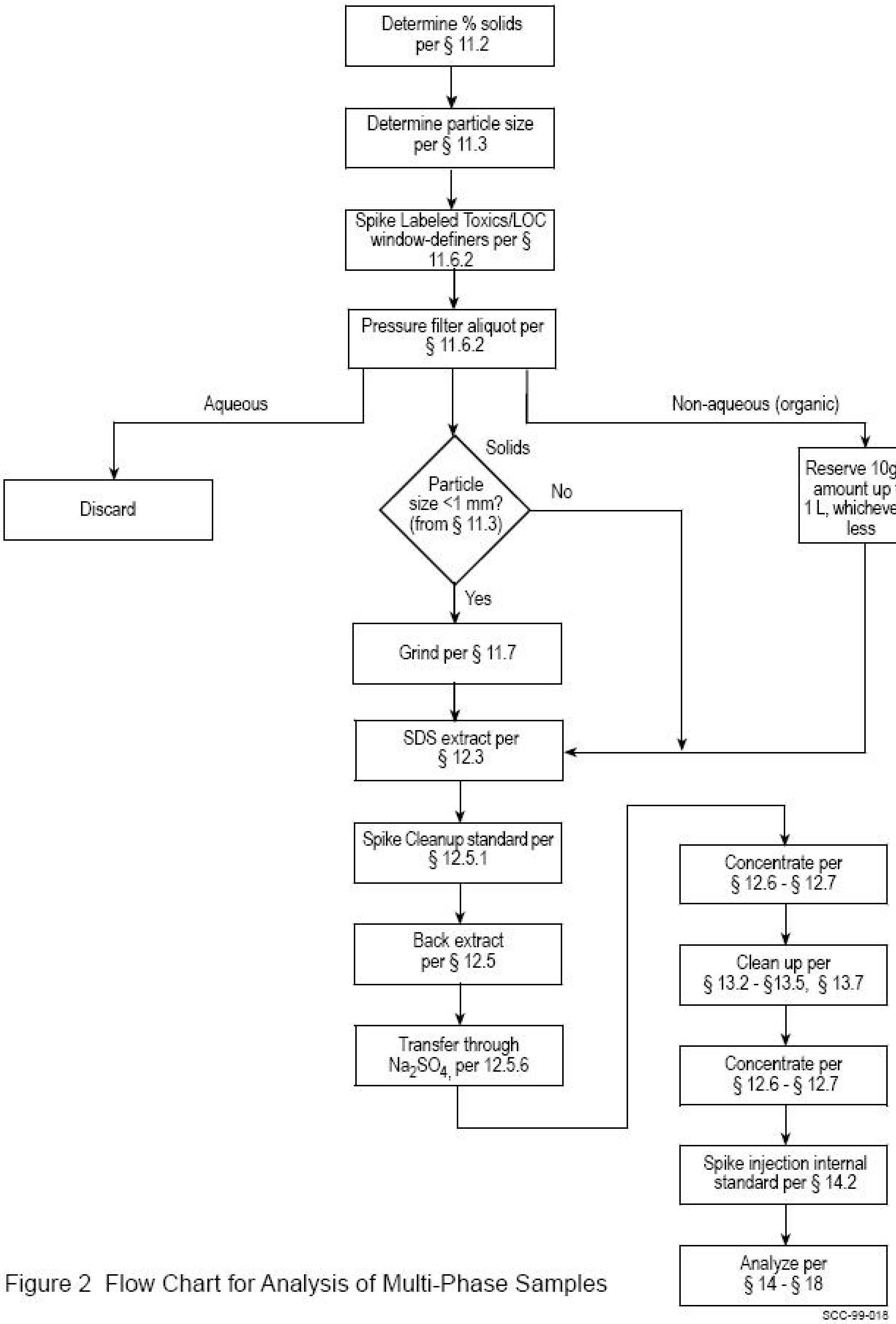

Figure 2 Flow Chart for Analysis of Multi-Phase Samples

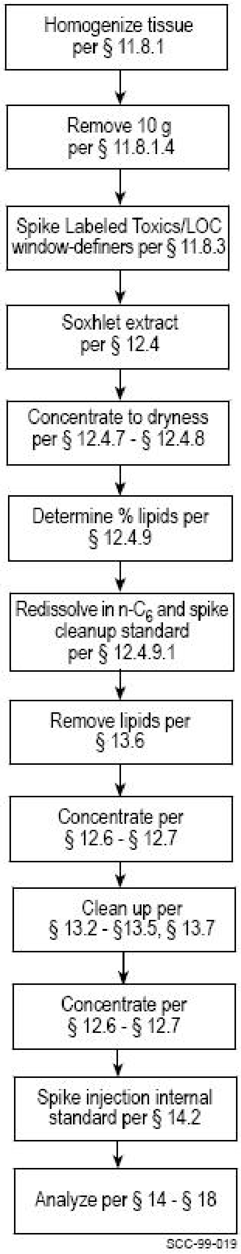

Figure 3 Flow Chart for Analysis of Tissue Samples

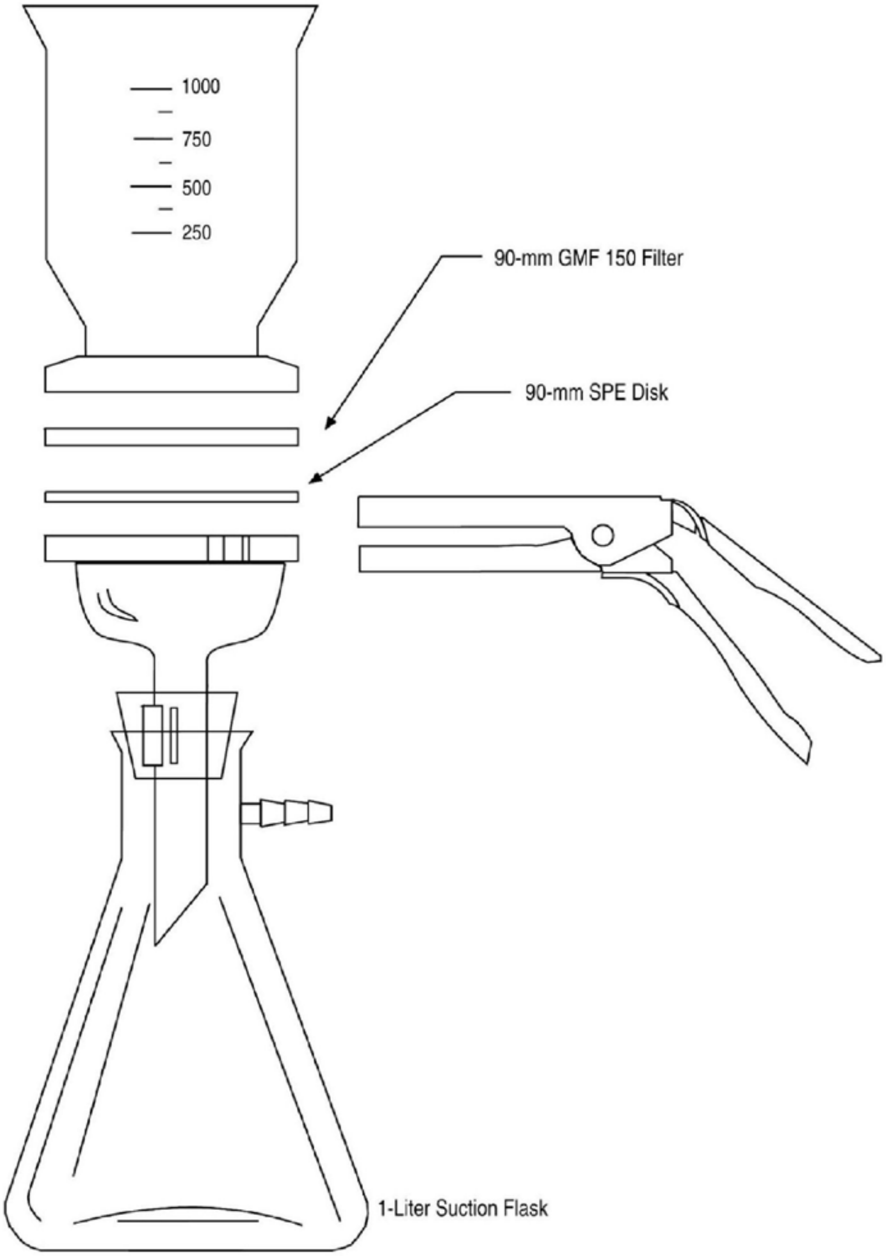

Figure 4. Solid-phase Extraction Apparatus

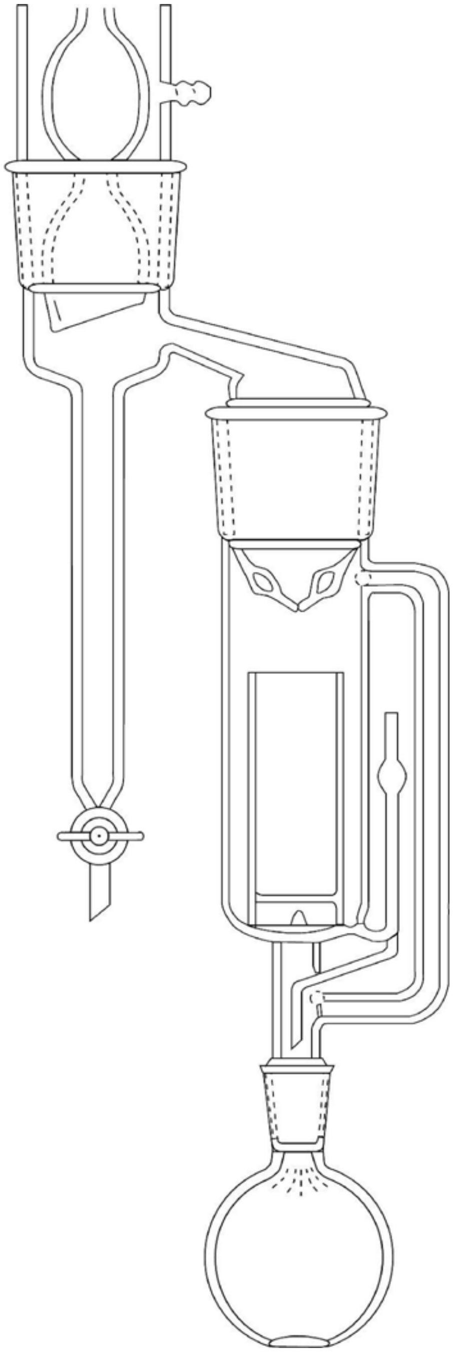

Figure 5. Soxhlet/Dean Stark Extractor

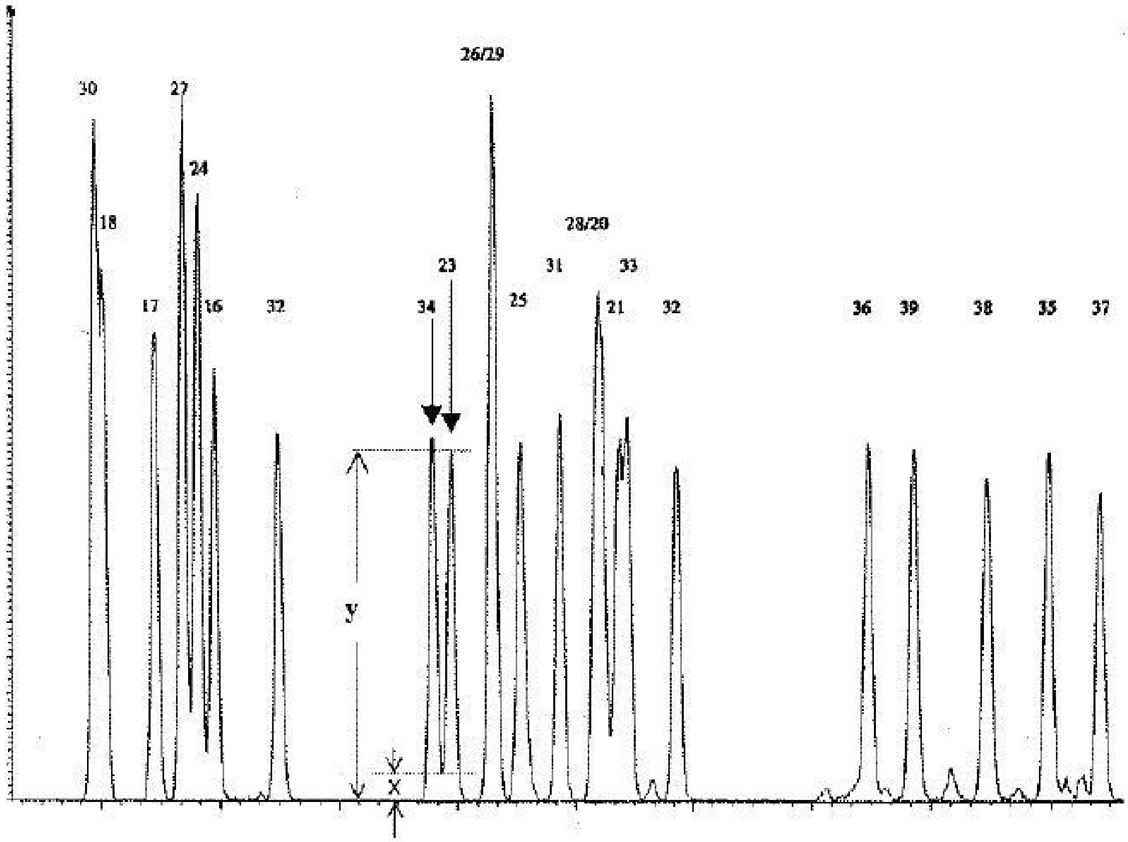

Figure 6 Octyl column resolution test #1: Separation of Cl-3 congeners 34 and 23 with valley <40% (i.e. 100x/y < 40%)

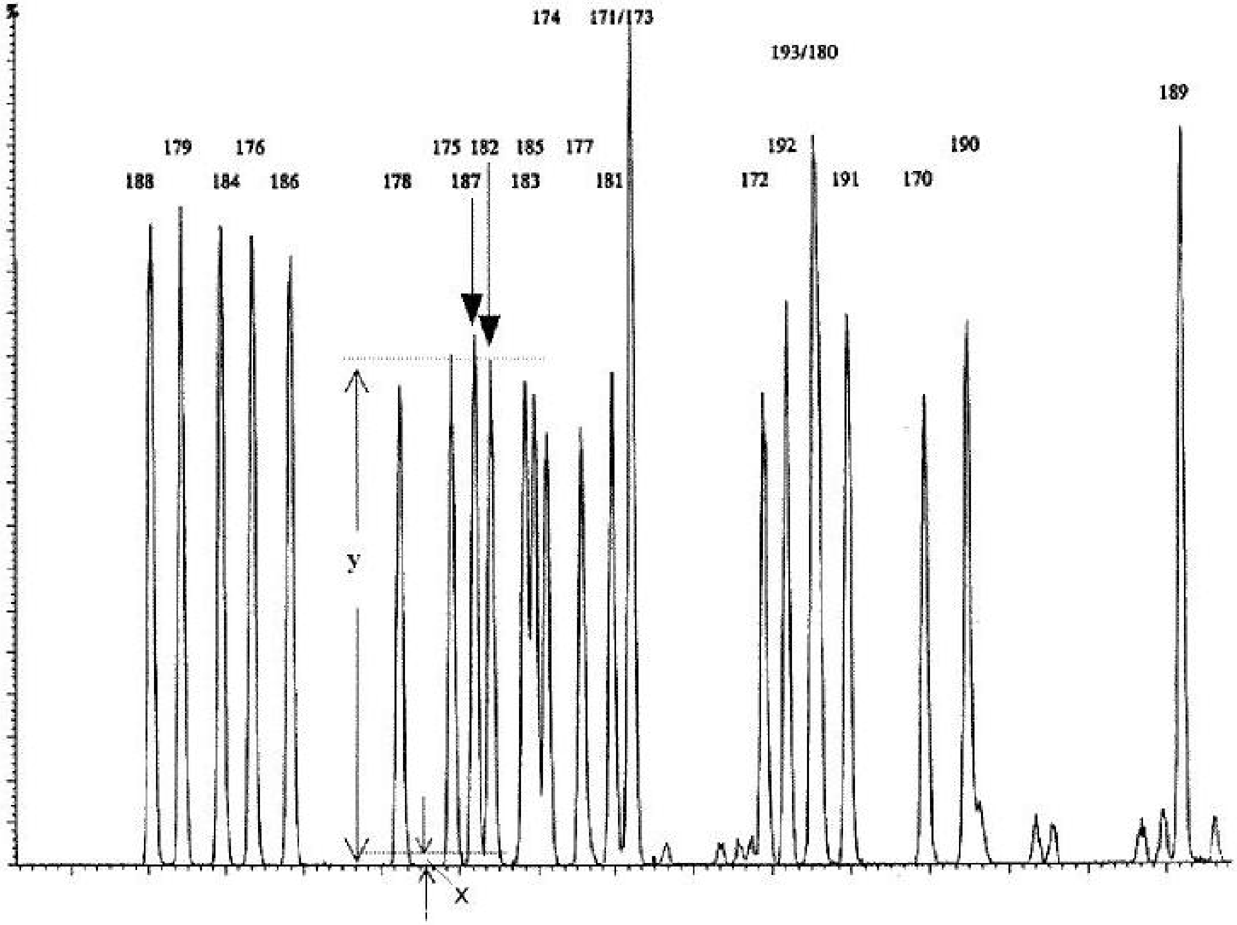

Figure 7 Octyl column resolution test #2: Separation of Cl-7 congeners 187 and 182 with valley < 40% (i.e. 100 x/y < 40%)

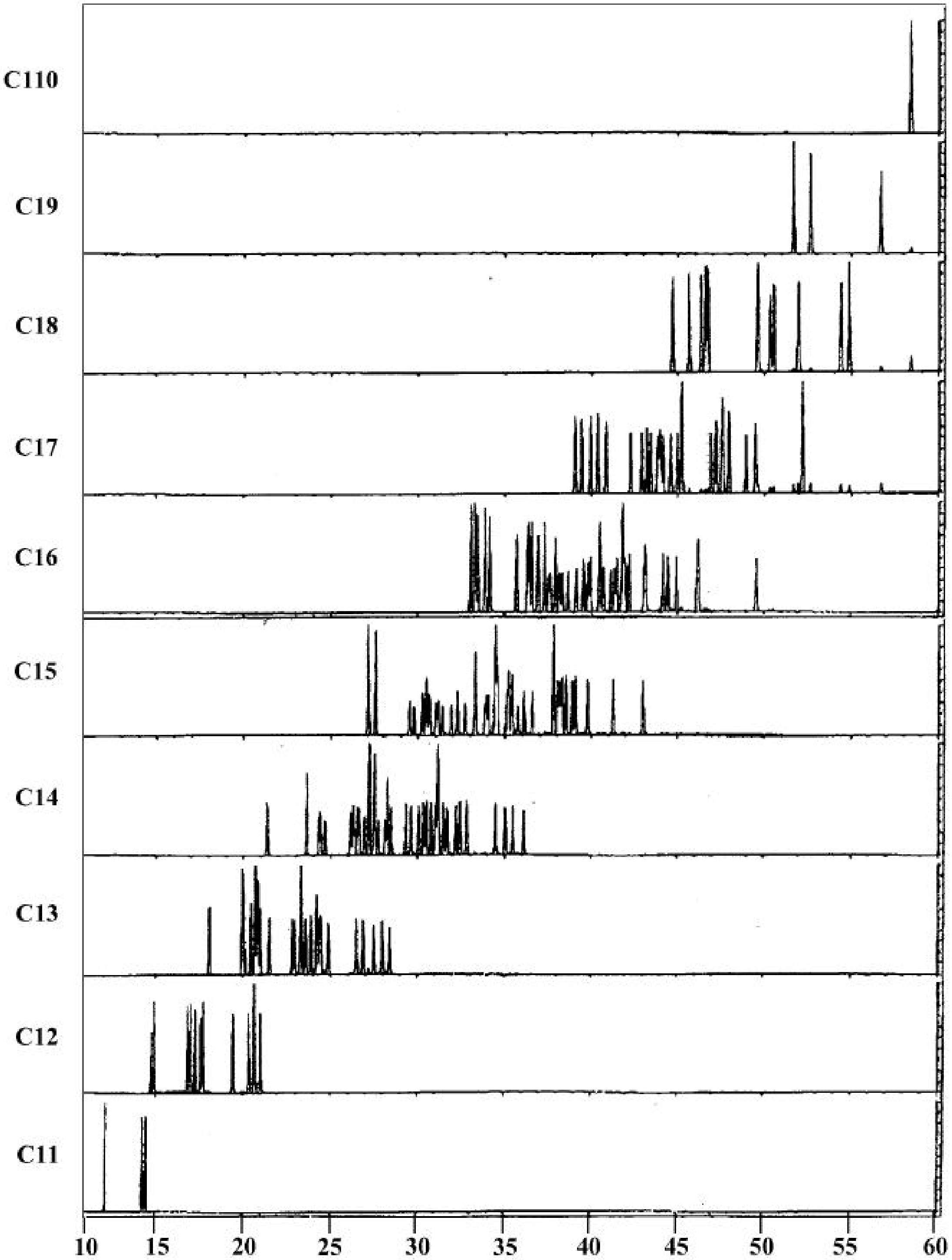

Figure 8. CB congeners at each level of chlorination on the SPB-octyl column

24.0 Glossary

These definitions and purposes are specific to this method, but have been conformed to common usage to the extent possible.

24.1 Units of weight and measure and their abbreviations

24.1.1 Symbols

ºC	degrees Celsius
µL	microliter
µm	micrometer
<	less than
>	greater than
%	percent

24.1.2 Alphabetical abbreviations

cm	centimeter
g	gram
h	hour
ID	inside diameter
in.	inch
L	liter
M	molecular ion
m	meter
mg	milligram
min	minute
mL	milliliter
mm	millimeter
m/z	mass-to-charge ratio
N	normal; gram molecular weight of solute divided by hydrogen equivalent of solute, per liter of solution
OD	outside diameter
pg	picogram
ppb	part-per-billion
ppm	part-per-million
ppq	part-per-quadrillion
ppt	part-per-trillion
psig	pound-per-square-inch gauge
v/v	volume per unit volume
w/v	weight per unit volume

24.2 Definitions and acronyms (in alphabetical order)

Analyte – A CB tested for by this method. The analytes are listed in Table 1.

Calibration standard (CAL) – A solution prepared from a secondary standard and/or stock solutions and used to calibrate the response of the HRGC/HRMS instrument.

Calibration verification standard (VER) – The mid-point calibration standard (CS-3) that is used to verify calibration. See Table 5.

CB – Chlorinated biphenyl congener. One of the 209 individual chlorinated biphenyl congeners determined using this method. The 209 CBs are listed in Table 1.

CS-0.2, CS-1, CS-2, CS-3, CS-4, CS-5 – See Calibration standards and Table 5

DeCB – Decachlorobiphenyl (PCB 209)

DiCB – Dichlorobiphenyl

Field blank – An aliquot of reagent water or other reference matrix that is placed in a sample container in the laboratory or the field, and treated as a sample in all respects, including exposure to sampling site conditions, storage, preservation, and all analytical procedures. The purpose of the field blank is to determine if the field or sample transporting procedures and environments have contaminated the sample.

GC – Gas chromatograph or gas chromatography

GPC – Gel permeation chromatograph or gel permeation chromatography

HpCB – Heptachlorobiphenyl

HPLC – High performance liquid chromatograph or high performance liquid chromatography

HRGC – High resolution GC

HRMS – High resolution MS

HxCB – Hexachlorobiphenyl

Labeled injection internal standard – All five, or any one of the five, $^{13}C_{12}$-labeled CB congeners spiked into the concentrated extract immediately prior to injection of an aliquot of the extract into the HRGC/HRMS. The five Labeled injection internal standards in this method are CBs with congener numbers 9L, 52L, 101L, 138L, and 194L.

Internal standard – a labeled compound used as a reference for quantitation of other labeled compounds and for quantitation of native CB congeners other than the congener of which it is a labeled analog. See Internal standard quantitation.

Internal standard quantitation – A means of determining the concentration of (1) a naturally occurring (native) compound by reference to a compound other than its labeled analog and (2) a labeled compound by reference to another labeled compound

IPR – Initial precision and recovery; four aliquots of a reference matrix spiked with the analytes of interest and labeled compounds and analyzed to establish the ability of the laboratory to generate acceptable precision and recovery. An IPR is performed prior to the first time this method is used and any time the method or instrumentation is modified.

Isotope dilution quantitation – A means of determining a naturally occurring (native) compound by reference to the same compound in which one or more atoms has been isotopically enriched. In this method, all 12 carbon atoms in the biphenyl molecule are enriched with carbon-13 to produce $^{13}C_{12}$- labeled analogs of the chlorinated biphenyls. The $^{13}C_{12}$-labeled CBs are spiked into each sample and allow identification and correction of the concentration of the native compounds in the analytical process.

K-D – Kuderna-Danish concentrator; a device used to concentrate the analytes in a solvent

Laboratory blank – See Method blank

Laboratory control sample (LCS) – See Ongoing precision and recovery standard (OPR)

Laboratory reagent blank – See Method blank

May – This action, activity, or procedural step is neither required nor prohibited.

May not – This action, activity, or procedural step is prohibited.

Method blank – An aliquot of reagent water that is treated exactly as a sample including exposure to all glassware, equipment, solvents, reagents, internal standards, and surrogates that are used with samples. The method blank is used to determine if analytes or interferences are present in the laboratory environment, the reagents, or the apparatus.

Method Detection Limit – The minimum concentration of a substance that can be measured and reported with 99% confidence that the analyte concentration is greater than zero (40 CFR 136, Appendix B)

Minimum level of quantitation (ML) – The lowest level at which the entire analytical system must give a recognizable signal and acceptable calibration point for the analyte. The ML represents the lowest concentration at which an analyte can be measured with a known level of confidence. It may be equivalent to the concentration of the lowest calibration standard, assuming that all method-specified sample weights, volumes, and cleanup procedures have been employed. The ML is calculated by multiplying the MDL (pooled or unpooled, as appropriate) by 3.18 and rounding the result to the number nearest to 1, 2, or 5 x 10^n, where n is zero or an integer (see 68 FR 11790).

MoCB – Monochlorobiphenyl

MS – Mass spectrometer or mass spectrometry

Must – This action, activity, or procedural step is required.

NoCB – Nonachlorobiphenyl

OcCB – Octachlorobiphenyl

OPR – Ongoing precision and recovery standard (OPR); a method blank spiked with known quantities of analytes. The OPR is analyzed exactly like a sample. Its purpose is to assure that the results produced by the laboratory remain within the limits specified in this method for precision and recovery.

Perfluorokerosene (PFK) – A mixture of compounds used to calibrate the exact m/z scale in the HRMS

Preparation blank – See Method blank

Quality control check sample (QCS) – A sample containing all or a subset of the analytes at known concentrations. The QCS is obtained from a source external to the laboratory or is prepared from a source of standards different from the source of calibration standards. It is used to check laboratory performance with test materials prepared external to the normal preparation process.

PeCB – Pentachlorobiphenyl

PCB – Polychlorinated biphenyl

Reagent water – Water demonstrated to be free from the analytes of interest and potentially interfering substances at the method detection limit for the analyte.

Relative standard deviation (RSD) – The standard deviation times 100 divided by the mean. Also termed "coefficient of variation."

RF – Response factor. See Section 10.5.

RR – Relative response. See Section 10.4.

SDS – Soxhlet/Dean-Stark extractor; an extraction device applied to the extraction of solid and semi-solid materials (Reference 11 and Figure 5)

Signal-to-noise ratio (S/N) – The height of the signal as measured from the mean (average) of the noise to the peak maximum divided by the width of the noise

Should – This action, activity, or procedural step is suggested but not required.

SICP – Selected ion current profile; the line described by the signal at an exact m/z

SPE – Solid-phase extraction; an extraction technique in which an analyte is extracted from an aqueous sample by passage over or through a material capable of reversibly adsorbing the analyte. Also termed liquid-solid extraction.

Stock solution – A solution containing an analyte that is prepared using a reference material traceable to EPA, the National Institute of Science and Technology (NIST), or a source that will attest to the purity and authenticity of the reference material.

TeCB – Tetrachlorobiphenyl

TEF – Toxicity equivalency factor; an estimate of the toxicity of a specific congener relative to 2,3,7,8-tetrachlorodibenzo-*p*-dioxin

TEQ – The toxicity equivalent concentration in an environmental sample. It is the sum of the concentrations of each individual toxic PCB and each individual 2,3,7,8-substituted, tetra-through octa-chlorinated, dibenzo-*p*-dioxin and dibenzofuran multiplied by their respective TEFs (Reference 1).

$\mathbf{TEQ_{PCB}}$ – The portion of the TEQ attributable to the toxic PCBs

TrCB – Trichlorobiphenyl

Unique GC resolution or uniquely resolved – Two adjacent chromatographic peaks in which the height of the valley is less than 40 percent of the height of the shorter peak. See Section 6.9.1.1.2 and Figures 6 and 7 for unique resolution specific to the SPB-octyl column.

VER – See Calibration verification

Appendix A - Preliminary Information for Determination of 209 CBs on the DB-1 Column

1.0 Column and Conditions

1.1 Column – 30 ± 5-m long x 0.25 ± 0.02-mm ID; 0.25 µm film DB-1 (J&W, or equivalent).

1.2 Suggested GC operating conditions:

Injector temperature:	270 ºC
Interface temperature:	290 ºC
Initial temperature:	75 ºC
Initial time:	2 minutes
Temperature program:	75-150 ºC at 15 ºC/minute
	150-270 ºC at 2.5 ºC/minute
Final time:	7 minutes
Carrier gas velocity:	40 cm/sec at 200 ºC

Note: *The GC conditions may be optimized for compound separation and sensitivity. Once optimized, the same GC conditions must be used for the analysis of all standards, blanks, IPR and OPR aliquots, and samples.*

2.0 Operating Information

2.1 Congener solutions – Mixes of individual congeners that will allow separation of all 209 congeners on the DB-1 column had not been developed when writing Method 1668C.

2.2 Elution order data – The congener mixes developed for the SPB-octyl column (Table 4 of Method 1668C) were run on the DB-1 column. Although some congeners in these mixes co-elute, the mixes allow determination of retention times for many congeners on the DB-1 column. These retention times are shown in Appendix Table A-1.

2.3 Window-defining congeners – The beginning and ending congeners at each level of chlorination are the same as for the SPB-octyl column. See Table 2 in Method 1668C.

2.4 Scan descriptors – The 6-function scan descriptors are shown in Appendix Table A-2.

Table A-1. Retention time (RT) References, Quantitation References, and Relative Retention Times (RRTs) for CB Congeners using a DB-1 Column

Labeled or Native CB[1]	Congener No.[2]	Retention Time and Quantitation References	Congener No.[2]	RT	RRT	RRT QC Limits[3]
$^{13}C_{12}$-2-MoCB[4]	1L	$^{13}C_{12}$-4-MoCB[4,5]	3L	09:17	0.8855	0.8776-0.8935
2-MoCB	1	$^{13}C_{12}$-2-MoCB[4]	1L	09:17	1.0000	0.9964-1.0072
3-MoCB	2	$^{13}C_{12}$-4-MoCB[4,5]	3L	10:22	0.9889	0.9809-0.9968
$^{13}C_{12}$-4-MoCB[4,5]	3L	$^{13}C_{12}$-2,2',5,5'-TeCB[7]	52L	10:29	0.5561	0.5473-0.5650
4-MoCB	3	$^{13}C_{12}$-4-MoCB[4,5]	3L	10:29	1.0000	0.9968-1.0064
$^{13}C_{12}$-2,2'-DiCB[4]	4L	$^{13}C_{12}$-4,4'-DiCB[4,5]	15L	11:08	0.7591	0.7477-0.7705
2,2'-DiCB	4	$^{13}C_{12}$-2,2'-DiCB[4]	4L	11:08	1.0000	0.9925-1.0075
2,6-DiCB	10	$^{13}C_{12}$-4,4'-DiCB[4,5]	15L	11:10	0.7614	0.7500-0.7727
2,5-DiCB	9	$^{13}C_{12}$-4,4'-DiCB[4,5]	15L	12:08	0.8273	0.8216-0.8330
2,4-DiCB	7	$^{13}C_{12}$-4,4'-DiCB[4,5]	15L	12:09	0.8284	0.8227-0.8341
2,3'-DiCB	6	$^{13}C_{12}$-4,4'-DiCB[4,5]	15L	12:31	0.8534	0.8477-0.8591
2,4'-DiCB[6]	8	$^{13}C_{12}$-4,4'-DiCB[4,5]	15L	12:43	0.8670	0.8614-0.8727
2,3-DiCB	5	$^{13}C_{12}$-4,4'-DiCB[4,5]	15L	12:46	0.8705	0.8648-0.8761
$^{13}C_{12}$-2,2',6-TrCB[4]	19L	$^{13}C_{12}$-2,4,4'-TrCB[5]	28L	13:31	0.7990	0.7892-0.8089
3,5-DiCB	14	$^{13}C_{12}$-4,4'-DiCB[4,5]	15L	13:36	0.9273	0.9216-0.9330
2,4,6-TrCB	30	$^{13}C_{12}$-2,4,4'-TrCB[5]	28L	14:06	0.8335	0.8286-0.8384
3,3'-DiCB	11	$^{13}C_{12}$-4,4'-DiCB[4,5]	15L	14:11	0.9670	0.9614-0.9727
3,4'-DiCB	13	$^{13}C_{12}$-4,4'-DiCB[4,5]	15L	14:26	0.9841	0.9784-0.9898
3,4-DiCB	12	$^{13}C_{12}$-4,4'-DiCB[4,5]	15L	14:27	0.9852	0.9795-0.9909
2,2',5-TrCB[6]	18	$^{13}C_{12}$-2,4,4'-TrCB[5]	28L	14:36	0.8631	0.8581-0.8680
$^{13}C_{12}$-4,4'-DiCB[4,5]	15L	$^{13}C_{12}$-2,2',5,5'-TeCB[7]	52L	14:40	0.7781	0.7692-0.7869
4,4'-DiCB	15	$^{13}C_{12}$-4,4'-DiCB[4,5]	15L	14:40	1.0000	0.9977-1.0043
2,2',4-TrCB	17	$^{13}C_{12}$-2,4,4'-TrCB[5]	28L	14:43	0.8700	0.8650-0.8749
2,3',6-TrCB	27	$^{13}C_{12}$-2,4,4'-TrCB[5]	28L	15:06	0.8926	0.8877-0.8975
2,3,6-TrCB	24	$^{13}C_{12}$-2,4,4'-TrCB[5]	28L	15:06	0.8926	0.8877-0.8975
2,2',3-TrCB	16	$^{13}C_{12}$-2,4,4'-TrCB[5]	28L	15:26	0.9123	0.9074-0.9172
2,4',6-TrCB	32	$^{13}C_{12}$-2,4,4'-TrCB[5]	28L	15:29	0.9153	0.9103-0.9202
$^{13}C_{12}$-2,2',6,6'-TeCB[4]	54L	$^{13}C_{12}$-3,3',4,4'-TeCB[4,5,9]	77L	16:02	0.6139	0.6075-0.6203
2,2',6,6'-TeCB	54	$^{13}C_{12}$-2,2',6,6'-TeCB[4]	54L	16:02	1.0000	0.9979-1.0042
2',3,5-TrCB	34	$^{13}C_{12}$-2,4,4'-TrCB[5]	28L	16:03	0.9488	0.9438-0.9537
2,3,5-TrCB	23	$^{13}C_{12}$-2,4,4'-TrCB[5]	28L	16:07	0.9527	0.9478-0.9576
2,4,5-TrCB	29	$^{13}C_{12}$-2,4,4'-TrCB[5]	28L	16:18	0.9635	0.9586-0.9685

Table A-1. Retention time (RT) References, Quantitation References, and Relative Retention Times (RRTs) for CB Congeners using a DB-1 Column

Labeled or Native CB[1]	Congener No.[2]	Retention Time and Quantitation References	Congener No.[2]	RT	RRT	RRT QC Limits[3]
2,3',5-TrCB	26	$^{13}C_{12}$-2,4,4'-TrCB[5]	28L	16:29	0.9744	0.9695-0.9793
2,3',4-TrCB	25	$^{13}C_{12}$-2,4,4'-TrCB[5]	28L	16:36	0.9813	0.9764-0.9862
2,4',5-TrCB	31	$^{13}C_{12}$-2,4,4'-TrCB[5]	28L	16:52	0.9970	0.9921-1.0020
$^{13}C_{12}$-2,4,4'-TrCB[5]	28L	$^{13}C_{12}$-2,2',5,5'-TeCB[7]	52L	16:55	0.8974	0.8930-0.9019
2,4,4'-TrCB[6]	28	$^{13}C_{12}$-2,4,4'-TrCB[5]	28L	16:55	1.0000	0.9980-1.0039
2,2',4,6-TeCB	50	$^{13}C_{12}$-3,3',4,4'-TeCB[4,5,9]	77L	16:55	0.6477	0.6414-0.6541
2,3,4-TrCB	21	$^{13}C_{12}$-2,4,4'-TrCB[5]	28L	17:21	1.0256	1.0207-1.0305
2,2',5,6'-TeCB	53	$^{13}C_{12}$-3,3',4,4'-TeCB[4,5,9]	77L	17:26	0.6675	0.6611-0.6739
2,3,3'-TrCB	20	$^{13}C_{12}$-2,4,4'-TrCB[5]	28L	17:22	1.0266	1.0217-1.0315
2',3,4-TrCB	33	$^{13}C_{12}$-2,4,4'-TrCB[5]	28L	17:24	1.0286	1.0236-1.0335
2,2',4,6'-TeCB	51	$^{13}C_{12}$-3,3',4,4'-TeCB[4,5,9]	77L	17:42	0.6777	0.6713-0.6841
2,3,4'-TrCB	22	$^{13}C_{12}$-2,4,4'-TrCB[5]	28L	17:43	1.0473	1.0424-1.0522
2,2',3,6-TeCB	45	$^{13}C_{12}$-3,3',4,4'-TeCB[4,5,9]	77L	18:00	0.6892	0.6828-0.6956
3,3',5-TrCB	36	$^{13}C_{12}$-2,4,4'-TrCB[5]	28L	18:16	1.0798	1.0749-1.0847
2,2',3,6'-TeCB	46	$^{13}C_{12}$-3,3',4,4'-TeCB[4,5,9]	77L	18:24	0.7045	0.6981-0.7109
3,4',5-TrCB	39	$^{13}C_{12}$-2,4,4'-TrCB[5]	28L	18:37	1.1005	1.0956-1.1054
$^{13}C_{12}$-2,2',5,5'-TeCB[7]	52L	$^{13}C_{12}$-2,2',5,5'-TeCB[7]	52L	18:51	1.0000	0.9956-1.0044
2,2',5,5'-TeCB[6]	52	$^{13}C_{12}$-3,3',4,4'-TeCB[4,5,9]	77L	18:51	0.7218	0.7154-0.7281
2,3',4,6-TeCB	69	$^{13}C_{12}$-3,3',4,4'-TeCB[4,5,9]	77L	18:52	0.7224	0.7160-0.7288
2,3',5',6-TeCB	73	$^{13}C_{12}$-3,3',4,4'-TeCB[4,5,9]	77L	18:57	0.7256	0.7192-0.7320
2,2',4,5'-TeCB	49	$^{13}C_{12}$-3,3',4,4'-TeCB[4,5,9]	77L	19:00	0.7275	0.7211-0.7339
2,2',3,5-TeCB	43	$^{13}C_{12}$-3,3',4,4'-TeCB[4,5,9]	77L	19:04	0.7301	0.7237-0.7364
3,4,5-TrCB	38	$^{13}C_{12}$-2,4,4'-TrCB[5]	28L	19:12	1.1350	1.1300-1.1399
2,2',4,4'-TeCB	47	$^{13}C_{12}$-3,3',4,4'-TeCB[4,5,9]	77L	19:15	0.7371	0.7307-0.7435
2,4,4',6-TeCB	75	$^{13}C_{12}$-3,3',4,4'-TeCB[4,5,9]	77L	19:20	0.7403	0.7339-0.7466
2,2',4,5-TeCB	48	$^{13}C_{12}$-3,3',4,4'-TeCB[4,5,9]	77L	19:20	0.7403	0.7339-0.7466
2,3,5,6-TeCB	65	$^{13}C_{12}$-3,3',4,4'-TeCB[4,5,9]	77L	19:31	0.7473	0.7409-0.7537
2,3,4,6-TeCB	62	$^{13}C_{12}$-3,3',4,4'-TeCB[4,5,9]	77L	19:36	0.7505	0.7441-0.7569
3,3',4-TrCB	35	$^{13}C_{12}$-2,4,4'-TrCB[5]	28L	19:41	1.1635	1.1586-1.1685
$^{13}C_{12}$-2,2',4,6,6'-PeCB[4]	104L	$^{13}C_{12}$-2,3',4,4',5-PeCB[5,9]	118L	19:45	0.7037	0.6977-0.7096
2,2',4,6,6'-PeCB	104	$^{13}C_{12}$-2,2',4,6,6'-PeCB[4]	104L	19:45	1.0000	0.9983-1.0034
2,2',3,5'-TeCB[6]	44	$^{13}C_{12}$-3,3',4,4'-TeCB[4,5,9]	77L	19:55	0.7626	0.7562-0.7690

Table A-1. Retention time (RT) References, Quantitation References, and Relative Retention Times (RRTs) for CB Congeners using a DB-1 Column

Labeled or Native CB[1]	Congener No.[2]	Retention Time and Quantitation References	Congener No.[2]	RT	RRT	RRT QC Limits[3]
$^{13}C_{12}$-3,4,4'-TrCB[4]	37L	$^{13}C_{12}$-2,4,4'-TrCB[5]	28L	20:03	1.1852	1.1803-1.1901
3,4,4'-TrCB	37	$^{13}C_{12}$-3,4,4'-TrCB[4]	37L	20:03	1.0000	0.9983-1.0033
2,3,3',6-TeCB	59	$^{13}C_{12}$-3,3',4,4'-TeCB[4,5,9]	77L	20:05	0.7690	0.7626-0.7754
2,2',3,4'-TeCB	42	$^{13}C_{12}$-3,3',4,4'-TeCB[4,5,9]	77L	20:07	0.7703	0.7639-0.7766
2,3',5,5'-TeCB	72	$^{13}C_{12}$-3,3',4,4'-TeCB[4,5,9]	77L	20:36	0.7888	0.7824-0.7951
2,3',4',6-TeCB	71	$^{13}C_{12}$-3,3',4,4'-TeCB[4,5,9]	77L	20:36	0.7888	0.7824-0.7951
2,3,4',6-TeCB	64	$^{13}C_{12}$-3,3',4,4'-TeCB[4,5,9]	77L	20:37	0.7894	0.7830-0.7958
2,2',3,4-TeCB	41	$^{13}C_{12}$-3,3',4,4'-TeCB[4,5,9]	77L	20:39	0.7907	0.7843-0.7971
2,2',3,6,6'-PeCB	96	$^{13}C_{12}$-2,3',4,4',5-PeCB[5,9]	118L	20:48	0.7411	0.7352-0.7470
2,3',4,5'-TeCB	68	$^{13}C_{12}$-3,3',4,4'-TeCB[4,5,9]	77L	20:52	0.7990	0.7926-0.8054
2,2',3,3'-TeCB	40	$^{13}C_{12}$-3,3',4,4'-TeCB[4,5,9]	77L	20:58	0.8028	0.7996-0.8060
2,3,3',5-TeCB	57	$^{13}C_{12}$-3,3',4,4'-TeCB[4,5,9]	77L	21:21	0.8175	0.8143-0.8207
2,2',4,5,'6-PeCB	103	$^{13}C_{12}$-2,3',4,4',5-PeCB[5,9]	118L	21:22	0.7613	0.7553-0.7672
2,3',4,5-TeCB	67	$^{13}C_{12}$-3,3',4,4'-TeCB[4,5,9]	77L	21:38	0.8283	0.8251-0.8315
2,2',4,4',6-PeCB	100	$^{13}C_{12}$-2,3',4,4',5-PeCB[5,9]	118L	21:41	0.7726	0.7666-0.7785
2,3,3',5'-TeCB	58	$^{13}C_{12}$-3,3',4,4'-TeCB[4,5,9]	77L	21:43	0.8315	0.8283-0.8347
2,3,4',5-TeCB	63	$^{13}C_{12}$-3,3',4,4'-TeCB[4,5,9]	77L	21:51	0.8366	0.8334-0.8398
2,2',3,5,6'-PeCB	94	$^{13}C_{12}$-2,3',4,4',5-PeCB[5,9]	118L	22:05	0.7868	0.7809-0.7928
2,4,4',5-TeCB	74	$^{13}C_{12}$-3,3',4,4'-TeCB[4,5,9]	77L	22:07	0.8468	0.8437-0.8500
2,3,4,5-TeCB	61	$^{13}C_{12}$-3,3',4,4'-TeCB[4,5,9]	77L	22:11	0.8494	0.8462-0.8526
2,3',4',5-TeCB	70	$^{13}C_{12}$-3,3',4,4'-TeCB[4,5,9]	77L	22:20	0.8551	0.8519-0.8583
2',3,4,5-TeCB	76	$^{13}C_{12}$-3,3',4,4'-TeCB[4,5,9]	77L	22:25	0.8583	0.8551-0.8615
2,2',3',4,6-PeCB	98	$^{13}C_{12}$-2,3',4,4',5-PeCB[5,9]	118L	22:28	0.8005	0.7975-0.8034
2,3',4,4'-TeCB[6]	66	$^{13}C_{12}$-3,3',4,4'-TeCB[4,5,9]	77L	22:29	0.8609	0.8577-0.8641
2,2',4,5,6'-PeCB	102	$^{13}C_{12}$-2,3',4,4',5-PeCB[5,9]	118L	22:32	0.8029	0.7999-0.8058
2,2',3,5',6-PeCB	95	$^{13}C_{12}$-2,3',4,4',5-PeCB[5,9]	118L	22:34	0.8040	0.8011-0.8070
2,2',3,5,6-PeCB	93	$^{13}C_{12}$-2,3',4,4',5-PeCB[5,9]	118L	22:36	0.8052	0.8023-0.8082
3,3',5,5'-TeCB	80	$^{13}C_{12}$-3,3',4,4'-TeCB[4,5,9]	77L	22:45	0.8711	0.8679-0.8743
2,2',3,4,6-PeCB	88	$^{13}C_{12}$-2,3',4,4',5-PeCB[5,9]	118L	22:49	0.8129	0.8100-0.8159
2,2',3,4',6-PeCB	91	$^{13}C_{12}$-2,3',4,4',5-PeCB[5,9]	118L	22:55	0.8165	0.8135-0.8195
2,3,3',4'-TeCB	55	$^{13}C_{12}$-3,3',4,4'-TeCB[4,5,9]	77L	22:57	0.8787	0.8756-0.8819
2,3',4,5,'6-PeCB	121	$^{13}C_{12}$-2,3',4,4',5-PeCB[5,9]	118L	23:04	0.8219	0.8189-0.8248

Table A-1. Retention time (RT) References, Quantitation References, and Relative Retention Times (RRTs) for CB Congeners using a DB-1 Column

Labeled or Native CB[1]	Congener No.[2]	Retention Time and Quantitation References	Congener No.[2]	RT	RRT	RRT QC Limits[3]
2,3,3',4'-TeCB	56	$^{13}C_{12}$-3,3',4,4'-TeCB[4,5,9]	77L	23:24	0.8960	0.8928-0.8992
2,3,4,4'-TeCB	60	$^{13}C_{12}$-3,3',4,4'-TeCB[4,5,9]	77L	23:24	0.8960	0.8928-0.8992
$^{13}C_{12}$-2,2',4,4',6,6'-HxCB[4]	155L	$^{13}C_{12}$-2,3',4,4',5,5'-HxCB[5,9]	167L	23:43	0.7104	0.7054-0.7154
2,2',4,4',6,6'-HxCB	155	$^{13}C_{12}$-2,2',4,4',6,6'-HxCB[4]	155L	23:43	1.0000	0.9986-1.0028
2,2',3,3',6-PeCB	84	$^{13}C_{12}$-2,3',4,4',5-PeCB[5,9]	118L	23:44	0.8456	0.8426-0.8486
2,2',3,5,5'-PeCB	92	$^{13}C_{12}$-2,3',4,4',5-PeCB[5,9]	118L	23:50	0.8492	0.8462-0.8521
2,2',3,4,6'-PeCB	89	$^{13}C_{12}$-2,3',4,4',5-PeCB[5,9]	118L	23:53	0.8510	0.8480-0.8539
2,2',3,4',5-PeCB	90	$^{13}C_{12}$-2,3',4,4',5-PeCB[5,9]	118L	24:07	0.8593	0.8563-0.8622
$^{13}C_{12}$-2,2',4,5,5'-PeCB[7]	101L	$^{13}C_{12}$-2,2',4,5,5'-PeCB[7]	101L	24:11	1.0000	0.9966-1.0034
2,2',4,5,5'-PeCB[6]	101	$^{13}C_{12}$-2,3',4,4',5-PeCB[5,9]	118L	24:11	0.8616	0.8587-0.8646
2,3,3',5',6-PeCB	113	$^{13}C_{12}$-2,3',4,4',5-PeCB[5,9]	118L	24:23	0.8688	0.8658-0.8717
3,3',4,5'-TeCB	79	$^{13}C_{12}$-3,3',4,4'-TeCB[4,5,9]	77L	24:27	0.9362	0.9330-0.9394
2,2',4,4',5-PeCB	99	$^{13}C_{12}$-2,3',4,4',5-PeCB[5,9]	118L	24:28	0.8717	0.8688-0.8747
2,2',3,4',6,6'-HxCB	150	$^{13}C_{12}$-2,3',4,4',5,5'-HxCB[5,9]	167L	24:52	0.7449	0.7399-0.7499
2,3',4,4',6-PeCB	119	$^{13}C_{12}$-2,3',4,4',5-PeCB[5,9]	118L	24:54	0.8872	0.8842-0.8901
2,3,3',5,6-PeCB	112	$^{13}C_{12}$-2,3',4,4',5-PeCB[5,9]	118L	25:00	0.8907	0.8878-0.8937
2,3,3',4,6-PeCB	109	$^{13}C_{12}$-2,3',4,4',5-PeCB[5,9]	118L	25:09	0.8961	0.8931-0.8990
2,2',3,5,6,6'-HxCB	152	$^{13}C_{12}$-2,3',4,4',5,5'-HxCB[5,9]	167L	25:17	0.7574	0.7524-0.7624
2,2',3,3',5-PeCB	83	$^{13}C_{12}$-2,3',4,4',5-PeCB[5,9]	118L	25:20	0.8919	0.8890-0.8949
2,2',3',4,5-PeCB	97	$^{13}C_{12}$-2,3',4,4',5-PeCB[5,9]	118L	25:22	0.9038	0.9008-0.9068
2,2',3,4,5-PeCB	86	$^{13}C_{12}$-2,3',4,4',5-PeCB[5,9]	118L	25:27	0.9068	0.9038-0.9097
$^{13}C_{12}$-3,4,4',5-TeCB[9]	81L	$^{13}C_{12}$-2,2',5,5'-TeCB[7]	52L	25:32	1.3546	1.3457-1.3634
3,4,4',5-TeCB[10]	81	$^{13}C_{12}$-3,4,4',5-TeCB[4,5,9]	77L	25:32	1.0000	0.9987-1.0026
2',3,4,5,6'-PeCB	125	$^{13}C_{12}$-2,3',4,4',5-PeCB[5,9]	118L	25:36	0.9121	0.9091-0.9151
2,3,4',5,6-PeCB	117	$^{13}C_{12}$-2,3',4,4',5-PeCB[5,9]	118L	25:37	0.9127	0.9097-0.9157
2,2',3,4,5'-PeCB	87	$^{13}C_{12}$-2,3',4,4',5-PeCB[5,9]	118L	25:38	0.9133	0.9103-0.9163
3,3',4,5-TeCB	78	$^{13}C_{12}$-3,3',4,4'-TeCB[4,5,9]	77L	25:40	0.9598	0.9566-0.9630
2,2',3,4,6,6'-HxCB	145	$^{13}C_{12}$-2,3',4,4',5,5'-HxCB[5,9]	167L	25:42	0.7698	0.7649-0.7748
2,3,4,4',6-PeCB	115	$^{13}C_{12}$-2,3',4,4',5-PeCB[5,9]	118L	25:44	0.9169	0.9139-0.9198
$^{13}C_{12}$-2,3,3',5,5'-PeCB[8]	111L	$^{13}C_{12}$-2,2',4,5,5'-PeCB[7]	101L	25:51	1.0689	1.0655-1.0724
2,3,3',5,5'-PeCB	111	$^{13}C_{12}$-2,3',4,4',5-PeCB[5,9]	118L	25:51	0.9210	0.9181-0.9240
2,2',3,4,4'-PeCB	85	$^{13}C_{12}$-2,3',4,4',5-PeCB[5,9]	118L	25:51	0.9210	0.9181-0.9240

Table A-1. Retention time (RT) References, Quantitation References, and Relative Retention Times (RRTs) for CB Congeners using a DB-1 Column

Labeled or Native CB[1]	Congener No.[2]	Retention Time and Quantitation References	Congener No.[2]	RT	RRT	RRT QC Limits[3]
2,3,4,5,6-PeCB	116	$^{13}C_{12}$-2,3',4,4',5-PeCB[5,9]	118L	25:48	0.9192	0.9163-0.9222
$^{13}C_{12}$-3,3',4,4'-TeCB[4,5,9]	77L	$^{13}C_{12}$-2,2',5,5'-TeCB[7]	52L	26:07	1.3855	1.3767-1.3943
3,3',4,4'-TeCB[6,10]	77	$^{13}C_{12}$-3,3',4,4'-TeCB[4,5,9]	77L	26:07	1.0000	0.9987-1.0026
2,2',3,3',6,6'-HxCB	136	$^{13}C_{12}$-2,3',4,4',5,5'-HxCB[5,9]	167L	26:10	0.7793	0.7743-0.7843
2,3',4,5,5'-PeCB	120	$^{13}C_{12}$-2,3',4,4',5-PeCB[5,9]	118L	26:12	0.9335	0.9305-0.9365
2,2',3,4',5,6'-HxCB	148	$^{13}C_{12}$-2,3',4,4',5,5'-HxCB[5,9]	167L	26:14	0.7858	0.7808-0.7908
2,3,3',4',6-PeCB	110	$^{13}C_{12}$-2,3',4,4',5-PeCB[5,9]	118L	26:16	0.9359	0.9329-0.9388
2,2',4,4',5,6'-HxCB	154	$^{13}C_{12}$-2,3',4,4',5,5'-HxCB[5,9]	167L	26:44	0.8008	0.7983-0.8033
2,2',3,3',4-PeCB	82	$^{13}C_{12}$-2,3',4,4',5-PeCB[5,9]	118L	26:48	0.9549	0.9519-0.9578
2,2',3,5,5',6-HxCB	151	$^{13}C_{12}$-2,3',4,4',5,5'-HxCB[5,9]	167L	27:18	0.8178	0.8153-0.8203
2,2',3,3',5,6'-HxCB	135	$^{13}C_{12}$-2,3',4,4',5,5'-HxCB[5,9]	167L	27:31	0.8243	0.8218-0.8268
2',3,4,5,5'-PeCB	124	$^{13}C_{12}$-2,3',4,4',5-PeCB[5,9]	118L	27:36	0.9834	0.9804-0.9863
2,2',3,4,5',6-HxCB	144	$^{13}C_{12}$-2,3',4,4',5,5'-HxCB[5,9]	167L	27:38	0.8278	0.8253-0.8303
2,3,3',4,5'-PeCB	108	$^{13}C_{12}$-2,3',4,4',5-PeCB[5,9]	118L	27:40	0.9857	0.9828-0.9887
2,2',3,4',5,6-HxCB	147	$^{13}C_{12}$-2,3',4,4',5,5'-HxCB[5,9]	167L	27:44	0.8308	0.8283-0.8333
2,3,3',4',5-PeCB	107	$^{13}C_{12}$-2,3',4,4',5-PeCB[5,9]	118L	27:45	0.9887	0.9857-0.9917
2,2',3,4',5',6-HxCB	149	$^{13}C_{12}$-2,3',4,4',5,5'-HxCB[5,9]	167L	28:01	0.8392	0.8367-0.8417
2,2',3,3',5,6-HxCB	134	$^{13}C_{12}$-2,3',4,4',5,5'-HxCB[5,9]	167L	28:35	0.8562	0.8537-0.8587
2,2',3,4,5,6'-HxCB	143	$^{13}C_{12}$-2,3',4,4',5,5'-HxCB[5,9]	167L	28:34	0.8557	0.8532-0.8582
$^{13}C_{12}$-2',3,4,4',5-PeCB[9]	123L	$^{13}C_{12}$-2,2',4,5,5'-PeCB[7]	101L	27:53	1.1530	1.1496-1.1564
2',3,4,4',5-PeCB[10]	123	$^{13}C_{12}$-2',3,4,4',5-PeCB[9]	123L	27:53	1.0000	0.9988-1.0024
2,2',3,4,4',6-HxCB	139	$^{13}C_{12}$-2,3',4,4',5,5'-HxCB[5,9]	167L	28:01	0.8392	0.8367-0.8417
2,3,3',4,5-PeCB	106	$^{13}C_{12}$-2,3',4,4',5-PeCB[5,9]	118L	28:04	1.0000	0.9970-1.0030
$^{13}C_{12}$-2,3',4,4',5-PeCB[5,9]	118L	$^{13}C_{12}$-2,2',4,5,5'-PeCB[7]	101L	28:04	1.1606	1.1571-1.1640
2,3',4,4',5-PeCB[6,10]	118	$^{13}C_{12}$-2,3',4,4',5-PeCB[5,9]	118L	28:04	1.0000	0.9988-1.0024
2,2',3,4,4',6'-HxCB	140	$^{13}C_{12}$-2,3',4,4',5,5'-HxCB[5,9]	167L	28:12	0.8447	0.8422-0.8472
$^{13}C_{12}$-2,3,4,4',5-PeCB[9]	114L	$^{13}C_{12}$-2,2',4,5,5'-PeCB[7]	101L	28:38	1.1840	1.1806-1.1875
2,3,4,4',5-PeCB[10]	114	$^{13}C_{12}$-2,3,4,4',5-PeCB[9]	114L	28:38	1.0000	0.9988-1.0023
2',3,3',4,5-PeCB	122	$^{13}C_{12}$-2,3',4,4',5-PeCB[5,9]	118L	28:48	1.0261	1.0232-1.0291
2,2',3,3',4,6-HxCB	131	$^{13}C_{12}$-2,3',4,4',5,5'-HxCB[5,9]	167L	28:52	0.8647	0.8622-0.8672
2,2',3,4,5,6-HxCB	142	$^{13}C_{12}$-2,3',4,4',5,5'-HxCB[5,9]	167L	28:59	0.8682	0.8657-0.8707
2,2',3,3',5,5'-HxCB	133	$^{13}C_{12}$-2,3',4,4',5,5'-HxCB[5,9]	167L	28:59	0.8682	0.8657-0.8707

Table A-1. Retention time (RT) References, Quantitation References, and Relative Retention Times (RRTs) for CB Congeners using a DB-1 Column

Labeled or Native CB[1]	Congener No.[2]	Retention Time and Quantitation References	Congener No.[2]	RT	RRT	RRT QC Limits[3]
2,2',3,3',4,6'-HxCB	132	$^{13}C_{12}$-2,3',4,4',5,5'-HxCB[5,9]	167L	29:32	0.8847	0.8822-0.8872
2,3,3',5,5',6-HxCB	165	$^{13}C_{12}$-2,3',4,4',5,5'-HxCB[5,9]	167L	29:21	0.8792	0.8767-0.8817
$^{13}C_{12}$-2,2',3,4',5,6,6'-HpCB[4]	188L	$^{13}C_{12}$-2',3,3',4,4',5,5'-HpCB[4,5,9]	189L	29:22	0.9511	0.7327-0.7411
2,2',3,4',5,6,6'-HpCB	188	$^{13}C_{12}$-2,2',3,4',5,6,6'-HpCB[4]	188L	29:22	1.0000	0.9989-1.0023
2,2',3,4',5,5'-HxCB	146	$^{13}C_{12}$-2,3',4,4',5,5'-HxCB[5,9]	167L	29:24	0.8807	0.8782-0.8832
$^{13}C_{12}$-2,3,3',4,4'-PeCB[9]	105L	$^{13}C_{12}$-2,2',4,5,5'-PeCB[7]	101L	29:30	1.2198	1.2130-1.2267
2,3,3',4,4'-PeCB[6,10]	105	$^{13}C_{12}$-2,3,3',4,4'-PeCB[9]	105L	29:30	1.0000	0.9989-1.0023
2,3,3',4,5',6-HxCB	161	$^{13}C_{12}$-2,3',4,4',5,5'-HxCB[5,9]	167L	29:32	0.8847	0.8822-0.8872
2,2',4,4',5,5'-HxCB[6]	153	$^{13}C_{12}$-2,3',4,4',5,5'-HxCB[5,9]	167L	29:48	0.8927	0.8902-0.8952
2,2',3,4,4',6,6'-HpCB	184	$^{13}C_{12}$-2',3,3',4,4',5,5'-HpCB[4,5,9]	189L	29:49	0.7482	0.7440-0.7524
3,3',4,5,5'-PeCB	127	$^{13}C_{12}$-2,3',4,4',5-PeCB[5,9]	118L	29:57	1.0671	1.0641-1.0701
2,3',4,4',5',6-HxCB	168	$^{13}C_{12}$-2,3',4,4',5,5'-HxCB[5,9]	167L	29:59	0.8982	0.8957-0.9006
2,2',3,4,5,5'-HxCB	141	$^{13}C_{12}$-2,3',4,4',5,5'-HxCB[5,9]	167L	30:31	0.9141	0.9116-0.9166
2,2',3,3',5,6,6'-HpCB	179	$^{13}C_{12}$-2',3,3',4,4',5,5'-HpCB[4,5,9]	189L	30:33	0.7666	0.7624-0.7708
2,2',3,4,4',5-HxCB	137	$^{13}C_{12}$-2,3',4,4',5,5'-HxCB[5,9]	167L	30:51	0.9241	0.9216-0.9266
2,2',3,3',4,5'-HxCB	130	$^{13}C_{12}$-2,3',4,4',5,5'-HxCB[5,9]	167L	30:57	0.9271	0.9246-0.9296
2,2',3,3',4,6,6'-HpCB	176	$^{13}C_{12}$-2',3,3',4,4',5,5'-HpCB[4,5,9]	189L	31:01	0.7783	0.7742-0.7825
$^{13}C_{12}$-2,2',3,4,4',5'-HxCB[7]	138L	$^{13}C_{12}$-2,2',3,4,4',5'-HxCB[7]	138L	31:20	1.0000	0.9973-1.0027
2,2',3,4,4',5'-HxCB[6]	138	$^{13}C_{12}$-2,3',4,4',5,5'-HxCB[5,9]	167L	31:20	0.9386	0.9361-0.9411
2,3,3',4',5',6-HxCB	164	$^{13}C_{12}$-2,3',4,4',5,5'-HxCB[5,9]	167L	31:22	0.9396	0.9371-0.9421
2,3,3',4',5,6-HxCB	163	$^{13}C_{12}$-2,3',4,4',5,5'-HxCB[5,9]	167L	31:28	0.9426	0.9401-0.9451
2,3,3',4,5,6-HxCB	160	$^{13}C_{12}$-2,3',4,4',5,5'-HxCB[5,9]	167L	31:33	0.9451	0.9426-0.9476
2,3,3',4,4',6-HxCB	158	$^{13}C_{12}$-2,3',4,4',5,5'-HxCB[5,9]	167L	31:35	0.9461	0.9436-0.9486
2,2',3,4,5,6,6'-HpCB	186	$^{13}C_{12}$-2',3,3',4,4',5,5'-HpCB[4,5,9]	189L	31:36	0.7930	0.7888-0.7972
2,2',3,3',4,5-HxCB	129	$^{13}C_{12}$-2,3',4,4',5,5'-HxCB[5,9]	167L	31:48	0.9526	0.9501-0.9551
$^{13}C_{12}$-3,3',4,4',5-PeCB[4,9]	126L	$^{13}C_{12}$-2,2',4,5,5'-PeCB[7]	101L	31:49	1.3156	1.3088-1.3225
3,3',4,4',5-PeCB[6,10]	126	$^{13}C_{12}$-3,3',4,4',5-PeCB[4,9]	126L	31:49	1.0000	0.9990-1.0021
2,3,4,4',5,6-HxCB	166	$^{13}C_{12}$-2,3',4,4',5,5'-HxCB[5,9]	167L	32:13	0.9651	0.9626-0.9675
$^{13}C_{12}$-2,2',3,3',5,5',6-HpCB[7]	178L	$^{13}C_{12}$-2,2',3,3',5,5',6-HpCB[7]	178L	32:14	1.0000	0.9974-1.0026
2,2',3,3',5,5',6-HpCB	178	$^{13}C_{12}$-2',3,3',4,4',5,5'-HpCB[4,5,9]	189L	32:14	0.8089	0.8068-0.8110
2,2',3,3',4,5',6-HpCB	175	$^{13}C_{12}$-2',3,3',4,4',5,5'-HpCB[4,5,9]	189L	32:33	0.8168	0.8147-0.8189
2,3,3',4,5,5'-HxCB	159	$^{13}C_{12}$-2,3',4,4',5,5'-HxCB[5,9]	167L	32:43	0.9800	0.9775-0.9825

Table A-1. Retention time (RT) References, Quantitation References, and Relative Retention Times (RRTs) for CB Congeners using a DB-1 Column

Labeled or Native CB[1]	Congener No.[2]	Retention Time and Quantitation References	Congener No.[2]	RT	RRT	RRT QC Limits[3]
2,2',3,4',5,5',6-HpCB[6]	187	^{13}C$_{12}$-2',3,3',4,4',5,5'-HpCB[4,5,9]	189L	32:46	0.8223	0.8202-0.8243
2,2',3,4,4',5,6'-HpCB	182	^{13}C$_{12}$-2',3,3',4,4',5,5'-HpCB[4,5,9]	189L	32:47	0.8227	0.8206-0.8248
2,2',3,3',4,4'-HxCB[6]	128	^{13}C$_{12}$-2,3',4,4',5,5'-HxCB[5,9]	167L	32:52	0.9845	0.9820-0.9870
2,3,3',4',5,5'-HxCB	162	^{13}C$_{12}$-2,3',4,4',5,5'-HxCB[5,9]	167L	33:00	0.9885	0.9860-0.9910
2,2',3,4,4',5',6-HpCB	183	^{13}C$_{12}$-2',3,3',4,4',5,5'-HpCB[4,5,9]	189L	33:06	0.8306	0.8285-0.8327
^{13}C$_{12}$-2,3',4,4',5,5'-HxCB[5,9]	167L	^{13}C$_{12}$-2,2',3,4,4',5'-HxCB[7]	138L	33:23	1.0654	1.0628-1.0681
2,3',4,4',5,5'-HxCB[10]	167	^{13}C$_{12}$-2,3',4,4',5,5'-HxCB[5,9]	167L	33:23	1.0000	0.9990-1.0020
2,2',3,4,5,5',6-HpCB	185	^{13}C$_{12}$-2',3,3',4,4',5,5'-HpCB[4,5,9]	189L	33:43	0.8461	0.8440-0.8482
2,2',3,3',4,5,6'-HpCB	174	^{13}C$_{12}$-2',3,3',4,4',5,5'-HpCB[4,5,9]	189L	34:07	0.8561	0.8540-0.8582
2,2',3,4,4',5,6-HpCB	181	^{13}C$_{12}$-2',3,3',4,4',5,5'-HpCB[4,5,9]	189L	34:11	0.8578	0.8557-0.8599
2,2',3,3',4',5,6-HpCB	177	^{13}C$_{12}$-2',3,3',4,4',5,5'-HpCB[4,5,9]	189L	34:22	0.8624	0.8603-0.8645
2,2'3,3',4,4',6-HpCB	171	^{13}C$_{12}$-2',3,3',4,4',5,5'-HpCB[4,5,9]	189L	34:40	0.8699	0.8678-0.8720
^{13}C$_{12}$-2,3,3',4,4',5 -HxCB[9]	156L	^{13}C$_{12}$-2,2',3,4,4',5'-HxCB[7]	138L	34:40	1.1064	1.1037-1.1090
2,3,3',4,4',5-HxCB[10]	156	^{13}C$_{12}$-2,3,3',4,4',5 -HxCB[9]	156L	34:40	1.0000	0.9990-1.0019
^{13}C$_{12}$-2,2',3,3',5,5',6,6'-OcCB[4]	202L	^{13}C$_{12}$-Cl8-PCB-194[5]	194L	34:56	0.8265	0.8245-0.8285
2,2',3,3',5,5',6,6'-OcCB	202	^{13}C$_{12}$-2,2',3,3',5,5',6,6'-OcCB[4]	202L	34:56	1.0000	0.9990-1.0019
^{13}C$_{12}$-2,3,3',4,4',5'-HxCB[9]	157L	^{13}C$_{12}$-2,2',3,4,4',5'-HxCB[7]	138L	34:57	1.1154	1.1128-1.1181
2,3,3',4,4',5'-HxCB[10]	157	^{13}C$_{12}$-2,3,3',4,4',5'-HxCB[9]	157L	34:57	1.0000	0.9990-1.0019
2,2',3,3',4,5,6-HpCB	173	^{13}C$_{12}$-2',3,3',4,4',5,5'-HpCB[4,5,9]	189L	35:04	0.8800	0.8779-0.8821
2,2',3,3',4,5',6,6'-OcCB	201	^{13}C$_{12}$-Cl8-PCB-194[5]	194L	35:25	0.8379	0.8360-0.8399
2,2',3,4,4',5,6,6'-OcCB	204	^{13}C$_{12}$-Cl8-PCB-194[5]	194L	35:36	0.8423	0.8403-0.8442
2,2',3,3',4,5,5'-HpCB	172	^{13}C$_{12}$-2',3,3',4,4',5,5'-HpCB[4,5,9]	189L	35:41	0.8954	0.8934-0.8975
2,3,3',4,5,5',6-HpCB	192	^{13}C$_{12}$-2',3,3',4,4',5,5'-HpCB[4,5,9]	189L	35:51	0.8996	0.8975-0.9017
2,2',3,3',4,4',6,6'-OcCB	197	^{13}C$_{12}$-Cl8-PCB-194[5]	194L	35:55	0.8498	0.8478-0.8517
2,2',3,4,4',5,5'-HpCB[6]	180	^{13}C$_{12}$-2',3,3',4,4',5,5'-HpCB[4,5,9]	189L	36:07	0.9063	0.9042-0.9084
2,3,3',4',5,5',6-HpCB	193	^{13}C$_{12}$-2',3,3',4,4',5,5'-HpCB[4,5,9]	189L	36:20	0.9118	0.9097-0.9138
2,3,3',4,4',5',6-HpCB	191	^{13}C$_{12}$-2',3,3',4,4',5,5'-HpCB[4,5,9]	189L	36:34	0.9176	0.9155-0.9197
2,2',3,3',4,5,6,6'-OcCB	200	^{13}C$_{12}$-Cl8-PCB-194[5]	194L	36:49	0.8711	0.8691-0.8730
^{13}C$_{12}$-3,3',4,4',5,5'-HxCB[4,9]	169L	^{13}C$_{12}$-2,2',3,4,4',5'-HxCB[7]	138L	37:19	1.1910	1.1883-1.1936
3,3',4,4',5,5'-HxCB[6,10]	169	^{13}C$_{12}$-3,3',4,4',5,5'-HxCB[4,9]	169L	37:19	1.0000	0.9991-1.0018
2,2',3,3',4,4',5-HpCB[6]	170	^{13}C$_{12}$-2',3,3',4,4',5,5'-HpCB[4,5,9]	189L	37:44	0.9469	0.9448-0.9490
2,3,3',4,4',5,6-HpCB	190	^{13}C$_{12}$-2',3,3',4,4',5,5'-HpCB[4,5,9]	189L	37:56	0.9519	0.9498-0.9540

Table A-1. Retention time (RT) References, Quantitation References, and Relative Retention Times (RRTs) for CB Congeners using a DB-1 Column

Labeled or Native CB[1]	Congener No.[2]	Retention Time and Quantitation References	Congener No.[2]	RT	RRT	RRT QC Limits[3]
2,2',3,3',4,5,5',6-OcCB	198	$^{13}C_{12}$-Cl8-PCB-194[5]	194L	38:34	0.9125	0.9105-0.9144
2,2',3,3',4,5,5',6'-OcCB	199	$^{13}C_{12}$-Cl8-PCB-194[5]	194L	38:43	0.9160	0.9140-0.9180
2,2',3,3',4,4',5,6'-OcCB	196	$^{13}C_{12}$-Cl8-PCB-194[5]	194L	39:05	0.9247	0.9227-0.9267
2,2',3,4,4',5,5',6-OcCB	203	$^{13}C_{12}$-Cl8-PCB-194[5]	194L	39:05	0.9247	0.9227-0.9267
$^{13}C_{12}$-2',3,3',4,4',5,5'-HpCB[4,5,9]	189L	$^{13}C_{12}$-2,2',3,3',5,5',6-HpCB[7]	178L	39:51	1.2363	1.2311-1.2415
2,3,3',4,4',5,5'-HpCB[10]	189	$^{13}C_{12}$-2',3,3',4,4',5,5'-HpCB[4,5,9]	189L	39:51	1.0000	0.9992-1.0017
2,2',3,3',4,4',5,6-OcCB[6]	195	$^{13}C_{12}$-Cl8-PCB-194[5]	194L	40:45	0.9641	0.9621-0.9661
$^{13}C_{12}$-2,2',3,3',4,5,5',6,6'-NoCB[4]	208L	$^{13}C_{12}$-Cl9-PCB-206[4,5]	206L	41:03	0.9149	0.9131-0.9168
2,2',3,3',4,5,5',6,6'-NoCB	208	$^{13}C_{12}$-2,2',3,3',4,5,5',6,6'-NoCB[4]	208L	41:03	1.0000	0.9992-1.0016
2,2',3,3',4,4',5,6,6'-NoCB	207	$^{13}C_{12}$-Cl9-PCB-206[4,5]	206L	41:32	0.9257	0.9238-0.9276
$^{13}C_{12}$-2,2',3,3',4,4',5,5'-OcCB[5]	194L	$^{13}C_{12}$-2,2',3,3',5,5',6-HpCB[7]	178L	42:16	1.3113	1.3061-1.3164
2,2',3,3',4,4',5,5'-OcCB	194	$^{13}C_{12}$-Cl8-PCB-194[5]	194L	42:16	1.0000	0.9992-1.0016
$^{13}C_{12}$-2,3,3',4,4',5,5',6-OcCB[4]	205L	$^{13}C_{12}$-Cl8-PCB-194[5]	194L	42:44	1.0110	1.0091-1.0130
2,3,3',4,4',5,5',6-OcCB	205	$^{13}C_{12}$-2,3,3',4,4',5,5',6-OcCB[4]	205L	42:44	1.0000	0.9992-1.0016
$^{13}C_{12}$-2,2',3,3',4,4',5,5',6-NoCB[4,5]	206L	$^{13}C_{12}$-2,2',3,3',5,5',6-HpCB[7]	178L	44:52	1.3919	1.3868-1.3971
2,2',3,3',4,4',5,5',6-NoCB[6]	206	$^{13}C_{12}$-Cl9-PCB-206[4,5]	206L	44:52	1.0000	0.9993-1.0015
$^{13}C_{12}$-2,2',3,3',4,4',5,5',6,6'-DeCB[4,5]	209L	$^{13}C_{12}$-2,2',3,3',5,5',6-HpCB[7]	178L	46:55	1.4555	1.4504-1.4607
2,2',3,3',4,4',5,5',6,6'-DeCB[6]	209	$^{13}C_{12}$-Cl10-PCB-209[4,5]	209L	46:55	1.0000	0.9993-1.0014

1. Abbreviations for chlorination levels

MoCB	monochlorobiphenyl	HxCB	hexachlorobiphenyl
DiCB	dichlorobiphenyl	HpCB	heptachlorobiphenyl
TrCB	trichlorobiphenyl	OcCB	octachlorobiphenyl
TeCB	tetrachlorobiphenyl	NoCB	nonachlorobiphenyl
PeCB	pentachlorobiphenyl	DeCB	decachlorobiphenyl

2. Suffix "L" indicates labeled compound
3. For native CBs determined by isotope dilution quantitation, RRT QC limits were constructed using -2 to +4 seconds around the retention time for the labeled analog. For native CBs determined by internal standard quantitation, RRT QC limits were constructed using a ± 2 percent window around the retention time for retention times in the range of 0.8-1.2 and a ± 4 percent window around the retention time for retention times <0.8 and >1.2. These windows may not be adequate for analyte identification (See the note in Section 16.4)
4. Labeled level of chlorination (LOC) window-defining congener
5. Labeled level of chlorination (LOC) quantitation congener
6. National Oceanic and Atmospheric Administration (NOAA) congener of interest
7. Instrument internal standard
8. Clean-up standard
9. Labeled internal standard for World Health Organization (WHO) toxic congener
10. WHO toxic congener

Table A-2. Scan Descriptors, Levels of Chlorination, m/z Information, and Substances Monitored by HRGC/HRMS

Function and Chlorine Level	m/z	m/z Type	m/z Formula	Substance
Fn-1 Cl-1	188.0393	M	$^{12}C_{12} H_9 {}^{35}Cl$	Cl-1 PCB
	190.0363	M+2	$^{12}C_{12} H_9 {}^{37}Cl$	Cl-1P CB
	200.0795	M	$^{13}C_{12} H_9 {}^{35}Cl$	$^{13}C_{12}$ Cl-1 PCB
	202.0766	M+2	$^{13}C_{12} H_9 {}^{37}Cl$	$^{13}C_{12}$ Cl-1 PCB
	218.9856	lock	$C_4 F_9$	PFK
Fn-2 Cl-2,3	222.0003	M	$^{12}C_{12} H_8 {}^{35}Cl_2$	Cl-2 PCB
	223.9974	M+2	$^{12}C_{12} H_8 {}^{35}Cl {}^{37} Cl$	Cl-2 PCB
	225.9944	M+4	$^{12}C_{12} H_8 {}^{37}Cl_2$	Cl-2 PCB
	234.0406	M	$^{13}C_{12} H_8 {}^{35}Cl_2$	$^{13}C_{12}$ Cl-2 PCB
	236.0376	M+2	$^{13}C_{12} H_8 {}^{35}Cl {}^{37} Cl$	$^{13}C_{12}$ Cl-2 PCB
	242.9856	lock	$C_6 F_9$	PFK
	255.9613	M	$^{12}C_{12} H_7 {}^{35}Cl_3$	Cl-3 PCB
	257.9584	M+2	$^{12}C_{12} H_7 {}^{35}Cl_2 {}^{37}Cl$	Cl-3 PCB
Fn-3 Cl-3,4,5	255.9613	M	$^{12}C_{12} H_7 {}^{35}Cl_3$	Cl-3 PCB
	257.9584	M+2	$^{12}C_{12} H_7 {}^{35}Cl_2 {}^{37}Cl$	Cl-3 PCB
	259.9554	M+4	$^{12}C_{12} H_7 {}^{35}Cl {}^{37}Cl_2$	Cl-3 PCB
	268.0016	M	$^{13}C_{12} H_7 {}^{35}Cl_3$	$^{13}C_{12}$ Cl-3 PCB
	269.9986	M+2	$^{13}C_{12} H_7 {}^{35}Cl_2 {}^{37}Cl$	$^{13}C_{12}$ Cl-3 PCB
	280.9825	lock	$C_6 F_{11}$	PFK
	289.9224	M	$^{12}C_{12} H_6 {}^{35}Cl_4$	Cl-4 PCB
	291.9194	M+2	$^{12}C_{12} H_6 {}^{35}Cl_3 {}^{37}Cl$	Cl-4 PCB
	293.9165	M+4	$^{12}C_{12} H_6 {}^{35}Cl_2 {}^{37}Cl_2$	Cl-4 PCB
	301.9626	M	$^{13}C_{12} H_6 {}^{35}Cl_4$	$^{13}C_{12}$ Cl-4 PCB
	303.9597	M+2	$^{13}C_{12} H_6 {}^{35}Cl_3 {}^{37}Cl$	$^{13}C_{12}$ Cl-4 PCB
	323.8834	M	$^{12}C_{12} H_5 {}^{35}Cl_5$	Cl-5 PCB
	325.8804	M+2	$^{12}C_{12} H_5 {}^{35}Cl_4 {}^{37}Cl$	Cl-5 PCB
	327.8775	M+4	$^{12}C_{12} H_5 {}^{35}Cl_3 {}^{37}Cl_2$	Cl-5 PCB
	337.9207	M+2	$^{13}C_{12} H_5 {}^{35}Cl_4 {}^{37}Cl$	$^{13}C_{12}$ Cl-5 PCB
	339.9178	M+4	$^{13}C_{12} H_5 {}^{35}Cl_3 {}^{37}Cl_2$	$^{13}C_{12}$ Cl-5 PCB
Fn-4 Cl-4,5,6	289.9224	M	$^{12}C_{12} H_6 {}^{35}Cl_4$	Cl-4 PCB
	291.9194	M+2	$^{12}C_{12} H_6 {}^{35}Cl_3 {}^{37}Cl$	Cl-4 PCB
	293.9165	M+4	$^{12}C_{12} H_6 {}^{35}Cl_2 {}^{37}Cl_2$	Cl-4 PCB
	301.9626	M+2	$^{13}C_{12} H_6 {}^{35}Cl_3 {}^{37}Cl$	$^{13}C_{12}$ Cl-4 PCB
	303.9597	M+4	$^{13}C_{12} H_6 {}^{35}Cl_2 {}^{37}Cl_2$	$^{13}C_{12}$ Cl-4 PCB
	323.8834	M	$^{12}C_{12} H_5 {}^{35}Cl_5$	Cl-5 PCB
	325.8804	M+2	$^{12}C_{12} H_5 {}^{35}Cl_4 {}^{37}Cl$	Cl-5 PCB
	327.8775	M+4	$^{12}C_{12} H_5 {}^{35}Cl_3 {}^{37}Cl_2$	Cl-5 PCB
	330.9792	lock	$C_7 F_{15}$	PFK
	337.9207	M+2	$^{13}C_{12} H_5 {}^{35}Cl_4 {}^{37}Cl$	$^{13}C_{12}$ Cl-5 PCB
	339.9178	M+4	$^{13}C_{12} H_5 {}^{35}Cl_3 {}^{37}Cl_2$	$^{13}C_{12}$ Cl-5 PCB
	359.8415	M+2	$^{13}C_{12} H_4 {}^{35}Cl_5 {}^{37}Cl$	Cl-6 PCB
	361.8385	M+4	$^{13}C_{12} H_4 {}^{35}Cl_4 {}^{37}Cl_2$	Cl-6 PCB
	363.8356	M+6	$^{13}C_{12} H_4 {}^{35}Cl_3 {}^{37}Cl_2$	Cl-6 PCB
	371.8817	M+2	$^{13}C_{12} H_4 {}^{35}Cl_5 {}^{37}Cl$	$^{13}C_{12}$ Cl-6 PCB
	373.8788	M+4	$^{13}C_{12} H_4 {}^{35}Cl_4 {}^{37}Cl_2$	$^{13}C_{12}$ Cl-6 PCB

Table A-2. Scan Descriptors, Levels of Chlorination, m/z Information, and Substances Monitored by HRGC/HRMS

Function and Chlorine Level	m/z	m/z Type	m/z Formula	Substance
Fn-5 Cl-5,6,7,8	323.8834	M	$^{12}C_{12}\,H_5\,^{35}Cl_5$	Cl-5 PCB
	325.8804	M+2	$^{12}C_{12}\,H_5\,^{35}Cl_4\,^{37}Cl$	Cl-5 PCB
	327.8775	M+4	$^{12}C_{12}\,H_5\,^{35}Cl_3\,^{37}Cl_2$	Cl-5 PCB
	337.9207	M+2	$^{13}C_{12}\,H_5\,^{35}Cl_4\,^{37}Cl$	$^{13}C_{12}$ Cl-5 PCB
	339.9178	M+4	$^{13}C_{12}\,H_5\,^{35}Cl_3\,^{37}Cl_2$	$^{13}C_{12}$ Cl-5 PCB
	354.9792	lock	$C_9\,F_{13}$	PFK
	359.8415	M+2	$^{12}C_{12}\,H_4\,^{35}Cl_5\,^{37}Cl$	Cl-6 PCB
	361.8385	M+4	$^{12}C_{12}\,H_4\,^{35}Cl_4\,^{37}Cl_2$	Cl-6 PCB
	363.8356	M+6	$^{12}C_{12}\,H_4\,^{35}Cl_3\,^{37}Cl_3$	Cl-6 PCB
	371.8817	M+2	$^{13}C_{12}\,H_4\,^{35}Cl_5\,^{37}Cl$	$^{13}C_{12}$ Cl-6 PCB
	373.8788	M+4	$^{13}C_{12}\,H_4\,^{35}Cl_4\,^{37}Cl_2$	$^{13}C_{12}$ Cl-6 PCB
	393.8025	M+2	$^{12}C_{12}\,H_3\,^{35}Cl_6\,^{37}Cl$	Cl-7 PCB
	395.7995	M+4	$^{12}C_{12}\,H_3\,^{35}Cl_5\,^{37}Cl_2$	Cl-7 PCB
	397.7966	M+6	$^{12}C_{12}\,H_3\,^{35}Cl_4\,^{37}Cl_3$	Cl-7 PCB
	405.8428	M+2	$^{13}C_{12}\,H_3\,^{35}Cl_6\,^{37}Cl$	$^{13}C_{12}$ Cl-7 PCB
	407.8398	M+4	$^{13}C_{12}\,H_3\,^{35}Cl_5\,^{37}Cl_2$	$^{13}C_{12}$ Cl-7 PCB
	427.7635	M+2	$^{12}C_{12}\,H_2\,^{35}Cl_7\,^{37}Cl$	Cl-8 PCB
	429.7606	M+4	$^{12}C_{12}\,H_2\,^{35}Cl_6\,^{37}Cl_2$	Cl-8 PCB
	431.7576	M+6	$^{12}C_{12}\,H_2\,^{35}Cl_5\,^{37}Cl_3$	Cl-8 PCB
	439.8038	M+2	$^{13}C_{12}\,H_2\,^{35}Cl_7\,^{37}Cl$	$^{13}C_{12}$ Cl-8 PCB
	441.8008	M+4	$^{13}C_{12}\,H_2\,^{35}Cl_6\,^{37}Cl_2$	$^{13}C_{12}$ Cl-8 PCB
	454.9728	QC	$C_{11}\,F_{17}$	PFK
Fn-6 Cl-8,9,10	427.7635	M+2	$^{12}C_{12}\,H_2\,^{35}Cl_7\,^{37}Cl$	Cl-8 PCB
	429.7606	M+4	$^{12}C_{12}\,H_2\,^{35}Cl_6\,^{37}Cl_2$	Cl-8 PCB
	431.7576	M+6	$^{12}C_{12}\,H_2\,^{35}Cl_5\,^{37}Cl_3$	Cl-8 PCB
	439.8038	M+2	$^{13}C_{12}\,H_2\,^{35}Cl_7\,^{37}Cl$	$^{13}C_{12}$ Cl-8 PCB
	441.8008	M+4	$^{13}C_{12}\,H_2\,^{35}Cl_6\,^{37}Cl_2$	$^{13}C_{12}$ Cl-8 PCB
	442.9728	QC	$C_{10}\,F_{13}$	PFK
	454.9728	lock	$C_{11}\,F_{13}$	PFK
	461.7246	M+2	$^{12}C_{12}\,H_1\,^{35}Cl_8\,^{37}Cl$	Cl-9 PCB
	463.7216	M+4	$^{12}C_{12}\,H_1\,^{35}Cl_7\,^{37}Cl_2$	Cl-9 PCB
	465.7187	M+6	$^{12}C_{12}\,H_1\,^{35}Cl_6\,^{37}Cl_3$	Cl-9 PCB
	473.7648	M+2	$^{13}C_{12}\,H_1\,^{35}Cl_8\,^{37}Cl$	$^{13}C_{12}$ Cl-9 PCB
	475.7619	M+4	$^{13}C_{12}\,H_1\,^{35}Cl_7\,^{37}Cl_2$	$^{13}C_{12}$ Cl-9 PCB
	495.6856	M+2	$^{13}C_{12}\,H_4\,^{35}Cl_9\,^{37}Cl$	Cl-10 PCB
	499.6797	M+4	$^{12}C_{12}\,^{35}Cl_7\,^{37}Cl_3$	Cl-10 PCB
	501.6767	M+6	$^{12}C_{12}\,^{35}Cl_6\,^{37}Cl_4$	Cl-10 PCB
	507.7258	M+2	$^{13}C_{12}\,H_4\,^{35}Cl_9\,^{37}Cl$	$^{13}C_{12}$ Cl-10 PCB
	509.7229	M+4	$^{13}C_{12}\,H_4\,^{35}Cl_8\,^{37}Cl_2$	$^{13}C_{12}$ Cl-10 PCB
	511.7199	M+6	$^{13}C_{12}\,H_4\,^{35}Cl_8\,^{37}Cl_4$	$^{13}C_{12}$ Cl-10 PCB

Isotopic masses used for accurate mass calculation

^{1}H	1.0078	^{37}Cl	36.9659
^{12}C	12.0000	^{19}F	18.9984
^{13}C	13.0034	^{35}Cl	34.9689

Exhibit 6

State Certification Los Alamos National Laboratory Industrial Wastewater Permit No. NM0028355

2020 TR BDD 0134 - 0146

NEW MEXICO
ENVIRONMENT DEPARTMENT

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Michelle Lujan Grisham
Governor

Howie C. Morales
Lt. Governor

James C. Kenney
Cabinet Secretary

Jennifer J. Pruett
Deputy Secretary

Original via FedEx-Copy via Electronic Mail

November 30, 2020

Mr. Charles Maguire, Director
Water Quality Protection Division (6WD)
U. S. Environmental Protection Agency
1201 Elm Street, Suite 500
Dallas, Texas 75202

Re: State Certification Los Alamos National Laboratory Industrial Wastewater
NPDES Permit No. NM0028355

Dear Director Maguire:

Enclosed, please find the state certification for the following proposed National Pollutant Discharge Elimination System (NPDES) permit NM0028355, Los Alamos National Laboratory Industrial Wastewater Permit. Comments and conditions are enclosed on separate sheets.

The U.S. Environmental Protection Agency (EPA) proposes to regulate discharges under the above referenced NPDES Individual permit. A state Water Quality Certification is required by the federal Clean Water Act (CWA) Section 401 to ensure that the action is consistent with state law (New Mexico Water Quality Act, New Mexico Statutes Annotated [NMSA] 1978, Sections 74-6-1 to -17) and complies with the State of New Mexico Water Quality Standards at 20.6.2 and 20.6.4 New Mexico Administrative Code (NMAC), Water Quality Management Plan and Continuing Planning Process, including Total Maximum Daily Loads (TMDLs), and Antidegradation Policy.

Pursuant to State regulations for permit certification at 20.6.2.2001 NMAC, EPA jointly with the New Mexico Environment Department (NMED) issued a public notice of the draft permit and announced a public comment period posted on the NMED web site at https://www.env.nm.gov/surface-water-quality/public-notices/ on November 27, 2019. The NMED public comment period ended on November 2, 2020. NMED received comments from the Buckman Direct Diversion Board and the Permittees, which were considered in this certification.

Sincerely,

Sarah
Holcomb
Digitally signed by Sarah Holcomb
Date: 2020.11.30 10:44:57 -07'00'
for

Shelly Lemon, Bureau Chief
Surface Water Quality Bureau

cc: (w/ enclosures)
Ms. Evelyn Rosborough, USEPA (6WDPN) via e-mail
Mr. Brent Larsen, USEPA (6WDPE) via e-mail
Mr. Isaac Chen, USEPA (6WDPE) via e-mail
Mr. Michael Hazen, ESHQSS, Triad National Security, LLC by email
Mr. Enrique Torres, EPC-DO, Triad National Security, LLC by email
Mr. Michael Saladen, EPC-CP, Triad National Security, LLC by email
Ms. Taunia Van Valkenburg, EPC-CP, Triad National Security, LLC by email
Ms. Jennifer Griffin, EPC-CP, Triad National Security, LLC by email
Mr. Michael Weis, USDOE NA-LA by email
Ms. Karen Armijo, USDOE NA-LA by email
Buckman Direct Diversion Board, via luke@egolflaw.com

Mr. Ken McQueen, Regional Administrator
Environmental Protection Agency
1201 Elm Street, Suite 500
Dallas, TX 75202

November 30, 2020

STATE CERTIFICATION

RE: **NM0028355, Los Alamos National Laboratory Industrial Wastewater**

Dear Regional Administrator McQueen:

The Cabinet Secretary of the New Mexico Environment Department (NMED) has delegated signatory authority for state certifications of federal Clean Water Act permits to the Surface Water Quality Bureau Chief. NMED examined the proposed NPDES permit referenced above. The following conditions are necessary to assure compliance with the applicable provisions of the Clean Water Act Sections 208(e), 301, 302, 303, 306, and 307 and with appropriate requirements of State law. Compliance with the terms and conditions of the permit and this certification will provide reasonable assurance that the permitted activities will be conducted in a manner which will not violate applicable water quality standards or the water quality management plan and will be in compliance with the antidegradation policy.

The State of New Mexico

( ) certifies that the discharge will comply with the applicable provisions of Sections 208(e), 301, 302, 303, 306 and 307 of the Clean Water Act and with appropriate requirements of State law

(x) certifies that the discharge will comply with the applicable provisions of Sections 208(e), 301, 302, 303, 306 and 307 of the Clean Water Act and with appropriate requirements of State law upon inclusion of the following conditions in the permit (see attachments)

( ) denies certification for the reasons stated in the attachment

( ) waives its right to certify

In order to meet the requirements of State law, including water quality standards and appropriate basin plan as may be amended by the water quality management plan, each of the conditions cited in the draft permit and the State certification shall not be made less stringent, unless changes are in response to formal comments received by EPA and discussed with NMED prior to the finalization of the draft permit.

NMED reserves the right to amend or revoke this certification if such action is necessary to ensure compliance with the State's water quality standards and water quality management plan.

Please contact Sarah Holcomb at (505) 819-9734 if you have any questions concerning this certification. Comments and conditions pertaining to this draft permit are attached.

Sincerely,

Shelly Lemon, Bureau Chief
Surface Water Quality Bureau

State of New Mexico Comments and Conditions on the Proposed NPDES Permit
Los Alamos National Laboratory Industrial Wastewater
NM0028355
November 30, 2020

The following conditions are necessary to ensure that discharges allowed under the National Pollutant Discharge Elimination System (NPDES) permit protect State of New Mexico surface water quality standards (WQS) adopted in accordance with Section 303 of the Clean Water Act (CWA) and the New Mexico Water Quality Act (NMSA 1978, §§ 74-6-1 to -17). State of New Mexico (State) WQS are codified in Title 20, Chapter 6, Part 4 of the New Mexico Administrative Code (20.6.4 NMAC), *Standards for Interstate and Intrastate Surface Waters*, as amended by the New Mexico Water Quality Control Commission (WQCC) on May 22, 2020 and most recently approved by the U.S. Environmental Protection Agency (EPA or USEPA) as of July 24, 2020. Additional state WQS are published in Title 20, Chapter 6, Part 2 of the New Mexico Administrative Code (20.6.2 NMAC), *Ground and Surface Water Protection*, as amended by the WQCC most recently on December 21, 2018.

NPDES regulations at 40 CFR § 122.44(d)(l)(i) require that permit "…limitations must control all pollutants or pollutant parameters... which the Director determines are or may be discharged at a level which will cause, have the reasonable potential to cause, or contribute to an excursion above any State water quality standard…"

40 CFR § 124.53(e) states that, "State certification shall be in writing and shall include: (1) Conditions which are necessary to assure compliance with the applicable provisions of CWA Sections 208(e), 301, 302, 303, 306 and 307 and with appropriate requirements of State law…"

Conditions of Certification:

Condition # 1:
Facilities at outfalls 001, 13S, 027, 022, 055, and 051 (which incorporate facilities operating under NAICS codes listed in the *Final Rule [June 22, 2020]* for TRI Reporting [noted above]) shall monitor and report PFAS in effluent once during the first year of coverage, or when the facility next discharges if no discharge occurs during the first year. Samples shall be analyzed by an accredited lab for all 18 PFAS analytes using EPA Method 537.1 (EPA 2018), and the DoD Quality Systems Manual Method 5.3 (2019) as guidance. Method and analysis shall be sufficiently sensitive to evaluate the New Mexico screening level for PFOA and PFOS.

The PFAS screening level in New Mexico is indicated below. The screening level is not a standard of quality and purity for the surface waters of New Mexico but allows detection and further evaluation of the existence of PFAS in discharges to determine if more attention is warranted.

PFAS Screening Level for New Mexico*	
PFOA + PFOS	0.070 ug/L

* Concentrations of PFOA and PFOS are summed before being compared to the screening level.

If PFOA and/or PFOS are detected above the New Mexico screening level, additional monitoring and reporting shall occur annually and in accordance with the same parameters and methods as required for the first sampling event. In addition, the permittee should take corrective action and identify ways to minimize, reduce, and eliminate PFAS from the industrial activity through product substitution and/or additional best management practices and operational controls. Results of past monitoring and any corrective actions taken should be documented by the permittee.

The permittee shall submit monitoring results for all 18 PFAS analytes under EPA Method 537.1, as required, to NMED at the following address:

> Point Source Program Manager
> Surface Water Quality Bureau
> New Mexico Environment Department
> P.O. Box 5469
> Santa Fe, NM 87502-5469

<u>Background for Condition #1</u>
New Mexico regulations (Standards for Interstate and Intrastate Surface Waters) under 20.6.4.13(F) NMAC state: Except as provided in 20.6.4.16 NMAC, surface waters of the state shall be free of toxic pollutants from other than natural causes in amounts, concentrations or combinations that affect the propagation of fish or that are toxic to humans, livestock or other animals, fish or other aquatic organisms, wildlife using aquatic environments for habitations or aquatic organisms for food, or that will or can reasonably be expected to bioaccumulate in tissues of fish, shellfish and other aquatic organisms to levels that will impair the health of aquatic organisms or wildlife or result in unacceptable tastes, odors or health risks to human consumers of aquatic organisms.

New Mexico regulations (Ground and Surface Water Protection) under 20.6.2.7(T)(2)(s) NMAC lists the following perfluorinated chemicals (PFCs) as toxic pollutants: perfluorohexane sulfonic acid (PHHxS), perfluorooctane sulfonate (PFOS), and perfluorooctanoic acid (PFOA).

The EPA revised the Emergency Planning and Community Right-to-Know Act (EPCRA) Section 313 list of reportable chemicals covered by the Toxics Release Inventory (TRI) to include the 172 per- and polyfluoroalkyl substances (PFAS) added by the National Defense Authorization Act.[1]

The following is a list of North American Industrial Classification System (NAICS) codes from EPA's Final Rule (June 22, 2020) that may be potentially affected by TRI reporting requirements:[2]

- *Facilities included in the following NAICS manufacturing codes (corresponding to Standard Industrial Classification (SIC) codes 20 through 39): 311*, 312*, 313*, 314*, 315*, 316, 321, 322, 323*, 324, 325*, 326*, 327, 331, 332, 333, 334*, 335*, 336, 337*, 339*, 111998*, 211130*, 212324*, 212325*, 212393*, 212399*, 488390*, 511110, 511120, 511130, 511140*, 511191, 511199, 512230*, 512250*, 519130*, 541713*, 541715* or 811490*. *Exceptions and/or limitations exist for these NAICS codes.*
- *Facilities included in the following NAICS codes (corresponding to SIC codes other than SIC codes 20 through 39): 212111, 212112, 212113 (corresponds to SIC code 12, Coal Mining (except 1241)); or 212221, 212222, 212230, 212299 (corresponds to SIC code 10, Metal Mining (except 1011, 1081, and 1094)); or 221111, 221112, 221113, 221118, 221121, 221122, 221330 (limited to facilities that combust coal and/or oil for the purpose of generating power for distribution in commerce) (corresponds to SIC codes 4911, 4931, and 4939, Electric Utilities); or 424690, 425110, 425120 (limited to facilities previously classified in SIC code 5169, Chemicals and Allied Products, Not Elsewhere Classified); or 424710 (corresponds to SIC code 5171, Petroleum Bulk Terminals and Plants); or 562112 (limited to facilities primarily engaged in solvent recovery services on a contract or fee basis (previously classified under SIC code 7389, Business Services, NEC)); or 562211, 562212, 562213, 562219, 562920 (limited to facilities regulated under the Resource Conservation and Recovery Act, subtitle C, 42 U.S.C. 6921 et seq.) (corresponds to SIC code 4953, Refuse Systems).*

- *Federal facilities.*

Information prepared by the EPA and the Agency for Toxic Substances and Disease Registry (ATSDR) demonstrates that PFAS are toxic and can pose hazards to human health and the environment.[3,4] *In EPA's PFAS Action Plan*[5] *program update, dated February 2020, the Agency recommends using a screening level of 40 parts per trillion (0.040 ug/L) to determine if PFOA and/or PFOS is present at a site and may warrant further attention.*

PFAS has been detected in nearly all environmental media. However, there is very limited data on industrial wastewater discharges of PFAS into the environment, in part due to the fact that relatively few facilities have NPDES permit limits or monitoring requirements for PFAS. The EPA identified only 13 industrial facilities that reported PFAS discharges on discharge monitoring reports (DMRs) in 2016 even though the EPA has identified several categories of industry that are likely to discharge PFAS, such as airports, military bases, fire-fighting equipment manufacturers, organic chemical manufacturers, paper and paperboard manufacturers, tanneries and leather treaters, textiles and carpet manufacturers, semiconductor manufacturers, household cleaning product manufacturers, petroleum refining, and landfills.[6]

Other states' PFAS guidance for various surface and groundwater screening levels are indicated in the tables below.[7,8]

Surface Water PFAS Guidelines in Other States				
	Oregon (ug/L)*	Michigan (ug/L)** DWS/not DWS	Minnesota (ug/L) Rivers	Alaska, Montana (ug/L)***
PFHpA	300	-	-	-
PFOA	24	0.420/12	2.7	0.070
PFOS	300	0.011/0.012	0.007	0.070
PFOSA	0.2	-	-	-
PFNA	1	-	-	-

* The Oregon DEQ wastewater initiation levels were adopted into rule (OAR 340-045-0100, Table A) in 2011. The PFAS are 5 chemicals on a list of 118 persistent priority pollutants for water that Oregon DEQ developed in response to state legislation. *Municipal wastewater treatment plants with effluent exceeding initiation levels are required to develop a pollution prevention plan that becomes a part of their NPDES permit*.
** Michigan's advisory levels are designed to protect human health (non-cancer values) and are based on whether the surface water is a drinking water source (DWS) or not.
*** For these states, concentrations of PFOA and PFOS are summed before being compared to the screening level.

Groundwater PFAS Guidelines in Other States						
	Maine (ug/L)*	New Jersey (ug/L)	New Hampshire (ug/L)**	Colorado, Rhode Island, Delaware (ug/L)*	Illinois (ug/L) ***	Minnesota (ug/L) ****
PFHpA	-	-	-	-	-	-
PFOA	0.400	0.010	0.012	0.070	0.021	0.035
PFOS	0.400	0.010	0.015	0.070	0.014	0.027
PFOSA	-	-	-	-	-	-
PFNA	-	-	0.011	-	0.021	-

* For these states, concentrations of PFOA and PFOS are summed before being compared to the screening level.
** Proposed rulemaking in New Hampshire covers 4 PFAS, and includes PFHxS = 0.018 ug/L.
*** Proposed rulemaking in Illinois covers 5 PFAS, and includes PFHxS = 0.140 ug/L and PFBS = 140 ug/L.
**** Health-based values (not maximum contaminant levels, or MCLs).

States use a variety of methods to test PFAS analytes in different media. The most widely used are EPA Method 537 (2008, applies to 14 PFAS) and EPA Method 537.1 (2018, applies to 18 PFAS). Some labs perform modifications, like using isotope dilution, to these methods for use in other matrices besides drinking water to account for lower reporting limits or greater accuracy. For example, modifications to Method 537.1 can be applied for non-drinking water media.[7]

Monitoring these toxic contaminants helps provide information about whether they are present in discharges to better control and mitigate PFAS in the environment. As stated on EPA's PFAS website,[9] *"PFAS can be found in living organisms, including fish, animals, and humans, where PFAS have the ability to build up and persist over time." Due to the characteristics of these contaminants (i.e., persistence in the environment and the human body, and evidence that exposure to PFAS can lead to adverse human health effects), NMED advocates taking a proactive approach and establishing PFAS sampling and reporting requirements to assure protection of New Mexico's surface waters, public health and the environment.*

[1] *https://www.epa.gov/toxics-release-inventory-tri-program/list-pfas-added-tri-ndaa*
[2] *https://www.federalregister.gov/documents/2019/12/04/2019-26034/addition-of-certain-per--and-polyfluoroalkyl-substances-community-right-to-know-toxic-chemical*
[3] *https://www.epa.gov/ground-water-and-drinking-water/drinking-water-health-advisories-pfoa-and-pfos*
[4] *https://www.atsdr.cdc.gov/pfas/pfas_fact_sheet.html*
[5] *https://www.epa.gov/sites/production/files/2020-01/documents/pfas_action_plan_feb2020.pdf*
[6] *EPA Office of Water, Preliminary Effluent Guidelines Program Plan 14, October 2019, EPA-821-R-19-005*
[7] *https://www.ecos.org/documents/ecos-white-paper-processes-and-considerations-for-setting-state-pfas-standards/*
[8] *http://pfas-1.itrcweb.org*
[9] *https://www.epa.gov/pfas/basic-information-pfas#health*

Condition # 2:

USEPA must continue the requirement in the draft permit to include a monitoring and compliance maximum discharge limit for Polychlorinated Biphenyls (PCBs) of 0.00064 micrograms per Liter (µg/L). The State requires that monitoring and reporting of PCBs be performed in accordance with USEPA published Method 1668C or later revisions. Pursuant to 20.6.4.14(A)(3) NMAC, Method 1668C is a State approved method for testing surface wastewater discharges. Additionally, Method 1668C has a Minimum Quantification Level (MQL) set at or below the applicable and limiting State WQS found in 20.6.4.900(J)(1) NMAC. Further supporting this requirement is that Method 1668C is the only known and least restrictive and readily available laboratory wastewater sampling method that can reasonably assure that the proposed discharges do not exceed the WQS limits of 20.6.4.900(J)(1) NMAC.

For Outfall 03A027 add footnote: EPA published congener Method 1668 Revision and detection limits shall be used for reporting purposes. The permittee is allowed to develop an effluent specific MDL in accordance with Appendix B of 40 CFR Part 136 (instructions in Part II.A of this permit).

Outfall 051 has recently discharged and according to representative effluent characteristics submitted in the application there may be a reasonable potential for the effluent to exceed state WQS and EPA should add an effluent limitation for PCBs at Outfall 051.

Background for Condition #2

Below, NMED provides an explanation for why specific PCB monitoring conditions are necessary for State certification. The following table summarizes the applicable PCB numeric criteria from 20.6.4.900(J)(1) NMAC for the receiving waters of this permit action:

		Aquatic Life			
Pollutant	Wildlife Habitat	Acute	Chronic*	Human Health-Organism Only	Type of Pollutant

PCBs	0.014 µg/L	2 µg/L	0.014 µg/L	0.00064 µg/L	Chronic, Persistent

*Note: * Chronic Aquatic Life Criterion does not apply to Segment 20.6.4.128 with a designated use of Limited Aquatic Life*

As PCBs are identified as a persistent pollutant the HH-OO criteria applies to both the coldwater aquatic life use in Segment 20.6.4.126 and the limited aquatic life use in Segment 20.6.4.128, consistent with 20.6.4.11(G) NMAC. USEPA reasonable potential analysis in the Fact Sheet determined that the PCB effluent characteristics at Outfalls 001, 13S and 027 have a reasonable potential to exceed State WQS. The point source discharge permit condition is calculated to meet numeric criteria based on a modified harmonic low flow per State WQS 20.6.4.11 NMAC and as consistent with the New Mexico Implementation Plan (2012).

The following is a summary of a portion of the monitoring and effluent limitation conditions for PCBs in Part I.A of the Draft Permit for Outfalls 001, 13S and 051:

		Concentration		Loading		
		Monthly Average	Daily Maximum	Monthly Average and Daily Maximum	Frequency	Sample Type
				lbs/day		
001	Total PCB (µg/l)	0.00064	0.00064	Report	1/Year	24-hr Composite
13S	Total PCB (µg/l)	0.00064	0.00064	Report	1/Year	24-hr Composite
027	Total PCB (µg/l)	0.00064	0.00064	Report	1/Quarter	Grab

As noted above and below, the Aroclor method is not sufficiently sensitive to assure that the Permittees will comply with the applicable effluent limit for PCBs contained within the permit and thus cannot be used for monitoring or compliance purposes under state law. The following demonstrates the MDL and MQL limits of several PCB testing methods:

Method	MDL	MQL
EPA Method 608 (Aroclor)	0.065 µg/L	0.02145 µg/L
EPA Method 625	30 µg/L	99 µg/L
SM 6410 B	30 µg/L	99 µg/L
EPA Method 1668C	7-30 pg/L	23-99 pg/L (0.000023-0.000099 µg/L)

Notes: EPA Method 1668 Revision A became Revision C in the May 18, 2012 Federal Register notice of 40 CFR Part 136.

The Aroclor method's MQL is two orders of magnitude above the effluent limitation provided in this draft permit as necessary to comply the State WQS. As documented above, the congener method, EPA Method 1668C, is the only method with a sufficiently sensitive detection limit below State WQS for Total PCBs and therefore must be used when it has been determined that PCBs *"are or may be discharged at a level which will cause, have the reasonable potential to cause, or contribute to an excursion above"* State WQS. Again, this condition constitutes *"monitoring requirements necessary to assure that any applicant for a Federal license or permit will comply with any applicable effluent limitations"* consistent with the provisions of the CWA Section 401(d). 33 U.S.C. §1341 (d).

The State received comments from the Permittees. By their letter dated October 28, 2020, Los Alamos National Laboratory (LANL) provided arguments to support the use of the PCB congener method (EPA

Method 1668C) for reporting purposes but not for enforcement or compliance purposes. As detailed below, the State considered these arguments but found them insufficient to support LANL's proposition:

1. *"NMED may only include reference methods that are approved by EPA under 40 CFR Part 136 for determining compliance with effluent limitations. 40 CFR § 136.1 requires the use of EPA Methods 608 or 625 or Standard Methods 6410.B for determining compliance with effluent limits in NPDES permits."* LANL further cites the May 18, 2012 Federal Register publication of the USEPA decision to defer consideration of inclusion of EPA Method 1668C as a 40 CFR Part 136 method in support of this comment.

The State respectfully disagrees. As noted above, the State is requiring this condition in order to assure compliance with the applicable effluent and state water quality limitation which can only be achieved by use of EPA Method 1668C. This conditional action, as previously stated, is consistent with the provisions of the CWA for State Certification at 401(d) and in accordance with 20.6.2.2001 NMAC and 20.6.4.14(A)(3) NMAC.

Furthermore in reviewing USEPA's action in May 2012, to defer adoption of EPA Method 1668C, they included as part of their discussion that "EPA is still evaluating the large number of public comments and intends to make a determination on the approval of this method [1668C] at a later date…[and t]his decision does not negate the merits of this method for the determination of PCB congeners in regulatory programs or for other purposes when analyses are performed by an experienced laboratory." (FR, Vol. 77, No.97, page 29763)

2. *"LANL is the only known facility in New Mexico where use of the Congener Method 1668 is required to determine compliance with an NPDES permit limit."*

LANL is correct that it is the only facility where the use of USEPA Method 1668C is required for compliance purposes, however there is a very specific reason for this. LANL is the only facility whose discharge has been shown to have a reasonable potential to exceed State WQS for PCBs. The State also notes that LANL is not the only NPDES permittee in New Mexico subject to the specific use of USEPA Method 1668C. For example, six other NPDES permits are required to use this method for monitoring and reporting only. These discharge to waters where PCBs have been identified as a probable cause of a water quality impairment, but there was insufficient data to determine if the discharge had a reasonable potential to exceed State WQS or may contribute to a listed impairment. Therefore, based on these facts, use of Method 1668C is the least restrictive means known by the State to assure that the proposed activity will not exceed or contribute to the degradation of state water quality.

Condition #3:

EPA must revise the publicly noticed Reasonable Potential analysis to include all relevant monitoring data submitted as part of the reapplication package and supplemental information updates and comments from the Permittees per the process in the *New Mexico Implementation Guidance (2012)*. As it stands, the public noticed versions of Reasonable Potential analysis for each outfall covered under this permit are not correctly reflected in the draft permit, and according to the Permittees' comments, also are not reflective of monitoring data they submitted or contain other inaccuracies. NMED requires that once revised, EPA discuss the results of the revisions with the Department prior to finalizing the draft permit to ensure that the permit is technically sound and meets the requirements of State law, including the *Standards for Interstate and Intrastate Waters* at 20.6.4 NMAC. NMED reserves the right to revoke and reissue certification if necessary, to ensure compliance with water quality standards.

Based on NMED's review of the Reasonable Potential (RP) spreadsheets public noticed with the draft permit and data submitted to EPA by the Permittees, it appears that limitations for Thallium and PCBs are necessary at several outfalls. Monitoring requirements shall exist in the final permit at outfalls where there is an impairment in the receiving waterbody, regardless of whether RP exists.

Outfall	Added Limits/Monitoring	Monitoring Frequency
001	Limit for thallium; monitoring for temperature – compliance schedule ok.	1/year
13S	Limit for thallium; monitoring for gross alpha	1/year
03A027	No additional limits or monitoring.	N/A
03A048	No RP for limits but monitoring for all impairments: gross alpha; cyanide; total mercury; PCBs; total selenium	1/year
03A113	EPA did not evaluate RP for PCBs at this outfall. A limit appears necessary.	1/year
03A160	EPA did not evaluate RP for PCBs at this outfall. A limit appears necessary.	1/year
03A181	It appears no RP spreadsheet was drafted for this outfall. Based on data, RP must be determined for copper and PCBs.	1/year
03A199	RP for thallium exists. EPA did not evaluate RP for PCBs.	1/year
03A022	EPA did not evaluate RP for PCBs. Monitoring requirements must stay in the permit for copper.	1/year
05A055	No additional limits or monitoring.	N/A
051	RP exists for Thallium. EPA did not evaluate RP for PCBs.	1/year

<u>Background for Condition #3:</u>

Below is a comparison of the effluent limitations in the administratively continued permit, water quality impairments as noted in the State of New Mexico CWA §303(d) Integrated List, notes on changes at the facility, pollutants detected in the effluent, and exceedances noted in 2015-2020 monitoring as compared to limits in the proposed permit. From this review, it appears that the following limits should either be added or modified in the final permit. Although RP exists for thallium at multiple outfalls EPA did not place limits into the draft permit.

Outfall Number	**Description**	**Receiving Stream - WQ Segment**	**Impairments**	**Changes to Facility**	**Impaired pollutants detected (2C) (ug/L)**	**RP**	**2015-2020 monitoring**	**Metals Monitoring/Limit in 2020 Permit**	**Needed Limitations or Monitoring in Final Permit based on RP**
001	Power Plant, SWWS, SERF, SCC, NMHFL	Sandia Canyon - 126	Aluminum, Total; Copper, Dissolved; Polychlorinated Biphenyls (PCBs); Temperature	added SCC, future add TA55	Cu 5.45, Al <19.3, PCB <0.0422, Temp, Thallium =0.442	Cu, Zn, PCB, Tl	Exceed PCB	Total Aluminum-report, Total Copper, Zinc, PCB	Thallium; monitoring for temp – compliance schedule ok.
13S	SWWS	Canada del Buey - 128	Alpha Particles; Polychlorinated Biphenyls (PCBs)		α <1.16 PCB<0.0333, Tl =0.6	PCB	No discharge	PCB	Thallium; monitoring for gross alpha (1/year)
03A027	SERF	Sandia Canyon - 126	Aluminum, Total; Copper, Dissolved; Polychlorinated Biphenyls (PCBs); Temperature		Cu 3.15, Al <19.3, PCB <0.0354, Temp	Cu, Zn	Exceed PCB and Cu limit	Total Aluminum, T Copper, PCB, Temperature, Zinc, Phosphorus	No additional limits or monitoring.
03A048	LANSCE	Los Alamos Canyon - 128	Alpha Particles; Cyanide; Mercury, Total; Polychlorinated Biphenyls (PCBs); Selenium, Total		α <1.85, CN<1.67, Hg <0.067, Se <2, PCB <0.0354		No exceed	Phosphorus	No RP for limits but monitoring for all impairments (1/year).
03A113	LEDA	Sandia Canyon - 128	Alpha Particles; Aluminum, Total; Mercury, Total; Polychlorinated Biphenyls (PCBs)		α=2.95, Al<19.3, Hg=0.011, PCB <0.354		Exceed WQS Cu 1x	Total Mercury, Alpha, Total Aluminum, Phosphorus	EPA did not evaluate RP for PCBs at this outfall. A limit appears necessary.
03A160	NMHFL	Ten Site Canyon - 128	Alpha Particles; Polychlorinated Biphenyls (PCBs)		α<0.96, PCB<0.0343	Cr6, Hg, Se, Cy	exceed Cy WQS, 2 exceed Cu WQS	Phosphorus, Mercury, Selenium, Cyanide, Chromium 6	EPA did not evaluate RP for PCBs at this outfall. A limit appears necessary.
03A181	TA-55	Mortandad Canyon - 128	Alpha Particles; Copper, Dissolved; Mercury, Total; Polychlorinated Biphenyls (PCBs)	future to SWWS?	α <0.772, Cu=3.24, Hg<0.067, PCB<0.0378		Cu 0.002	Phosphorus	It appears no RP spreadsheet was drafted for this outfall. Based on data, RP must be determined for copper and PCBs.
03A199	LDCC	Tributary to Sandia Canyon - 126	Aluminum, Total; Copper, Dissolved; Polychlorinated Biphenyls (PCBs); Temperature		Temp, Tl 0.282, Al=<19.3, Cu=3.15, PCB<0.0354		ok	Total Aluminum, T Copper, Temperature, Zn, P	RP for Thallium exists. EPA did not evaluate RP for PCBs.

Outfall Number	Description	Receiving Stream - WQ Segment	Impairments	Changes to Facility	Impaired pollutants detected (2C) (ug/L)	RP	2015-2020 monitoring	Metals Monitoring/Limit in 2020 Permit	Needed Limitations or Monitoring in Final Permit based on RP
03A022	Sigma	Mortandad Canyon - 128	Alpha Particles; Copper, Dissolved; Mercury, Total; Polychlorinated Biphenyls (PCBs)	new heat exchanger	α <1.14, Cu=5.46, Hg<0.067, PCB<0.0351		above WQS for copper	Dissolved Copper-report	EPA did not evaluate RP for PCBs. Monitoring requirements must stay in the permit for copper (1/year).
05A055	HEWTF	Canon de Valle - 128	Alpha Particles		not present	Al, Cu, Pb, Se, Zn	No discharge	TNT, RDX, perchlorate, Aluminum, Copper, Lead, Selenium, Zinc	No additional limits or monitoring.
051	RLWTF	Mortandad Canyon - 128	Alpha Particles; Copper, Dissolved; Mercury, Total; Polychlorinated Biphenyls (PCBs)		α=2.22, Cu=11, PCB<0.0378, Hg <0.067	Cu		Dissolved Copper	RP exists for Thallium. EPA did not evaluate RP for PCBs.

<u>Comments that are not Conditions of Certification:</u>

Comment 1: There appears to be a typo in Footnote 5 for Outfall 001. NMED proposes revision to delete last sentence "6T3 Temperature of 20°C (68°F) shall not be exceeded for six or more consecutive hours in a 24-hour period on more than three consecutive days. ~~Daily maximum temperature shall be determined by 6T3 temperature record when 6T3 temperature~~ ."

Comment 2:
Please ensure that all of the notices of change submitted by LANL since the 2019 NPDES Permit Re-Application was submitted on March 26, 2019 are incorporated.

- Revision 3 to Outfall 03A048 fact sheet to add a Chlorine monitoring system, submitted July 14, 2020 (EPC-DO: 20-222)
- Revision 3 to the Outfall 001 Flow Diagram which addresses improvements made to reduce the temperature of effluent discharged to the outfall as follows:
    - Piping modification to allow for effluent stored in the Reuse Tank to be routed (as needed) to the power plant cooling tower prior to discharge.
    - Piping modification to allow for blowdown associated with the Strategic Computing Complex (SCC) Cooling Towers to be routed to the Reuse Tank where (as needed) it can either be recycled to SERF or routed to the power plant cooling tower prior to discharge.

  This change will not increase the volume or impact the effluent quality (i.e., no new chemicals) other than to reduce the temperature. This change was submitted as a notice of change on July 16, 2020 (EPC-DO: 20-221).
- Renovation of the power plant. This change was submitted as a notice of change on November 26, 2019 (EPC-DO: 19-430). This will increase the volumes at Outfall 001 as indicated below, and were incorporated into the antidegradation calculations.

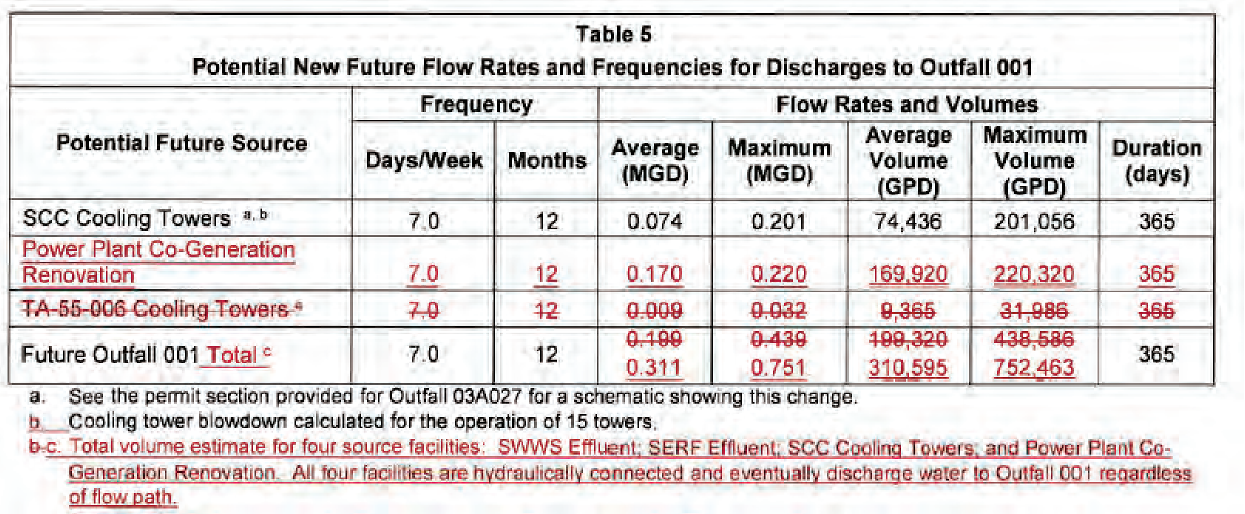


Table 5
Potential New Future Flow Rates and Frequencies for Discharges to Outfall 001

Potential Future Source	Frequency		Flow Rates and Volumes				
	Days/Week	Months	Average (MGD)	Maximum (MGD)	Average Volume (GPD)	Maximum Volume (GPD)	Duration (days)
SCC Cooling Towers [a, b]	7.0	12	0.074	0.201	74,436	201,056	365
<u>Power Plant Co-Generation Renovation</u>	<u>7.0</u>	<u>12</u>	<u>0.170</u>	<u>0.220</u>	<u>169,920</u>	<u>220,320</u>	<u>365</u>
~~TA-55-006 Cooling Towers [c]~~	~~7.0~~	~~12~~	~~0.009~~	~~0.032~~	~~9,365~~	~~31,986~~	~~365~~
Future Outfall 001 <u>Total</u> [c]	7.0	12	~~0.199~~ <u>0.311</u>	~~0.439~~ <u>0.751</u>	~~199,320~~ <u>310,595</u>	~~438,586~~ <u>752,463</u>	365

a. See the permit section provided for Outfall 03A027 for a schematic showing this change.
<u>b.</u> Cooling tower blowdown calculated for the operation of 15 towers.
~~b~~-c. <u>Total volume estimate for four source facilities: SWWS Effluent; SERF Effluent; SCC Cooling Towers; and Power Plant Co-Generation Renovation. All four facilities are hydraulically connected and eventually discharge water to Outfall 001 regardless of flow path.</u>

- Startup of 5 additional Cooling Towers at the SCC. This modification was included as a future change in the 2019 NPDES Permit Application submitted March 26, 2019 (see EPC-DO: 19-106).

Exhibit 7

Federal Register Vol. 77, No. 97, Page 29763

2020 TR BDD 0147

III. Changes Between the Proposed Rule and the Final Rule

Except as noted below, the content of the final rule is the same as that of the proposed rule.

A. EPA Is Not Adding EPA Method 1614A

The Agency proposed to add Method 1614A, ''Brominated Diphenyl Ethers in Water, Soil, Sediment, and Tissue by HRGC/HRMS.'' EPA developed this method to determine 49 polybrominated diphenyl ether (PBDE) congeners in aqueous, solid, tissue, and multi-phase matrices. This method uses isotope dilution and internal standard high resolution gas chromatography/high resolution mass spectrometry (HRGC/HRMS). The commenters were divided on whether EPA should approve this method. Two commenters stated that Method 1614A would be a valuable addition to the list of approved methods, while two other commenters stated that the method has not been sufficiently validated for use in Clean Water Act programs. Upon further evaluation of the data supporting the use of this test procedure and the peer review comments, EPA agrees with those commenters who stated that additional validation data are needed to fully characterize the performance of this method for various matrices and has decided not to include Method 1614A in today's final rule.

B. Deferral of Action on EPA Method 1668C

The Agency proposed to add EPA Method 1668C, ''Chlorinated Biphenyl Congeners in Water, Soil, Sediment, Biosolids, and Tissue by HRGC/HRMS.'' This method measures individual chlorinated biphenyl congeners in environmental samples by isotope dilution and internal standard high resolution gas chromatography/high resolution mass spectrometry (HRGC/HRMS). As discussed in the proposal, Part 136 methods for chlorinated biphenyls (PCBs) only measure a mixture of congeners in seven Aroclors—PCB–1016, PCB–1221, PCB–1232, PCB–1242, PCB–1248, PCB–1254, and PCB–1260, while Method 1668C can measure the 209 PCB congeners in these mixtures.

EPA began development of this method in 1995, initially covering 13 congeners labeled ''toxic'' by the World Health Organization. In 1999, EPA expanded the scope of the method to include all 209 PCB congeners. The method has been used to support several studies, including the 2001 National Sewage Sludge Survey and the National Lake Fish Tissue Survey. Since 1999, EPA has revised the method to incorporate additional information and data collected such as the results of an inter-laboratory validation study, peer reviews of the method and the validation study data, additional QC performance criteria and MDL data, and user experiences. In the development and subsequent multi-laboratory validation of this method, EPA evaluated method performance characteristics, such as selectivity, calibration, bias, precision, quantitation and detection limits. The Agency is aware that this method is being used in some states in their regulatory programs and by other groups for some projects with good success. For example, in a study of data comparability between two laboratories on samples collected from the Passaic River in New Jersey, in which 151 PCB congeners were identified and measured, accuracy, as measured by analysis of an NIST SRM, was 15% or better. Recoveries of the PCB congeners ranged from 90% to 124% and averaged 105%; precision ranged from 4.2 to 23% (Passaic River 2010). This type of data shows that recoveries and precision for this method are within the performance achievable with other approved methods.

EPA received comments from thirty-five individuals or organizations on this method. Of these commenters, five (three states, one laboratory, and one laboratory organization) supported the approval of this method. Some states indicated that they are already requiring this method for use in permits and for other purposes. On the other hand, industry and industry groups/associations were critical of the method for various reasons. Commenters opposing the method provided a detailed critique of the method, the inter-laboratory study, the peer reviews and the other supporting documentation. Among the criticisms of the inter-laboratory study, commenters argued that: (1) EPA did not produce documentation supporting changes to the method approved by EPA for the interlaboratory study, (2) the raw data for wastewater and biosolids was poor and is not fit for use in a comprehensive interlaboratory study, (3) EPA cited certain guidelines such as ASTM but deviated from those guidelines (*e.g.,* used only one Youden pair per matrix), (4) the peer reviewers' qualifications were questioned, (5) the addendum and the pooled MDLs/MLs were not subjected to peer review, (6) MDL/ML are flawed, the process to calculate MDLs/MLs for congeners that co-elute was flawed, the MDL/ML ignored the ubiquitous problem of background contamination, and (7) the validation study did not include all matrices in the method (soil and sediment excluded). In addition, some commenters also suggested that EPA should first promulgate new detection and quantitation procedures. Further, commenters raised questions about possible adverse effects of this new method on compliance monitoring as well as concerns about data reporting and costs.

EPA is still evaluating the large number of public comments and intends to make a determination on the approval of this method at a later date. In the meantime, the Agency has decided to go forward with the promulgation of the other proposed analytical methods to expedite their implementation by the regulated community and laboratories. This decision does not negate the merits of this method for the determination of PCB congeners in regulatory programs or for other purposes when analyses are performed by an experienced laboratory.

C. EPA Is Not Adding ASTM Methods D7574–09 and D7485–09

In today's rule, EPA is not adding two proposed ASTM methods, ASTM D7574–09 ''Standard Test Method for Determination of Bisphenol A (BPA),'' and ASTM D7485–09 ''Standard Test Method for Determination of NP, OP, NP1EO, and NP2EO.'' These two methods involve liquid chromatography and tandem mass spectrometry (LC/MS/MS). The methods have been tested by a single laboratory in several environmental waters, and may be useful for many applications. However, EPA has decided to postpone approval of these two methods for general use until completion of a full inter-laboratory validation study designed to fully characterize the performance of these methods across multiple laboratories and matrices.

D. Revisions and Clarifications to EPA Method 200.7

EPA Method 200.5 ''Determination of Trace Elements in Drinking Water by Axially Viewed Inductively Coupled Plasma—Atomic Emission Spectrometry'' employs a plasma torch viewed in the axial orientation to measure chemical elements (metals). As stated earlier in today's rule, EPA is adding Method 200.5 for some metals in Table IB. Both Methods 200.5 and 200.7 are acceptable methods under Part 136 and both methods employ ICP/AES technology. However, Method 200.5 includes performance data for the axial configuration that is not in Method 200.7 because the axial technology torch

Exhibit 8

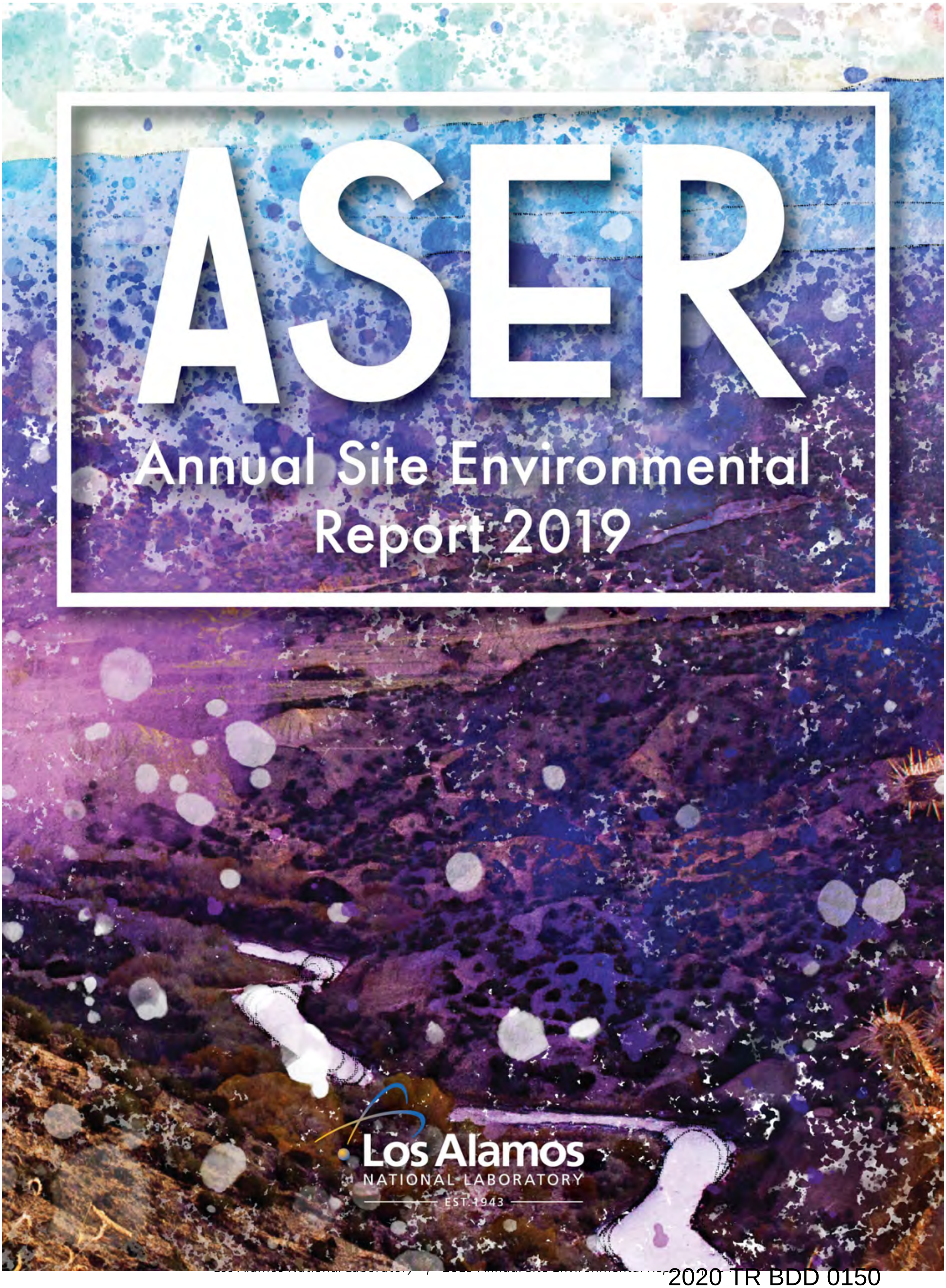
2019 LANL Annual Site Environmental Report

2020 TR BDD 0148 - 0483

LA-UR-20-26673

Title:	Los Alamos National Laboratory 2019 Annual Site Environmental Report
Author(s):	Hansen, Leslie Ann Bruggeman, David Alan Chan, Allison Gaukler, Shannon Marie Kowalewski, Ashley Marie McNaughton, Michael
Intended for:	Report Environmental Regulatory Document
Issued:	2020-09-23 (rev.1)

2020 TR BDD 0148



ASER

Annual Site Environmental Report 2019

Los Alamos
NATIONAL LABORATORY
EST. 1943

LOS ALAMOS NATIONAL LABORATORY
GOVERNING POLICY FOR THE ENVIRONMENT

- We are committed to act as stewards of our environment to achieve our mission in accordance with all applicable environmental requirements.
- We set continual improvement objectives and targets, measure and document our progress, and share our results with our workforce, sponsors, and public.
- We reduce our environmental risk through legacy cleanup, pollution prevention, and long-term sustainability programs.

ANNUAL SITE ENVIRONMENTAL REPORT FOR 2019
LA-UR-20-26673
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LA-UR-20-26673

Issued September 2020

Los Alamos National Laboratory
2019 Annual Site Environmental Report

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ABSTRACT

Los Alamos National Laboratory's (the Laboratory's) annual site environmental reports are prepared by the Laboratory's environmental organizations, as required by U.S. Department of Energy Order 231.1B, Administrative Change 1, *Environment, Safety, and Health Reporting*, and Order 458.1, Administrative Change 3, *Radiation Protection of the Public and the Environment*.

The following chapters in this report discuss our success in complying with environmental laws, regulations, and orders (Chapter 2, Compliance Summary); how we manage the Laboratory's environmental performance (Chapter 3, Environmental Programs); how we monitor for air emissions of radioactive materials and climate conditions (Chapter 4, Air Quality); how we monitor for effects of Laboratory operations on groundwater quality (Chapter 5, Groundwater Protection); how we monitor the movement of chemicals and radionuclides by storm water runoff and the levels of chemicals and radionuclides in deposited sediment (Chapter 6, Watershed Quality); how we monitor for the presence, levels, and effects of chemicals and radionuclides in plants, animals, and soil (Chapter 7, Ecosystem Health); and finally, what radionuclide dose or risk from chemical exposure members of the public may experience as a result of Laboratory operations (Chapter 8, Public Dose and Risk Assessment).

This report follows plain language guidelines, as required for federal agencies by the Plain Language Act of 2010. More information about plain language can be found at http://www.plainlanguage.gov/index.cfm. You will notice we have substantially reduced the use of acronyms and abbreviations and are using active voice and personal pronouns.

We hope you find this report useful. If you have suggestions for improving this report, additional questions, or want a copy of this report, please contact us at envoutreach@lanl.gov, or call the Communications Office at 505-665-7000.

This report, its supplemental tables, and the 2019 *Annual Site Environmental Report Summary* are available at http://www.lanl.gov/environment/environmental-report.php.

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Audrey Krehik
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Mary Jo Chastenet
Jeff Whicker

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Los Alamos National Laboratory (the Laboratory) is located in Los Alamos County in north-central New Mexico, approximately 60 miles north-northeast of Albuquerque and 25 miles northwest of Santa Fe. The mission of the Laboratory is to solve national security challenges through scientific excellence. Inseparable from our focus on excellence in science and technology is our commitment to environmental stewardship and full compliance with environmental protection laws. Part of the Laboratory's commitment is to report on its environmental performance. This site environmental report

Sampling sediment at the Laboratory

- characterizes the Laboratory's environmental performance, including effluent releases, environmental monitoring, and estimated radiological doses to the public and the environment;
- summarizes environmental occurrences and responses;
- confirms compliance with environmental standards and requirements;
- highlights significant programs and efforts; and
- describes property clearance activities in accordance with U.S. Department of Energy (DOE) Order 458.1.

Los Alamos National Laboratory has changed substantially since it was founded as part of the Manhattan Project in 1943. Undoubtedly, the future will continue to bring significant changes to the mission and operations of the Laboratory. Regardless of these changes, we are committed to operating the site sustainably.

The Laboratory's Governing Policy on Environment

We are committed to act as stewards of our environment to achieve our mission in accordance with all applicable environmental requirements. We set continual improvement objectives and targets, measure and document our progress, and share our results with our workforce, sponsors, and the public. We reduce our environmental risk through legacy cleanup, pollution prevention, and long-term sustainability programs.

Environmental stewardship requires an active management system to provide environmental policy, planning, implementation, corrective actions, and management review. We use an Environmental Management System to accomplish this. The Laboratory has been certified to the International Organization for Standardization's 14001 standard for the Environmental Management System since April 2006.

The following chapters in this report discuss a range of topics: our success in complying with environmental laws, regulations, and orders (Chapter 2, Compliance Summary); how we manage the Laboratory's environmental performance (Chapter 3, Environmental Programs); how we monitor for air emissions of radioactive materials and climate conditions (Chapter 4, Air Quality); how we monitor for effects of Laboratory operations on groundwater quality (Chapter 5, Groundwater Protection); how we monitor the movement of chemicals and radionuclides by storm water runoff and the levels of chemicals and radionuclides in deposited sediment (Chapter 6, Watershed Quality); how we monitor for the presence, levels, and effects of chemicals and radionuclides in plants, animals, and soil (Chapter 7, Ecosystem Health); and finally, what radionuclide dose or risk from chemical exposure members of the public may experience as a result of Laboratory operations (Chapter 8, Public Dose and Risk Assessment).

2019 Environmental Performance Summary

Our environmental performance can be summarized as follows:

- The Laboratory operated under 14 different types of environmental permits and legal orders (Table 2-22 in Chapter 2).
- Work continued on supplemental environmental projects agreed to under a 2016 settlement agreement with the State of New Mexico.
- The New Mexico Environment Department granted certificates of completion for 32 remedial sites in fiscal year 2019. Of the remaining sites, 134 are deferred because of ongoing operations, and 914 have investigations or corrective actions either in progress or pending.
- The Laboratory was fully in compliance with its Clean Air Act, Title V Operating Permit emission limits.
- We discharged approximately 115 million gallons of liquid effluents from eight permitted outfalls. Five of the 794 outfall samples collected (0.6 percent) exceeded effluent quality limits in the outfall permit (Table 2-6 in Chapter 2).
- Two areas of the regional aquifer at the Laboratory have groundwater contaminants that are of sufficient concentration and extent to warrant actions, such as interim measures, further characterization, and potential remediation under the 2016 Consent Order: RDX contamination in the vicinity of Technical Area 16 and chromium contamination beneath Sandia and Mortandad Canyons. Interim measures to control the chromium plume boundary are ongoing and are showing positive results (Chapter 5, Groundwater Protection).
- Five environmental occurrences were reported under DOE Order 232.2, *Occurrence Reporting and Processing of Operations Information* (Table 2-19 in Chapter 2).
- The Laboratory had 6 inspections or audits conducted by regulating agencies or external auditors in 2019 (Table 2-20 in Chapter 2).
- One unplanned release of approximately 2 gallons of treated effluent from the Radioactive Liquid Waste Treatment Facility occurred on Laboratory property, and was reported. We made 19 reports of unplanned nonradioactive liquid releases to the New Mexico Environment Department.
- Work continued on stabilizing and repairing Manhattan Project National Historical Park properties at the Laboratory.
- The Laboratory adopted an updated plan for mitigating wildland fire fuels and addressing forest health, and also hired a Fire Management Officer.
- Radiological doses to the public from Laboratory operations were less than 1 millirem per year, and health risks are indistinguishable from zero.

2019 Environmental Monitoring Highlights

During 2019, we completed the following:

- The Laboratory operated 27 stack monitoring stations and 38 ambient air monitoring stations to measure levels of airborne radiological materials. During 2019, the radioactive emissions from all Laboratory sources amounted to approximately 1 percent of the regulatory limit, and concentrations of airborne radioactive material measured in ambient air samples were below the applicable concentration levels for environmental compliance.
- Laboratory staff conducted more than 100 Hydrology Protocol assessments that covered almost 80 miles of streams. New Mexico Environment Department personnel participated in approximately half of the 2019 assessments. The purpose of the assessments is to determine which watercourses on Laboratory property are ephemeral, and which are intermittent, in order to better identify the appropriate surface water quality standards.
- The Laboratory conducted foodstuffs sampling from various locations around the Laboratory, in the surrounding communities, and from regional background locations. Foodstuffs samples were analyzed for radionuclides and inorganic elements (mostly metals). Foodstuffs produced by animals, such as milk and eggs, were also tested for PCBs. Based on this data, the dose from eating local or regional foodstuffs, including crops, eggs, milk, tea, deer, and elk, is well below 0.1 millirem per year. Radionuclide concentration in publicly available food is consistent with global fallout or naturally occurring material, and any contributions from the Laboratory are too small to measure.
- The 2019 biota dose assessment confirms previous assessments and shows that there are no harmful effects to the biota populations at LANL from Laboratory radioactive materials.

An additional summary of this report can be found in the Los Alamos National Laboratory Annual Site Environmental Report Summary. The full report and the summary are available on the Laboratory's website: http://www.lanl.gov/environment/environmental-report.php.

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Los Alamos National Laboratory (LANL, or the Laboratory) was established in 1943 as Project Y of the Manhattan Project, with the objective of designing and building the world's first nuclear weapons. The Laboratory continues to operate today with a national security mission, surrounded by the diverse communities of northern New Mexico and employing approximately 12,000 people.

BACKGROUND AND PURPOSE

Background

In March 1943, a small group of scientists came to Los Alamos, New Mexico, for Project Y of the Manhattan Project. Their goal was to develop the world's first nuclear weapon. By 1945—when the first nuclear bomb was tested at Trinity Site in southern New Mexico—more than 3,000 civilian and military personnel were working at Los Alamos Laboratory (Figure 1-1).

Figure 1-1. Entrance to Los Alamos Scientific Laboratory Technical Area 1, circa 1950

The Laboratory's original mission to design, develop, and test nuclear weapons has broadened and evolved over time. The current mission is to solve national security challenges through scientific excellence.

The United States Atomic Energy Commission took ownership of Los Alamos Laboratory in 1946. In 1947, Los Alamos Laboratory became Los Alamos Scientific Laboratory. The U.S. Department of Energy (DOE) took ownership in 1977, and Los Alamos Scientific Laboratory became known as Los Alamos National Laboratory (LANL, or the Laboratory) in 1981. The National Nuclear Security Administration, a semi-autonomous agency within DOE, has overseen the management and operating contract for the Laboratory since 2000.

From 1943 through May 2006, the Laboratory was operated by the Regents of the University of California. In June 2006, Los Alamos National Security, LLC, took over the contract to manage and operate the Laboratory. They operated the Laboratory through 2018. In 2014, DOE decided to separate the cleanup of legacy waste from the management and operating contract at the Laboratory. The legacy waste cleanup work was transitioned to a bridge contract under DOE's Office of Environmental Management in October 2015. A new contractor, Newport News Nuclear BWXT–Los Alamos, LLC (N3B), took over the legacy waste cleanup in April 2018. Triad National Security, LLC, was awarded the most recent management and operating contract for the Laboratory, and they took over managing the Laboratory in November 2018. Currently, both the National Nuclear Security Administration and the Office of Environmental Management maintain field offices in Los Alamos, New Mexico.

Purpose

This document serves as a consolidated site environmental report, fulfilling the annual reporting requirements of both the National Nuclear Security Administration and DOE's Office of Environmental Management for the site under DOE Orders 231.1B Chg 1, *Environment, Safety, and Health Reporting,* and 458.1 Chg 3, *Radiation Protection of the Public and the Environment*. In this document, "we" refers to the people who work at Los Alamos National Laboratory, including employees of both DOE and contractor organizations.

As part of the Laboratory's commitment to protecting the environment, we monitor and report on how Laboratory activities affect the environment. The objectives of this annual report are to

- characterize the site's environmental performance, including effluent discharges, air emissions, environmental monitoring, and estimated radiological doses to the public from releases of radioactive materials;
- summarize environmental occurrences and responses;
- document compliance with environmental standards and requirements;
- highlight significant programs and efforts; and
- summarize property clearance activities.

The chapters in this report discuss our compliance with environmental laws, regulations, and orders (Chapter 2, Compliance Summary); how we manage the Laboratory's environmental performance (Chapter 3, Environmental Programs); how we monitor for air emissions of radioactive materials and climatic conditions (Chapter 4, Air Quality); how we monitor for effects of Laboratory operations on groundwater quality (Chapter 5, Groundwater Protection); how we monitor the movement of chemicals and radionuclides by storm water runoff and the levels of chemicals and radionuclides in deposited sediment (Chapter 6, Watershed Quality); how we monitor for the presence, levels, and effects of chemicals and radionuclides in plants, animals, and soil (Chapter 7, Ecosystem Health); and finally, what radioactive dose or risk from chemical exposure members of the public may experience as a result of Laboratory operations (Chapter 8, Public Dose and Risk Assessment).

ENVIRONMENTAL SETTING

Location

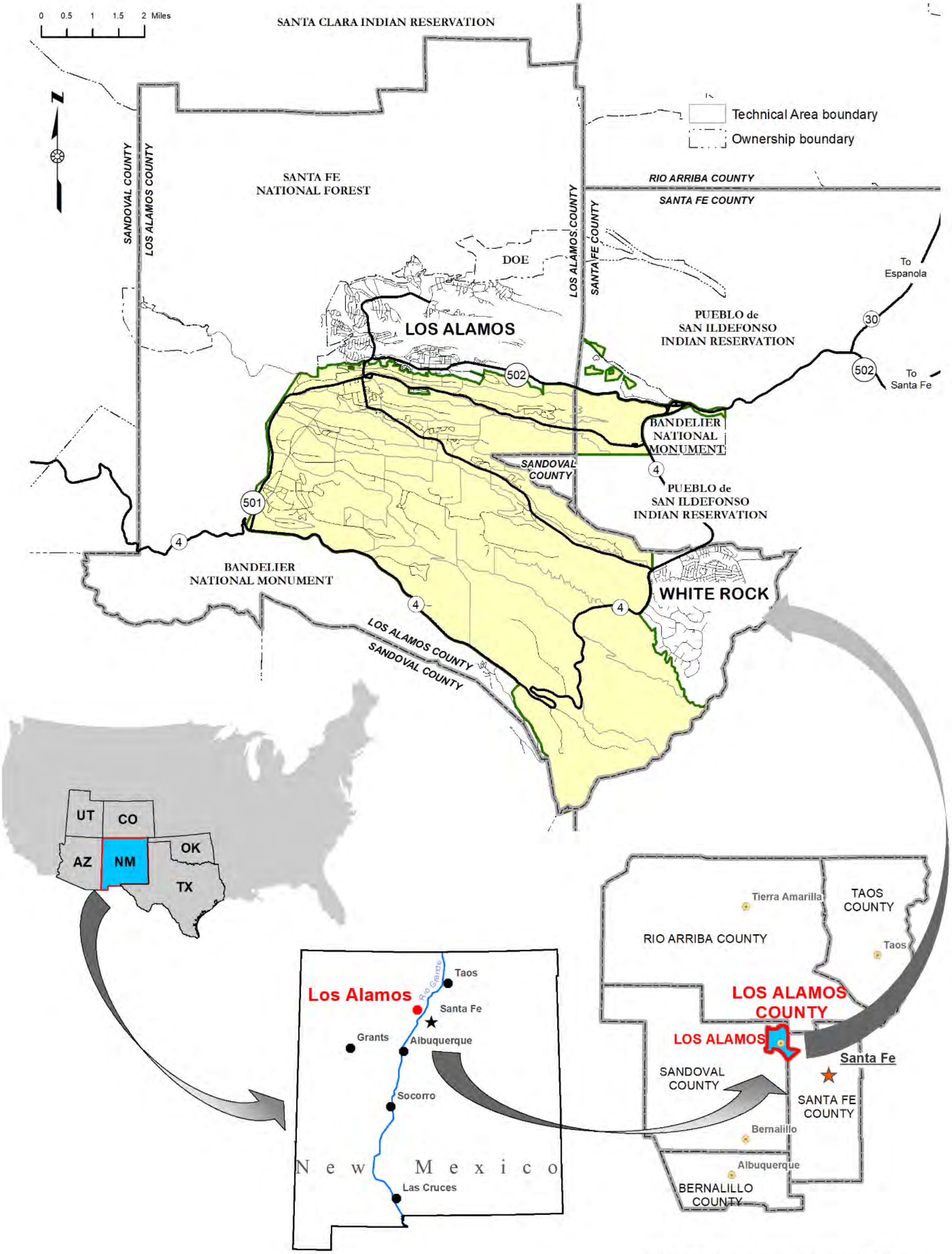
Los Alamos National Laboratory is located in Los Alamos County, in north-central New Mexico, approximately 60 miles north-northeast of Albuquerque and 25 miles northwest of Santa Fe (Figure 1-2). The Laboratory is located on the Pajarito Plateau, a series of fingerlike mesas separated by canyons at the eastern edge of the Jemez Mountains. Mesa tops range in elevation from approximately 7,800 feet on the flanks of the Jemez Mountains on the western side to about 6,200 feet on the eastern side, at the edge of White Rock Canyon, which drops down to the Rio Grande. The Laboratory property is about 40 square miles, which includes areas with active operations and some additional DOE properties, such as a proposed land transfer tract in Rendija Canyon (labeled “DOE” in Figure 1-2). Most Laboratory-developed areas are on the mesa tops.

At the end of 2019, 12,558 people were employed by the primary contractors at the Laboratory, and an additional 1,014 people were employed by staff augmentation, protective force, and legacy waste cleanup subcontractors. The LANL-affiliated workforce resides predominantly in Los Alamos, Santa Fe, Rio Arriba, Bernalillo, Sandoval, and Taos counties and includes regular workers, temporary workers, and students.

New Mexico’s 2019 population was 2,096,826 people (Census 2020a), and the estimated population within a 50-mile radius of Los Alamos was 510,983 residents (CIESIN 2020). The counties with substantial land area within 50 miles of the Laboratory are Los Alamos, Santa Fe, Sandoval, and Rio Arriba. The estimated racial and ethnic composition of the population within these counties, based on data from the U.S. Census Bureau’s American Community Survey from 2014 through 2018, is shown in Table 1-1 (Census 2020b). Figure 1-2 shows the Laboratory’s location in the northern New Mexico region. Figure 1-3 shows municipalities and tribal properties within 50 miles of the Laboratory.

Table 1-1. Estimated Racial and Ethnic Composition of the Population within Los Alamos, Santa Fe, Sandoval, and Rio Arriba Counties during 2014–2018 (Census 2020b)

Race	Number of People
White alone	261,829
Black or African American alone	4,867
American Indian and Alaska Native alone	29,008
Asian alone	5,012
Some other race alone	35,179
Two or more races	11,454
Ethnicity	**Number of People**
Hispanic or Latino, of any race	161,724
Not Hispanic or Latino	185,625



Map #19-066-04, Updated March 11, 2019, GIS Program/IFPROG

Figure 1-2. Regional location of the Laboratory

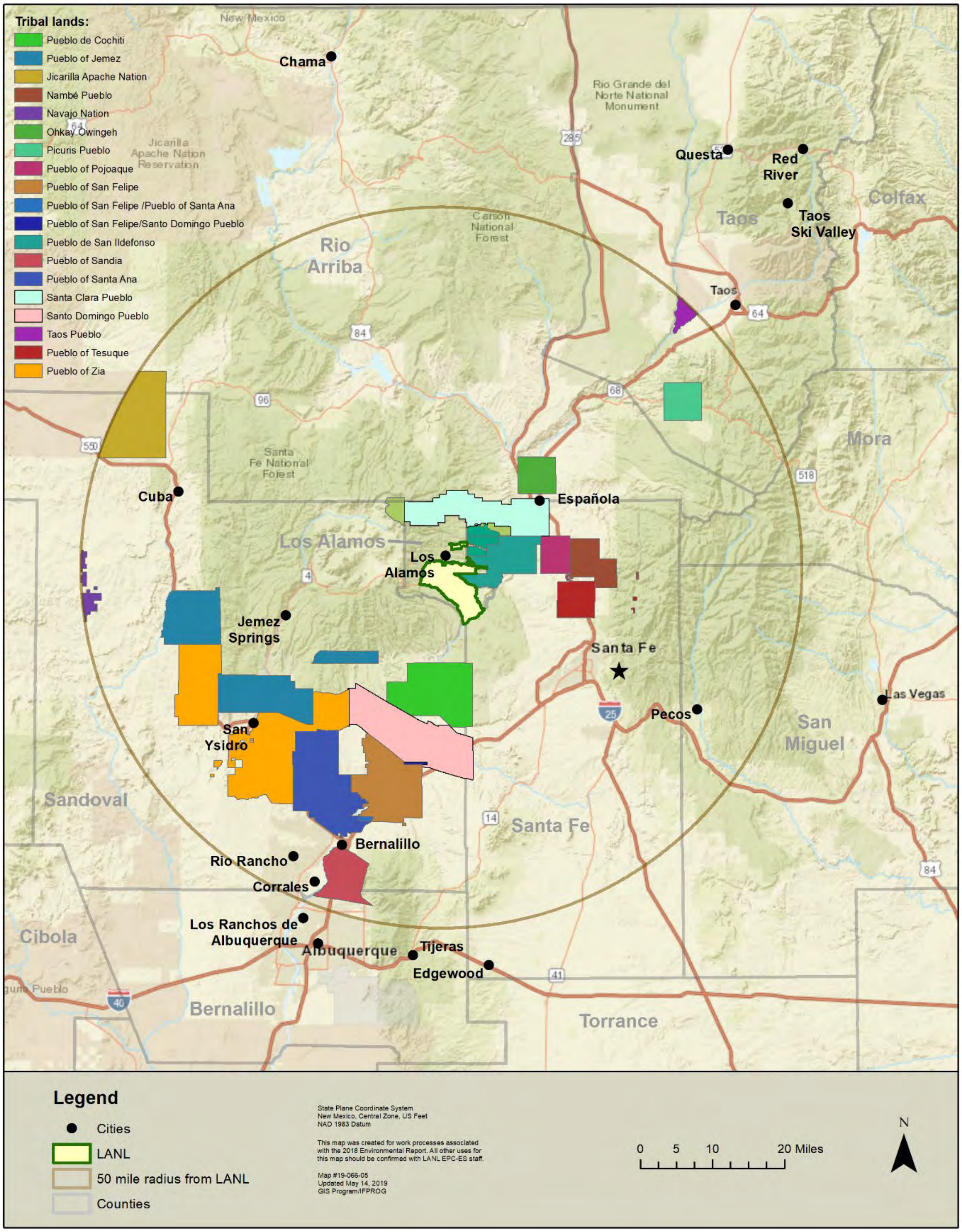


Figure 1-3. Municipalities and tribal properties within a 50-mile radius of the Laboratory

The land surrounding the Laboratory is largely undeveloped, and large tracts of land north, west, and south of the Laboratory site are held by the Santa Fe National Forest, the U.S. Bureau of Land Management, Bandelier National Monument, and Los Alamos County. The townsite of Los Alamos borders the Laboratory to the north, and the townsite of White Rock borders it to the east. The Pueblo de San Ildefonso also borders the Laboratory to the east. Santa Clara Pueblo is north of the Laboratory but does not share a border (Figure 1-2).

Geology

Los Alamos National Laboratory lies along a continental rift called the Rio Grande Rift. Continental rifts result from tectonic plates in the Earth’s lithosphere moving apart. The rift allows magma to rise close to the earth’s surface, and volcanoes are a common feature of rifts. The Jemez Mountains are the remnant of a large collapsed volcanic field, and most of the rocks that make up the Pajarito Plateau are the products of volcanic eruptions.

The mesas of the Pajarito Plateau are mostly composed of Bandelier Tuff. Tuff is a type of soft rock that forms from volcanic ash. The Bandelier Tuff is more than 1,000 feet thick in the western part of the plateau and thins to about 260 feet thick on the eastern edge of the plateau above the Rio Grande.

On the western side of the Pajarito Plateau, the Bandelier Tuff overlaps the Tschicoma Formation of the Jemez Mountains. The Tschicoma Formation is an older rock layer of volcanic dacite. Eastward near the Rio Grande, a layer of sand and gravel that underlies the Bandelier Tuff, known as the Puye Formation, becomes visible in places. The Puye Formation is important in storing groundwater. Basalt rocks originating from the Cerros del Rio volcanos east of the Rio Grande mix with the Puye Formation along the river and extend beneath the Bandelier Tuff in places.

These rock formations all overlie the sediments of the Santa Fe Group, which extend between the Laboratory and the Sangre de Cristo Mountains and are more than 3,300 feet thick. The Santa Fe Group sediments are also important for groundwater storage.

Rifts are associated with faults in the earth. The modern rift boundary in the Los Alamos area consists of a local master fault and three subsidiary faults, known as the Pajarito fault zone. Past and present studies at the Laboratory investigate the earthquake hazards associated with these faults (Gardner et al. 1990, Larmat 2019).

Climate

Los Alamos County has a semi-arid climate, meaning that more water is lost from the soil and plants through evaporation and transpiration than is received as annual precipitation. Annual temperatures and amounts of precipitation differ across the area because of the 1,000-foot elevation change and the complex topography.

Four distinct seasons occur in Los Alamos County. Winters are generally mild, with occasional snowstorms. Spring is the windiest season. Summer is the rainy season, with frequent afternoon thunderstorms. Fall is typically dry, cool, and calm.

On average, winter temperatures range from 30 °F to 50 °F during the daytime and from 15 °F to 25 °F during the nighttime. The Sangre de Cristo Mountains to the east of the Rio Grande act as a barrier to wintertime arctic air masses, making the occurrence of subzero temperatures rare. On average, summer temperatures range from 70 °F to 88 °F during the day and from 50 °F to 59 °F during the night.

From 1981 to 2010, the average annual precipitation (which includes both rain and the water equivalent of snow, hail, or any other frozen precipitation) was about 19 inches. The average annual snowfall was about 57 inches. The rainy season begins in early July and ends in early September. Afternoon thunderstorms form while moist air from the Pacific Ocean and the Gulf of Mexico lifts over the Jemez Mountains. Thunderstorms yield short, heavy downpours and an abundance of lightning. Local lightning density, among the highest in the United States, is estimated at 15 strikes per square mile per year.

The complex topography of the Pajarito Plateau influences local wind patterns. Daytime winds in the Los Alamos area are predominately from the south, as heated daytime air moves up the Rio Grande valley. Nighttime winds on the Pajarito Plateau are lighter and more variable than daytime winds and are typically from the west, a result of prevailing upper-level winds from the west and the downslope flow of cooled mountain air.

The climatology of Los Alamos County is summarized in Chapter 4, Air Quality, and explained further in Dewart et al. (2017).

Hydrology

Surface water on the Laboratory occurs primarily as ephemeral flow—associated with individual rain storms and lasting only a few hours to days—or intermittent flow, associated with events like snowmelt and lasting only a few days to weeks. Some springs on the edge of the Jemez Mountains supply water year-round to western sections of some canyons on Laboratory property, but the amount of water is not enough to maintain surface flows across the plateau to the eastern Laboratory boundary.

Groundwater in the Los Alamos area occurs in three modes: water in the near-surface sediments in the bottoms of some canyons (alluvial groundwater); water in underground porous rock layers underlain by a more solid rock layer and therefore perched above the regional aquifer (perched-intermediate groundwater); and the regional aquifer, located in saturated Santa Fe Group sediments.

The regional aquifer is the only aquifer in the area capable of serving as a municipal water supply. The source of most water added to the regional aquifer appears to be rain and snow that fall on the Jemez Mountains. A secondary source is local infiltration of water in canyon bottoms on the Pajarito Plateau (Birdsell et al. 2005). The upper portion of the regional aquifer beneath the Laboratory discharges into the Rio Grande through the springs in White Rock Canyon.

Biological Resources

The Pajarito Plateau is very biologically diverse, partly because of the dramatic 5,000-foot elevation change from the Rio Grande up to the top of the Jemez Mountains and partly because of the many steep canyons that dissect the area. The major types of vegetative cover in this area include the following: (1) one-seed juniper (*Juniperus monosperma*) savannas along the Rio Grande on the eastern border of the plateau, extending upward on the south-facing sides of canyons at elevations between 5,600 and 6,200 feet; (2) juniper woodlands with scattered piñon (*Pinus edulis*) trees, generally between 6,200 and 6,900 feet in elevation and covering large portions of the mesa tops and north-facing canyon slopes at the lower elevations; (3) ponderosa pine (*Pinus ponderosa*) woodlands on the western portion of the plateau at between 6,900 and 7,500 feet in elevation; and (4) mixed-conifer woodlands and forests at elevations of 7,500 to 9,500 feet, overlapping the ponderosa pine community both in the deeper canyons and on north-facing canyon slopes and extending onto the slopes of the Jemez Mountains. Local wetland and riparian areas enrich the diversity of plants and animals found on the plateau.

The frequent drought conditions occurring throughout New Mexico since 1998 have resulted in the loss of many forest and woodland trees. Between 2002 and 2005, more than 90 percent of the mature piñon trees in the Los Alamos area died from a combination of drought stress and bark beetle infestation (Breshears et al. 2005). Large numbers of mature ponderosa pine and other conifer trees in the area have also died. This mortality of forest trees is projected to continue into the 2050s (Williams et al. 2013).

Two major wildfires have also affected the Laboratory: the Cerro Grande fire in 2000 and the Las Conchas fire in 2011. Both fires resulted in loss of forest trees on the slopes of the Jemez Mountains west of the Laboratory and were followed by large flash floods that caused extensive soil erosion and some damage to infrastructure. A 1,000-year storm event in September 2013 also resulted in flooding and damage.

Cultural Resources

The Pajarito Plateau is an archaeologically complex region. Surveys of approximately 90 percent of the DOE land in Los Alamos County have identified more than 1,800 prehistoric and historic cultural sites. Nearly 79 percent of the sites were constructed and used by Ancestral Pueblo people during the thirteenth, fourteenth, and fifteenth centuries. However, there is evidence of human activity on this landscape from the Paleoindian Period (16,000–8,000 BC) through the Historic Period (seventeenth century–present). Cultural resource specialists at the Laboratory document and evaluate these cultural sites for their eligibility in the National Register of Historic Places.

The Laboratory itself is also associated with events of national significance in recent history. We have evaluated more than 300 buildings and structures at the Laboratory used during the Manhattan Project and Cold War historical periods (1943–1990) for listing in the National Register of Historic Places. Of these, 171 buildings have been declared eligible.

Established in 2014, the Manhattan Project National Historical Park, managed by the National Park Service, includes units at Hanford, Washington; Oak Ridge, Tennessee; and Los Alamos. Nine buildings associated with the design and assembly of Gadget (the atomic bomb tested at Trinity Site), the Little Boy weapon (the atomic bomb detonated over Hiroshima, Japan), and the Fat Man weapon (the atomic bomb detonated over Nagasaki, Japan) are currently part of the Manhattan Project National Historical Park at Los Alamos National Laboratory. Eight additional Laboratory buildings and structures, identified in the park legislation, are considered eligible properties for inclusion in the Park.

LABORATORY ACTIVITIES AND FACILITIES

The mission of the Laboratory is to solve national security challenges through scientific excellence. The current goals of the Laboratory are to: (1) deliver national nuclear security and broader global security mission solutions; (2) attract, inspire, and develop world-class talent to ensure a vital future workplace; (3) foster excellence in science and engineering disciplines essential for national security missions; and

(4) enable mission delivery through next-generation facilities, infrastructure, and operational excellence. Mission focus areas include

- nuclear deterrence and stockpile stewardship;
- protecting against nuclear threats;
- emerging threats and opportunities; and
- energy security solutions.

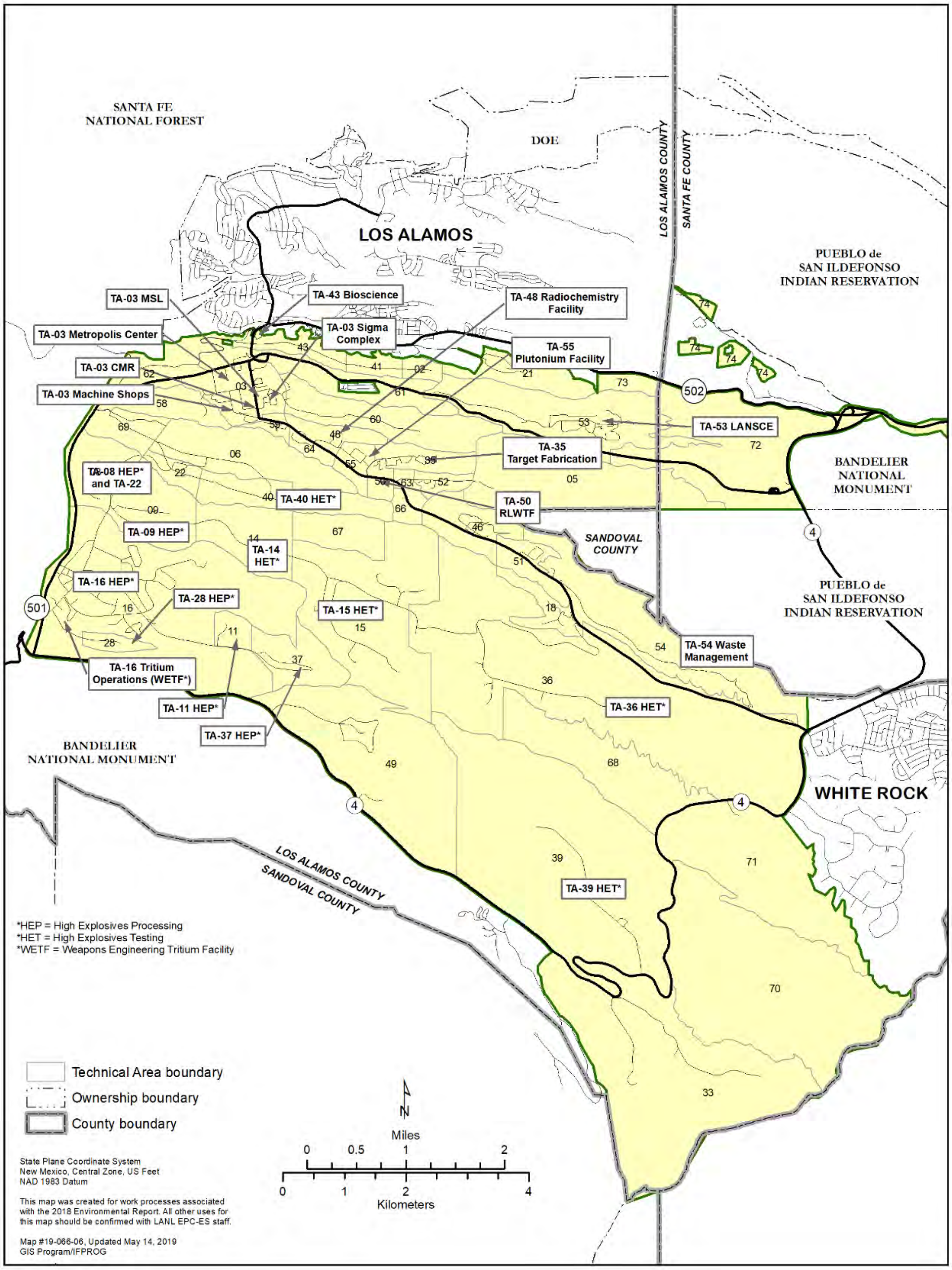
The Laboratory property is organized into 49 technical areas that contain buildings, experimental areas, support facilities, roads, and utility rights-of-way (Figure 1-4 and Appendix C, Descriptions of Technical Areas and their Associated Programs). Developed areas account for less than half of the total land area; many portions of the Laboratory act as buffer areas for security, safety, and possible future expansion. The Laboratory has about 904 permanent buildings and temporary structures, with approximately 8.2 million square feet under roof (LANL 2019). Areas of the Laboratory undergoing legacy waste cleanup activities are administratively controlled by the DOE's Office of Environmental Management.

In May 2008, the DOE/National Nuclear Security Administration issued a site-wide environmental impact statement for continued operation of the Laboratory (DOE 2008). In the 2008 Site-Wide Environmental Impact Statement, the Laboratory identified 15 facilities as being key for evaluating the potential environmental impacts of continued operation (Table 1-2). Activities in the key facilities represent the majority of environmental impacts associated with Laboratory operations.

Table 1-2. Key Facilities

Facility	Technical Area(s)
Plutonium Facility Complex	55
Chemistry and Metallurgy Research (CMR) Building	03
Sigma Complex	03
Materials Science Laboratory (MSL)	03
Target Fabrication Facility	35
Machine Shops	03
Nicholas C. Metropolis Center for Modeling and Simulation	03
High Explosives Processing (HEP) Facilities	08, 09, 11, 16, 22, 37
High Explosives Testing (HET) Facilities	14, 15, 36, 39, 40
Los Alamos Neutron Science Center (LANSCE)	53
Biosciences Facilities (formerly Health Research Laboratory)	03, 16, 35, 43, 46
Radiochemistry Facility	48
Radioactive Liquid Waste Treatment Facility (RLWTF)	50
Solid Radioactive and Chemical Waste Facilities	50, 54
Weapons Engineering Tritium Facility (WETF)	16

The remaining Laboratory facilities were identified as non-key facilities, examples of which include the Nonproliferation and International Security Center; the National Security Sciences Building, which is the main administration building; and the Technical Area 46 sewage treatment facility.



See Table 1-2 for acronym definitions.

Figure 1-4. Technical Areas (TAs) and key facilities of the Laboratory in relation to surrounding landholdings

In April 2018, the DOE/National Nuclear Security Administration published a supplement analysis that reviewed changes at the Laboratory and evaluated the adequacy of the 2008 Site-Wide Environmental Impact Statement for LANL operations during 2018–2022 (DOE 2018). The supplement analysis indicated that the environmental impacts that occurred during 2008–2017 and those projected for 2018–2022 have not substantially changed from the impacts that were projected in the Site-Wide Environmental Impact Statement Record of Decisions and are bounded by the analyses presented in the 2008 Site-Wide Environmental Impact Statement.

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Compliance with environmental laws and orders is part of Los Alamos National Laboratory's (LANL, or the Laboratory) environmental stewardship. This chapter summarizes the Laboratory's 2019 compliance with laws and orders, such as permit conditions and limits, inspections, notices of violations, occurrences, and accomplishments. A list of the Laboratory's environmental permits for operations is provided at the end of the chapter. The following provides a partial list of the environmental laws and orders that apply to the Laboratory:

Radiation Protection

- DOE Order 458.1, *Radiation Protection of the Public and the Environment*
- Clean Air Act – *Radionuclide National Emission Standards for Hazardous Air Pollutants*

Waste Management

- DOE Order 435.1, *Radioactive Waste Management*
- Resource Conservation and Recovery Act
- 2016 Compliance Order on Consent
- Federal Facility Compliance Act

Air Quality

- Clean Air Act
- New Mexico Air Quality Control Act

Water Quality

- Clean Water Act
- New Mexico Water Quality Act
- 2016 Compliance Order on Consent
- Energy Independence and Security Act

Natural and Cultural Resources

- National Environmental Policy Act
- National Historic Preservation Act
- Endangered Species Act
- Migratory Bird Treaty Act
- Floodplain, Wetland, and Invasive Species Executive Orders

Other Environmental Protections

- Toxic Substances Control Act
- Federal Insecticide, Fungicide, and Rodenticide Act
- New Mexico Pesticide Control Act
- DOE Order 231.1B, *Environment, Safety, and Health Reporting*
- DOE Order 231.2, *Occurrence Reporting and Processing of Operations Information*
- Emergency Planning and Community Right-to-Know Act
- DOE Order 436.1, *Departmental Sustainability*

INTRODUCTION

Environmental laws are designed to protect human health and the environment by

- regulating the handling, transportation, and disposal of materials and wastes;
- regulating detrimental impacts to biological and cultural resources, air, and water; and
- requiring analysis of the environmental impacts of new operations.

This chapter summarizes the Laboratory's compliance with state and federal environmental regulations and permits and Department of Energy (DOE) environmental orders, including inspections, notices of violations, occurrences, and accomplishments.

RADIATION PROTECTION

DOE Order 458.1 Chg 3, *Radiation Protection of the Public and the Environment*

DOE Order 458.1 directs DOE facilities to keep radiological doses to the public and the environment as low as reasonably achievable and to monitor for routine and nonroutine releases of radioactive materials. The order requires DOE sites to do the following:

- Ensure the radiological dose to the public as a result of their activities does not exceed 100 millirem in any given year.
- Comply with the order's dose limits for wildlife and plants.
- Notify the public about any radiation doses resulting from operations.
- Use radiological limits authorized by DOE to evaluate property that has the potential to contain residual radioactivity (e.g., surplus equipment, waste shipped for disposal offsite, or land parcels transferred to new owners) before releasing it to ensure that the dose does not exceed 25 millirem per year above background for real estate or 1 millirem per year above background for moveable items.

Estimated Maximum Possible Radiological Dose to the Public

During 2019, the estimated maximum radiological dose to a member of the public from Laboratory operations was less than 1 millirem. Radiation doses to wildlife and plants were below the annual DOE dose limits (Whicker et al. 2020). Chapter 8 provides details of the Laboratory's annual radiological dose estimates for the public, and Chapter 7 presents dose estimates for wildlife and plants.

Property Released from the Laboratory

Real Estate

A land parcel, Tract A-16-b (about six acres adjacent to DP Canyon), was conveyed to Los Alamos County in 2019 (LANL 2016a).

Recycled Metals

Metals exposed to ionizing radiation during Laboratory operations are evaluated for release before recycling. About 826 tons of metal were recycled in 2019. Much of that amount was from the Los Alamos Neutron Science Center's accelerator. About 76 tons were released from activities associated with the legacy waste cleanup program at Technical Area 21.

Releases from the Los Alamos Neutron Science Center were evaluated by following the protocol outlined in the Multi-Agency Radiation Survey and Assessment for Materials and Equipment manual and were independently reviewed by DOE. Releases from Technical Area 21 met the criteria for unrestricted radiological release under Title 10, Part 835 of the Code of Federal Regulations, *Occupational Radiation Protection*, and DOE Order 458.1.

Personal Property Items

Laboratory personnel survey and release smaller personal property items (e.g., tools and furniture) from radiologically controlled areas on an on-demand basis. These items typically remain onsite and, once cleared, have no restrictions. The policies and procedures for releasing these items comply with Title 10, Part 835 of the Code of Federal Regulations, *Occupational Radiation Protection*.

N3B (the Laboratory's legacy waste cleanup contractor) surveyed and released personal property throughout 2019 as part of ongoing environmental remediation and waste packaging and shipping operations. Leased equipment was also routinely surveyed and released from N3B-controlled environmental sites. Within Technical Area 54, 643 government and nongovernment vehicles and motorized equipment were surveyed and released from radiologically controlled areas. Dome skin fabric removed from storage dome 230 during a reskinning project was surveyed, released, and shipped to an industrial waste landfill approved to receive that type of waste for disposal.

Establishment and Use of Authorized Limits

Screening action levels for radionuclides in soils are evaluated every year to determine if an update is needed. In 2016, recalculation of the screening action levels was needed (1) due to a significant update to version 7.0 of the dose assessment code RESRAD (Yu et al. 2001) and (2) to apply "reference person" dosimetry (LANL 2016b). The Laboratory requested that DOE evaluate the new soil-screening action levels for use as authorized limits for land conveyance and transfer, and these values were approved in early 2017. There were no updates to the screening action levels in 2019. These authorized limits were used in the transfer of Tract A-16-b.

WASTE MANAGEMENT SUMMARY

Management of wastes generated by Laboratory operations is a crucial component of compliance with environmental laws and is discussed in the next several sections. The following callout provides an explanation of some waste types.

What are the types of radioactive waste?

Transuranic Waste – Waste is classified as transuranic waste when the activity of alpha-emitting transuranic radionuclides with half-lives of 20 years or more (such as plutonium, cesium, and strontium) is greater than 100 nanocuries per gram of waste.

Mixed Transuranic Waste – Mixed transuranic waste is transuranic waste along with at least one waste defined as hazardous under the Resource Conservation and Recovery Act.

Low-Level Waste – Low-level radiological waste contains added radioactivity, but does not contain high-level waste (the highly radioactive waste resulting from the reprocessing of spent nuclear fuel, transuranic waste, or tailings from the milling of uranium or thorium ore). It also does not contain any waste defined as hazardous under the Resource Conservation and Recovery Act.

Mixed Low-Level Waste – Mixed low-level waste is low-level waste along with at least one waste defined as hazardous under the Resource Conservation and Recovery Act.

Table 2-1 summarizes radiological and some hazardous wastes generated at the Laboratory and the current disposal pathways of such waste.

Table 2-1. LANL Waste Types and Disposal Methods

Waste Type	Method for Disposal	2019 Disposal Amount
Solid Transuranic Waste and Solid Mixed Transuranic Waste	The Laboratory sends solid transuranic and mixed transuranic wastes offsite to the Waste Isolation Pilot Plant in Carlsbad, New Mexico, when the transuranic or mixed transuranic waste meets the plant's waste acceptance criteria. Some transuranic and mixed transuranic waste is stored at the Laboratory while waiting for an acceptable disposal pathway to be identified. In 2019, LANL waste was also shipped from long-term storage at Waste Control Specialists (Andrews County, Texas) to the Waste Isolation Pilot Plant for disposal.	8,270 cubic yards (6,322.5 cubic meters) from LANL; 4 cubic yards (3.1 cubic meters) from Waste Control Specialists in Andrews County, Texas
Solid Low-level Radioactive Waste	The Laboratory sends solid low-level radioactive waste offsite to licensed treatment, storage, and disposal facilities. These sites include the Nevada Nuclear Security Site, operated by the DOE, and commercial facilities operated by Energy Solutions (Clive, Utah); Perma-Fix Northwest, Inc. (Richland, Washington), and Waste Control Specialists (Andrews County, Texas).	48,957 cubic yards (37,431 cubic meters)
Liquid Radioactive Waste	The Laboratory treats liquid radioactive waste onsite at the Radioactive Liquid Waste Treatment Facility in Technical Area 50. The treated water is either evaporated or released at permitted Outfall 051.	694,982 gallons
Solid Hazardous Waste	The Laboratory sends solid hazardous waste offsite for treatment and disposal at licensed treatment, storage, and disposal facilities. In 2019, these facilities included Veolia North America (Henderson, Colorado) and Clean Harbors (Clive, Utah).	150 tons
Solid Mixed Low-Level Waste	The Laboratory sends solid mixed low-level waste offsite to licensed treatment, storage, and disposal facilities. In 2019, these facilities included Energy Solutions (Clive, Utah), Perma-Fix of Florida, Inc. (Gainesville, Florida), and Waste Control Specialists (Andrews County, Texas). Some mixed low-level waste is treated at one of the licensed treatment, storage, and disposal facilities to meet land-disposal restrictions and is then disposed of at the Nevada Nuclear Security Site.	6,108 cubic yards (4,670 cubic meters)

Waste Type	Method for Disposal	2019 Disposal Amount
Solid Nonhazardous Waste	The Laboratory sends sanitary solid waste, construction debris, and demolition debris to the Los Alamos County Eco Station for transfer to municipal landfills such as the municipal waste landfill in Rio Rancho, New Mexico. Los Alamos County operates this transfer station and is responsible to the State of New Mexico for obtaining all related permits for these activities. The Laboratory also sends solid nonhazardous waste to regional facilities in Arizona and Colorado.	2,727 tons
Liquid Sanitary Waste	The Laboratory treats liquid sanitary waste onsite at the Sanitary Waste Water Treatment Plant. Treated water is reused in Laboratory cooling towers and is released at permitted Outfall 001.	1,249,214 gallons
PCB Wastes*	Waste containing polychlorinated biphenyls (PCBs), including fluorescent light ballasts and contaminated soils, was sent to U.S. Environmental Protection Agency-authorized treatment and disposal facilities, including Clean Harbors (Clive, Utah) and Veolia North America (Henderson, Colorado).	358 tons
Asbestos Waste	Asbestos-containing waste is deposited at any of several waste disposal sites operated in accordance with Title 40, Part 61, Section 154 of the Code of Federal Regulations.	88 tons

**This total includes waste containing only PCBs. If a waste with PCBs also contains hazardous or low-level waste, the weight of that waste is captured in the other category.*

RADIOACTIVE WASTES

DOE Order 435.1 Chg 1, *Radioactive Waste Management*

Laboratory operations that use nuclear materials generate four types of radioactive wastes: low-level radioactive waste (also called low-level waste), mixed low-level waste, transuranic waste, and mixed transuranic waste. Radioactive waste generated during Laboratory operations must (1) meet Laboratory onsite storage requirements and (2) meet requirements for transportation to and disposal at a final facility. All facets of radioactive waste generation, storage, and disposal are regulated by DOE Order 435.1 Chg 1, *Radioactive Waste Management*, and DOE Manual 435.1-1.

Onsite Low-Level Radioactive Waste Disposal

Material Disposal Area G at Technical Area 54 (Area G) is the only active waste disposal facility at the Laboratory. Operations began at Area G in 1957 and included the disposal of low-level radioactive waste, certain infectious waste containing radioactive materials, asbestos-containing material, PCBs, and temporary storage of transuranic waste. Mixed low-level waste and mixed transuranic waste have been stored in surface structures at Area G. The capacity to dispose of low-level waste at Area G is very limited; waste is accepted for disposal only under special circumstances and with prior authorization. In 2019, the Laboratory did not dispose of any low-level waste in Area G. The Laboratory used 2,337 cubic yards (1,787 cubic meters) of inert material for fill.

Planning for the closure of Area G has been underway since 1992. Under the 2016 Compliance Order on Consent, the Laboratory is working with the New Mexico Environment Department Hazardous Waste Bureau to develop and implement corrective measures for solid waste management units at Area G. Environmental monitoring at Area G currently includes (1) a direct radiation thermoluminescent dosimeter monitoring network (Chapter 4); (2) an environmental air-station monitoring network

(Chapter 4); (3) a groundwater monitoring network (Chapter 5); and (4) periodic soil, vegetation, and small mammal sampling (Chapter 7). Table 2-2 provides the 2019 status of DOE's low-level waste disposal facility management process for Area G.

Table 2-2. DOE Low-Level Waste Disposal Facility Management Status for Area G

Management Process Phase	Status
Performance Assessment/Composite Analysis	Revision 4 was approved in 2009 (LANL 2008). The annual determination of adequacy for fiscal year 2019 was published in March 2020.
Closure Plan	Plan issued in 2009 (LANL 2009).
Performance Assessment/Composite Analysis Maintenance Program	Plan issued in 2011 (LANL 2011). Updated analyses and modeling of erosion and groundwater transport were completed in 2018 (Atchley et al. 2018, Pawar et al. 2018).
Disposal Authorization Statement	Revision 2 was issued November 15, 2018. This revision identifies the DOE Environmental Management field office in Los Alamos as the responsible field office.

HAZARDOUS WASTES

Resource Conservation and Recovery Act

The Resource Conservation and Recovery Act regulates hazardous wastes from generation to disposal. Hazardous wastes include all solid wastes that are (1) listed as hazardous by the U.S. Environmental Protection Agency; (2) ignitable, corrosive, reactive, or toxic; (3) batteries, pesticides, lamp bulbs, or solids that contain mercury; and (4) a hazardous waste as listed above that has been mixed with a radiological waste (mixed waste). Under the Resource Conservation and Recovery Act, facilities must obtain a permit from their regulatory authority before they treat, store, or dispose of hazardous wastes.

The State of New Mexico is authorized by the U.S. Environmental Protection Agency to issue and enforce hazardous waste facility permits. On November 8, 1989, the New Mexico Environment Department issued the first LANL Hazardous Waste Facility Permit to store and treat hazardous waste at the Laboratory. The Laboratory's Hazardous Waste Facility Permit establishes the standards for LANL's management of hazardous wastes. The permit allows for the storage and sometimes treatment of hazardous waste at 27 separate hazardous waste management units (sites) at the Laboratory. It also provides specific reporting requirements to the New Mexico Environment Department and to the public. The permit is issued to DOE and its field offices (the National Nuclear Security Administration Los Alamos Field Office and the DOE-Environmental Management Los Alamos Field Office), along with the management and operating contractor Triad and the legacy waste cleanup contractor N3B.

What do these waste terms mean?

Treatment – Waste treatment is any process that changes the physical, chemical, or biological characteristics of a waste to minimize its threat to the environment.

Storage – Waste storage is the temporary holding of waste before the waste is treated, disposed of, or stored somewhere else. A **storage unit** stores hazardous waste. Examples of such units include tanks, containers, drip pads, and containment buildings.

Disposal – Waste disposal is the discharge, deposit, injection, or placing of any waste on or in the land or water. A disposal facility is any site where the waste is intentionally placed and where it will remain.

Remediated Waste – Waste that has undergone treatment.

Permit Modifications, Reports, and Other Activities

The Hazardous Waste Facility Permit sometimes needs modification to address new information, changes in a facility, or changes in regulatory requirements. Notices of permit modification approvals are mailed to members of the public who sign up for a LANL facility mailing list maintained by the New Mexico Environment Department.

In 2019, the Laboratory submitted four permit modification requests. All four were Class I modifications, which are minor changes that keep a permit current with routine changes to the facility or its operations. The four permit modification requests involved routine changes associated with (1) modifying unit structures, descriptions, and figures; (2) adding allowances for hazardous waste generators; and (3) managing the listing of Solid Waste Management Units and Areas of Concern covered in the permit.

The New Mexico Environment Department approved five Class I permit modifications, and one final closure plan was issued in 2019.

- In January 2019, the New Mexico Environment Department approved the request to add a new waste-stream description to the Permit Attachment C-Waste Analysis Plan.
- In January 2019, the New Mexico Environment Department issued a final closure plan for an open burning treatment unit at Technical Area 16.
- In February 2019, the New Mexico Environment Department approved a request to update Attachment K of the Hazardous Waste Permit. One Solid Waste Management Unit was added to Table K-1, and one Area of Concern was removed from Table K-3 and added to Table K-1.
- In June 2019, the New Mexico Environment Department approved a request to update descriptions of emergency equipment and organizational names throughout the permit.
- In August 2019, the New Mexico Environment Department approved a request to update the Environmental Protection Agency 877-12 (Part A) Form in Permit Attachment B to include exemptions for generators and add aerosol cans as a universal waste.
- In August 2019, the New Mexico Environment Department approved a request to update the permit to add a support structure at Technical Area 54, Area G, Pad 11.

The management and operating contractor, in coordination with the legacy waste cleanup contractor, sent demolition activity notifications to the New Mexico Environment Department for the 2019 quarters ending in June, September, and December. One fiscal year 2019 notification was also sent for the Laboratory, covering all relevant demolition activities from October 1, 2018, to September 30, 2019. The fiscal year notification was submitted to the New Mexico Environment Department, along with the December 2019 quarterly report.

In 2019, there were two emergency treatment events approved under the New Mexico Hazardous Waste Act. The first authorized the destruction of a small container with a suspected unstable chemical. The second approval was for destruction of ten containers with suspected unstable chemicals. In December 2019, in anticipation of the permit renewal application for the LANL Hazardous Waste Facility Permit, an informational public meeting was held to solicit questions from the community and to inform the community of proposed waste management activities.

Inspections, Noncompliances, and Notices of Violation

The Laboratory provides advance written notice to the New Mexico Environment Department of any changes to any permitted unit or activity that may result in a noncompliance with the permit. The Laboratory also provides verbal and written reports of any noncompliance that may endanger human health or the environment when a noncompliance is discovered. Instances of noncompliance that do not threaten human health or the environment, such as exceeding a storage holding time, are compiled and reported annually to the New Mexico Environment Department.

During the reporting period (October 1, 2018, through September 30, 2019), there was one release at or from a permitted unit under operational control of Triad. On September 12, 2019, at the Technical Area 55 High-Efficiency Neutron Counting pad, a battery was overfilled during routine maintenance. Subsequent charging expanded the battery acid, causing it to overflow the battery. The spilled material (less than one quart) had a pH of 0 to 1. Emergency personnel responded and cleaned the area by neutralizing and then absorbing the spilled material. The subsequent waste generated from cleanup activities was placed in a container and compliantly managed.

Individual notices or reports of noncompliance with the Hazardous Waste Facility Permit during fiscal year 2019 were sent to the New Mexico Environment Department in letters dated as follows:

- December 10, 2018, Request for Extension of the One-Year Storage Limit at the Los Alamos National Laboratory, Technical Area 54, Area L (EPC-DO: 18-422/LA-UR-18-30935)
- November 29, 2018, Notification of Anticipated Noncompliance with the Los Alamos National Laboratory Hazardous Waste Facility Permit, EPA ID No. NM890010515 (EPC-DO: 18-433/LA-UR-18-30998)

In November 2019, the Laboratory submitted the fiscal year 2019 noncompliance report to the New Mexico Environment Department. The Laboratory reported 48 instances of noncompliance with the LANL Hazardous Waste Facility Permit. Reported instances included failure to fix deterioration or malfunction of equipment or structures; eyewash, safety shower, and/or fire extinguishers out of inspection; container labeling issues; inadequate aisle spacing; missed inspections; shipment operating-record differences for drums that had already been shipped to the Waste Isolation Pilot Plant; and failure to store hazardous waste for less than one year. Other instances of noncompliance were associated with delayed posting of correspondence to the LANL Public Reading Rooms and delayed email notifications to individuals on the LANL facility mailing list. Abovementioned instances of noncompliance were identified by management and operating contractor Triad through internal site-wide compliance assessments conducted by hazardous waste management experts. N3B personnel conducted weekly inspections to identify noncompliance with the permit in the legacy waste cleanup program.

On December 17, 2018, a notice of violation was issued to the Laboratory for storing hazardous waste for greater than one year. On April 3, 2019, a settlement agreement was finalized with a penalty of $61,750.

A notice of violation was issued on November 8, 2018, for (1) failure to notify the New Mexico Environment Department within three days of a hazardous waste characterization discrepancy, (2) failure to determine that a solid waste was a hazardous waste, and (3) failure to properly complete a hazardous waste manifest. A settlement agreement was reached on March 31, 2019, for a penalty of $54,750.

On March 27, 2019, a notice of violation was issued to the Laboratory, with no associated penalties, citing damage to domes at Technical Area 54. The New Mexico Environment Department determined that part of the violation cited in the notice was adequately addressed but required monthly updates documenting progress of the repairs to the dome.

A final notice of violation during fiscal year 2019 was issued to the Laboratory on August 20, 2019, along with a notice of proposed penalties. This notice cited 16 violations noted during an inspection by the New Mexico Environment Department conducted from April 29, 2019, through May 2, 2019. The New Mexico Environment Department determined that the violations cited in the notice were adequately addressed and that no further action was required. The New Mexico Environment Department, the DOE field offices, the management and operations contractor, and the legacy waste cleanup contractor filed a final settlement agreement with a penalty assessed at $153,938 on December 24, 2019.

N3B implemented corrective actions to address items identified in a Notice of Violation issued on August 20, 2019, from the New Mexico Environment Department and to more broadly evaluate and address the extent of condition and causes to minimize the potential for recurrence. Laboratory personnel continue to develop and improve waste management tools and processes to facilitate compliance with recordkeeping requirements in the permit. They also work with waste-handling personnel and waste management personnel to identify and implement corrective actions that will prevent recurrences of other types of noncompliance.

Settlement Agreement and Stipulated Final Order

On January 22, 2016, the National Nuclear Security Administration (NNSA), Los Alamos National Security, and the State of New Mexico signed a Settlement Agreement to resolve potential penalties associated with a drum of transuranic waste that contributed to the 2014 contamination event at the Waste Isolation Pilot Plant. The settlement agreement includes five supplemental environmental projects, which NNSA and the Laboratory implemented. Below are the 2019 activities on the supplemental environmental projects.

1. Road Improvement Project – Improve routes at the Laboratory used to transport transuranic waste to the Waste Isolation Pilot Plant.

   The U.S. Army Corps of Engineers selected a design engineering firm to manage the redesign of the intersection between State Route 4 and East Jemez Road. The selected firm, Bohannon Houston, developed five options to redesign the intersection. An integrated project team reviewed all five designs and selected a preferred concept. This team consisted of representatives from the County of Los Alamos, the County of Santa Fe, the New Mexico Department of Transportation, the National Park Service, the National Nuclear Security Administration, and the Pueblo de San Ildefonso. Bohannon Houston submitted a cost estimate to complete the design and construction. The design was completed in August 2019. Funding for the intersection construction is being pursued.

2. Triennial Review Project – Conduct an independent, external triennial review of environmental regulatory compliance and operations.

In accordance with the January 2016 Settlement Agreement and Stipulated Final Order, NNSA and the Laboratory agreed to conduct independent, external triennial reviews of environmental regulatory compliance and operations at LANL. The first triennial review was conducted in 2018, with the final report issued on September 14, 2018. A second triennial review will be conducted in 2021, and a final report will be issued in September 2021.

3. Watershed Enhancement Project – Design and install engineering structures in and around the Laboratory to reduce storm water velocity and decrease sediment load to improve water quality in the area. This project includes a Low Impact Development Master Plan for the Laboratory (LANL 2017a).

   The Laboratory coordinated construction on the main gate entry storm water pond with the Potable Water Line Replacement Project activities (see list item 5 below). The project was certified to the New Mexico Environment Department in April 2019. However, additional work on the Potable Water Line Replacement Project in this area postponed final completion to December 2019.

   Construction on the upper Cañon de Valle project began in September 2018, and this project was completed and certified to the New Mexico Environment Department in April 2019. The La Mesita East Low Impact Development Project at Technical Area 53 was completed in November 2019, and it was certified to the New Mexico Environment Department in December 2019.

   The mid-Mortandad watershed project design was completed in April 2018, and construction activities began in October 2018. Due to weather and other construction delays, work is scheduled for completion in early 2020.

   Two of the five additional storm water low-impact development projects, Technical Area 53 La Mesita Swale and Technical Area 53 East La Mesita Drive, were completed in November 2019, and the project was certified by the New Mexico Environment Department in December 2019.

4. Surface Water Sampling Project – Conduct targeted sampling for sediment, storm water runoff, atmospheric deposits, and aquatic life in watersheds in and around the Laboratory to better understand surface water quality and stream-reach characteristics in the region. Share these results with the public and the New Mexico Environment Department.

   All storm water sampling was completed in 2018. During 2019, personnel collected samples of aquatic life from stream reaches in six watersheds in and around the Laboratory.

   Laboratory personnel evaluated four locations in and around the Laboratory using the New Mexico Environment Department's Hydrology Protocol Level 2 Criteria (New Mexico Environment Department 2011). The Hydrology Protocol distinguishes between ephemeral, intermittent, and perennial stream reaches and documents the uses supported by those waters.

5. Potable Water Line Replacement Project – Replace aging potable water lines and install metering equipment for Laboratory potable water systems.

   In 2019 the Laboratory completed construction of the Phase A and B waterlines, including installation of the meters, air-relief valves, and pressure relief valves. The lines are completely operational, and the only remaining activities are to cut and cap four locations of the old line, finish site restoration, and complete asphalt and concrete repair and replacement.

The 2016 Compliance Order on Consent

A settlement agreement between the New Mexico Environment Department and DOE, the 2016 Compliance Order on Consent (modified in 2017; available at https://www.env.nm.gov/hazardous-waste/lanl/) addresses cleanup of legacy wastes. It supersedes the Compliance Order on Consent issued in 2005. The order guides and governs ongoing cleanup of legacy waste by N3B at the Laboratory through an annual work-planning process. Campaigns are planned using risk-based criteria to group, prioritize, and implement corrective actions. The annual planning process allows for revisions to cleanup campaigns based on actual work progress, changed conditions, and funding.

The Laboratory has two types of legacy waste corrective action sites: (1) Solid Waste Management Units and (2) Areas of Concern. Solid Waste Management Units are areas where solid wastes were spilled or disposed of. Examples of these units include certain septic tanks, firing sites, landfills, sumps, and areas that historically received liquid effluents from outfalls. Areas of Concern are areas that may have received a hazardous waste or hazardous constituents through soil movement or the flow of liquid wastes from Laboratory facilities. Examples include canyon bottoms downstream from historical outfalls.

As of October 1, 2019, the Laboratory had 1,405 corrective action sites listed in Appendix A of the 2016 Compliance Order on Consent. During fiscal year 2019, one site received a certificate of completion with controls, 31 sites received certificates of completion without controls, and no sites were changed to a deferred status. Therefore, at the end of fiscal year 2019, 85 corrective action sites had certificates of completion with controls, 272 had certificates of completion without controls, and 134 sites were deferred until they no longer have active operations. The remaining 914 Solid Waste Management Units and Areas of Concern had investigations or corrective actions (or both) either in progress or pending.

The Compliance Order on Consent also addresses remediation of groundwater containing contaminants resulting from Laboratory operations. Groundwater remediation activities are discussed in detail in Chapter 5, Groundwater Protection.

During the fiscal year, the Laboratory submitted the following documents to the New Mexico Environment Department Hazardous Waste Bureau as part of the Consent Order deliverables:

- six investigation reports,
- eight Periodic Monitoring Reports for five monitoring groups,
- an annual update on the Integrated Facility Groundwater Monitoring Program,
- an annual update for Los Alamos/Pueblo Canyons Sediment Monitoring,
- one report on the Sandia Canyon wetlands performance,
- two biennial erosion control inspection reports,
- two progress letter reports for investigation work completed under the Consent Order, and
- a Corrective Measures Study/Corrective Measures Implementation progress report.

Federal Facility Compliance Act

The Federal Facility Compliance Act requires federal facilities that generate or store mixed radioactive and hazardous wastes to submit a Site Treatment Plan that includes a schedule to develop treatment capacities and technologies to treat all the facility’s mixed waste. In October 1995, the State of New Mexico issued a Federal Facility Compliance Order to the Laboratory requiring a Site Treatment Plan for mixed radioactive and hazardous wastes.

While identifying treatment and disposal options for the mixed waste inventory, the Laboratory's Site Treatment Plan allows the Laboratory to store accumulated mixed waste at permitted storage units for more than one year. Such storage is otherwise prohibited by the Land Disposal Restrictions provision of the Resource Conservation and Recovery Act. The Site Treatment Plan provides enforceable time periods in which the facility is required to treat or otherwise meet land disposal restriction requirements for the accumulated waste.

The Laboratory updates its Site Treatment Plan annually. The annual report documents the amount of mixed waste that has been stored at the Laboratory under the plan provisions during the previous fiscal year and the amount shipped to approved Treatment, Storage, and Disposal Facilities. The Site Treatment Plan Report is due to the New Mexico Environment Department on March 31 each year, using data from the previous fiscal year (October 1 to September 31).

During fiscal year 2019, mixed low-level waste covered under the Laboratory's Site Treatment Plan increased as a result of an ongoing transuranic waste recharacterization activity. There was a backlog of stored mixed low-level and mixed transuranic waste because of shipping pauses during fiscal year 2018, limited shipments to the Waste Isolation Pilot Plant, and restrictions onsite at Area G. The restrictions delayed the final confirmation, characterization, certification, and shipment of mixed transuranic waste for offsite disposal to the Waste Isolation Pilot Plant.

Table 2-3 provides the volumes of mixed waste managed under the Site Treatment Plan at the Laboratory during fiscal year 2019. These waste volumes may be adjusted slightly by reconciliation during the New Mexico Environment Department review of the Site Treatment Plan update. Approved Site Treatment Plan updates are available at http://www.env.nm.gov/hazardous-waste/lanl-ffco-stp/.

Table 2-3. Approximate Volumes of Mixed Wastes Stored and Shipped Offsite for Treatment and/or Disposal under the Laboratory's Site Treatment Plan by the Management and Operating Contractor (Triad) and the Legacy Waste Cleanup Contractor (N3B) During Fiscal Year 2019

LANL Contractor	Volume of mixed wastes stored at LANL under the Site Treatment Plan	Volume of mixed wastes shipped offsite under the Site Treatment Plan
Mixed Low-level Waste		
Triad	35 cubic yards (27 cubic meters)	3.8 cubic yards (2.7 cubic meters)
N3B	290 cubic yards (221.5 cubic meters)	0.3 cubic yards (0.2 cubic meters)
Mixed Transuranic Waste		
Triad	452 cubic yards (345.6 cubic meters)	171 cubic yards (130.6 cubic meters)
N3B	1,839 cubic yards (1,406.2 cubic meters)	61 cubic yards (46.9 cubic meters)

OTHER WASTES

Specific Chemical Wastes: Toxic Substances Control Act

The Toxic Substances Control Act addresses the production, import, use, and disposal of specific chemicals, including PCBs. The Laboratory is responsible for keeping records and reporting the import or export of small quantities of chemicals used for LANL research activities and the disposal of PCB-containing substances. PCB-containing substances include (1) dielectric fluids, (2) solvents, (3) oils, (4) waste oils, (5) heat-transfer fluids, (6) hydraulic fluids, (7) slurries, (8) soil, and (9) materials contaminated by spills.

In 2019, the Laboratory shipped offsite for disposal or recycling 109 containers (1,484 tons) of PCB-containing wastes. About 1,851 cubic yards (1,415 cubic meters) of waste contaminated with PCBs were sent to a U.S. Environmental Protection Agency-authorized treatment and disposal facility in Veolia, Colorado. This total includes wastes classified as PCB wastes, as well as waste in other categories (such as low-level wastes) that also contained PCBs.

Laboratory staff conducted 11 Toxic Substances Control Act reviews for chemicals imported or exported by the Laboratory's Property Management Group Customs Office in 2018. These reviews were conducted to ensure certain chemical compounds follow the Toxic Substances Control Act requirements before these compounds are imported or exported out of the country. These shipments were all properly categorized, and the chemical compound samples were sent to collaborative researchers in other countries.

AIR QUALITY AND PROTECTION

Clean Air Act

Title V Operating Permit

Under the Clean Air Act, the Laboratory is regulated as a major source of air pollutants based on its potential to emit nitrous oxides, carbon monoxide, and volatile organic compounds. Because the Laboratory has a Clean Air Act Title V Operating Permit, it must keep air emissions of regulated pollutants below permit limits. In 2019, the Laboratory submitted its five-year renewal application and one Title V administrative revision application. These two permitting actions are summarized as follows:

- The current Title V Operating Permit has an expiration date of February 27, 2020. The Laboratory is required to submit a Title V renewal application 12 months before the expiration date. The Laboratory submitted the renewal application on February 26, 2019. The New Mexico Environment Department is currently reviewing the application.
- In March 2019, LANL submitted a minor modification application to add one additional evaporative sprayer at the existing Sigma Mesa evaporation basins. The New Mexico Environment Department approved this minor modification on July 18, 2019.

Every year the Laboratory certifies its compliance with the conditions of its Title V Operating Permit and reports any permit deviations that occurred to the New Mexico Environment Department. Deviations occur when any permit condition is not met. In 2019, the Laboratory maintained compliance with all permit terms and conditions and had no Title V Operating Permit deviations. Additionally, all emissions were well below permitted allowable levels. Table 2-4 summarizes the Laboratory's emissions data and provides a list of the major sources of these air pollutants at the Laboratory.

Table 2-4. Calculated Emissions of Regulated Air Pollutants Reported to the New Mexico Environment Department in 2019

Emission Unit	Pollutants (tons)					
	Nitrous Oxides	Sulfur Oxides	Particulate Matter	Carbon Monoxide	Volatile Organic Compounds	Other Hazardous Air Pollutants
Asphalt plant	0.003	0.002	0.002	0.12	0.002	0.002
Technical Area 03 power plant (3 boilers)	10.30	0.11	1.35	7.10	0.98	0.34
Technical Area 03 power plant (combustion turbine)	2.30	0.16	0.31	0.31	0.10	0.06
Research and development chemical use	n/a[1]	n/a	n/a	n/a	12.02	4.86
Degreaser	n/a	n/a	n/a	n/a	0.061	0.061
Data disintegrator	n/a	n/a	0.19	n/a	n/a	n/a
Stationary standby generators[2]	6.13	0.18	0.25	1.36	0.25	0.002
Miscellaneous small boilers	19.41	0.12	1.56	15.50	1.11	0.37
Permitted generators (11 units)	2.92	0.077	0.12	1.52	0.27	0.001
TOTAL	41.06	0.65	3.78	25.91	14.73	5.70
Permit Limits (tons/year)	245	150	120	225	200	120

[1] n/a = not applicable

[2] The stationary standby generators are no longer sources in the Laboratory's Title V permit. However, they are included in this table for comparison with previous annual site environmental reports.

The Laboratory's emissions in 2019 were significantly lower than the permit limits. For example, nitrogen oxide emissions were approximately 14 percent of the permit limit, carbon monoxide emissions were 11 percent of the permit limit, and particulate matter emissions were 3 percent of the permit limit. No emissions in excess of permit limits occurred from any of the permitted sources.

Figure 2-1 depicts a 5-year history of pollutant emissions at the Laboratory. Emissions from 2015 through 2019 remained relatively constant.

Management of Refrigerants and Halons under Title VI – Stratospheric Ozone Protection

Title VI of the Clean Air Act regulates chemicals known to deplete the ozone layer in the atmosphere. Chemicals include halons, chlorofluorocarbons, and hydrochlorofluorocarbons, as well as some other non-ozone-depleting chemicals such as hydrofluorocarbons. These chemicals are primarily used as refrigerants, solvents, propellants, and foam-blowing agents. The regulation prohibits the Laboratory from knowingly venting or otherwise releasing into the environment any of these chemicals during maintenance, service, repair, or disposal of refrigeration equipment (such as air conditioners, refrigerators, chillers, or freezers) or fire-suppression systems. All technicians who work on refrigeration equipment at the Laboratory are certified by the U.S. Environmental Protection Agency.

The Laboratory is working to remove refrigeration equipment that uses ozone-depleting substances and replace it with equipment using more environmentally friendly refrigerants listed as acceptable under the U.S. Environmental Protection Agency's Significant New Alternatives Program. In 2019, 4,143 pounds of refrigerant were sent offsite for disposal. Of that amount, 3,411 pounds were ozone-depleting refrigerants. Additionally, the Laboratory has one remaining fire-suppression system that uses halon.

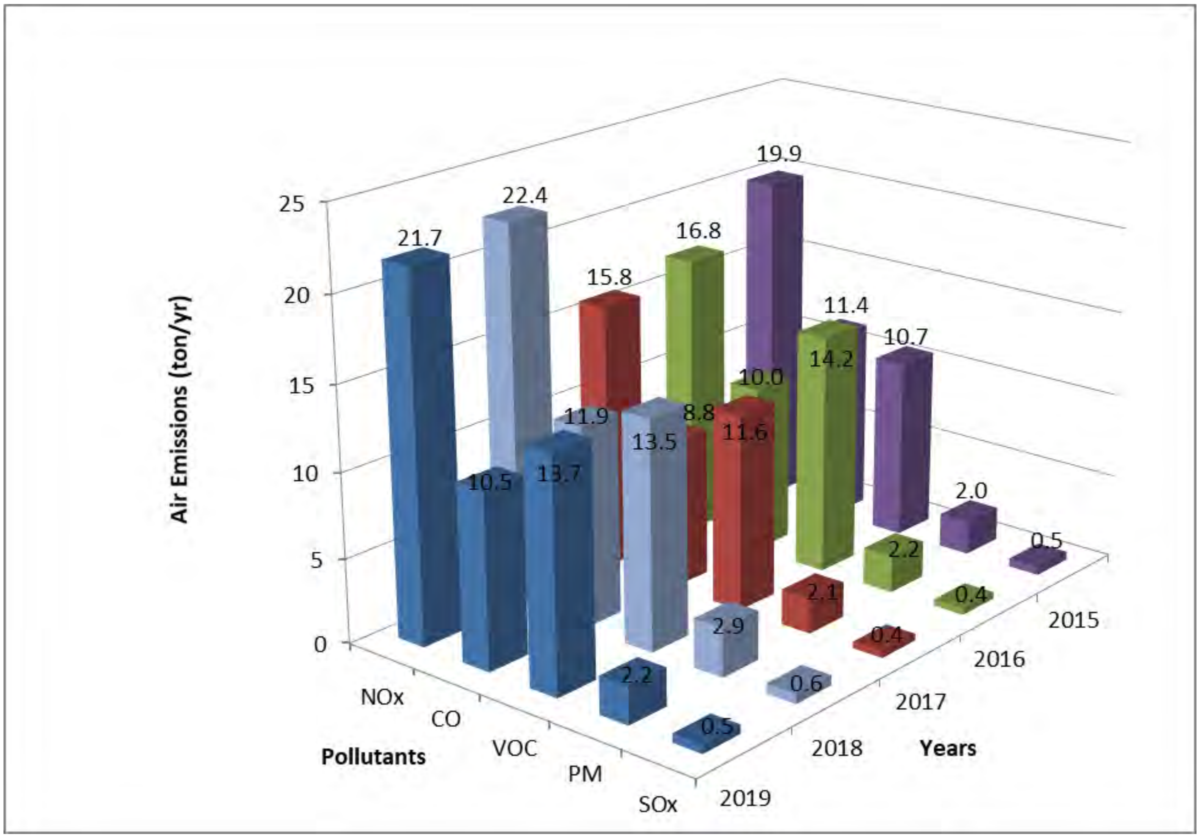

Figure 2-1. This graph plots Laboratory criteria pollutant emissions from 2015 through 2019. These totals do not include small boilers or standby generators.

Regulation of Airborne Radionuclide Emissions under the Radionuclide National Emission Standards for Hazardous Air Pollutants

Emissions of airborne radionuclides are regulated under the Radionuclide National Emission Standards for Hazardous Air Pollutants, which sets a dose limit of 10 millirem per year to any member of the public for air emissions. The estimated maximum dose of air emissions to a member of the public in 2019 was 0.43 millirem, less than 5 percent of the limit (see Chapter 8, Public Dose and Risk Assessment). In March 2019, the Laboratory received U.S. Environmental Protection Agency approval for a major new release point, the Flanged Tritium Waste Container venting project. The project is expected to begin operations in late 2020.

New Mexico Air Quality Control Act

New Source Reviews

The State of New Mexico requires that new or modified emission sources be evaluated to determine whether they (1) do not require a construction permit because they are exempted under the New Mexico Administrative Code ("exempted"), (2) do not produce sufficient emissions to require a construction permit ("no permit required"), (3) require a notice of intent to construct, or (4) require a construction permit. In 2019, the Laboratory submitted to the State of New Mexico three "exempted" notifications for air emissions from the following exempt activities:

- Seventeen small gas-fired comfort heaters and boilers
- One electric-powered thermal evaporator
- One small paint booth equipped with two-stage, high-efficiency particulate air filtration

Asbestos Notifications

The Asbestos National Emission Standards for Hazardous Air Pollutants require the Laboratory to provide advance notice to the New Mexico Environment Department Air Quality Bureau for large renovation jobs that involve asbestos and for all demolition projects. The standards also require that facilities conducting activities that involve asbestos mitigate visible airborne emissions and properly package and dispose of all asbestos-containing wastes. In 2019, 16 large renovation and demolition projects were completed. Advance notification to the New Mexico Environment Department was submitted for each project. All waste was properly packaged and disposed of at approved landfills.

SURFACE WATER QUALITY AND PROTECTION

Clean Water Act

The primary goal of the Clean Water Act is to restore and maintain the chemical, physical, and biological integrity of the nation's waters. This act requires National Pollutant Discharge Elimination System permits for several types of effluent and storm water discharges. The permits described below establish specific chemical, physical, and biological criteria and management practices the Laboratory must meet when discharging water. The U.S. Environmental Protection Agency, Region 6, provides and enforces the Laboratory's Clean Water Act permits. The New Mexico Environment Department certifies the permits as being protective of waters in New Mexico and performs some compliance inspections and monitoring on behalf of the U.S. Environmental Protection Agency.

LANL's National Pollutant Discharge Elimination System Industrial and Sanitary Point Source Outfall Permit

The Laboratory's current National Pollutant Discharge Elimination System Industrial and Sanitary Point Source Outfall Permit NM0028355 (Outfall Permit) became effective on October 1, 2014, with final modifications implemented May 2015. This Outfall Permit includes one sanitary and ten industrial outfalls that discharge into four watersheds in the region, with the amount of discharge varying from year to year (Table 2-5).

To demonstrate compliance with the permit's water-quality limits, the Laboratory's current Outfall Permit requires weekly, monthly, quarterly, yearly, and term sampling of effluents (treated waste water) released to the environment. The sampling results are compared to the permit limits and are reported every month in a Discharge Monitoring Report to the U.S. Environmental Protection Agency and the New Mexico Environment Department. Additionally, any engineering changes or flow changes that would affect quality or quantity of the effluents are reported in a Notice of Planned Change to the U.S. Environmental Protection Agency and the New Mexico Environment Department.

Table 2-5. Volume of Effluent Discharged from Permitted Outfalls in 2019

Outfall No.	Building No.	Description	Canyon Receiving Discharge	2019 Discharge (gallons)
03A048	53-963/978	Los Alamos Neutron Science Center cooling tower	Los Alamos	25,790,900
051	50-1	Technical Area 50 Radioactive Liquid Waste Treatment Facility	Mortandad	21,345
04A022*	3-2238	Sigma emergency cooling system	Mortandad	1,622,448
03A160	35-124	National High Magnetic Field Laboratory cooling tower	Mortandad	0
03A181	55-6	Plutonium Facility cooling tower	Mortandad	2,958,376
13S	46-347	Sanitary waste water system plant	Sandia	0
001	3-22	Power plant (includes treated effluent from sanitary waste water system plant)	Sandia	72,149,900
03A027	3-2327	Strategic Computing Complex cooling tower	Sandia	0
03A113	53-293/952	Los Alamos Neutron Science Center cooling tower	Sandia	198,530
03A199	3-1837	Laboratory Data Communications Center	Sandia	12,654,400
05A055	16-1508	High Explosives Wastewater Treatment Facility	Water	0
			2019 Total:	115,395,899

**This outfall's designation was changed from 03A022 to 04A022 in the October 2014 permit renewal to reflect only emergency cooling water and roof drain/storm water discharges to the outfall (cooling tower blowdown was diverted to the sanitary waste water system plant).*

Laboratory personnel collected 794 samples in 2019 from Outfalls 001, 03A048, 03A113, 03A181, 03A199, 04A022, and 051. Five of these samples (0.6 percent) exceeded a permit limit (Table 2-6). Each of these instances was addressed immediately by correcting the cause or ceasing the discharge until corrective actions could be implemented that would return the effluent to compliance. Outfalls 13S, 03A027, 03A160, and 05A055 did not discharge in 2019.

The Laboratory has been working on projects to identify and reduce PCBs in water discharged to Outfall 001. Efforts have included cleaning out PCBs in upstream sumps, tanks, cleanouts, and manholes. We have also optimized the treatment process at the sanitary waste water system treatment plant to increase its ability to reduce PCBs in its effluent. These combined efforts resulted in an annual compliance sample result at Outfall 001 of 0 milligrams/liter total PCB in May 2019.

The current National Pollutant Discharge Elimination System Permit NM002835 expired on September 30, 2019, but it was administratively continued on October 22, 2019, by the U.S. Environmental Protection Agency. The National Pollutant Discharge Elimination System permit and regulations require the permittees to submit a reapplication to the U.S. Environmental Protection Agency 180 days before the existing permit expires. The Laboratory submitted a permit reapplication on March 26, 2019, and the U.S. Environmental Protection Agency issued a draft permit for public comment on November 30, 2019.

Table 2-6. Instances in which Samples Exceeded Permit Limits at National Pollutant Discharge Elimination System Permitted Industrial and Sanitary Outfalls in 2019

Outfall No.	Parameter	Date	Permit Limit (mg/liter)	Result (mg/liter)	Corrective Action
051	Whole Effluent Toxicity	Jun 18	100%	56%[a]	Increased the alkalinity to >50 milligrams/liter and pH to >7.5.
03A199	Total Residual Chlorine	Jun 19	0.011	0.42	Resumed addition of dechlorination chemical and replaced a failed controller so that the dechlorination chemical is automatically added.
03A199	Total Residual Chlorine	Nov 20	0.011	0.32	Added a backup pump and revised the maintenance procedure to route blowdown to the Sanitary Waste Water System (instead of the outfall) when the chemical feed system is being worked on.
03A181	Total Residual Chlorine	Jun 19	0.011	0.04	Realigned the blowdown valve to correct the dechlorination chemical to blowdown ratio; removed the valve handles to prevent future accidental realignment; and added a warning tag to the valve.
03A181	Total Residual Chlorine	Jul 9	0.011	0.06	Replaced the malfunctioning chemical feed pump associated with the addition of dechlorination chemical.

[a] *Daphnia pulex* Mean Survival

National Pollutant Discharge Elimination System General Permit for Discharges of Storm Water from Construction Sites

The National Pollutant Discharge Elimination System General Permit for Discharges of Storm Water from Construction Sites (Construction General Permit) regulates storm water discharges from construction sites covering one or more acres or projects less than one acre that are part of a common plan-of-development. Laboratory compliance with the Construction General Permit includes developing storm water pollution prevention plans and conducting site inspections during construction. A storm water pollution prevention plan describes project activities, site conditions, best management practices for sediment and erosion control, and permanent control measures, such as detention ponds for storm water, required to reduce pollutants in storm water discharges. Laboratory personnel inspect the location and condition of storm water controls during construction and identify corrective actions, if needed.

In 2019, Triad was responsible for 33 storm water pollution prevention plans for construction sites and performed 783 inspections, with sites found fully compliant during 89.5 percent of them. N3B implemented six construction projects under the Construction General Permit. Each project included preparing and implementing a site-specific storm water pollution prevention plan and regular inspections to document compliance with Construction General Permit requirements. No corrective actions were documented. The U.S. Army Corps of Engineers managed three construction projects at the Laboratory during 2019, including their storm water pollution prevention plans. They conducted 96 inspections. Items found not to be in compliance were addressed with corrective actions that rehabilitated storm water pollution prevention measures.

National Pollutant Discharge Elimination System Multi-Sector General Permit for Storm Water Discharges Associated with Industrial Activities

The National Pollutant Discharge Elimination System Multi-Sector General Permit for Storm Water Discharges Associated with Industrial Activities (Multi-Sector General Permit) regulates storm water discharges from specific industrial activities and associated facilities. Industrial activities conducted at the Laboratory and covered under the Multi-Sector General Permit include the following: (1) metal and ceramic fabrication, (2) wood product fabrication, (3) hazardous waste treatment and storage, (4) vehicle and equipment maintenance, (5) recycling activities, (6) electricity generation, (7) warehousing activities, and (8) asphalt manufacturing. The purpose of the Multi-Sector General Permit is to minimize offsite migration of pollutants in storm water.

The Multi-Sector General Permit requires the development of storm water pollution prevention plans, identification of potential pollutants, implementation of storm water control measures, and monitoring of storm water discharges. Additional permit requirements include

- inspecting facility storm water controls, identifying conditions requiring corrective action, and performing corrective actions as needed;
- sampling storm water runoff at monitored discharge points at each industrial facility and comparing results to benchmark values, impaired water limits (the New Mexico surface water quality standards), and effluent limitations; and
- visually inspecting storm water runoff samples to assess color; odor; floating, settled, or suspended solids; foam; oil sheen; and other indicators of storm water pollution.

A permit tracking number issued to an operator by the U.S. Environmental Protection Agency authorizes storm water discharge from a specific facility or group of facilities. Responsibilities for Multi-Sector General Permit compliance at the Laboratory are identified by permit tracking number and operator in Table 2-7.

Table 2-7. Multi-Sector General Permit Tracking Numbers by Operator and Covered Industrial Activity

Permit Tracking Number	Industrial Activities Covered	Responsible Operator	Operator Role	Date Permit Coverage Began
NMR050011	Technical Area 54 Maintenance Facility West	N3B	Environmental Management Legacy Cleanup	5/2/2018
NMR050012	Technical Area 54 Areas G and L	N3B	Environmental Management Legacy Cleanup	5/2/2018
NMR050013	Metal and ceramic fabrication, wood product fabrication, vehicle and equipment maintenance, recycling activities, electricity generation, warehousing activities, and asphalt manufacturing	Triad National Security, LLC	National Nuclear Security Administration Operations and Management	11/1/2018

Because the Laboratory's Multi-Sector General Permit implementation and compliance have specific operators, annual compliance activities are reported separately for each operator.

Management and Operating Contractor (Triad) Compliance Summary

Eight facilities operated by Triad are permitted under the Multi-Sector General Permit. Storm water monitoring under the permit occurs from April 1 through November 30 every year. Under the current permit, the benchmark values for some pollutants are the same as New Mexico surface water quality standards.

If an exceedance occurs, it is documented as a condition that triggers corrective action, which includes evaluation of potential sources and either follow-up action or documentation of why no action is required. All identified corrective actions associated with exceedances in 2019 have been completed. An exceedance of a benchmark value does not trigger a corrective action if it is determined that the exceedance is solely attributable to natural background sources.

In 2019, we completed the following tasks as part of the Multi-Sector General Permit compliance:

- 96 inspections of storm water controls at the eight active permitted facilities,
- one annual inspection at each of 39 sites having “no exposure” status,
- collection of 90 samples at eight active permitted sites,
- 245 inspections of ISCO automated sampler equipment,
- 116 inspections of single-stage samplers at substantially identical discharge points (discharge points that discharge storm water from the same source and with the same control measures and amount of storm water runoff per unit area),
- 46 visual inspections at 15 monitored discharge points,
- 66 visual inspections at 16 substantially identical discharge points, and
- 234 corrective actions, including
    - 28 corrective actions to mitigate exceedances,
    - nine additional storm water control measures installed at six active permitted sites,
    - maintenance, repair, or replacement of 63 control measures at seven active permitted sites,
    - 85 actions to remedy control measures inadequate to meet nonnumeric effluent limits, and
    - 58 corrective actions to address unauthorized releases (spills) or discharges.

By meeting permit-defined criteria under Triad’s Permit Tracking Number NMR050013, the Laboratory discontinued monitoring for 17 types of pollutants at eight active permitted sites for 2019. Two pollutants registered below benchmark values at one site, so monitoring for these pollutants was discontinued. Also, monitoring for 15 other pollutants was discontinued at eight sites because these constituents were not detected in storm water samples obtained at the monitored outfalls.

Tables 2-8 through 2-10 summarize the exceedance of water quality standards (i.e., impaired waters limits), effluent limitations, or quarterly benchmarks under the management and operating contractor’s National Pollutant Discharge Elimination System Multi-Sector General Permit.

Table 2-8. 2019 Exceedances of the Management and Operating Contractor's (Triad's) National Pollutant Discharge Elimination System Multi-Sector General Permit-Impaired Waters* Limits

Discharge Point	Exceeded Parameters		Date(s) Exceeded
	Copper, Dissolved	Aluminum, Total Recoverable	
002	✓		04/22/2019
005	✓	✓	04/22/2019
009	✓	✓	04/23/2019
012	✓		07/25/2019
022	✓	✓	04/22/2019
026	✓	✓	04/01/2019
029	✓		04/22/2019
032		✓	04/30/2019
037		✓	07/26/2019
039	✓		07/25/2019
042		✓	04/23/2019
075	✓	✓	04/22/2019
076		✓	06/17/2019

**An impaired-waters exceedance means that the value exceeds a New Mexico surface water quality standard, as provided in Standards for Interstate and Intrastate Surface Waters, Title 20, Chapter 6, Part 4 of the New Mexico Administrative Code. Eighteen of 44 impaired waters results (41 percent) exceeded a New Mexico surface water quality standard.*

Table 2-9. 2019 Exceedances of the Management and Operating Contractor's (Triad's) National Pollutant Discharge Elimination System Multi-Sector General Permit Quarterly Benchmarks*

Discharge Point	Exceeded Parameters				Date(s) Exceeded
	Aluminum, Total Recoverable	Iron, Total	Zinc, Dissolved	Nitrate plus Nitrite Nitrogen	
002		✓			04/22/2019
005		✓			06/15/2019, 08/07/2019, 10/04/2019
009		✓			04/23/2019, 08/08/2019
022	✓	✓	✓	✓	04/22/2019 – aluminum, zinc; 07/02/2019 – iron; 08/06/2019 – nitrate plus nitrite nitrogen; 10/04/2019 – aluminum
076	✓	✓	✓		08/06/2019 – iron; 10/04/2019 – aluminum, iron, zinc

**A quarterly benchmark exceedance means the value exceeded a benchmark value defined in the Multi-Sector General Permit. Benchmarks are not permit limits. The benchmark values for copper, aluminum, and zinc are the same as New Mexico surface water quality standards. Fifteen of 50 benchmark results measured (30 percent) resulted in a benchmark value exceedance.*

Table 2-10. 2019 Exceedances of the Management and Operating Contractor's (Triad's) National Pollutant Discharge Elimination System Multi-Sector General Permit Effluent Limitations*

Discharge Point	Exceeded Parameters			Date(s) Exceeded
	Total Suspended Solids, Daily Limit	**Total Suspended Solids, 30-Day Avg.**	**pH, Daily Limit**	
043	✓	✓	✓	7/25/2019 – Total Suspended Solids daily limit; 08/07/2019 – Total Suspended Solids daily limit, Total Suspended Solids 30-day avg. pH daily limit

An effluent limitation exceedance means the value exceeded an effluent limit defined in the Multi-Sector General Permit. Three of four effluent limitation results measured (75 percent) resulted in an effluent limit exceedance.

Legacy Cleanup Contractor (N3B) Compliance Summary

N3B completed the following corrective actions in 2019.

Technical Area 54 Areas G and L – The combined results of routine facility inspections, visual assessments, and benchmark and impairment sampling generated 22 corrective actions. Of these, 13 corrective actions were due to baseline monitoring exceedances of total magnesium levels in storm water, seven were due to the discovery of storm water controls in a deteriorated state, one was due to the observance of poor housekeeping conditions at Area L, and one corrective action was due to the discovery of a hydraulic fluid leak at Area G. All corrective actions were completed within 45 days of discovery. No incidents of noncompliance with the Multi-Sector General Permit are known regarding this facility.

Technical Area 54 Maintenance Facility West – One incident involved approximately five gallons of diesel fuel spilled from a forklift, and the second involved a release of hydraulic fluid from staged equipment at the site. In both cases, immediately following discovery, the impacted soil was removed and managed appropriately. Corrective actions were completed within 45 days of discovery. No incidents of noncompliance with the Multi-Sector General Permit are known regarding this facility.

Table 2-11 summarizes the exceedance of water quality standards (i.e., impaired waters), effluent limitations, or quarterly benchmarks for N3B's National Pollutant Discharge Elimination System Multi-Sector General Permit.

Table 2-11. 2019 Exceedances of the Legacy Cleanup Contractor's (N3B's) National Pollutant Discharge Elimination System Multi-Sector General Permit Quarterly Benchmarks*

Discharge Point	Exceeded Parameters					Date(s) Exceeded
	Magnesium, Total	Chemical Oxygen Demand	Cadmium, Total	Lead, Total	Mercury, Total	
050	✓					4/23, 6/14, 8/3, 10/4
051	✓	✓	✓	✓		7/26 – excluding chemical oxygen demand, 10/4
053	✓	✓				5/30 – magnesium, total, 6/17, 10/24
069	✓	✓				4/29 – magnesium, total, 6/17, 8/6 – magnesium, total, 10/4 – magnesium, total
072	✓	✓			✓	10/4

**A quarterly benchmark exceedance means the value exceeded a benchmark value defined in the Multi-Sector General Permit. Benchmarks are not permit limits. The benchmark values for aluminum are the same as New Mexico surface water quality standards. Forty-two of 134 benchmark results measured (31 percent) resulted in a benchmark value exceedance.*

LANL's Individual Permit Authorization to Discharge under the National Pollutant Discharge Elimination System (from Solid Waste Management Units and Areas of Concern)

The Individual Permit Authorization to Discharge under the National Pollutant Discharge Elimination System (Individual Permit) authorizes discharges of storm water from certain Solid Waste Management Units and Areas of Concern (hereafter called sites) at the Laboratory. The permit lists 405 sites that must be managed to remain in compliance with its terms and conditions. The objective is to prevent storm water runoff from transporting pollutants of concern from these sites to surface waters. Pollutants of concern potentially occurring at these sites include metals, organic chemicals, high explosives, and radionuclides.

The U.S. Environmental Protection Agency issued the original permit in 2010, and it has been administratively continued. A new draft permit was issued by the U.S. Environmental Protection Agency in November 2019 for public comment; the public comment period has been extended to May 31, 2020.

The Individual Permit has technology-based requirements for storm water control. This means that storm water controls that reflect best industry practices, considering their availability, economic achievability, and practicability, are required at each of the 405 permitted sites. Examples of controls used to manage storm water under the Individual Permit include retention berms and coir logs. These storm water controls are routinely inspected and are maintained as needed.

The permit required the Laboratory to install baseline controls at all 405 sites. These baseline controls were completed and certified to the U.S. Environmental Protection Agency in 2010–2011. The 405 sites have been grouped into 250 small sub-watersheds, known as site monitoring areas, for permit monitoring. Specific locations within each site monitoring area are used to sample storm water runoff from the sites. If target action levels of pollutants, which are based on New Mexico surface water quality standards, are exceeded in the storm water samples, the sites enter into corrective action and additional controls are installed within the site monitoring area. Once all control measures have been installed and the results of sampling confirm that all pollutants of concern for a site monitoring area are below target action levels, the Laboratory certifies to the U.S. Environmental Protection Agency that the corrective actions are complete for the sites in that site monitoring area.

If all storm water control measures have been installed, but the Laboratory cannot demonstrate that all results are below target action levels (for example, if natural background concentrations at the site are above the target action levels), the Laboratory can request that a site be placed into alternative compliance. For a site placed into alternative compliance, the completion of the corrective action is accomplished according to an individual site compliance schedule determined by the U.S. Environmental Protection Agency.

In summary, the process of complying with the Individual Permit can be broken down into five categories: (1) installing and maintaining control measures, (2) performing storm water sampling to determine the effectiveness of control measures, (3) conducting additional corrective action if a target action level is exceeded, (4) reporting results of fieldwork and monitoring to the U.S. Environmental Protection Agency and the New Mexico Environment Department, and (5) certifying that corrective action is complete or requesting alternative compliance to the U.S. Environmental Protection Agency.

Site monitoring areas where the Laboratory has not collected sufficient storm water samples to date (for example, because of a lack of local rainfall) are referred to as being in “extended baseline monitoring.” Site monitoring areas that have collected storm water samples with results that have exceeded target action levels enter into corrective action, and one path to completion of corrective action is installing “enhanced” controls. After installation of the enhanced controls is complete, additional storm water sampling is required and is referred to as “corrective action monitoring.”

In 2019, LANL completed the following tasks to comply with the requirements of the Individual Permit:

- Published an update to the 2018 Site Discharge Pollution Prevention Plan, which identified pollutant sources, described control measures, and defined monitoring at all permitted sites.
- Published the “Storm Water Individual Permit Annual Report for Reporting Period January 1–December 31, 2019,” which presents compliance status for all permitted sites, conducted activities, and accomplished milestones to comply with the Individual Permit.
- Completed 1,094 inspections of storm water controls at the 250 site monitoring areas.
- Completed 1,152 sampling equipment inspections.
- Conducted storm water monitoring at 132 site monitoring areas.
- Collected extended baseline confirmation samples at 13 site monitoring areas.
- Collected corrective action confirmation samples at four site monitoring areas.
- Installed 46 additional control measures at 31 site monitoring areas.
- Held two public meetings as required by the Individual Permit.
- Submitted alternative compliance requests for 14 site/site monitoring area combinations.
- Submitted analytical results following certification of enhanced controls at seven site/site monitoring area combinations.
- Submitted certification of corrective action complete with analytical results below target action levels at three site/site monitoring area combinations.
- Submitted certification of corrective action complete following a certificate of completion from the New Mexico Environmental Department at 16 site/site monitoring area combinations.
- Submitted Individual Permit reapplication on June 15, 2019.

For more information on surface water quality at the Laboratory, see Chapter 6, Watershed Quality.

Table 2-12 summarizes the exceedance of target action levels for storm water samples collected in 2019 for the Individual Permit.

Aboveground Storage Tank Program

The Laboratory's Aboveground Storage Tank Program manages compliance with the requirements of the U.S. Environmental Protection Agency under the Clean Water Act and with the New Mexico Administrative Code regulations administered by the New Mexico Environment Department's Petroleum Storage Tank Bureau. The Laboratory operates 10 tank systems with 12 storage tanks.

In 2019, Petroleum Storage Tank Bureau staff inspected three aboveground storage tanks at the Laboratory. Two facilities were issued Notices of Violation following the inspections. Inspection findings at one facility were addressed and received a Certificate of Compliance from the Petroleum Storage Tank Bureau, whereas corrective actions are in progress at the second facility. Work is ongoing to upgrade a tank system that was previously issued a Notice of Violation, and this work is scheduled to be completed in 2020. Following completion of the work, the Petroleum Storage Tank Bureau will re-inspect the facility. All work is being conducted in accordance with regulations identified in New Mexico Administrative Code Title 20, Chapter 5.

The U.S. Environmental Protection Agency requires spill prevention, control, and countermeasure plans for facilities with aboveground storage tank systems. In 2019, Laboratory staff members completed updates to two of these plans and began updates to three other plans. Laboratory staff conducted all annual and monthly inspections for the facilities. In 2019, the Laboratory was in full compliance with the federal Clean Water Act requirements for the tanks.

Clean Water Act Section 404/401 Permits

Section 404 of the Clean Water Act requires that the Laboratory receive verification from the U.S. Army Corps of Engineers that proposed projects within perennial, intermittent, or ephemeral watercourses comply with Clean Water Act nationwide permit conditions. Additionally, Section 401 of the Clean Water Act requires states to certify that Section 404 permits issued by the U.S. Army Corps of Engineers comply with state water quality standards. The New Mexico Environment Department reviews Section 404/401 permit applications and issues separate Section 401 certification letters, which may include additional requirements to meet state stream standards for individual Laboratory projects. Section 404/401 verifications and certifications that were issued or active at the Laboratory in 2019 are listed in the Summary of Permits and Legal Orders section at the end of this chapter.

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Table 2-12. 2019 Exceedances of LANL's National Pollutant Discharge Elimination System Individual Permit Target Action Levels

Site Monitoring Area (SMA)	Parameter	Type of Exceedance*	Number of Exceedances	Total Number of Samples Taken	Date(s) Exceeded	Description and Corrective Action
A-SMA-2	Copper, dissolved	maximum target action level	2	2	7/25/2019 10/4/2019	The Site Monitoring Area is being evaluated for a corrective action recommendation.
	Gross alpha, total	average target action level	2	2		
DP-SMA-0.6	Gross alpha, total	average target action level	1	1	7/26/2019	The Site Monitoring Area is being evaluated for a corrective action recommendation.
DP-SMA-3	Gross alpha, total	average target action level	2	2	7/25/2019 8/9/2019	The Site Monitoring Area is being evaluated for a corrective action recommendation.
LA-SMA-5.2	Arsenic, dissolved	average target action level	1	1	7/26/2019	The Site Monitoring Area is being evaluated for a corrective action recommendation.
	Gross alpha, total	average target action level	1	1		
	Radium-226 and Radium-228, total	average target action level	1	1		
	Selenium, total	average target action level	1	1		
	Zinc, dissolved	maximum target action level	1	1		
LA-SMA-5.361	Gross alpha, total	average target action level	1	1	8/7/2019	The Site Monitoring Area is being evaluated for a corrective action recommendation.
	Selenium, total	average target action level	1	1		
LA-SMA-6.3	Aluminum, dissolved	maximum target action level	1	1	7/26/2019	The Site Monitoring Area is being evaluated for a corrective action recommendation.
	Gross alpha, total	average target action level	1	1		
	Selenium, total	average target action level	1	1		
M-SMA-12.5	Gross alpha, total	average target action level	1	1	7/25/2019	The Site Monitoring Area is being evaluated for a corrective action recommendation.
	Selenium, total	average target action level	1	1		
M-SMA-12.8	Aluminum, dissolved	maximum target action level	1	1	7/25/2019	The Site Monitoring Area is being evaluated for a corrective action recommendation.
	Gross alpha, total	average target action level	1	1		
	Selenium, total	average target action level	1	1		
PJ-SMA-11	Copper, dissolved	maximum target action level	1	1	7/2/2019	The Site Monitoring Area is being evaluated for a corrective action recommendation.
	Gross alpha, total	average target action level	1	1		

Site Monitoring Area (SMA)	Parameter	Type of Exceedance*	Number of Exceedances	Total Number of Samples Taken	Date(s) Exceeded	Description and Corrective Action
P-SMA-2.2	Copper, dissolved	maximum target action level	1	1	7/25/2019	The Site Monitoring Area is being evaluated for a corrective action recommendation.
	Gross alpha, total	average target action level	1	1		
	Mercury, total	average target action level and maximum target action level	1	1		
	Total PCBs	average target action level	1	1		
	Zinc, dissolved	maximum target action level	1	1		
PT-SMA-2	Copper, dissolved	maximum target action level	1	2	7/25/2019	The Site Monitoring Area is being evaluated for a corrective action recommendation.
	Gross alpha	average target action level	2	2	7/25/2019 10/4/2019	
R-SMA-2.5	Aluminum, dissolved	maximum target action level	1	1	8/8/2019	The Site Monitoring Area is being evaluated for a corrective action recommendation.
	Gross alpha, total	average target action level	1	1		
S-SMA-5.2	Gross alpha, total	average target action level	1	1	7/26/2019	The Site Monitoring Area is being evaluated for a corrective action recommendation.
	Total PCBs	average target action level	1	1		
T-SMA-2.5	Gross alpha, total	average target action level	1	1	7/26/2019	The Site Monitoring Area is being evaluated for a corrective action recommendation.
	Selenium, total	average target action level	1	1		
T-SMA-7.1	Copper, dissolved	maximum target action level	1	1	7/25/2019	The Site Monitoring Area is being evaluated for a corrective action recommendation.
	Gross alpha, total	average target action level	1	1		
W-SMA-6	Gross alpha	average target action level	1	1	7/7/2019	The Site Monitoring Area is being evaluated for a corrective action recommendation.

**The maximum target action level is the target for individual maximum values recorded at a site, and the average target action level is the target for the geometric mean of applicable monitoring results at a site. Target action levels are benchmarks, not permit limits.*

The Energy Independence and Security Act: Storm Water Management Practices

Section 438 of the Energy Independence and Security Act of 2007 establishes storm water runoff requirements for federal development and redevelopment projects. Any federal project more than 5,000 square feet that alters the flow of water over the surface of the ground must implement low-impact development controls to maintain pre-development water temperatures, flow rates, flow volumes, and duration. Examples of appropriate controls include vegetated swales, infiltration basins, permeable pavement, vegetated strips, rain barrels, and cisterns. The goal is to manage runoff through infiltration, evapotranspiration, or harvest and reuse.

The Laboratory currently identifies projects for Section 438 compliance through the permits and requirements identification process and excavation permitting. The Laboratory's Environmental Protection and Compliance Division is responsible for implementing Section 438 compliance. Staff work with internal and subcontractor design and construction personnel to meet the requirements. Section 438 guidance is published in the LANL Engineering Standards Manual. In 2019, there were nine projects completed that required Energy Independence and Security Act compliance. As part of Section 438 compliance, the following projects used swales, bioretention basis, and revegetation to manage storm water discharge: parking lots in Technical Area 03, Technical Area 40, and Technical Area 35; the West Jemez Walkway Project; the East Jemez Erosion Control Project; and the Technical Area 46 Decontamination and Demolition Project. All Energy Independence and Security Act requirements for these projects were completed in 2019.

New Mexico Water Quality Act: Surface Water Protection

Under the New Mexico Water Quality Act, the New Mexico Water Quality Control Commission adopts standards for New Mexico surface waters. *Standards for Interstate and Intrastate Surface Waters*, Title 20, Chapter 6, Part 4 of the New Mexico Administrative Code, define designated surface water uses for the state, set water quality criteria to protect those uses, and provide an anti-degradation policy. The Laboratory's National Pollutant Discharge Elimination System permits, along with any dredge and fill activities approved under Section 404 of the Clean Water Act, must be certified by the New Mexico Environment Department to ensure New Mexico water quality standards are met.

Additionally, under Section 303(d) of the Clean Water Act, the New Mexico Environment Department determines which stream reaches (delineated as assessment units) within the state are impaired for their designed use(s). The New Mexico Environment Department uses the Laboratory's surface water monitoring data in developing its list of impaired waters for the assessment units on Laboratory property. The discharge limits and monitoring requirements in the Laboratory's National Pollutant Discharge Elimination System permits are determined, in part, by the impairment status of affected watercourses. In 2019, most assessment units at the Laboratory were listed as impaired, sometimes because of naturally occurring substances. See Chapter 6, Watershed Quality, for more information.

GROUNDWATER QUALITY AND PROTECTION

Safe Drinking Water Act

The Los Alamos County Department of Public Utilities supplies water for Los Alamos, White Rock, the Laboratory, and Bandelier National Monument. The Department of Public Utilities issues an annual drinking water quality report, as required by the Safe Drinking Water Act. The report is available at https://www.losalamosnm.us/common/pages/DisplayFile.aspx?itemId=15763913. For 2019, the drinking water quality for Los Alamos met all U.S. Environmental Protection Agency regulations.

New Mexico Water Quality Act: Groundwater Quality Standards

In fiscal year 2019, the Laboratory reported to the New Mexico Environment Department 13 instances of a contaminant detected in groundwater at a location where the contaminant had not been previously detected above a standard or screening level (Table 2-13). The standards and screening levels for this reporting requirement include the following: (1) the New Mexico Environment Department Soil Screening Levels Summary Table A-1 Values for Tap Water, (2) the New Mexico Water Quality Control Commission groundwater standard, and (3) the U.S. Environmental Protection Agency maximum contaminant levels.

Table 2-13. 2019 Locations with First-time Groundwater Quality Standard or Screening Level Exceedances

Parameter Name	Location	Groundwater Zone	Sample Date	Result	Standard or Screening Level Value	Units	Type of Standard or Screening Level
RDX	R-69 S1	Regional Aquifer	1/31/2019	19.7	7.02	µg/L	New Mexico Environment Department Tap Water Screening Level[a]
RDX	R-69 S1	Regional Aquifer	1/31/2019	14.4	7.02	µg/L	New Mexico Environment Department Tap Water Screening Level[a]
RDX	R-69 S2	Regional Aquifer	2/13/2019	14.7	7.02	µg/L	New Mexico Environment Department Tap Water Screening Level[a]
Iron	MSC-16-06293	Alluvial Groundwater	3/8/2019	1490.00	1000	µg/L	New Mexico Groundwater Standard[b]
Iron	WCO-1r	Alluvial Groundwater	3/15/2019	1560.00	1000	µg/L	New Mexico Groundwater Standard[b]
Iron	Burning Ground Spring	Intermediate Spring	3/16/2019	1390.00	1000	µg/L	New Mexico Groundwater Standard[b]
Barium	CdV-16-02657r	Alluvial Groundwater	3/16/2019	2160.00	2000	µg/L	New Mexico Groundwater Standard[b]
Iron	CdV-16-02657r	Alluvial Groundwater	3/16/2019	1430.00	1000	µg/L	New Mexico Groundwater Standard[b]
RDX	CdV-16-02657r	Alluvial Groundwater	3/16/2019	148.00	9.66	µg/L	New Mexico Environment Department Tap Water Screening Level[a]
Iron	R-25b	Perched-Intermediate Groundwater	3/18/2019	1120.00	1000	µg/L	New Mexico Groundwater Standard[b]

Parameter Name	Location	Groundwater Zone	Sample Date	Result	Standard or Screening Level Value	Units	Type of Standard or Screening Level
Nitrate-Nitrite as Nitrogen	18-MW-18	Alluvial Groundwater	4/17/2019	10.90	10	mg/L	U.S. Environmental Protection Agency Maximum Contaminant Level
Phenol	R-9i S2	Perched-Intermediate Groundwater	6/16/2019	6.70	5	µg/L	New Mexico Groundwater Standard[b]
Fluoride	R-11	Regional Aquifer	7/11/2019	3.02	1.6	mg/L	New Mexico Groundwater Standard[b]

[a]The New Mexico Environment Department Tap Water Screening Level for RDX was updated from 7.02 to 9.66 micrograms per liter in February 2019.

[b]New Mexico Water Quality Control Commission groundwater standards published December 21, 2018

Note: µg/L = micrograms per liter; mg/L = milligrams per liter

New Mexico Water Quality Act: Groundwater Discharge Regulations

Under the New Mexico Water Quality Act, the New Mexico Water Quality Control Commission sets regulations for liquid discharges onto or below ground surfaces to protect groundwater. The New Mexico Environment Department enforces groundwater discharge regulations and may require a facility that discharges effluents to submit a discharge plan and obtain a permit. At the beginning of 2019, the Laboratory had five discharge permits. In June 2019, the New Mexico Water Quality Control Commission vacated the Laboratory's discharge permit DP-1132 for discharges from the Technical Area 50 Radioactive Liquid Waste Treatment Facility and remanded it back to the New Mexico Environment Department for a public hearing. The public hearing was completed, and this discharge permit application is pending.

Technical Area 46 Sanitary Waste Water System Plant Discharge Permit DP-857

On December 16, 2016, the Laboratory was issued a renewal and modification for Discharge Permit DP-857. This permit applies to combined effluent discharges from the Technical Area 46 sanitary waste water system plant, the Sanitary Effluent Reclamation Facility, and the Sigma Mesa evaporation basins.

The permit conditions require quarterly, semi-annual, and annual sampling of (1) the sanitary waste water system plant's treated water product before discharge; (2) effluent from Outfalls 001, 03A027, and 13S (outfalls that can discharge water from the sanitary waste water system plant); and (3) alluvial groundwater well SCA-3 in Sandia Canyon. In 2019, none of the samples collected exceeded New Mexico groundwater standards, and one inspection of Discharge Permit DP-857 facilities was conducted by the New Mexico Environment Department.

Domestic Septic Tank Disposal Systems Discharge Permit DP-1589

On July 22, 2016, the New Mexico Environment Department issued Discharge Permit DP-1589 to the Laboratory for discharges from eight septic tank disposal systems. These septic systems (a combined septic tank and leach field) are located in remote Laboratory areas, where access to the sanitary waste water system plant's collection system is not practicable. Five of the eight septic tank disposal systems are active; the remaining three systems are inactive because water service to the buildings using the systems is disconnected.

Discharge Permit DP-1589 requires monitoring and inspections for the Laboratory’s septic tank disposal systems. These actions include, but are not limited to, the following: (1) routine septic tank sampling, (2) septic tank water-tightness testing, (3) inspection of the septic tank for the accumulation of scum and solids, and (4) inspection of the leach field disposal system.

The permit conditions require semi-annual and annual sampling of active septic tank disposal systems. In 2019, none of the samples collected exceeded permit requirements. No inspections of Discharge Permit DP-1589 facilities were conducted.

Technical Area 50 Radioactive Liquid Waste Treatment Facility Discharge Plan and Permit Application DP-1132

On August 20, 1996, the Laboratory submitted a discharge plan and permit application for the Radioactive Liquid Waste Treatment Facility at Technical Area 50. On November 18, 2011, the New Mexico Environment Department requested an updated discharge plan and permit application for this facility, including the solar evaporative tank for discharged treated water located at Technical Area 52. The Laboratory submitted an application on February 16, 2012, and supplemental information on August 10, 2012. On September 13, 2013, the New Mexico Environment Department issued a draft discharge permit for public review and comment. On April 19, 2018, the New Mexico Environment Department held a public hearing in Los Alamos, New Mexico, on the application. Following issuance of the Hearing Officer’s Report, the Secretary of the New Mexico Environment Department issued DP-1132 on August 29, 2018.

During the April, May, and June 2019 meetings of the New Mexico Water Quality Control Commission, the commission considered a motion by a third party concerning discharge permit DP-1132. In the June 2019 meeting, the Water Quality Control Commission vacated discharge permit DP-1132 and remanded it back to the Secretary of the New Mexico Environment Department for a public hearing. On November 14, 2019, the New Mexico Environment Department held a public hearing in Los Alamos, New Mexico, on the Laboratory’s application. The discharge permit application is currently pending a final decision by the Secretary of the New Mexico Environment Department.

Beginning on the day DP-1132 was vacated, June 18, 2018, the Laboratory continued discharge to the evaporation system or Outfall 051 under Temporary Permissions granted by the New Mexico Environment Department. Under these Temporary Permissions, the Laboratory is following all the permit requirements contained in the previously issued DP-1132, except posting of select documents to the Laboratory’s Electronic Public Reading Room. In addition, the Laboratory also meets current State of New Mexico Groundwater Quality Standards requirements.

Discharge Permit DP-1132 and the subsequent Temporary Permissions after DP-1132 was vacated for the Radioactive Liquid Waste Treatment Facility require the Laboratory to implement operational, monitoring, and closure actions. Examples of these actions are (1) monthly sampling of treated effluent; (2) quarterly and annual groundwater monitoring at seven alluvial, perched-intermediate, and regional aquifer wells; (3) installing a soil moisture monitoring system beneath the Technical Area 52 solar evaporation tank; and (4) removing from service seven tanks that do not have secondary containment. In 2019, all requirements were met on or before deadlines, all effluent sample results met groundwater quality standards, and no compliance inspections were completed. All groundwater monitoring well samples met groundwater quality standards, except for exceedances associated with the chromium project, as presented in Chapter 5, Groundwater Protection. In addition, although no compliance inspection was completed, New Mexico Environment Department personnel did complete several tours related to the reconsideration of Discharge Permit DP-1132.

Land Application of Treated Groundwater Discharge Permit DP-1793

On July 27, 2015, the New Mexico Environment Department issued Discharge Permit DP-1793 to the Laboratory for the discharge of treated groundwater by land application (spraying treated groundwater onto the surface of the ground). Activities involving land application of treated groundwater include well pumping tests, aquifer tests, well rehabilitation, and groundwater tracer studies. Under the permit, individual work plans must be submitted for each land application project. Work plans are posted to the Laboratory's Electronic Public Reading Room for a 30-day public comment period. Each work plan addresses how groundwater will be treated so that constituent concentrations are less than 90 percent of the New Mexico groundwater standards before discharge.

Injection of Treated Groundwater into Class V Underground Injection Control Wells Discharge Permit DP-1835

On August 31, 2016, the New Mexico Environment Department issued Discharge Permit DP-1835. This permit covers the injection of treated groundwater into six Class V underground injection control wells located in Mortandad Canyon. This permit authorized the withdrawal of chromium-contaminated groundwater from three extraction wells, treatment by ion exchange, and the injection of treated groundwater back into the regional aquifer by six underground injection control wells. On June 28, 2017, the Laboratory requested this permit language be modified, since a fourth extraction well was planned. On July 21, 2017, the New Mexico Environment Department approved this request. Treated groundwater is sampled to demonstrate that chromium concentrations are less than 90 percent of the New Mexico groundwater standard for chromium (50 micrograms per liter) before injection.

Discharge Permit DP-1835 requires quarterly reporting to document (1) influent and discharge volumes, flow rates, and effluent sample results of the treatment systems; (2) volumes injected and water levels above static (no pumping) level for the injection wells; (3) volumes extracted from the extraction wells; (4) groundwater sample results and groundwater contour maps from the monitoring wells; (5) any operations or maintenance activities completed, including replacement of ion exchange vessels or well work-overs; (6) any completed periodic mechanical integrity testing; and (7) changes to operations.

CrIN-6 was drilled and installed in 2017 as a single-screen injection well as part of the Chromium Interim Measure. Measured chromium concentrations of approximately 260 micrograms per liter in CrIN-6 were obtained from initial pumping from the well. This work led to a model-based evaluation of the optimal operational configuration to meet the interim measure objectives. The results indicated that extraction, rather than injection, from the CrIN-6 location would provide the most optimal approach for meeting the interim measure objective. Based on the evaluation, the New Mexico Environment Department approved proceeding with the recommendation to convert CrIN-6 from an injection well to an extraction well (CrEX-5). The conversion of the CrIN-6 well to an extraction well took place in May–June 2019.

Compliance Order on Consent Groundwater Activities

In 2019, the Laboratory performed groundwater protection activities as directed by the New Mexico Environment Department under the Compliance Order on Consent. Activities included sampling and testing groundwater from wells for general monitoring of groundwater quality, investigating the chromium and RDX (hexahydro-1,3,5-trinitro-1,3,5-triazine) groundwater plumes, and supporting the chromium interim measure.

Interim measures are actions taken at a contaminated site to reduce chances of human or environmental exposures before the remedial investigation is complete. The goal of the chromium interim measure is to control migration of the chromium groundwater plume while the Laboratory assesses cleanup methods. In 2019, water treatment operations supporting the chromium interim measure included (1) withdrawing chromium-contaminated groundwater from the regional aquifer using up to five extraction wells, (2) treating such water using ion exchange, and (3) injecting the treated groundwater back into the regional aquifer using injection wells. In 2019, the CrEX-1 and CrEX-2 wells were used for extraction from January through late April and from early July through the end of the year. The CrEX-3 well was used for extraction only in July 2019. The CrEX-4 and CrEX-5 wells were used for extraction from mid-November through the end of the year. The CrIN-3, CrIN-4, and CrIN-5 wells were used for injection during the entire year. The CrIN-1 and CrIN-2 wells were used for injection during November–December 2019.

More information is available in Chapter 5, Groundwater Protection.

OTHER ENVIRONMENTAL STATUTES AND ORDERS

National Environmental Policy Act

The National Environmental Policy Act requires federal agencies to consider the environmental impacts of proposed activities, operations, and projects. The DOE has analyzed the impacts of Laboratory operations and activities in a Site-Wide Environmental Impact Statement (DOE 2008a). The Records of Decision for the Site-Wide Environmental Impact Statement (DOE 2008b, DOE 2009) described the operations and activities DOE has approved and any required mitigations.

Laboratory staff specializing in the National Environmental Policy Act review proposed projects to determine if associated impacts have been analyzed in the 2008 Site-Wide Environmental Impact Statement for the Continued Operation of Los Alamos National Laboratory or other existing National Environmental Policy Act documents.

In 2019, staff reviewed approximately 1,000 proposed projects. Those projects or activities that do not have coverage under existing documents require new or additional analyses. The Laboratory projects that required additional National Environmental Policy Act analyses in 2019 are listed below.

In June 2019, the National Nuclear Security Administration published the “The Final Environmental Assessment for the Construction and Operation of a Solar Photovoltaic Array at Los Alamos National Laboratory, Los Alamos, New Mexico” (DOE 2019a). The environmental assessment analyzed a proposal for the Laboratory to construct and operate a 10-megawatt ground-mounted solar photovoltaic system and associated facilities. The proposed solar photovoltaic array location is on approximately 55-plus acres, of which around 50 acres are within a previously disturbed area that was used as a borrow pit in the northwest corner of Technical Area 16 at the Laboratory. The solar photovoltaic array and power transmission line would be designed, constructed, and operated to increase onsite electrical power generation and provide for efficient and sustainable electrical power capability and resilience. The DOE issued a Finding of No Significant Impact with mitigation measures.

In July 2019, the National Nuclear Security Administration published the "Final Supplemental Environmental Assessment for the Wildfire Hazard Reduction and Forest Health Improvement Program at Los Alamos National Laboratory, Los Alamos, New Mexico" (DOE 2019b). In 2000, DOE issued the "Environmental Assessment for the Wildfire Hazard Reduction and Forest Health Improvement Program at Los Alamos National Laboratory" (DOE 2000). The Environmental Assessment evaluated the potential environmental impacts of strategies for addressing wildland fires that threaten Laboratory operations. In 2019, DOE issued this final supplemental environmental assessment to address new strategies that reflect conditions that have changed at LANL since the 2000 Environmental Assessment was issued, including longer fire seasons, changes in vegetation, and global climate change. The DOE issued a Finding of No Significant Impact with mitigation measures.

Four Los Alamos National Laboratory projects were categorically excluded from further DOE National Environmental Policy Act review in 2019:

- Technical Area 68 Water Canyon Test Site Expansion (CX-270449)
- Los Alamos National Laboratory Cellular and Radio Communications Upgrades (CX-270451)
- Construction and Operation of Technical Area 03 Parking Structure (CX-270456)
- Construction and Operation of Technical Area 50 Parking Structure (CX-270459)

National Historic Preservation Act

As amended, the National Historic Preservation Act of 1966 requires federal agencies to consider the effects of their activities on historic properties, including archaeological sites and historic buildings, and requires a mitigation plan for any adverse effects to the properties. LANL's Cultural Resources Management Plan (LANL 2017b) describes the process for implementing the National Historic Preservation Act and associated laws and regulations.

In fiscal year 2019, archaeologists supported 10 Triad projects by performing new historic property surveys or verifying results from previous surveys. Additionally, archaeologists evaluated 17 archaeological sites for eligibility for inclusion in the National Register of Historic Places (Register). These findings were reported to the New Mexico State Historic Preservation Office, which concurred that all 17 sites were eligible for inclusion in the Register.

Archaeologists conducted an annual inspection of the Museum of Indian Arts and Culture located in Santa Fe, New Mexico. The focus of the inspection was to ensure compliance with regulations to preserve and curate artifacts from archaeological sites excavated on Laboratory property since 1949. These inspections are required under *Curation of Federally-Owned and Administered Archaeological Collections*, Title 36, Part 79 of the Code of Federal Regulations.

Archaeologists working for the legacy waste cleanup contractor reviewed 21 environmental remediation and contact-handled transuranic waste projects. They also surveyed 61 acres to inventory cultural resources in Technical Area 05. During the survey, archeologists identified three potential new sites, and site recording is ongoing.

Cultural resources historic buildings staff supported 24 Laboratory projects by performing inspections and research on the historical use of the buildings using the LANL National Security Research Center, documents available through the public reading room, and historical photographs. Historic buildings staff conducted archival documentation for five projects impacting historic buildings at Technical Areas

03, 15, 16, and 46. This work included taking interior and exterior photographs of the buildings. Cultural resources historic buildings staff also participated in surveillance and maintenance evaluations for the most significant historic properties located at the Laboratory, including the 17 buildings and structures that are either included in the Manhattan Project National Historical Park or that are Park eligible (see Chapter 3).

Cultural resources staff continues to conduct consultations with the Accord Pueblos (Pueblo de San Ildefonso, Santa Clara Pueblo, Pueblo of Jemez, and Pueblo de Cochiti) regarding the identification and preservation of traditional cultural properties, human remains, and sacred objects in compliance with the National Historic Preservation Act and the Native American Graves Protection and Repatriation Act.

Endangered Species Act

The Endangered Species Act requires federal agencies to protect federally listed threatened or endangered species, including their habitats. The Laboratory implements these requirements through the Habitat Management Plan (LANL 2017c).

The Laboratory contains habitat for three federally listed species: the southwestern willow flycatcher (*Empidonax traillii extimus*), the Jemez Mountains salamander (*Plethodon neomexicanus*), and the Mexican spotted owl (*Strix occidentalis lucida*). Two other federally listed species occur near the Laboratory: the New Mexico meadow jumping mouse (*Zapus hudsonius luteus*) and the western distinct population segment of the yellow-billed cuckoo (*Coccyzus americanus*). The southwestern willow flycatcher, yellow-billed cuckoo, and New Mexico meadow jumping mouse have not been observed on Laboratory property. In addition, several federal species of concern and state-listed species potentially occur within the Laboratory (Table 2-14) (Hathcock et al. 2015).

The Laboratory reviews proposed projects to determine if they could potentially impact federally listed species or their habitats. In 2019, biologists reviewed 689 excavation permits, 226 project profiles in the permits and requirements identification system, 18 minor siting proposals, and 12 storm water pollution prevention plans for potential impacts to threatened or endangered species. If there is a potential for impacts, biologists work with project personnel to either modify the project to avoid the impacts or to prepare a biological assessment for consultation with the U.S. Fish and Wildlife Service. In 2019, the Laboratory prepared one biological assessment. This assessment analyzed the impacts to listed species for the construction and operation of a suite of projects in four technical areas in the weapons facility operations directorate. This biological assessment received concurrence back from the U.S. Fish and Wildlife Service. In 2019, the Laboratory did not find any projects out of compliance with endangered species protection requirements.

Laboratory staff also conducted surveys for the Mexican spotted owl, Jemez Mountains salamander, and southwestern willow flycatcher. In 2019, Mexican spotted owls were found on Laboratory property in the same nesting locations as past years. Staff found two Mexican spotted owl nests, and breeding was confirmed at both nests. Southwestern willow flycatchers were not found during surveys, but one willow flycatcher of unknown subspecies was recorded during bird banding operations.

Table 2-14. Threatened, Endangered, and Other Sensitive Species Occurring or Potentially Occurring at the Laboratory

Scientific Name	Common Name	Protected Status[1]	Potential to Occur[2]
Empidonax traillii extimus	Southwestern willow flycatcher	E	Moderate
Mustela nigripes	Black-footed ferret	E	Low
Strix occidentalis lucida	Mexican spotted owl	T	High
Coccyzus americanus	Yellow-billed cuckoo (western distinct population segment)	T, NMS	Low
Zapus hudsonius luteus	New Mexico meadow jumping mouse	E, NME	Low
Haliaeetus leucocepahlus	Bald eagle	NMT, S1	High
Cynanthus latirostris magicus	Broad-billed hummingbird	NMT	Low
Amazilia violiceps	Violet-crowned hummingbird	NMT	Low
Gila pandora	Rio Grande chub	NMS	Moderate
Plethodon neomexicanus	Jemez Mountains salamander	E, NME	High
Falco peregrinus anatum	American peregrine falcon	NMT, FSOC	High
Falco peregrinus tundrius	Arctic peregrine falcon	NMT, FSOC	Moderate
Accipiter gentiles	Northern goshawk	NMS, FSOC	High
Lanius ludovicianus	Loggerhead shrike	NMS	High
Vireo vicinior	Gray vireo	NMT	High
Myotis ciliolabrum melanorhinus	Western small-footed myotis bat	NMS	High
Myotis volans interior	Long-legged bat	NMS	High
Euderma maculatum	Spotted bat	NMT	High
Corynorhinus townsendii pallescens	Townsend's pale big-eared bat	NMS, FSOC	High
Nyctinomops macrotis	Big free-tailed bat	NMS	High
Bassariscus astutus	Ringtail	NMS	High
Vulpes vulpes	Red fox	NMS	Moderate
Ochotona princeps nigrescens	Goat peak pika	NMS, FSOC	Low
Lilium philadelphicum var. andinum	Wood lily	NME	High
Cypripedium calceolus var. pubescens	Greater yellow lady's slipper	NME	Moderate
Speyeria nokomis nitocris	New Mexico silverspot butterfly	FSOC	Moderate
Mentzelia springeri	Springer's blazing star	NMSOC, FSOC, FSS	Moderate

[1] C = Federal Candidate Species; E = Federal Endangered; FSOC = Federal Species of Concern; FSS = Forest Service Sensitive Species; NME = New Mexico Endangered; NMS = New Mexico Sensitive Taxa (informal); NMSOC = New Mexico Species of Concern; NMT = New Mexico Threatened; PE = Proposed Endangered; PT = Proposed Threatened; S1 = Heritage New Mexico: Critically Imperiled in New Mexico; T = Federal Threatened.

[2] Low = No known habitat exists at the Laboratory. Moderate = Habitat exists, though the species has not been recorded recently. High = Habitat exists, and the species occurs at the Laboratory.

Migratory Bird Treaty Act

Under the Migratory Bird Treaty Act, it is unlawful "by any means or manner to pursue, hunt, take, capture [or] kill" any migratory birds, except as permitted by regulations issued by the U.S. Fish and Wildlife Service. As part of complying with the Laboratory's Migratory Bird Treaty Act, Laboratory staff review projects for potential impacts to migratory birds, and staff carry out bird population monitoring projects. These efforts support DOE's commitment to "promote monitoring, research, and information exchange related to migratory bird conservation and program actions that may affect migratory birds . . . ," as stated in the September 12, 2013, Memorandum of Understanding between the DOE and the U.S. Fish and Wildlife Service.

In project reviews, Laboratory biologists provide specific comments for projects that have the potential to impact migratory birds, their eggs, or their nestlings. In general, projects that remove vegetation that may contain bird nests are scheduled before or after the bird nesting season. In 2019, staff did not find any projects out of compliance with migratory bird protection requirements. However, in April 2019, an active bird nest was removed from a structure by an employee. A fact-finding was held and several corrective actions were taken to ensure this does not happen again. It was reported to the U.S. Fish and Wildlife Service.

In 2019, the Laboratory continued annual breeding season and winter surveys for birds in all major habitat types and continued monitoring nest boxes for use by birds. As part of a long-term monitoring project at two open detonation sites and one open burning site, the Laboratory's point count surveys and nest box monitoring results continue to suggest that operations at these sites are not negatively affecting bird populations. In addition, biologists captured and banded birds during the breeding season in Sandia Canyon to monitor breeding bird populations, and during fall migration in Pajarito Canyon to monitor use of Laboratory lands by migrating birds. In 2019, 1,926 birds were banded at the Laboratory.

Floodplain and Wetland Executive Orders

The Laboratory complies with Executive Order 11988, *Floodplain Management*, and Executive Order 11990, *Protection of Wetlands*, by preparing floodplain and wetland assessments for projects in floodplains or near wetlands. In 2019, two floodplain assessments were prepared: one was for a fencing project in Sandia Canyon (Technical Area 72) and the other was for a fencing project in Starmer's Canyon (Technical Area 08). No violations of DOE's floodplain/wetland environmental review requirements were recorded.

Invasive Species Executive Order

Current compliance with Executive Order 13751, *Safeguarding the Nation from the Impacts of Invasive Species*, is limited to staff identifying invasive species and working with maintenance crews to treat isolated invasive plant species populations. Larger, well-established populations of some species like Siberian elm (*Ulmus pumila*), Russian olive (*Elaeagnus angustifolia*), and saltcedar (*Tamarix ramosissima*) are removed opportunistically, in conjunction with other construction projects. Currently, there is not an established program to identify, treat, and track populations of invasive plant species. However, developing an invasive species best management practices document is a mitigation requirement of the Finding of No Significant Impact for the Final Supplemental Environmental Assessment for the Wildfire Hazard Reduction and Forest Health Improvement Program at Los Alamos National Laboratory, Los Alamos, New Mexico (DOE 2019c), and the Laboratory plans to meet this requirement in 2020. The Laboratory has developed an app for electronic devices that allows users to identify and mark the locations of invasive plant species so that they can track spread and plan for future removals. A current list of invasive species known to occur at LANL is presented below in Table 2-15.

Table 2-15. List of Common Names and Latin Names of Invasive Species Known to Occur at LANL

Common Name	Latin Name
Giant leopard slug	*Limax maximus*
Eurasian collared-dove	*Streptopelia decaocto*
European starling	*Sturnus vulgaris*
Bull thistle	*Cirsium vulgare*
Canada thistle	*Cirsium arvense*
Cheatgrass	*Bromus tectorum*
Dalmatian toadflax	*Linaria dalmatica*
Field bindweed	*Convolvulus arvensis*
Jointed goatgrass	*Aegilops cylindrica*
Kochia	*Kochia scoparia*
Leafy spurge	*Euphorbia esula*
Lehmann lovegrass	*Eragrostis lehmanniana*
Mullein	*Verbascum spp.*
Myrtle spurge	*Euphorbia myrsinites*
Nodding plumeless thistle	*Carduus nutans*
Oxeye daisy	*Leucanthemum vulgare*
Puncturevine	*Tribulus terrestris*
Redtop	*Agrostis gigantea*
Rough cocklebur	*Xanthium strumarium*
Russian knapweed	*Acroptilon repens*
Russian olive	*Elaeagnus angustifolia*
Russian thistle	*Salsola kali*
Saltcedar	*Tamarix ramosissima*
Scotch cotton thistle	*Onopordum acanthium*
Siberian elm	*Ulmus pumila*
Smooth brome	*Bromus inermis*
Teasel	*Dipsacus spp.*
Tree of heaven	*Ailanthus altissima*
Whitetop	*Cardaria draba*
Yellow salsify	*Tragopogon dubius*

Federal Insecticide, Fungicide, and Rodenticide Act; New Mexico Pesticide Control Act; and National Pollutant Discharge Elimination System Pesticide General Permit

Two laws and one nationwide Clean Water Act permit regulate how the Laboratory uses and reports its use of pesticides (chemicals that destroy plant, fungal, or animal pests). The Federal Insecticide, Fungicide, and Rodenticide Act regulates the distribution, sale, and use of pesticides. The New Mexico Pesticide Control Act regulates (1) the licensing and certification of pesticide workers, (2) record keeping, (3) equipment inspection, (4) application of pesticides, and (5) storage and disposal of pesticides. The National Pollutant Discharge Elimination System Pesticide General Permit requires annual reporting of pesticide use to the U.S. Environmental Protection Agency.

In 2019, pesticide usage was reported to the U.S. Environmental Protection Agency in accordance with the National Pollutant Discharge Elimination System Pesticide General Permit. Table 2-16 shows the amounts of pesticides the Laboratory used in 2019.

Table 2-16. Pesticides used in 2019

Herbicide	Amount
Velossa	18.21 gallons
Ranger Pro Herbicide	35.19 gallons
Insecticide	**Amount**
Maxforce Complete Brand Granular Insect Bait	0.41 pounds
Summit B.T.I Briquets	0.25 briquets
Tempo SC Ultra Insecticide	0.0062 pounds
PT Wasp Freeze II and Hornet Insecticide	0.48 pounds
Vikon S	0.009 gallons
Water Treatment Chemical	**Amount**
Garratt-Callahan Formula 314-T	114 pounds
Garrett-Callahan Formula 316	6 pounds, 5 ounces
Houghton Chemical Purobrom Tablets	3,692 pounds

DOE Order 231.1B, *Environment, Safety, and Health Reporting*

DOE Order 231.1B, *Environment, Safety, and Health Reporting*, requires the timely collection and reporting of information on environmental issues that could adversely affect the health and safety of the public and the environment at DOE sites. This report fulfills DOE Order 231.1B requirements to publish an annual site environmental report.

The intent of this report is to

- characterize site environmental management performance, including effluent releases, environmental monitoring, types and quantities of radioactive materials emitted, and radiological doses to the public;
- summarize environmental occurrences and responses reported during the calendar year;
- confirm compliance with environmental standards and requirements;
- highlight significant programs and efforts, including environmental performance indicators, performance measures programs, or both; and
- summarize property clearance activities.

The Laboratory began environmental monitoring in 1945 and published the first comprehensive environmental monitoring report in 1970. Current and past reports are available at https://www.lanl.gov/environment/environmental-report.php.

Emergency Planning and Community Right-to-Know Act

The Emergency Planning and Community Right-to-Know Act requires emergency plans for more than 360 hazardous substances, if they are present at a facility in amounts above specified thresholds. Under this act, the Laboratory is required to notify state and local officials and the community about the following items: (1) changes at the Laboratory that might affect the local emergency plan or if the

Laboratory's emergency planning coordinator changes; (2) leaks, spills, and other releases of listed chemicals into the environment, if these releases exceed specified quantities; (3) the annual inventory of the quantities and locations of hazardous chemicals above specified thresholds present at the facility; and (4) total annual releases to the environment of listed chemicals that exceed specified thresholds. Table 2-17 identifies what community and emergency planning reporting the Laboratory performed in 2019.

Table 2-17. Status of Emergency Planning and Community Right-To-Know Act Reporting in 2019

Emergency Planning and Community Right-To-Know Act Section	Description of Reporting	Status (Yes, No, or Not Required)
Section 302–303	Planning notification	Not required
Section 304	Extremely hazardous substance or hazardous substance release notification	Not required
Section 311–312	Material safety data sheet/ Hazardous chemical inventory	Yes
Section 313	Toxics release inventory reporting	Yes

For Section 313 reporting, the listed chemicals that met the criteria for reporting in 2019 were lead and mercury. In 2019, the largest use of reportable lead and mercury was from offsite waste transfers. Table 2-18 summarizes the reported releases in 2019. There are no compliance violations associated with this use or release of lead or mercury.

Table 2-18. Summary of 2019 Total Annual Releases under Emergency Planning and Community Right-to-Know Act, Section 313

Reported Release	Lead (pounds)	Mercury (pounds)
Air emissions	3.7	0.86
Water discharges	0.24	0.003
Onsite land disposal (firing range)	1,845	0
Offsite waste transfers	15,901	124

DOE Order 232.2A, *Occurrence Reporting and Processing of Operations Information*

DOE Order 232.2A, *Occurrence Reporting and Processing of Operations Information*, requires reporting of abnormal events or conditions that occur during facility operations. An "occurrence" is one or more events or conditions that may adversely affect workers, the public, property, the environment, or DOE's mission. Reportable environmental occurrences at the Laboratory for 2019 are listed in Table 2-19. For some programs that provide information on a fiscal year basis in this report, occurrences that were reported during October through December of 2018 were provided in the Environmental Occurrences table in the 2018 Annual Site Environmental Report.

Table 2-19. 2019 Environmental Occurrences

Title	Description and Comments	Status
Receipt of Notice of Deficiency for Class B Violations of an Aboveground Storage Tank	At 0800 on Thursday, May 2, 2019, Triad received a Notice of Deficiency from the New Mexico Environment Department Petroleum Storage Tank Bureau for Class B compliance violations of the Technical Area 03, Building 2459 Aboveground Storage Tank. Specifically, the Notice of Deficiency cited violations of the New Mexico Administrative Code for failure to replace degraded piping and to install an anti-siphon valve on the tank. Per the Notice of Deficiency, LANL must correct the violations within 30 days of the notice to avoid issuance of a Notice of Intent to Red Tag the tank by the New Mexico Environment Department. In response, LANL initiated an expedited procurement of a certified aboveground storage tank installer to correct the violations. The tank remains fully operational. Absorbent pads were affixed to the piping to reduce the potential release of diesel oil until repairs could be completed. There has been no identified impact to soil, surface water, or groundwater.	Closed
Receipt of Notice of Violation with Proposed Civil Penalties for Violations of LANL's Hazardous Waste Operating Permit	On Wednesday, August 21, 2019, the Triad Utilities & Institutional Facilities Facility Operations Director designee received a Notice of Violation from the New Mexico Environmental Department for 11 alleged violations of the New Mexico Hazardous Waste Permit Regulations and LANL's Hazardous Waste Operating Permit. Specifically, the Notice of Violation cited violations for Triad's alleged failure to properly store, characterize, label, and maintain record keeping of hazardous waste. The New Mexico Environment Department proposed to assess civil penalties to settle the alleged violations.	Closed
Dump Truck Leaks Hydraulic Fluid During Operations at Technical Area 55	At 0910, on Wednesday, June 5, 2019, a Triad Roads and Grounds worker was operating a dump truck at Technical Area 55 near building 314 when the filter on the dump truck's hydraulic system failed, releasing approximately 30 gallons of hydraulic fluid onto a graveled surface. When the operator noticed the leaking hydraulic fluid, he immediately paused work, turned off the engine, and began spill response procedures. The operator set up a barricade around the leaked fluid, deployed a spill kit, and contacted the project superintendent. The project superintendent notified the Operations Center and Environment, Safety, and Health personnel. A team was immediately deployed to begin excavating the contaminated soil under an active emergency excavation permit. Approximately 230 cubic feet of contaminated soil was removed and placed into sealed containers. The containers were turned over to a Waste Management Coordinator for proper disposal, and the site was covered and secured for follow-up soil sampling. Work in the area remained paused until confirmatory soil samples could be taken. There was no impact to the health and safety of workers.	Closed

Title	Description and Comments	Status
Technical Area 54 Technical Safety Requirement Violation; Training Deficiency Identified with the List of Qualified Individuals at Technical Area 54	On November 26, 2018, the N3B Technical Area 54 Facility Operations Manager was notified of a training deficiency. The List of Qualified Individuals did not capture the periodic lockout/tagout training requirement. All Shift Operations Supervisors, Operations Center Operators, and Nuclear Operators fell out of qualification when the training expired on November 26. This was not recognized until November 26, 2018, when training personnel were performing an internal audit of training records. Because the operations center staff fell out of qualification, minimum staffing requirements per the Technical Area 54 Area G Technical Safety Requirements could not be met. Immediate actions taken by Facility Operations paused all work and placed the facility into warm standby. A shift order was published; this order prohibited work that required lockout/tagout and lockout/tagout refresher training for all operations staff. This training was scheduled for the next day.	Closed
Receipt of Notice of Violation with proposed civil penalties from New Mexico Environment Department	On August 21, 2019, the N3B Technical Area 54 Facility Operations Director was notified of a Notice of Violation by letter from the New Mexico Environment Department. The New Mexico Environment Department conducted a hazardous waste Compliance Evaluation Inspection during the week of April 29, 2019, and determined that LANL violated the New Mexico Hazardous Waste Management Regulations or LANL's Hazardous Waste Operating Permit. The notice of violation cited 16 violations that require LANL to provide a written description of the actions taken to address the violations. Five of the 16 cited violations are the responsibility of N3B, and the rest of the violations are the responsibility of Triad. Additionally, the New Mexico Environment Department issued a Notice of Proposed Penalty letter related to the notice of violation, with proposed civil penalties to settle the violations.	Closed

DOE Order 436.1, *Departmental Sustainability*

The purpose of this DOE order is to ensure that the DOE carries out its missions in a sustainable manner that addresses national energy security and global environmental challenges. As directed by this order, the Laboratory had adopted an Environmental Management System and prepares and implements an annual Site Sustainability Plan. We discuss LANL's Environmental Management System and its Site Sustainability Plan in detail in Chapter 3.

INSPECTIONS AND AUDITS

Table 2-20 lists the environmental inspections conducted by regulating agencies and external auditors at the Laboratory during 2019.

Table 2-20. Environmental Inspections and Audits Conducted at the Laboratory during 2019

Date	Purpose	Performing Entity
5/20–24/2019 and 12/2–4/2019	Environmental Management System Surveillance Audit, covering clauses of the ISO 14001:2015 standard	NSF International
1/15/2019, 3/26/2019, and 7/23/2019	Petroleum storage tank inspections	New Mexico Environment Department
5/21/2019–5/23/2019	Carlsbad Field Office Annual Recertification	Environmental Protection Agency, Carlsbad Field Office
10/21/2019–10/24/2019	Enterprise Assessments	DOE Headquarters/ Office of Enterprise Assessments
9/12/19	Waste Control Specialists Annual Recertification Audit	Waste Control Specialists
4/29/2019–5/2/2019	Annual Audit and Resource Conservation and Recovery Act Permit Site Inspections	New Mexico Environment Department – Hazardous Waste Bureau
1/28/2019–1/31/2019	Generator Site Technical Review	Carlsbad Field Office and Nuclear Waste Partnership

UNPLANNED RELEASES

Air Releases

In 2019, there were no unplanned air releases.

Liquid Releases

In 2019, Triad made 20 reports of unplanned liquid releases to the New Mexico Environment Department as required by the New Mexico Water Quality Control Commission regulations (Table 2-21). Corrective actions were taken for all liquid releases; all corrective actions were communicated to the New Mexico Environment Department.

One unplanned release of treated effluent occurred at the TA-50 Radioactive Liquid Waste Treatment Facility on Laboratory property. Approximately two gallons of treated effluent leaked from a faulty valve; the effluent was contained on a concrete pad located at the facility. The release occurred during a discharge to NPDES Outfall 051; the water met NPDES permit discharge limits and DP-1132 effluent levels for Outfall 051.

Table 2-21. 2019 Unplanned Reportable Releases

Material Released	Number of Instances	Approximate Total Release (Gallons)
Potable Water	8	289,935
Sanitary Waste Water	3	5,175
Treated Sanitary Effluent	1	500
Potable Water Comingled with Coolant/Cutting Oil	1	500
Hydraulic Fluid	5	97
Concrete Washout Water	1	20
Treated Effluent from Radioactive Liquid Waste Treatment Facility	1	2

SITE RESILIENCE

Updated in 2018, the National Climate Assessment explains what current and future climate change is likely to mean for the United States (Gonzalez et al. 2018). Predictions are made for temperature, precipitation (including snowpack), and wildland fires. DOE Order 436.1, *Departmental Sustainability*, directs the Laboratory to determine how its facilities and operations can mitigate risks associated with climatic factors, such as increasing temperatures and increasing wildland fire risk, and to identify the types of facilities/operations that could be impacted.

In 2015, LANL began tracking climatic risk indices related to temperature, precipitation, wind, indicator species, and storm water flow. These indices will assist the Laboratory in identifying when actions are necessary to protect facilities and operations. Below are the results of indices available in 2019.

Temperature

Temperature data have been collected in Los Alamos since 1910. Long-term trends in annual average temperatures are reported in the Meteorological Monitoring section of Chapter 4 and are shown in Figure 2-2. The temperatures between 1960 and 2000 had no trend. The years 2001–2010 were approximately 1.5 degrees Fahrenheit (°F) warmer than the previous 40 years, and the years 2011–2018 were approximately 3 °F warmer than the 1960–2000 averages. When average temperatures are broken down into summer and winter minimums and maximums, the summer minimum temperatures (graphed in Figure 2-3) demonstrate the strongest increasing trend from 1990 onward (an increase of approximately 4 °F).

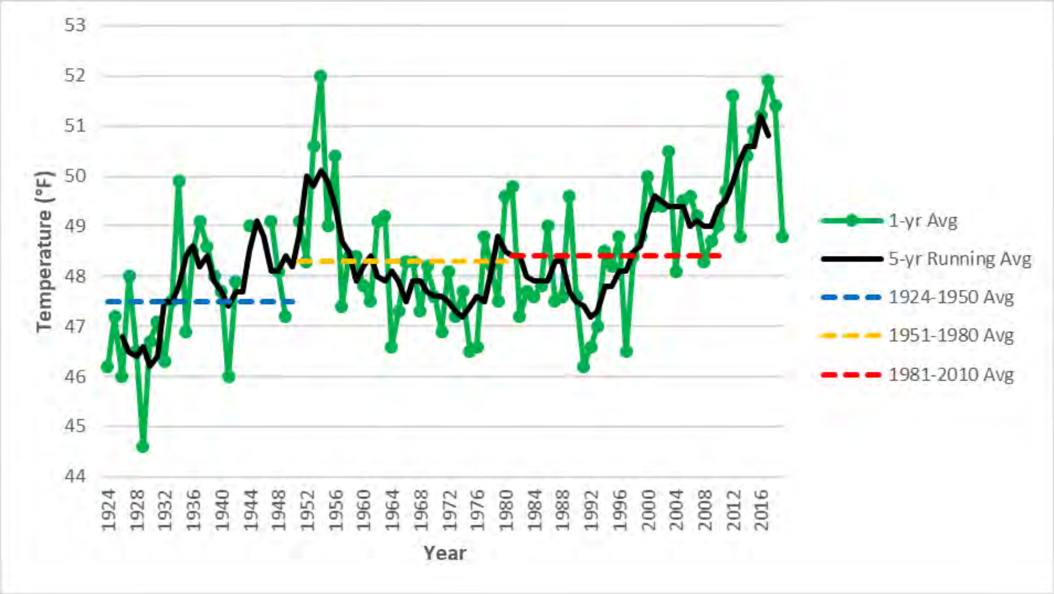


Figure 2-2. Annual average temperatures for Los Alamos. The dashed lines represent long-term climatological average temperatures, the black line represents the 5-year running average temperature, and the green line represents the 1-year average.

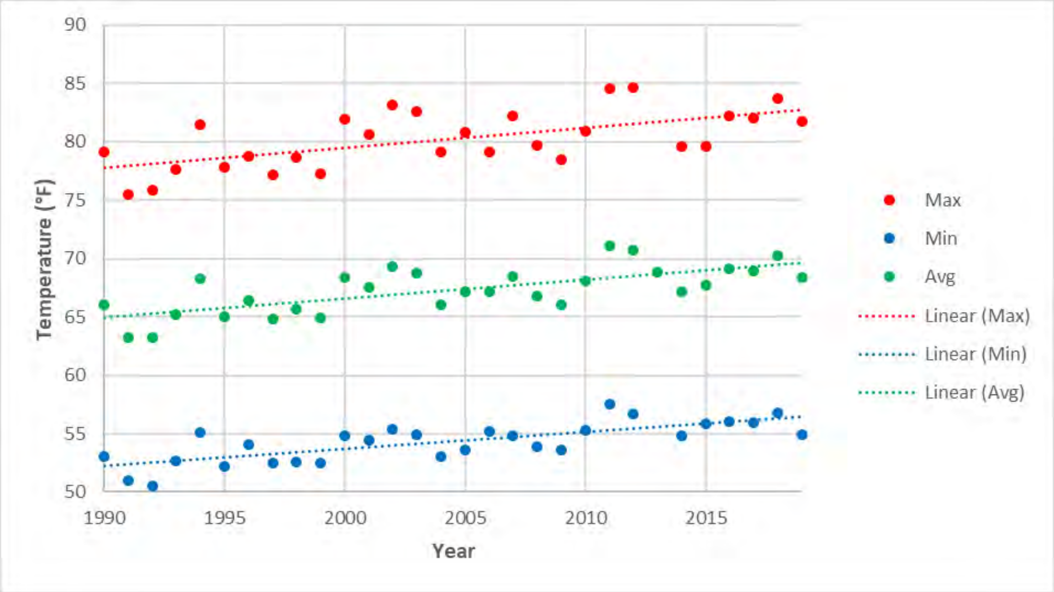


Figure 2-3. Average summer (June, July, August) Los Alamos temperatures. The dashed lines represent the trend line for maximum, minimum, and average summer temperatures, which show that summer temperatures have been continuously increasing since 1990.

Similar to the annual average temperature, heating and cooling degree days did not exhibit any trend during 1950–1990. Since 1990, cooling degree days (Figure 2-4) have increased and heating degree days (Figure 2-5) have decreased. Thus, less energy has been needed to heat buildings, but more energy has been needed to cool buildings.

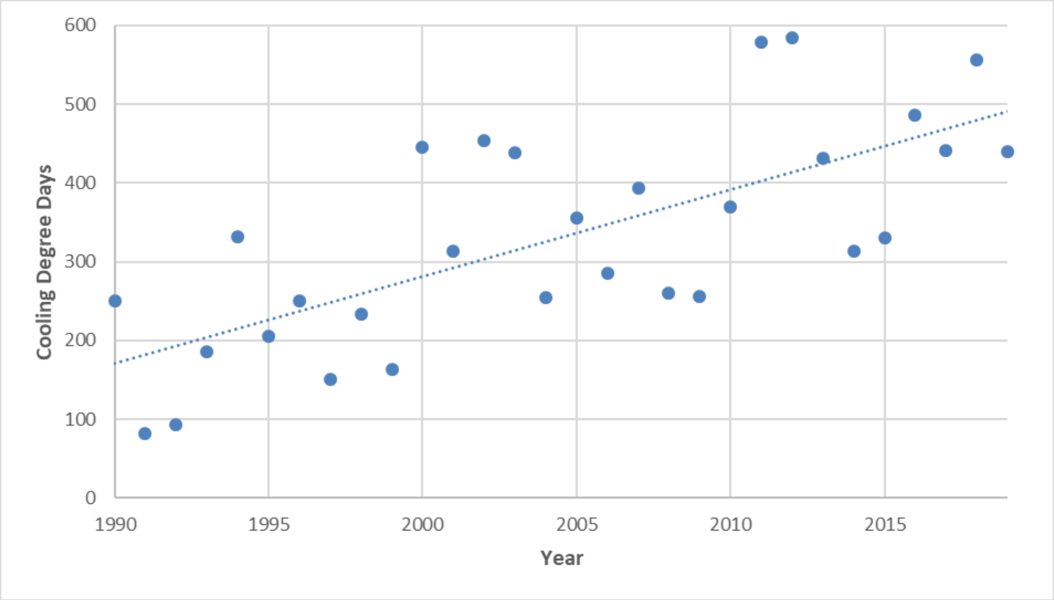


Figure 2-4. Los Alamos cooling degree days per year. The dashed line represents the trend line for cooling degree days, which shows cooling degree days have increased, resulting in more energy needed to cool buildings.

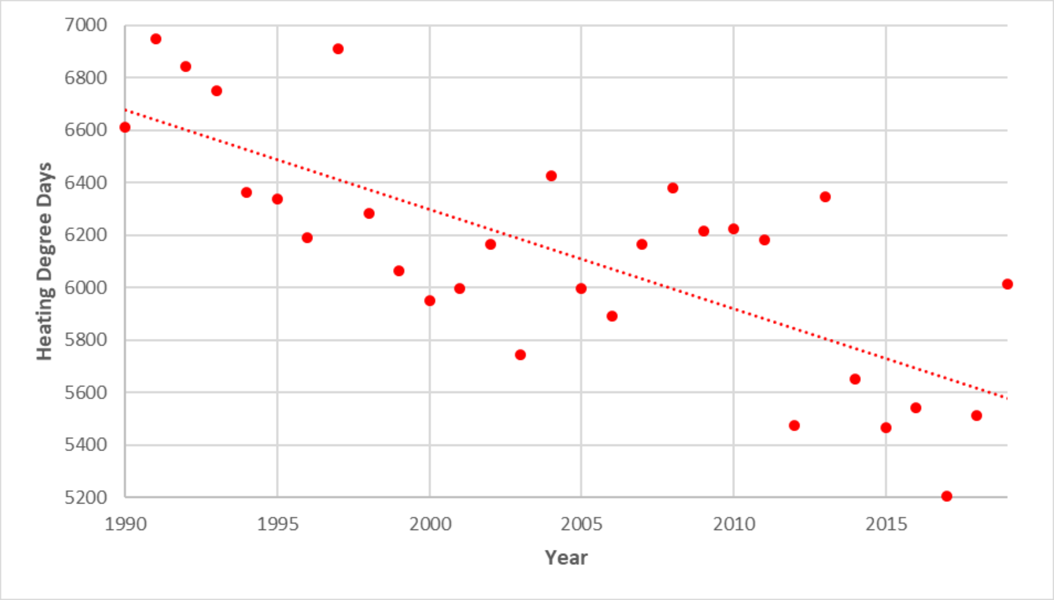
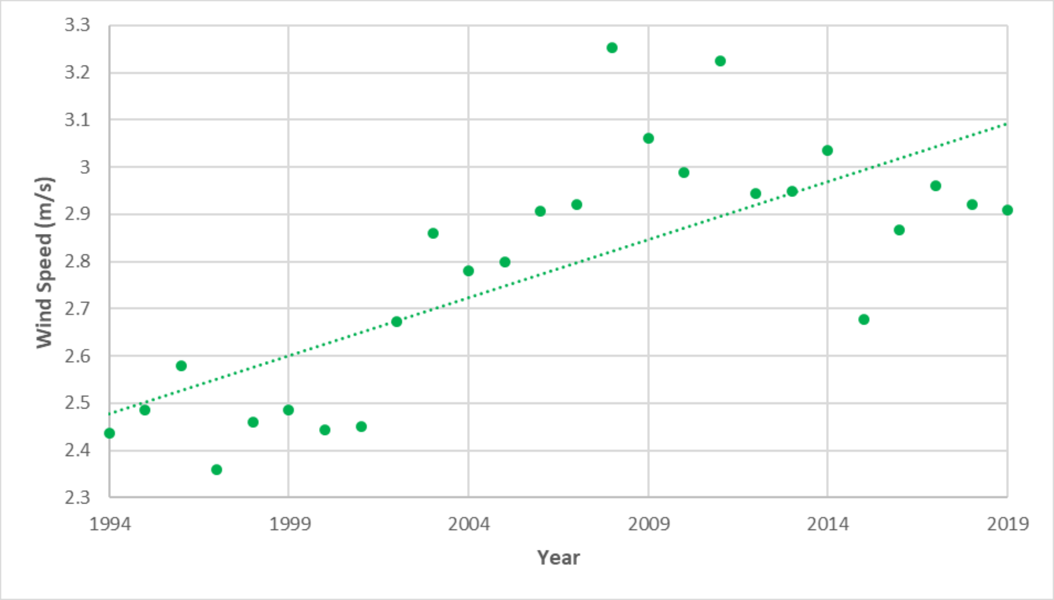


Figure 2-5. Los Alamos heating degree days. The dashed line represents the trend line for heating degree days, which shows that heating degree days have decreased, resulting in less energy needed to heat buildings.

Wind Speed

The annual average wind speed measured at the Laboratory's meteorological tower of record at Technical Area 06 has increased approximately 20 percent over the past 25 years (Figure 2-6). Although not shown here, the monthly average wind speed during spring months (windiest months) shows an increase by approximately 1 meter per second. Winds are produced by low- and high-pressure weather systems that move across New Mexico. Near the ground's surface, wind speeds are also influenced by the type of vegetation present (for example, forests versus grasslands). The Laboratory's current hypothesis is that the extensive loss of trees in the local area caused by wildfires, drought, and bark beetle infestations has led to a decrease in the amount of wind resistance provided by trees, allowing wind speeds near the surface to increase. There is no trend in the annual peak gusts recorded at Technical Area 06 since 1990 (Kelly et al. 2015).



Note: m/s = meters per second.

Figure 2-6. Technical Area 06 annual average wind speed at 12 meters above the ground. The dashed line represents the trend line for wind speed, which shows the annual average wind speed has been increasing since 1994.

Annual Red Flag Warnings

The National Weather Service issues Red Flag Warnings when critical weather conditions may result in extreme fire behavior. The National Weather Service began recording the number of Red Flag Warnings per year for the Los Alamos area in 2012 (Figure 2-7). Red Flag Warnings have increased over the past 4 years, but since 2012, there has not been a trend. Some Laboratory operations, including explosives testing, are restricted on days when the National Weather Service issues Red Flag Warnings.

If the following weather conditions occur simultaneously for 3 or more hours, a Red Flag Warning can be issued.

- Sustained winds at or above 20 miles per hour
- Relative humidity less than 15 percent
- Above-average temperatures

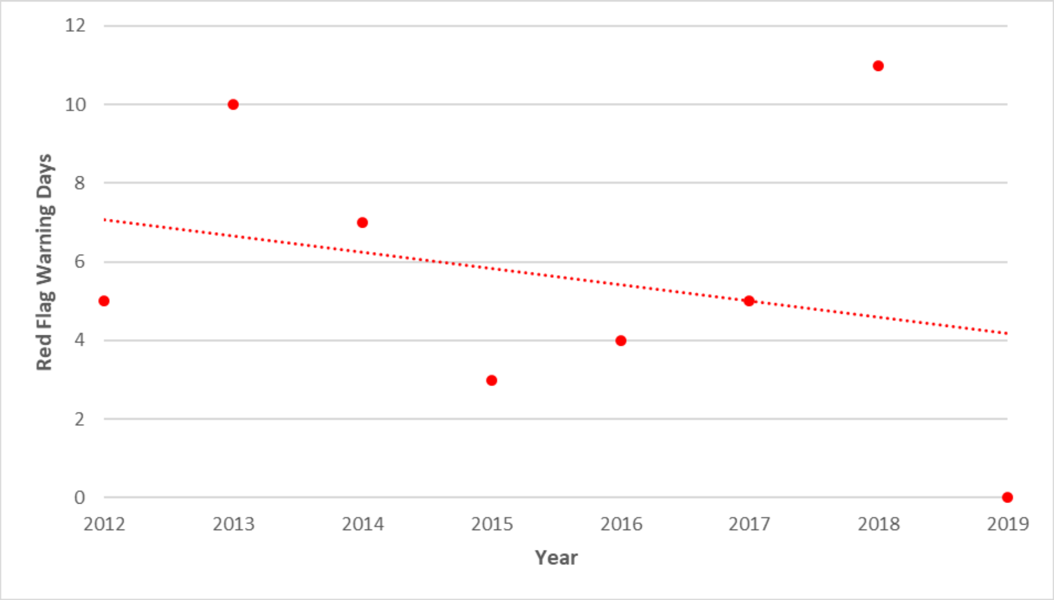


Figure 2-7. Number of National Weather Service Red Flag Warning days for zone 102 (Los Alamos). Since 2015, there has been an increase in the number of red flag days, but overall there has not been a trend.

Precipitation

The Laboratory analyzed the annual average precipitation (Figure 2-8) and the number of days per year with heavy rain events (Figure 2-9). From 1924 through 2010, the annual average precipitation was 18 inches, with a standard deviation of 4.4 inches. A long-term drought began in 1998, with precipitation under 15 inches between 2000 and 2003 and again in 2011 and 2012. Annual precipitation values were as low as 10 inches in 2003 and 2012.

The frequency of heavy rain events (Figure 2-9), defined as precipitation greater than 0.5 inches in one day, does not demonstrate a significant long-term trend since 1950. Although not shown here, there is also no trend in the heaviest events (precipitation greater than 0.75 inches or greater than 1.0 inch per day) in the past 50 years.

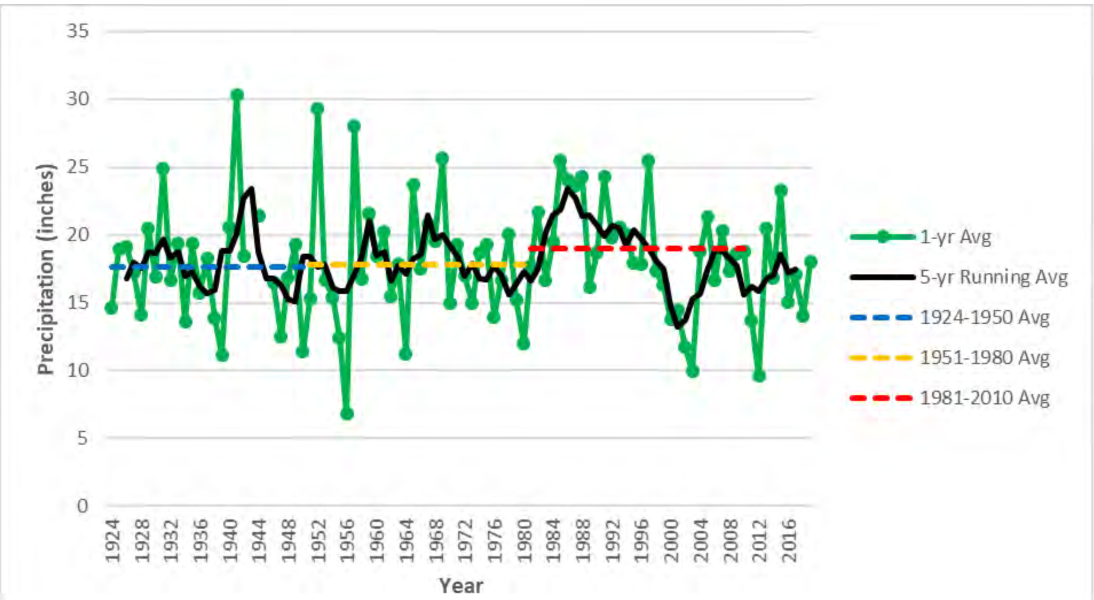


Figure 2-8. Annual precipitation totals for Los Alamos. The dashed lines represent long-term climatological average total precipitation, the black line represents the 5-year running average precipitation, and the green line represents the 1-year total precipitation. Significant drought since the 1990s has resulted in below-average precipitation in many recent years.

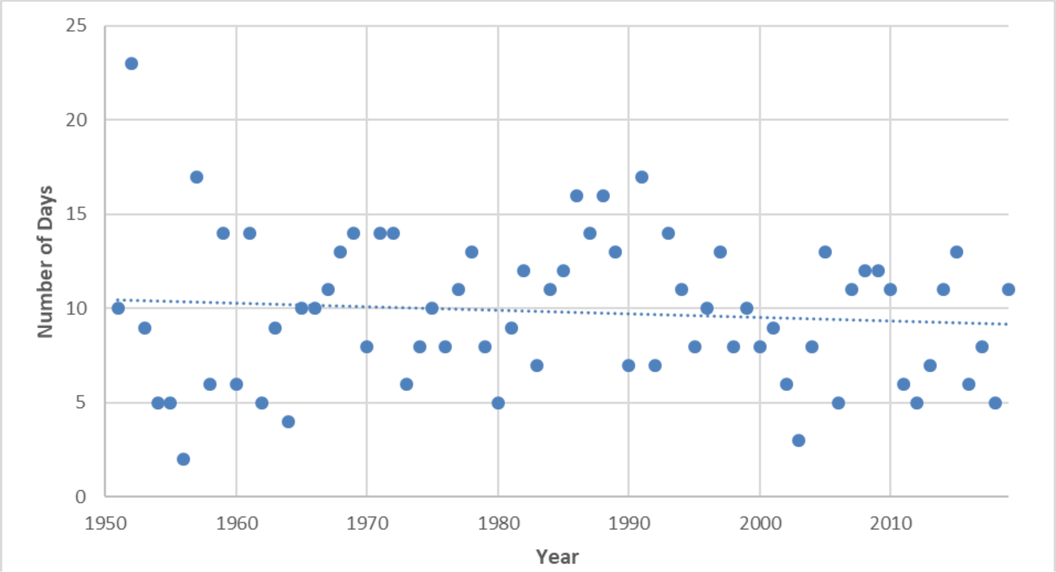


Figure 2-9. Number of days per year with precipitation greater than 0.5 inches. The dashed line represents the trend line for days with precipitation greater than 0.5 inches. The slight decreasing trend since 1950 is not statistically significant.

Annual average snowfall (Figure 2-10) demonstrates a decrease in the long-term trend since 1950. Since the drought began in 1998, there have been only three years with above-average recorded snowfall (1981–2010 average = 57 inches).

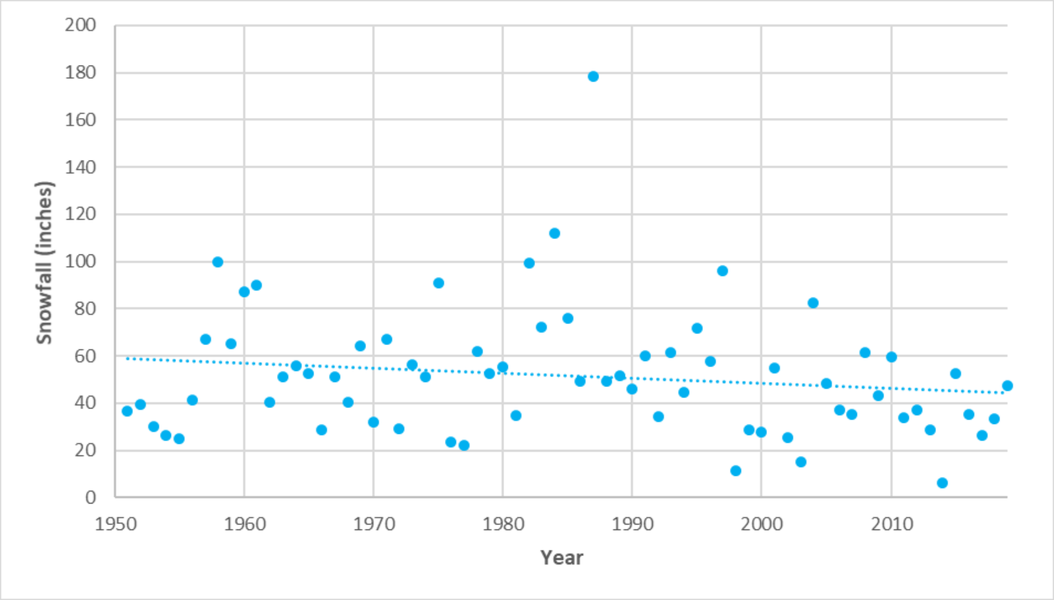


Figure 2-10. Annual average snowfall in Los Alamos. The dashed line represents the trend line for snowfall, which shows a decrease in annual snowfall.

Climatic Summary

Average temperatures in Los Alamos have increased over the past 15 to 25 years, consistent with predictions from the National Climate Assessment for the southwestern United States. The annual average temperatures for the southwest are predicted to rise by 3.7 °F–4.8 °F by 2036–2065, and the temperatures measured at Los Alamos are consistent with these predictions. Increases in cooling degree days and reductions in heating degree days will produce increased summer air-conditioning costs and reduced winter heating costs.

Although predictions of changes in precipitation are less certain than temperature predictions, the National Climate Assessment predicts decreasing winter and spring precipitation in the southwest. The Laboratory's data are consistent with these predictions, in particular over the last 22 years, with below-average snowfall in 86 percent of the years. The National Climate Assessment does not make a specific prediction for the southwest for heavy precipitation events. The Laboratory's data do not show a trend in heavy precipitation events in Los Alamos.

The National Climate Assessment predicts increasing wildland fires in the southwest as a result of warming, drought, and insect outbreaks. Two major wildland fires have impacted the Laboratory in the past 20 years: the 2000 Cerro Grande fire and the 2011 Las Conchas fire. Precursors to these fires included warm, dry years, and local bark beetle infestations (LANL 2012). The Los Alamos data are consistent with predictions of increasing wildland fires. The annual average wind speed has been increasing, likely related to the reduction in forest cover caused by tree mortality. Increases in average wind speeds affect emergency planning in the event of an aerial release of hazardous substances.

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SUMMARY OF PERMITS AND LEGAL ORDERS

Table 2-22 presents the environmental permits and legal orders under which the Laboratory operated in 2019.

Table 2-22. Environmental Permits and Legal Orders under which the Laboratory Operated in 2019

Name	Activity	Issuing and Revision Dates	Expiration Date	Administering Agency
Los Alamos National Laboratory Hazardous Waste Facility Permit	A permit regulating management of hazardous wastes at the Laboratory, including storage and treatment. This permit also has standards for closure of indoor and outdoor areas used for hazardous waste storage or treatment. https://www.env.nm.gov/hazardous-waste/lanl-permit/	Renewed November 2010	December 2020	New Mexico Environment Department
Administrative Compliance Order No. HWB-14-20	An order issued for violations of the Hazardous Waste Act and the Laboratory's Hazardous Waste Facility Permit associated with the Waste Isolation Pilot Plant drum breach. As part of the settlement, DOE is funding a series of projects, including road improvements on transport routes to the Waste Isolation Pilot Plant. https://www.energy.gov/sites/prod/files/2015/01/f19/LANL%20ACO%20120614.pdf	• Issued December 6, 2014 • Settlement Agreement and Stipulated Final Order issued on January 22, 2016	None	New Mexico Environment Department
Compliance Order on Consent	An order giving requirements to investigate, perform corrective actions, and monitor solid waste management units and areas of concern. https://www.env.nm.gov/wp-content/uploads/2016/05/Consent-Order-modified-Feb-2017.pdf	• Issued March 1, 2005 • Revised October 29, 2012 • Replaced by 2016 Compliance Order on Consent on June 24, 2016 • 2016 Compliance Order on Consent modified February 2017	None	New Mexico Environment Department

Name	Activity	Issuing and Revision Dates	Expiration Date	Administering Agency
Federal Facilities Compliance Order [for Mixed Wastes]	An order requiring the Laboratory to submit an annual update to its Site Treatment Plan for treating all of its mixed hazardous and radiological wastes (mixed waste). https://www.env.nm.gov/wp-content/uploads/sites/12/2019/10/LANL_10-4-1995_FFCO.pdf and https://www.env.nm.gov/wp-content/uploads/sites/12/2019/10/LANL_FFCO_5-20-1997_Ammendment.pdf	• Issued October 4, 1995 • Amended May 20, 1997	None	New Mexico Environment Department
Authorization to Discharge [from Outfalls] Under the National Pollutant Discharge Elimination System	A permit authorizing the Laboratory to discharge industrial and sanitary liquid effluents through outfalls under specific conditions, including water quality requirements and monitoring requirements. http://permalink.lanl.gov/object/tr?what=info:lanl-repo/lareport/LA-UR-15-23948	• Issued August 12, 2014 • Effective October 1, 2014 • Modified May 1, 2015 • Permit Reapplication Submitted March 26, 2019 • Administratively Continued • October 22, 2019	September 30, 2019 [administratively continued until new permit becomes effective]	U.S. Environmental Protection Agency
National Pollutant Discharge Elimination System Pesticide General Permit	A permit authorizing the discharge of pesticides at the Laboratory that have potential to enter waters in the United States. https://www.regulations.gov/document?D=EPA-HQ-OW-2015-0499-0118	• Issued October 31, 2011 • Reissued October 31, 2016	October 31, 2021	U.S. Environmental Protection Agency
Clean Air Act, Title V Operating Permit	A permit regulating air emissions from Laboratory operations (for example, emissions from the power plant, asphalt batch plant, and permanent generators). These emissions are subject to operating, monitoring, and recordkeeping requirements. https://cswab.org/wp-content/uploads/2017/04/Los-Alamos-Final-P100R2-Title-V-permit-2015.pdf	• Issued August 7, 2009 • Reissued October 17, 2018	February 27, 2020	New Mexico Environment Department

Name	Activity	Issuing and Revision Dates	Expiration Date	Administering Agency
New Mexico Air Quality Control Act Construction Permits	Permits regulating construction or modification of air emissions sources, including the following:			New Mexico Environment Department
	• Technical Area 03 power plant Permit modification 2 (NSR 2195-B-M2)	• Issued September 27, 2000 • Reissued November 1, 2011	None	
	• Asphalt plant at Technical Area 60 Permit revision 1 (GCP3-2195-G)	• Issued October 29, 2002 • Reissued September 12, 2006	None	
	• 1600-kilowatt generator at Technical Area 33 Permit revision 4 (NSR 2195-F R4)	• Issued October 10, 2002 • Reissued December 12, 2013	None	
	• Two 20-kilowatt generators and one 225-kilowatt generator at Technical Area 33 (NSR 2195-P)	Issued August 8, 2007	None	
	• Data disintegrator (NSR 2195-H R1)	• Issued October 22, 2003 • Revised June 14, 2006	None	
	• Chemistry and Metallurgy Research Replacement facility, Radiological Laboratory/Utility/Office Building Permit revision 2 (NSR 2195-N)	• Issued September 16, 2005 • Reissued September 25, 2012	None	
	• LANL exemption notifications–rock crusher removed (NSR 2195)	Issued June 16, 1999	None	
	• Technical Area 35, building 213, beryllium machining (NSR 632 R1)	• Issued December 26, 1985 • Revised June 14, 2006	None	
	• Technical Area 03, building 141, beryllium technology facility (NSR 634 M2R1)	• Issued October 30, 1986 • Revised June 14, 2006	None	
	• Technical Area 55 beryllium machining (NSR 1081 M1R7)	• Issued July 1, 1994 • Revised June 14, 2006	None	

Name	Activity	Issuing and Revision Dates	Expiration Date	Administering Agency
Clean Water Act, Section 404/401 Permits	The U.S. Army Corps of Engineers authorizes certain work within watercourses at the Laboratory under Clean Water Act Section 404 permits. The projects below were authorized to operate under a Section 404 nationwide permit with Section 401 certification.	Effective March 19, 2017 (all current nationwide Section 404 permits); a previous version was in effect until March 18, 2017.	March 18, 2022 (all current nationwide Section 404 permits)	U.S. Army Corps of Engineers and New Mexico Environment Department (all permits and verifications)
	• Mid–Mortandad Supplemental Environmental Project • Upper Cañon de Valle Supplemental Environmental Project	• Permit verification received March 27, 2018; completion of project is pending. • Permit verification received March 21, 2018; project completed on April 30, 2019.		
Clean Water Act, Section 404/401 Permits (cont.)	The following projects had an ongoing annual monitoring requirement: • Sandia Canyon, Technical Area 72 firing site storm water controls • Water Canyon storm drain reconstruction project • Mortandad Wetlands Enhancement	• Annual monitoring and reporting required through 2019 • Annual monitoring and reporting required through 2021 • Annual monitoring and reporting required through 2022		
National Pollutant Discharge Elimination System General Permit for Discharges from Construction Activities	A general permit (not LANL-specific) authorizing the discharge of pollutants during construction activities under specific conditions. Conditions include water quality requirements, inspection requirements, erosion and sediment controls, notices of intent to discharge, preparation of storm water pollution prevention plans, and other conditions. (https://www.epa.gov/sites/production/files/2016-09/documents/cgp2012_finalpermitpart1-9-updatedurl.pdf)	Effective February 16, 2017	February 16, 2022	U.S. Environmental Protection Agency

Name	Activity	Issuing and Revision Dates	Expiration Date	Administering Agency
National Pollutant Discharge Elimination System Multi-Sector General Permit for Storm Water Discharges Associated with Industrial Activity	A general permit (not LANL-specific) authorizing facilities with some industrial activities to discharge storm water and some non-storm water runoff. The permit provides specific conditions for the authorization, including pollutant limits to meet water quality standards, inspection requirements, compliance with biological and cultural resource protection laws, and other conditions. (http://www.epa.gov/sites/production/files/2015-10/documents/msgp2015_finalpermit.pdf)	Effective June 4, 2015	June 4, 2020	U.S. Environmental Protection Agency
[Individual Permit] Authorization to Discharge [from Solid Waste Management Units and Areas of Concern] Under the National Pollutant Discharge Elimination System	A permit authorizing the Laboratory to discharge storm water from 405 Solid Waste Management Units and Areas of Concern under specific conditions. Conditions include requirements for monitoring and for corrective actions where necessary to minimize pollutants in the storm water discharges. (https://www.env.nm.gov/swqb/documents/swqbdocs/NPDES/Permits/NM0030759-LANLStormwater.pdf)	Issued November 1, 2010	• October 31, 2015 • Application for renewal submitted to the U.S. Environmental Protection Agency in 2019 • Administratively extended by the U.S. Environmental Protection Agency, pending issuance of new permit	U.S. Environmental Protection Agency
The United States Energy Independence and Security Act of 2007, Section 438	The sponsor of any development or redevelopment project involving a federal facility with a footprint that exceeds 5,000 square feet shall use site planning, design, construction, and maintenance strategies for the property to maintain or restore, to the maximum extent technically feasible, the predevelopment hydrology of the property with regard to temperature, rate, volume, and flow duration.	Issued December 19, 2007	None	U.S. Environmental Protection Agency

Name	Activity	Issuing and Revision Dates	Expiration Date	Administering Agency
Groundwater Discharge Permit DP-857	A permit authorizing discharges to groundwater from the Laboratory's sanitary waste water system plant and the Sanitary Effluent Reclamation Facility.	Issued December 16, 2016	December 16, 2021	New Mexico Environment Department
Groundwater Discharge Permit DP-1589	A permit authorizing discharges to groundwater from the Laboratory's eight septic tank/disposal systems.	Issued July 22, 2016	July 22, 2021	New Mexico Environment Department
Groundwater Discharge Permit DP-1793	A permit authorizing discharges to groundwater from the Laboratory's land application of treated groundwater.	Issued July 27, 2015	July 27, 2020 Transferred to N3B on April 30, 2018	New Mexico Environment Department
Groundwater Discharge Permit DP-1835	A permit authorizing discharges to groundwater from the Laboratory's injection of treated groundwater into six Class V underground injection control wells.	Issued August 31, 2016	December 1, 2021 Transferred to N3B on April 30, 2018	New Mexico Environment Department
Groundwater Discharge Permit DP-1132	A permit authorizing discharges to groundwater from the Laboratory's Radioactive Liquid Waste Treatment Facility to three discharge locations: Outfall 051, mechanical evaporator system, or solar evaporation tank system.	Pending. Discharges occurring under Temporary Permission authorized by New Mexico Environment Department.	Pending	New Mexico Environment Department

QUALITY ASSURANCE

Waste Management

Triad's program for waste management, including quality assurance, is described in the institutional procedure P409*, LANL Waste Management*, and flow-down documents.

Air Quality and Protection

Air quality compliance activities are performed in accordance with the procedures and processes described in EPC-CP-QAP-001, *Environmental Compliance Programs Quality Assurance Plan*; EPC-CP-QAP-901, *EPC-CP Quality Procedure to Supplement ADESH-0007, Document Control;* and a series of Program Implementation Plans (PIPs):

- EPC-CP-PIP-0101, *Rad-NESHAP Compliance Program*
- EPC-CP-PIP-0340, *Title V Operating Permit Program*
- EPC-CP-PIP-0301, *Greenhouse Gas Monitoring and Emissions Reporting*
- EPC-CP-PIP-0310, *Air Quality Refrigerants*
- EPC-CP-PIP-0320, *Emergency Planning and Community Right-to Know Act (EPCRA) Section 313 Reporting*
- EPC-CP-PIP-0330, *Air Quality Regulatory Review and Permitting*
- EPC-CP-PIP-0370, *Asbestos NESHAP Compliance*
- EPC-CP-PIP-0380, *Beryllium NESHAP Compliance*

These documents ensure that compliance activities are planned, performed, and documented using approved procedures, data quality objectives, and integrated work processes. More than 20 detailed Quality Procedures (QPs) are in place that flow down from these Program Implementation Plans.

Air Quality Compliance team members conduct semi-annual internal inspections of all permitted sources using detailed checklists to ensure all permit requirements are met. Additionally, the New Mexico Environmental Department Air Quality Bureau conducts annual external inspections of LANL's compliance with their Title V Operating Permit.

Analytical data are used to generate various compliance monitoring reports and deliverables submitted to regulatory agencies, as required by the permit. Each report is subjected to a quality peer review before submission to ensure data are correct and representative, and meet the established data quality objectives. All reports submitted to regulatory agencies are maintained as quality records in accordance with the permit and ADESH-QP-006, *Records Management Plan*.

Refrigerant program personnel also conduct internal semi-annual audits to ensure that refrigerant used in service, maintenance, repair, and disposal activities on refrigeration equipment is accounted for, thereby ensuring compliance with the no-venting prohibition under federal regulations.

Members of the Radioactive Air Emissions Management team conduct stack sampling and monitoring activities, sampler inspections, flow measurements, and data analyses to meet regulatory requirements. All activities are conducted per procedure and with peer review. Representatives of the U.S. EPA Region 6 periodically visit the site to evaluate operations. Analytical data calculations and compliance reports for the Radioactive Air Emissions Management team are subject to reviews similar to those described for the Air Quality Compliance program.

Surface Water Quality and Protection

Triad surface water compliance activities are performed in accordance with the procedures and processes described in EPC-CP-QAP-001, *Environmental Compliance Programs Quality Assurance Plan*; EPC-CP-QAP-901, *EPC-CP Quality Procedure to Supplement ADESH-0007*; and EPC-CP-QAPP-NPDES IPSP, *Quality Assurance Project Plan for the National Pollutant Discharge Elimination System Industrial Point Source Permit Self-Monitoring Program*. These documents ensure that compliance activities are planned, performed, and documented using approved procedures, data quality objectives, monthly/quarterly/yearly sampling plans, and integrated work processes. In 2019, the following procedures were used to collect samples, prepare discharge monitoring reports, and prepare reapplications surveys:

- ENV-DO-QP-100, *General Field Safety*
- ENV-RCRA-QP-037, *Performing National Pollutant Discharge Elimination System Reapplication Surveys*
- EPC-CP-QP-005, *Sampling at National Pollutant Discharge Elimination System Permitted Point Source Outfalls*
- EPC-CP-QP-060, *Preparing Discharge Monitoring Reports for the National Pollutant Discharge Elimination System Industrial Point Source Permit Self-Monitoring Program*

Surface water compliance samples are collected and the associated data are analyzed using established data quality objectives that define the appropriate type of data to collect and establish guidelines for the acceptance and use of the analytical data to make decisions regarding the compliance at each outfall. These data quality objectives are developed in accordance with U.S. Environmental Protection Agency QA/G-4, *Guidance for the Data Quality Objectives Process*.

In 2019, the following procedures were used to collect samples and prepare reports for the Triad Construction General Permit and the Multi-Sector General Permit programs:

National Pollutant Discharge Elimination System Construction General Permit:

- ENV-RCRA-QAPP-NPDES CGP, *Quality Assurance Project Plan for the NPDES Construction General Permit Program*
- EPC-CP-QP-2002, *Performing CGP Stormwater Inspections*
- EPC-CP-TP-2003, *CGP Rain Gage Operation and Maintenance*

National Pollutant Discharge Elimination System Multi-Sector General Permit:

- ENV-CP-QAPP-MSGP, *Quality Assurance Project Plan for Stormwater Multi-Sector General Permit for Industrial Activities Program*
- EPC-CP-TP-2102, *Installing, Setting Up, and Operating ISCO Samplers*
- EPC-CP-TP-2103, *Inspecting Stormwater Runoff Samplers and Retrieving Samples for the MSGP*
- EPC-CP-QP-027, *Installing, Inspecting, and Maintaining MSGP Single Stage Samplers*
- EPC-CP-QP-064, *MSGP Stormwater Visual Assessments*
- EPC-CP-QP-2106, *Processing MSGP Stormwater Samples*
- ENV-CP-QP-044, *Preparing Stormwater Discharge Monitoring Reports for the NPDES Multi-Sector General Permit*
- EPC-CP-QP-023, *MSGP Routine Facility Inspections*
- EPC-CP-QP-022, *MSGP Corrective Actions*

- EPC-CP-QP-2110, *MSGP Stormwater Pollution Prevention Plan Preparation and Maintenance* (new procedure draft is in progress)

In 2019, N3B used the following procedures to collect samples and prepare reports for surface water monitoring under the Individual Permit, Multi-Sector General Permit, and environmental surveillance programs:

- N3B-AP-ER-5008, *Verifying and Certifying Individual Permit Corrective Action Measures*
- N3B-DI-ER-4010, *Desk Instruction for Managing Electronic Precipitation Data for Storm Water Projects*
- N3B-DI-ER-4011, *Desk Instruction for Managing Electronic Stage and Discharge Data from Stream Gage Stations*
- N3B-SOP-ER-3002, *Spring and Surface Water Sampling*
- N3B-SOP-ER-4001, *Processing Surface Water Samples*
- N3B-SOP-ER-4002, *Splitting Surface Water Samples with a Dekaport Splitter*
- N3B-SOP-ER-4003, *Operation and Maintenance of Gage Stations for Storm Water Projects*
- N3B-SOP-ER-4004, *Installing, Setting Up and Operating Automated Storm Water Samplers*
- N3B-SOP-ER-5002, *Inspection, Installation, and Maintenance of Non-Engineered NPDES Individual Permit Storm Water Control Measures*
- N3B-SOP-ER-5004, *Inspecting Automated Storm Water Samplers and Retrieving Samples*
- N3B-SOP-ER-5006, *Determining and Evaluating Drainage Area Boundaries*
- N3B-GDE-ER-5013, *Inspection Guidance for Environmental Programs Watershed, Retention, and No Exposure Controls*
- N3B-ER-GUIDE-5014, *Geomorphic Characterization*
- N3B-GDE-ER-5011, *Hydrology for Individual Permit Corrective Actions and Control Measures–Design Guide*
- N3B-GDE-ER-5015, *Stormwater Best Management Practices Manual*
- N3B-SOP-ER-5016, *Multi-Sector General Permit Quarterly Facility Inspection and Corrective Actions*
- N3B-PLN-RGC-0002, *Storm Water Pollution Prevention Plan Chromium Piping and Infrastructure Project Phase 5 – R-70 Drilling and Well Installation and CrIN-6 to CrEX-5*
- N3B-PLN-RGC-0004, *Storm Water Pollution Prevention Plan TA-21 DP Site Aggregate Area Demolition and Disposal Cleanup Project*
- N3B-PLN-RGC-0006, *Storm Water Pollution Prevention Plan for Technical Area 54 Maintenance Facility West*
- N3B-PLN-RGC-0005, *Storm Water Pollution Prevention Plan for Technical Areas G and L*
- N3B-QP-RGC-003, *Land Application of Drill Cuttings*
- N3B-AP-RGC-0002, *Minor Spill Response Reporting Procedure*
- N3B-PLN-RGC-0001, *Sediment Management Decision Tree Guidance*
- N3B-PLN-RGC-0003, *Un-permitted Discharge Reporting*
- N3B-QP-RGC-0002, *Land Application of Groundwater*
- N3B-QP-RGC-0004, *MSGP Stormwater Visual Assessments*

Groundwater Quality and Protection

Triad’s Groundwater Quality and Protection program operates in accordance with EPC-CP-QAP-001, *Environmental Compliance Programs Quality Assurance Plan*. Discharges to treatment facilities that are part of this program are conducted in accordance with the Laboratory’s P409-1*, Los Alamos National Laboratory Waste Acceptance Criteria*.

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This chapter highlights the programs the Laboratory has in place to (1) comply with environmental laws and regulations and (2) reduce the risk of Laboratory operations adversely affecting the environment. All of the Laboratory's environmental programs contribute to and are part of the Laboratory's Environmental Management System.

We first discuss processes and programs that support Laboratory-wide activities to improve our environmental performance. These processes and programs include the Pollution Prevention Program, the Site Sustainability Program, the Site Cleanup and Workplace Stewardship Program, and the Project Review process.

Next we discuss our dedicated "core" programs that lead our compliance with specific environmental laws. Core programs are generally composed of subject matter experts who are knowledgeable in the requirements of laws such as the Clean Air Act, the Clean Water Act, the National Environmental Policy Act, and the Resource Conservation and Recovery Act.

Finally, we discuss the process the Laboratory uses to ensure that the results from its monitoring and compliance sampling meet DOE standards for data quality.

Figure 3-1. View looking northeast from the Main Hill road in Los Alamos (New Mexico State Road 502) toward the Rio Grande Valley and the Sangre de Cristo Mountains

INTRODUCTION

The Laboratory has three overarching objectives for our environmental performance: clean up the past, control the present, and create a sustainable future. This chapter describes the institutional processes and dedicated "core" programs we use to manage the Laboratory's environmental performance. These institutional processes and programs combine to form the Environmental Management System.

INSTITUTIONAL PROCESSES AND PROGRAMS

Environmental Management System

Certification of the Laboratory's Environmental Management System to the International Organization for Standardization's 14001 Standard

The International Organization for Standardization is independent and nongovernmental. It brings together experts to develop voluntary international standards that provide solutions to global challenges. These standards describe the best practices for conducting a wide range of activities. The 14001 standard specifies the best practices for an environmental management system to improve an organization's environmental performance, including reducing environmental impacts and waste and becoming more sustainable. The Laboratory has maintained independent, third-party certification for its environmental management system under the 14001 standard since April 2006. In 2017, the Laboratory's environmental management system was certified under the updated 14001:2015 standard.

When the legacy waste cleanup contract was separated from the management and operating contract in 2018, each contractor organization took responsibility for its own Environmental Management System. Triad National Security, LLC, currently manages the certified Environmental Management System described above.

N3B is building its Environmental Management System to align with its specific procedures and work controls. The N3B Environmental Management System works toward conducting audits each year to seek International Organization for Standardization 14001 certification.

Environmental Management System Program Activities

The Deputy Laboratory Director for Operations chairs the Environmental Senior Management Steering Committee for the Laboratory's management and operating contractor. The committee sets institutional objectives and annual targets for environmental performance. The three institutional objectives for the Laboratory's environmental performance are (1) clean the past, (2) control the present, and (3) create a sustainable future.

Within these three objectives, the Laboratory's Environmental Senior Management Steering Committee identified the following targets (desired actions) for the 2019 fiscal year.

Clean the Past - Targets

- Continue to implement the institutional Facility Footprint Reduction Plan
- Continue to disposition equipment, materials, and metals no longer in use
- Manage interfaces with the new environmental management contractor

Control the Present - Targets

- Maintain and improve environmental and waste management compliance programs, including educating line management and subcontract technical representatives
- Adopt and implement the Workplace Stewardship Policy
- Complete the Supplemental Environmental Projects associated with the Waste Isolation Pilot Plant Settlement Agreement
- Implement pollution prevention and federal sustainability requirements, including the LANL Site Sustainability Plan and selection of DOE-approved sustainable products
- Educate workers about environmental initiatives and successes
- Engage environmental subject matter experts at the conceptual phase of the site- and facility-planning processes by using the integrated review tool
- Encourage use of the environmental lifecycle process analysis tool
- Initiate environmental permit renewals early

Create a Sustainable Future - Targets

- Use pollution prevention practices to minimize and avoid generating wastes
- Develop and implement the path forward to meet energy and water sustainability goals
- Develop and implement environmentally sustainable solutions that improve energy, water, air, soil, radioactive material or waste management, equipment management, and chemical or material use

Evaluate resource vulnerabilities (e.g., water) that pose potential risks to mission

The Laboratory annually updates a list of the significant environmental aspects that could be associated with its activities. Table 3-1 lists and describes the environmental aspects identified for 2019, along with some example activities.

Managers and teams from each Laboratory directorate develop environmental action plans each year using the institutional objectives and targets, along with their evaluation of their own work activities. In 2019, we developed and tracked 234 actions in 12 of these action plans.

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Table 3-1. LANL Significant Environmental Aspects

Environmental Aspects	Description	Examples
Air emissions	Activities that release or have the potential to release material into the air	• Point source air emissions from stacks, vents, ducts, or pipes • Use of greenhouse gas contributors such as refrigerants, vehicles, and electricity generated with coal
Interaction with surface water and storm water	Activities that release or have the potential to release pollutants into a watercourse or through direct discharge to or contact with storm water (for example, discharge onto the ground near a waterway)	• Discharges from permitted outfalls • Spills and unintended discharges • Activity within the boundary of a watercourse
Discharge to waste water systems	Activities that release or have the potential to release material to or from a waste water treatment system (sanitary, chemical, or radiological)	• Laboratory sinks • Kitchens and bathrooms • Waste water collected and transported to a waste water facility
Interaction with drinking water supplies/systems or groundwater	Activities that release or have the potential to release material into a drinking water supply system or into the groundwater. This includes planned or unplanned releases onto the ground or into surface water that have the potential to migrate to groundwater. Impacts can be positive or negative.	• Cooling tower water supply use • Installation or abandonment of groundwater wells or associated systems • Land application of water or injection of treated water into an aquifer • Septic systems and sanitary holding tanks • Permitted waste water storage basins
Work within or near floodplains and wetlands	Building structures or impoundments in a floodplain or wetland, or activities that release or have the potential to release material onto or into a floodplain, wetland, or area of overland flow	• Monitoring well operations • Structures built in a floodplain or wetland • Activities or emergencies that disrupt the integrity of a floodplain or wetland
Interaction with wildlife and/or habitat	Activities that impact or have the potential to impact federally protected wildlife or their habitats, migratory birds, and other wildlife not managed under any federal law	• Removal of weeds, trees, brush, or invasive species • Installation and operation of fencing, buildings, power lines, towers, drainage, or other structures • Installation and operation of outdoor lighting • Work operations that generate noise
Biological hazards	Activities that generate, use, or dispose of biological agents. This excludes human viral, bacterial, or bloodborne pathogens.	Management of medical materials and byproducts

Environmental Aspects	Description	Examples
Interaction with soil resources	Activities that disturb surface or subsurface soils, or release or have potential to release material onto or into the ground. This includes planned or unplanned deposition of airborne particulates and releases of solids or liquids onto or into the ground, and activities that may result in migration or deposition of radioactive constituents onto or into the ground. Activities may result from routine work or from emergency or off-normal events.	• Ground-disturbing activities—for example, construction, utility line repair, or maintenance of dirt roads • Operations that result in point source air emissions from stacks, vents, ducts, or pipes • Operations that are sources of diffuse air emissions such as open burning/open detonation, remediation activities, and decontamination and decommissioning projects • New construction, site selection, brownfield vs. greenfield development
Spark- or flame-producing activities	Activities that cause or have the potential to start a fire or wildfire	• Off-road vehicle use • Construction or outdoor maintenance work activities • Outdoor spark- or flame-producing operations • Smoking
Cultural/historical resources	Activities that impact or have the potential to impact cultural or historical resources. Resources include, but are not limited to, historical buildings, buildings of special significance, archaeological sites, traditional cultural properties, historic homesteads, and trails. Activities may result from routine work or from emergencies or off-normal events.	• Maintenance or expansion of existing areas (trails, walkways, roads, easements) • Ground-disturbing activities below grade or surface areas • Maintenance, modification, or demolition of structures, including potentially or designated historic structures • Off-road vehicle use • Vegetation removal and weed mitigation activities • Archaeological excavations
Visual resources	Activities that impact or have the potential to impact visual landscapes	• Construction, management and maintenance of access roads, fencing, utility corridors, and power transmission systems • Construction, management, and maintenance of staging areas, storage yards, debris piles, litter, and other “eye sores” • Tree thinning • Security or after-hours lighting
Hazardous or radioactive material and waste packaging and transportation	Activities that handle, package, or transport hazardous waste or radioactive materials	• Transportation of chemicals • Transportation of low-level radiological waste, mixed low-level waste, or transuranic waste

Environmental Aspects	Description	Examples
Radioactive waste generation and management	Activities that generate or manage (handle, store, or dispose of) radioactive waste	• Laboratory or research and development procedures using or generating radioactive material • Cleanup of historical waste disposal areas • Development of alternative processes or controls that reduce radioactive materials utilization and/or cross-contamination
Hazardous or mixed-waste generation and management	Activities that generate or manage (handle, store, treat, or dispose of) hazardous or mixed waste	• Laboratory or research and development procedures using or generating hazardous materials • Disposal of unused, unspent laboratory chemicals
Solid or sanitary waste generation and management	Activities that generate or manage (handle, store, treat, or dispose of) nonhazardous and nonradioactive waste intended for disposal at a municipal or industrial waste landfill	• Laboratory, machining, and process operations wastes (nonhazardous or nonradioactive) • Nonrecyclable waste—for example, some office waste and some construction and demolition debris
Interaction with contaminated sites	Activities that have the potential to increase or spread contamination because they are conducted within the boundary of or in close proximity to contaminated areas. Contaminated areas include solid waste management areas, radiological sites, nuclear facilities, or high-explosives sites.	• Construction • Mitigation • Demolition • Open detonation
Chemical (industrial and laboratory) use and storage	Activities that result in the purchase, use, management, movement, or storage of chemicals. Activities may result from routine work or from emergency or off-normal events.	• Chemical use in research laboratories • Vehicle operation and maintenance (fuels, coolants, lubricants, etc.) • Building cleaning and maintenance (janitorial supplies) • Application of pesticides, fertilizers, and other roads and grounds maintenance chemicals
Radioactive material use and storage	Activities that handle or store radioactive materials	• Radioactive material machining or processing • Change in location of activities or operations involving work with radioactive materials • Evaluation of processes and operations to increase efficient use of materials
Surplus properties and material management	Activities that manage (handle or store) in-use materials, surplus supplies, real estate, or other property	• Managing (leasing, renting, selling, or purchasing) active or inactive real estate; includes evaluation of property for contamination • Managing (storing, using, recycling, reusing, disposing of) surplus property • Cleanup and recommissioning of work areas • Decontamination and decommissioning facilities

Environmental Aspects	Description	Examples
Resource use and conservation	Activities or practices that impact resource use and affect conservation, may increase or reduce demand or wastes, or may drive increases in efficiency of resource use (labor, natural material, energy, etc.), use of alternative material, or reuse/recycling opportunities	• Applying sustainable design principles— for example, cool roofs, natural lighting, insulated glass, recycled or low-impact building materials • Procuring alternative energy or fuel sources for the Laboratory • Amount or change in the amount of energy or water required for a scope of work • Reusing and repurposing materials, equipment, and supplies • Purchasing "green" or environmentally preferable products
Storage of materials in tanks	Activities that involve handling or storing materials in tanks	Operating or maintaining aboveground tanks in accordance with the Laboratory's hazardous waste permit
Engineered nanomaterials	Activities involving intentionally created particles with one or more dimensions between 1 and 100 nanometers	• Nanotechnology research and development that generates nanoparticles requiring environmental or worker safety controls • Nanoparticle waste characterization, packaging, storage, transport, treatment, or disposal

The online course *EMS - Environmental Awareness Training* is required for all employees, including subcontractors, who are onsite for longer than 2 weeks. Retraining is required every 2 years. The course is an overview of environmental requirements for the site.

The Environmental Management System Program has external audits and internal assessments every year. All findings and corrective actions generated from these audits and assessments are tracked to closure in an issues management system. In 2019, two external certification audits and one internal assessment found two minor nonconformities (a minor deficiency that does not seriously affect the efficiency of the Environmental Management System) related to waste management and document control, as well as several opportunities for improvement related to outdoor work areas, document control systems, performance tracking, and communications. In fiscal year 2019, the Laboratory's Environmental Management System scored green on all of the following federal government metrics:

- Activities, products, and services and their associated environmental aspects were evaluated for significance and documented. Any necessary changes were made or are scheduled to be made.
- Measurable environmental objectives were in place.
- Operational controls were established, implemented, controlled, and maintained in accordance with operating criteria.
- An environmental compliance audit program was in place, and audits were completed according to schedule. Audit findings were documented, and corrective actions were implemented.
- As directed by Executive Order 13834, *Efficient Federal Operations*, sustainability goals were addressed.

Operating Experience Program

The Laboratory has an operating experience and lessons learned program called OPEX at LANL. The purpose of the program is to capture and apply lessons from past experiences and to communicate best practices to prevent or reduce the severity of future undesirable events. OPEX at LANL collects and distributes information from inside the Laboratory and from other sources, including the other DOE sites. The program provides an online database of relevant lessons and best practices for workers to use and share, as well as a quarterly publication that provides event trends, causes, and learning opportunities.

Pollution Prevention

The Laboratory's Pollution Prevention Program works to reduce waste and pollution resulting from Laboratory operations. The program focuses on (1) reducing all types of radioactive waste; (2) funding and supporting projects that reduce or eliminate the use of hazardous chemicals; and (3) promoting the purchase of products that are energy efficient, water efficient, made of renewable materials, or non-ozone depleting; contain recycled content; or contain nontoxic or less-toxic substances. The program staff also support the Laboratory's Site Sustainability Plan and prepare an annual Hazardous Waste Minimization Report for the New Mexico Environment Department.

The program supports site-wide initiatives to address environmental risks that may affect the successful completion of the LANL mission. For example, program staff are working with scientists and equipment managers to reduce the amount of water used by cooling towers so that operations can continue and expand using less additional groundwater. Program staff are also leading an effort to upgrade LANL's

Chemical Management Program, which will reduce the amount of unused chemicals at the Laboratory that are disposed of as waste.

We recognize pollution prevention projects across the Laboratory through annual pollution prevention awards and internal and external communications. The following examples of 2019 pollution prevention projects illustrate the work of LANL scientists and engineers to achieve reduction of waste and pollution at its source at the Laboratory.

Dissolving Post-Detonation Debris with Ammonium Bifluoride

Nuclear forensics is the investigation of nuclear materials to find evidence for the source and enrichment levels of the material. This project explored using micro-X-ray fluorescence spectrometry as a prescreening tool and using ammonium bifluoride as a digestion reagent for dissolving samples. These methods have the potential to eliminate the use of the hazardous substance hydrofluoric acid in the prescreening process. This is a multi-year effort. In 2019, the researchers focused their efforts on the use of ammonium bifluoride on synthetic post-detonation debris to verify its efficacy. Ammonium bifluoride will next be tested on real-world nuclear forensic samples.

Benchtop Analysis of New Methods of Treating Silica in Water

LANL relies on cooling towers to cool supercomputing facilities and the Los Alamos Neutron Science Center. Cooling towers work as very large recirculating evaporative coolers. The locally sourced water used in these towers is very high in silica, which becomes more concentrated as water evaporates from the system. Because of the high silica concentrations, operators must replace the system water more frequently than they would otherwise, which means the cooling towers consume more water.

The Pollution Prevention Program funded researchers to examine two silica treatment methods to address this issue. The first method is the use of polyethylene glycol to inhibit silica polymerization and therefore enable less frequent replacement of system water in cooling towers. The second method focused on the removal of soluble silica using an absorption reaction with modified alumina substrates. Both methods showed promise during this first year of investigation.

Cooling Tower Water Sampling and Analysis

To improve the information used to calculate the amount of water replacement needed in cooling towers, we collected and analyzed 86 samples from 16 cooling tower locations for trace mineral concentrations, including silica. This work will continue into 2020 to build a robust data set.

Site Sustainability

The Laboratory's sustainability efforts align with Executive Order 13834, *Efficient Federal Operations*, which requires federal agencies to prioritize actions that enable more effective accomplishment of their missions, cut costs, reduce waste, and enhance the resilience of federal infrastructure and operations. We are taking strategic actions to replace aging infrastructure, increase the energy efficiency of current operations, and meet a growing demand for electrical power. Our current initiatives include (1) replacing the current LANL Steam Plant with a new, more efficient combined heat and power plant, (2) planning a 10-megawatt photovoltaic development, and (3) implementing a Smart Labs Program to increase energy efficiency in existing facilities while ensuring safe and efficient work spaces. (For more information about Smart Labs, visit https://betterbuildingssolutioncenter.energy.gov/accelerators/smart-labs.)

The fiscal year 2020 Site Sustainability Plan focuses on three primary strategies: (1) make targeted investments for efficiency, (2) transparently track our progress through metrics to achieve a more efficient and resilient Laboratory, and (3) engage employees and programs at all levels in the Laboratory. The intent of the Site Sustainability Program is to incorporate energy and water conservation and cleaner production measures into everyday business practices.

Successes and Challenges

Site Sustainability successes from 2019 include the following:

- Recommissioning heating, ventilation, and air conditioning systems in 40 facilities (1.5 million square feet)
- Upgrading or replacing building automation systems in 15 facilities
- Implementing facility fault detection and data analytics software (Skyspark) in 60 facilities
- Using Energy Savings Performance Contracts for heating, ventilation, air conditioning, and lighting upgrades (projected $1.2 million in annual savings over a 20-year period)
- Using an energy savings performance contract for the Steam Plant Replacement Project
- Analyzing potential photovoltaic sites and completing an environmental assessment of the sites
- Implementing the energy efficiency components of a Smart Labs Program
- Updating the Engineering Standards Manual to incorporate more sustainable design criteria, including high-performance sustainable buildings and Smart Labs
- Insulating 120 feet of steam and condensate piping, reducing both heat loss and greenhouse gas emissions

Our sustainability investments are designed to reduce growth in energy demand while supporting hiring and mission growth. In 2019, the Laboratory reduced its water-use intensity (gallons used per square foot of building) by 13 percent compared with fiscal year 2007 and achieved a 0.5 percent reduction in energy intensity (British thermal units used per square foot of building) compared with fiscal year 2015.

Table 3-2 provides the Laboratory's specific site sustainability goals, our progress toward meeting those goals in fiscal year 2019, and planned strategies for making additional progress towards those goals.

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Table 3-2. Fiscal Year 2019 Status and Planned Strategies for the Laboratory's Site Sustainability Goals

Goal	Fiscal Year 2019 Status	2-Year Plans	5-Year Plans	10-Year Plans
Greenhouse Gas Production				
Achieve a 50% reduction in Scope 1 and 2 greenhouse gas emissions by fiscal year 2025 compared with fiscal year 2008.	LANL achieved a 24.4% reduction in Scope 1 and 2 greenhouse gas emissions compared with fiscal year 2008.	LANL plans to reduce greenhouse gas emissions by completing Phase I of the Steam Plant Replacement Project, which will reduce greenhouse gas emissions by adding a more efficient generator and controls.	Phases 2 and 3 of the Steam Plant Replacement Project will increase efficiency of the entire plant by 20%. LANL will pursue a 10-megawatt photovoltaic installation onsite. The main coal source of power for the Laboratory will shut down, and investments in low-carbon sources are planned.	LANL will pursue investments in renewable energy as needed to support mission growth.
Achieve a 25% reduction in Scope 3 greenhouse gas emissions by fiscal year 2025 compared with fiscal year 2008.	LANL increased its Scope 3 greenhouse gas emissions compared with fiscal year 2008 due mostly to an increase in air travel.	LANL will install personal vehicle charging stations. LANL is investigating a federal tax incentive for employees who carpool and use bus transportation.	As LANL invests in local energy sources, transmission and distribution emissions will reduce. LANL will continue to install personal vehicle charging stations as needed.	
Energy Management				
For buildings included in this goal, achieve a 25% reduction of energy intensity (British thermal units used per gross square foot) by fiscal year 2025 compared with fiscal year 2015.	LANL achieved a 0.5% energy intensity reduction even though an additional 2,000 employees were hired and new mission work started in nonexcluded facilities.	LANL will continue to invest in energy reduction initiatives, including building automation upgrades; heating, ventilation, and air conditioning recommissioning in facilities; and lighting upgrades in facilities. LANL will implement Smart Labs in eight facilities over the next 10 years.		
Complete Energy Independence Security Act Section 432 continuous (4-year cycle) energy and water evaluations.	LANL met the annual target of completing 25% of the energy and water assessments.	LANL will continue to evaluate covered facilities on a 4-year cycle to identify energy and water conservation measures and prioritize and implement energy and water conservation projects.		

Goal	Fiscal Year 2019 Status	2-Year Plans	5-Year Plans	10-Year Plans
Meter all individual buildings for electricity, natural gas, steam, and water, where energy management is cost effective and appropriate.	LANL has a total of 338 meters, which consist of 264 electric meters, 47 natural gas meters, 1 steam meter, and 26 water meters.	LANL plans to install meters during major renovations and in facilities with planned Smart Lab upgrades.		
Water Management				
Reduce potable water intensity (gallons used per gross square foot) by 36% by fiscal year 2025 compared with fiscal year 2007.	LANL achieved a 13% reduction in water intensity compared with fiscal year 2007.	LANL will continue Sanitary Effluent Reclamation Facility operations and implement targeted water conservation actions. LANL will also increase water metering.	LANL will continue Sanitary Effluent Reclamation Facility operations and implement targeted water conservation actions. LANL plans to make improvements in cooling tower operations.	LANL will continue Sanitary Effluent Reclamation Facility operations and implement targeted water conservation actions. LANL will operate a newly built supercomputing facility with minimal water use.
Waste Management				
Divert at least 50% of nonhazardous solid waste, excluding construction and demolition debris, each year.	LANL diverted 51.1% of nonhazardous solid waste in fiscal year 2019.	LANL will maintain recycling and source reduction programs to sustain performance levels above 50%.		
Divert at least 50% of construction and demolition waste each year.	LANL diverted 40% of waste from construction and demolition activities.	LANL will continue waste diversion efforts to sustain performance levels above 50% and close to 100%.		
Fleet Management				
Reduce fleet-wide per-mile greenhouse gas emissions by 30% by fiscal year 2025 compared with fiscal year 2014.	LANL has 365 low-greenhouse-gas vehicles.	LANL will continue to acquire fuel-efficient vehicles and low-greenhouse-gas emitting vehicles.		
Reduce annual petroleum consumption by 20% by fiscal year 2015 compared with fiscal year 2005, and maintain the 20% reduction thereafter.	LANL achieved a 33.25% reduction in fleet petroleum usage compared with fiscal year 2005.	LANL will continue to acquire fuel-efficient vehicles and plug-in vehicles.		

Goal	Fiscal Year 2019 Status	2-Year Plans	5-Year Plans	10-Year Plans
Increase annual alternative fuel consumption by 10% by fiscal year 2015 compared with fiscal year 2005, and maintain the 10% increase thereafter.	LANL increased fleet alternative fuel use by 279% compared with fiscal year 2005.	LANL will continue to acquire fuel-efficient vehicles and offer E-85 fuel for operations vehicles.		
Have at least 50% of new government passenger vehicles be vehicles that produce zero emissions or are plug-in hybrid electric vehicles by fiscal year 2025.	LANL has five net-zero emission or plug-in hybrid electric vehicles (~2% of the passenger vehicle fleet).	Economically priced, plug-in hybrid vehicles available through the General Services Administration are needed before LANL can cost-effectively expand the plug-in hybrid fleet.		
Clean and Renewable Energy				
Acquire a minimum of 25% of the Laboratory's total electric and thermal energy from renewable or alternative sources by fiscal year 2025, and maintain at least 25% clean energy usage thereafter.	LANL acquired 11.1% of its total electrical and thermal energy from onsite renewable or alternative resources.	LANL is in the planning phase for a 10-megawatt photovoltaic installation either onsite or offsite.	The main coal source of power for the Laboratory will shut down, and investments in low-carbon sources are planned.	LANL will pursue investments in firmed wind technology as needed to support mission growth.
Acquire a minimum of 30% of the Laboratory's total electric energy from renewable or alternative sources by fiscal year 2025, and maintain at least 30% clean electric energy usage thereafter.	LANL obtained 6.8% renewable energy due to the 3-megawatt Abiquiu Low Flow Turbine and the addition of the megawatt-scale photovoltaic plant to its generation profile.	LANL is in the planning phase for a 10-megawatt photovoltaic installation either onsite or offsite.	The main coal source of power for the Laboratory will shut down, and investments in low-carbon sources are planned.	LANL will pursue investments in firmed wind technology as needed to support mission growth.

Goal	Fiscal Year 2019 Status	2-Year Plans	5-Year Plans	10-Year Plans
Green Buildings				
Comply with the revised Guiding Principles for High-Performance Sustainable Buildings for a minimum of 17% of LANL's existing buildings that are >5,000 gross square feet by 2025, with progress to 100% thereafter.	LANL achieved an average of 90% implementation of the revised Guiding Principles for High-Performance Sustainable Buildings in 34 facilities. A total of 5% of the qualifying buildings comply with the Guiding Principles.	LANL will continue to focus on elements of the Guiding Principles, providing a high return on investments, such as a program to maintain energy savings. High-Performance Sustainable Buildings certification is planned for five facilities every 2 years.		
Achieve an energy, waste, or water net-zero value in 1% of existing buildings that are >5,000 gross square feet by fiscal year 2025.	LANL's current focus is on high return-on-investment elements of the Guiding Principles, such as recommissioning and developing a continuous commissioning program to maintain energy savings.	LANL will focus on high return-on-investment energy-efficiency projects in facilities.	LANL will work to include "net-zero ready" concepts in the Engineering Standards Manual for major modifications.	Existing facilities should incorporate "net-zero ready" design elements for major modifications.
Achieve a net-zero energy value in all designs for new buildings >5,000 gross square feet beginning in fiscal year 2020.	LANL is evaluating its 10-year site plan for opportunities to engage net-zero design elements.	LANL is benchmarking other DOE facilities with existing net-zero facilities to review site Engineering Standards for net-zero inclusion.	LANL will work to include "net-zero ready" concepts in the Engineering Standards Manual.	New facilities should incorporate "net-zero ready" design elements.
Increase regional and local planning coordination and involvement.	The Laboratory sponsors and engages in ongoing relationships with all neighbors to promote common goals and interests and to resolve cross-jurisdictional issues.	The Laboratory will continue to participate as a positive partner with many community efforts. In addition, LANL—a large stakeholder—has the ability to bring diverse entities together in a common effort.		

Goal	Fiscal Year 2019 Status	2-Year Plans	5-Year Plans	10-Year Plans
Acquisition and Procurement				
Promote sustainable acquisitions and procurements to the maximum extent practicable, ensuring that provisions specifying biobased products are included in 95% of applicable contracts.	All new construction contracts contain a new "Green, Sustainable Products" clause.	Other major contracts will be updated to include sustainability clauses.		
Measures, Funding, and Training				
Implement annual targets for energy-savings performance contracts in fiscal year 2017 and annually thereafter as part of Section 14 of Executive Order 13693.	Phase 1 of the Steam Plant Acquisition Project has been awarded.	Phase 1 of the Steam Plant Acquisition Project will be completed.	Phases 2 and 3 of the Steam Plant Acquisition Project will be completed.	LANL will investigate other energy-saving performance contract options.
Electronics Stewardship				
Select products registered in the Electronic Product Environmental Assessment Tool for at least 95% of eligible purchases.	A total of 83.8% of eligible electronic acquisitions are environmentally sustainable.	LANL will continue to acquire environmentally sustainable electronic products.		
Enable power management on 100% of eligible personal computers, laptops, and monitors.	LANL uses power management for 100% of its eligible computers.	LANL will continue to use power management in 100% of its eligible computers. Laboratory staff will continue to evaluate products that may provide a workaround to the issue of power management interfering with cybersecurity scanning.		
Enable automatic duplexing on 100% of eligible computers and imaging equipment.	Duplex printing is configured in 34.2% of the total owned printers onsite.	As new automatic duplexing features become available for Windows computers, LANL will evaluate implementation.		

Goal	Fiscal Year 2019 Status	2-Year Plans	5-Year Plans	10-Year Plans
Reuse or recycle 100% of used electronics with environmentally sound disposition methods.	Disposal of the Laboratory's information technology equipment is done in accordance with its internal procedures for security purposes. The Laboratory works with a certified recycler for equipment recycling.	LANL will continue to recycle to the maximum extent possible while still complying with site security requirements.		
Establish a power usage effectiveness target in the range of 1.2–1.4 for new data centers and less than 1.5 for existing data centers.	LANL achieved power usage effectiveness of 1.28 in its largest data center, the Strategic Computing Complex; 1.4 in the Laboratory Data Communications Center; and 1.5 in the Central Computing Facility, the oldest data center.	LANL will continue to increase server virtualization efforts and retire existing legacy systems.		

Site Cleanup and Workplace Stewardship Program

In some locations at the Laboratory, materials and equipment have been abandoned after projects ended or staff retired. We established the Site Cleanup and Workplace Stewardship Program in 2013 to assist with the proper disposition of these items and to prevent similar occurrences in the future. The program staff work with the responsible organizations to develop a work plan for abandoned items, clean indoor and outdoor spaces, and implement sustainable housekeeping practices. The Site Cleanup and Workplace Stewardship Program works closely with the Property Management Group, Environmental Protection and Compliance Division, and Infrastructure Programs Office. One goal of the program is to divert as much material as possible from waste streams.

In 2019, the Site Cleanup and Workplace Stewardship Program

- continued improving the management of sheds and transportable storage buildings at LANL, including
  - confirming the owning organization, location, signage needs, and points of contact for some of the 1,200+ storage structures onsite;
  - adding a point-of-contact sign to each storage structure;
  - working with the owning organizations to clean out and remove unneeded storage; and
  - removing more than 15 storage structures;
- worked with the Pollution Prevention Program to obtain covers for metal and wood recycling bins across the site to reduce the potential for pollution in storm water runoff;
- coordinated more than 25 cleanup projects across the Laboratory, including
  - Technical Area 03 – removing abandoned equipment and asphalt and concrete debris piles, cleaning out storage structures, and removing abandoned-in-place electrical equipment in two parking areas;
  - Technical Area 43 – disconnecting and recycling several large refrigeration units and cleaning out a large laboratory and office space in preparation for closing the building;
  - Technical Area 35 – cleaning out storage structures and a storage room full of legacy equipment;
  - Technical Area 48 – cleaning out and removing storage structures that are in extremely poor condition;
  - Technical Area 53 – recycling two old storage structures and a steel plate;
  - Technical Area 58 Mercury Road – dismantling the abandoned radar trailer, recycling two bins of metal, and preparing the lead and asbestos waste for disposal;
  - Technical Area 60 Sigma Mesa – finishing Phase Five of cleanup, which included cleaning up wood and metal debris; preparing large metal cables for recycling; establishing a controlled laydown yard for craft material and equipment; cleaning up an old laydown yard; and adding chains, signs, and stanchions to prevent future accumulations of abandoned equipment and debris;
- installed signs with structure numbers and point-of-contact information on 50+ storage structures and laydown areas; and

- with funding from the DOE Office of Nuclear Materials Integration, coordinated a metal recycling project, including the release of more than 250 potentially activated metal items—weighing approximately 1.5 million pounds total—that were shipped to a metal recycler.

Greenhouse Gas Reduction

In fiscal year 2019, the Laboratory achieved a 24.4 percent reduction in Scope 1 and 2 greenhouse gas emissions compared with fiscal year 2008. Scope 1 emissions are direct emissions from Laboratory-owned or -leased equipment and vehicles. Scope 2 emissions are emissions generated by utility companies while producing electricity, heat, or steam purchased by the Laboratory. The Site Sustainability Program's initiatives to reduce energy use contributed to reducing greenhouse gas emissions.

The Laboratory's energy use is expected to steadily increase over the next 10 years as high-performance computing and expanded activities at the Los Alamos Neutron Science Center consume greater amounts of electrical power. We plan to reduce greenhouse gas emissions by completing Phase I of the Steam Plant Replacement project, which will add a more efficient generator and controls. We are also pursuing a 10-megawatt photovoltaic installation either onsite or offsite.

Project Review

All new or modified activities or projects conducted at the Laboratory must be reviewed for environmental and other compliance requirements. The Integrated Review Tool is a web-based application for identifying permits and requirements for projects and for applying for an excavation, fill, and soil disturbance permit. Work owners or planners enter their project information into the application, and subject matter experts review the projects and identify the relevant requirements and any permits needed to perform the work.

The Integrated Project Review Program coordinates environmental subject matter expert reviews and interacts with work owners and planners for the management and operating contractor. The program is represented by subject matter experts from the following compliance programs: Air Quality, Biological Resources, Cultural Resources, Environmental Health Physics, National Environmental Policy Act, Solid Waste Management Units and Areas of Concern, Resource Conservation and Recovery Act, Waste and Materials Management, and Water Quality.

N3B project managers use the Integrated Review Tool for some projects and internal N3B procedures for the remaining projects. N3B uses procedures N3B-P351, *Project Review Process*, and N3B-P101-17, *Excavation/Fill/Soil Disturbance*, to identify compliance requirements for new or modified activities. The procedures engage with subject matter experts from the following N3B compliance programs: Air Quality, Biological Resources, Cultural Resources, Safety and Industrial Hygiene, National Environmental Policy Act, Resource Conservation and Recovery Act, Waste and Materials Management, and Water Quality.

In 2019, subject matter experts reviewed 224 management and operating contractor projects for permits and requirements identification and 693 projects for excavation, fill, and soil-disturbance permitting. In addition, 36 legacy waste cleanup projects were reviewed in the Integrated Review Tool for permits and requirements identification.

Over the last several years, the Integrated Project Review Program has supported integration of project review processes and improvements in the integrated review tool. "Permits and Requirements Identification for the Requestor" training was developed in 2018 and implemented through the Laboratory's training system in 2019. "Integrated Review Tool – Geographic Information Systems" training was developed and launched in 2019. "Excavation, Fill, and Soil Disturbance Permit Process" training was developed in 2019 and will be launched in 2020.

DEDICATED "CORE" PROGRAMS

Air Quality Program

The Laboratory maintains a rigorous air quality program that addresses emissions of both radioactive and nonradioactive air pollutants. The program consists of three main parts: compliance and permitting, stack monitoring, and ambient air monitoring.

Compliance and Permitting: LANL operates under a number of air emissions permits issued by the New Mexico Environment Department Air Quality Bureau and under approvals issued by the U.S. Environmental Protection Agency for construction of new facilities or operations involving radionuclide emissions. These permits and approvals have federally enforceable emission limits and require specific pollution-control devices, monitoring of emissions from stacks, and detailed recordkeeping and reporting.

LANL is authorized to use materials and operate equipment that produces some air pollutants under the conditions defined in our Title V Operating Permit. Our permitted emission sources include a steam plant, a combustion turbine, boilers and heaters, emergency generators, beryllium operations, chemical use, degreasers, data destruction (paper shredder), evaporative sprayers, and a small asphalt batch plant. Each source type has its own emission limits for both criteria air pollutants and hazardous air pollutants. The Title V Operating Permit also includes facility-wide emission limits for criteria and hazardous air pollutants. As part of compliance with the Title V Operating Permit, we report emissions and provide monitoring records from the permitted sources twice a year to the New Mexico Environment Department, which inspects the Laboratory periodically for compliance.

What are these air quality terms?

A **stack** is a vertical chimney or pipe that releases gases produced by industrial processes into the air.

Ambient air is atmospheric air in its natural state.

Criteria air pollutants are six specific pollutants regulated by the U.S. Environmental Protection Agency under the Clean Air Act because they cause smog, acid rain, or other health hazards.

Hazardous air pollutants are chemicals and radionuclides that, at high-enough levels, are known or suspected to cause cancer, other serious health effects, or adverse environmental effects.

Stack Monitoring: As described in greater detail in Chapters 2 and 4, the Laboratory rigorously controls and monitors emissions of radionuclides from building stacks as required by the Clean Air Act. We evaluate operations to determine the potential for stack emissions to adversely affect the public or the environment. In 2019, 27 stacks were continuously sampled for the emission of radioactive materials to the air.

Ambient Air Monitoring: The Laboratory operates a network of ambient air quality monitoring stations to detect other possible radioactive air emissions (discussed further in Chapter 4). The network includes stations located onsite, in adjacent communities, and in regional locations. In 2019, we operated 38 ambient air quality monitoring stations at distances up to 25 miles from the Laboratory.

Water Quality Programs

The Laboratory operates multiple programs that deal with the quality of surface waters and groundwater. We comply with five National Pollutant Discharge Elimination System permits: the outfall permit, the individual permit for storm water discharges, the construction general permit, the multi-sector general permit, and the pesticide general permit (all discussed further in Chapter 2). The Laboratory monitors and remediates groundwater (see Chapter 5) and conducts environmental surveillance monitoring on surface water base flow, storm water flow, and deposited sediments (see Chapter 6). We also have implemented low-impact development projects at Technical Areas 03 and 53 that reduce the amount of storm water runoff from developed areas to improve the quality of the storm water flow.

In 2019, we continued the process to renew the Laboratory's individual permit for storm water discharges. Our original renewal application was submitted in 2014. We resubmitted the renewal application to the U.S. Environmental Protection Agency on June 15, 2019. The Laboratory's current individual permit has been administratively continued until a new final permit is issued by the U.S. Environmental Protection Agency.

In 2019, the Laboratory operated under five groundwater discharge permits issued by the New Mexico Environment Department. These permits covered discharges from the sanitary waste water system plant and the sanitary effluent reuse facility; discharges from eight septic tank systems; land application of treated groundwater; injection of treated groundwater into the aquifer through six underground injection control wells; and the Technical Area 50 Radioactive Wastewater Treatment Facility. In June 2019, the New Mexico Water Quality Control Commission vacated the groundwater discharge permit for the Technical Area 50 Radioactive Wastewater Treatment Facility and remanded it back to the New Mexico Environment Department for a public hearing. That hearing took place in November 2019. In the interim, water discharges from the treatment facility have been taking place in accordance with an approved temporary permission from the New Mexico Environment Department.

In 2019, we continued operating the Laboratory's site-wide network of storm water gage stations to monitor stream flow and collect storm water samples in all major canyons. We also continued operating the early notification system that provides the operators of Santa Fe's Buckman Direct Diversion (which diverts water from the Rio Grande for Santa Fe's drinking water supply) early notification of storm water flows through Los Alamos Canyon into the Rio Grande. We documented the effectiveness of installed sediment-control measures for the Los Alamos/Pueblo Canyon watershed and the Sandia Canyon wetlands to the New Mexico Environment Department.

Hydrology Protocol Study

In the New Mexico *Standards for Interstate and Intrastate Surface Waters* (Title 20, Chapter 6, Part 4 of the New Mexico Administrative Code), Section 128 uniquely classifies some stream reaches on Laboratory property as ephemeral-intermittent reaches (both ephemeral and intermittent). These waters, referred to as "Segment 128 waters," are the only waters within the State of New Mexico with this combined designation. Understanding the actual flow regime (either ephemeral or intermittent) for these stream reaches would give the New Mexico Environment Department better information to identify and apply the appropriate surface water quality standard.

The Segment 128 waters at the Laboratory have mostly semi-arid hydrologic characteristics and likely represent ephemeral waters (having water briefly only in direct response to precipitation). However, intermittent surface water conditions (having water for extended periods at certain times of the year) may occur in some locations. These include locations below springs and areas where groundwater that flows in unconsolidated sand or gravel (known as alluvium) under a streambed reaches the surface. Structures installed to slow storm water and promote sediment deposition can alter a stream by promoting increased water storage in the alluvium and increasing the potential for persistent flows. The portions of the stream above and below these water control structures warrant a flow regime evaluation. A hydrology protocol has been developed by the New Mexico Environment Department to distinguish between perennial, intermittent, and ephemeral watercourses in New Mexico.

During the 2015 triennial review of New Mexico's water quality standards, the New Mexico Environment Department, the DOE, the Laboratory, and Amigos Bravos (a nonprofit organization that works on water-related issues in New Mexico) entered into a formal legal agreement to meet and confer on the appropriate level of water quality protections to be assigned to the Segment 128 waters. Part of the agreement was for all parties to share information and data to identify (a) which Segment 128 waters are ephemeral and which are intermittent; (b) the existing uses of Segment 128 waters; (c) the presence of macroinvertebrates or shellfish in these waters; and (d) any significant change to the chemical, physical, or biological integrity of these waters.

Between 2015 and 2017, key milestones from the legal agreement were achieved, and Hydrology Protocol assessments were completed on three Segment 128 stream reaches. Work was suspended in 2018 due to drought conditions and other LANL priorities. However, in 2019, Laboratory staff conducted more than 100 Hydrology Protocol assessments that covered almost 80 miles of streams. New Mexico Environment Department personnel participated in approximately half of the 2019 assessments.

Sanitary Sewage Sludge Management

On March 24, 2014, the New Mexico Environment Department Solid Waste Bureau approved the Laboratory's application to operate a facility to compost solid wastes produced by the Laboratory's Sanitary Waste Water System. The goal of this project is to eliminate the transport of sewage biosolids offsite for landfill disposal. Full-scale operations at the Technical Area 46 Sanitary Waste Water System Compost Facility began in late 2014. On April 18, 2018, the New Mexico Environment Department approved a registration renewal. The compost will be land-applied at the Laboratory for beneficial use, including landscaping, post-construction remediation, and rangeland restoration. Before compost can be land-applied, it must meet pollutant concentration limits, Class A pathogen requirements, and vector attraction reduction requirements as specified in the U.S. Environmental Protection Agency's *Standards for the Use or Disposal of Sewage Sludge* in the Code of Federal Regulations Title 40, Part 503.

In 2019, the Sanitary Waste Water System Compost Facility produced 48.2 tons of composted biosolids. Finished compost was stockpiled at the facility. The Sanitary Waste Water System Compost Facility now uses an in-vessel composter that was brought online in 2018. The in-vessel system provides better control of temperature, moisture, and airflow. We plan to land-apply compost at predetermined sites within Laboratory boundaries in the near future. The final locations and rates for compost application are subject to site selection criteria, best management practices, and administrative controls. For example, compost will not be applied in canyon bottoms, wetlands, or in areas with shallow perched alluvial groundwater. Application rates will not exceed agronomic rates provided by the New Mexico State University Cooperative Extension Service (Robert Flynn, personal communication, 5 February 2013).

Cultural Resources Management

Approximately 90 percent of DOE land in Los Alamos County has been surveyed by the Laboratory's cultural resources staff for prehistoric and historic cultural resources. These surveys have identified nearly 1,900 sites with a history of occupation dating back to 10,000 years. About 79 percent of the Laboratory's cultural resources sites are associated with Ancestral Pueblo people: structures, villages, trails, agricultural features, rock art, and more. However, the sites at the Laboratory also include Archaic Period lithic scatters; late 19th and early 20th century homestead, ranching, and logging sites; and Laboratory buildings used during the Manhattan Project and Cold War eras (~1943–1990).

Current cultural resource management initiatives at the Laboratory include (1) completing cultural resources surveys on all DOE property; (2) evaluating and determining the potential eligibility of historic buildings and archeological sites to be listed in the National Register of Historic Places; and (3) conducting outreach activities and tours.

Archaeologists working for the legacy waste cleanup contractor N3B facilitate the cultural resources compliance reviews for legacy waste cleanup projects. The N3B archaeologists, the DOE Environmental Management Los Alamos Field Office cultural resources program manager, the DOE National Nuclear Security Administration Los Alamos Field Office cultural resources program manager, and management and operating contractor archaeologists meet every 2 weeks to discuss legacy waste cleanup activities across the Laboratory on lands managed by the National Nuclear Security Administration Los Alamos Field Office.

In 2019, we recorded archaeological sites and guided projects in avoiding them for a wide variety of ground-disturbing activities. N3B archaeologists conducted site avoidance and monitoring for the R-70 well drilling and well installation in Technical Area 05 and aggregate area sampling in Technical Area 33. Major projects supported by the management and operating contractor cultural resources staff included (1) the Second Fiber Optics Line Project in Technical Areas 70 and 71, and on Santa Fe National Forest, Bureau of Land Management, Santa Fe County, and private lands; (2) the Calibration Site Project in Technical Area 68; (3) legacy site recording in Technical Area 16; and (4) the Area 1 Waterline Installation Project in Technical Areas 15 and 36.

We assessed the condition and updated photographic records of Nake'muu Pueblo in September 2019. We supported Laboratory technical meetings with Santa Clara Pueblo, the Pueblo of Jemez, and Pueblo de San Ildefonso. In addition, in 2019, we supported DOE's technical meeting with Pueblo de San Ildefonso, Santa Clara Pueblo, Pueblo de Cochiti, and the Pueblo of Jemez. We continued to monitor seasonal recreational use of trails in Technical Areas 70 and 71 and DOE preservation districts in Pueblo Canyon (Technical Area 74). N3B cultural resources staff presented three briefings to legacy waste cleanup employees about the importance of archaeological sites and historic buildings at the Laboratory.

We also completed the final context and documentation reports for two properties in Technical Area 03 to support decontamination and decommissioning of Laboratory buildings. Other historic building work included evaluating a Manhattan Project–era guard shack in Technical Area 08 for eligibility for inclusion in the National Register of Historic Places and overseeing projects to restore Manhattan Project National Historical Park properties and Park-eligible structures (see the Manhattan Project National Historical Park section below). We conducted archival photography of buildings in Technical Areas 03, 15, 16, and 46, and we continued to work with the Bradbury Science Museum to integrate the Laboratory's historical artifacts into the museum's catalog system.

Manhattan Project National Historical Park

The Manhattan Project was a research and development effort during World War II to produce the world's first nuclear weapons. Legislation establishing the Manhattan Project National Historical Park was passed in 2014. The park has units in Los Alamos, New Mexico; Oak Ridge, Tennessee; and Hanford, Washington. Nine Manhattan Project–era buildings at the Laboratory associated with the design and assembly of the "Gadget" (the atomic bomb tested at Trinity Site), the "Little Boy" weapon (the bomb detonated over Hiroshima, Japan), and the "Fat Man" weapon (the bomb detonated over Nagasaki, Japan) are part of the park properties at the Laboratory. Eight additional Laboratory buildings and structures, identified in the establishing legislation, are considered "park-eligible" properties.

In 2019, Laboratory cultural resources staff worked with National Park Service staff to stabilize, repair, and restore two concrete bunkers (the "Battleship Bunkers") in Technical Area 18 (Figures 3-2 and 3-3). One of these bunkers is located within the Manhattan Project National Historical Park boundaries, and the other is eligible for the National Register of Historic Places. This project repaired degraded concrete on the buildings' exteriors to return them to their original Manhattan Project appearance.

Figure 3-2. Bunker 18-2 during concrete restoration in July 2019

Figure 3-3. Bunker 18-5 during concrete restoration in July 2019

Also, in 2019, we began planning to (1) stabilize and repair a concrete pad in the V-Site Park unit in Technical Area 16; (2) remove vegetation at the Concrete Bowl, a Park-eligible property in Technical Area 06; and (3) remove a degraded concrete cap that was installed as part of repairs conducted in 2012 at Park Gun Site buildings in Technical Area 08.

We began replacing the wooden wing walls on the only remaining Manhattan Project–era magazine (a Park–eligible structure). We conducted surveillance and maintenance inspections at all 17 Park and

Park-eligible properties and on 18 Cold War–era buildings identified as candidates for long-term preservation.

The DOE hosted three sessions of public tours of the Manhattan Project–era structures at Pajarito Site in Technical Area 18 (Figures 3-4 and 3-5). Dates in April and October coincided with dates that the Trinity site was open to the public, and dates in July coincided with the Los Alamos Science Fest. Visitors had opportunities to learn about the history of the Pajarito Plateau—from 10,000 years in the past through the Homesteading era—and many significant events of the Manhattan Project at Los Alamos.

Figure 3-4. Public tour at Pajarito Site in Technical Area 18 during July 2019

Figure 3-5. Visitors inside the Slotin building at Pajarito Site in Technical Area 18 during July 2019

Biological Resources Management

Our goal is to minimize impacts to sensitive species and their habitats and to ensure that all activities comply with federal and state requirements for biological resources protection. The Laboratory contains habitat for three species that are federally listed as either threatened or endangered. Two of these species, the Mexican spotted owl and the Jemez Mountains salamander, have been found on site. Willow flycatchers of unknown subspecies are sometimes detected during migration, but no southwestern willow flycatchers have been documented breeding on Laboratory property.

Accomplishments

We annually inform and educate the Laboratory workforce about biological resources compliance requirements, including restrictions on the timing and location of work activities to protect federally listed species. The biological resources staff also provide information on avoiding impacts to migratory birds from vegetation removal projects and other known hazards to birds—such as open pipes and bollards—and safety briefings on encountering wildlife.

Laboratory biologists annually conduct surveys for the presence of threatened and endangered species that have habitat on LANL property. In 2019, surveys for the Mexican spotted owl confirmed the presence of owls in both Mortandad and Threemile Canyons. Both nests produced young in 2019. Southwestern willow flycatchers were not found during surveys in 2019. Jemez Mountains salamander surveys were conducted around the Research Park at Technical Area 03 in 2019, and no salamanders were detected.

Throughout 2019, we attended or presented at conferences, workshops, and meetings for professional and educational development, collaboration, and outreach. Notable activities included presenting at the Expanding Your Horizons Workshop for fifth- through eighth-grade girls and attending the Joint Annual Meeting of the Arizona and New Mexico chapters of The Wildlife Society and the American Fisheries Society, the Southwest Chapter of the Society for Ecological Restoration meeting, the Southwest Partners in Amphibian and Reptile Conservation meeting, and the New Mexico Avian Conservation Partners meeting.

LANL biologists were authors on several peer-reviewed publications in 2019. The papers addressed a range extension for the yellow-bellied marmot (*Marmota flaviventris*; Frey et al. 2019), loggerhead shrikes (*Lanius ludovicianus*; Hathcock and Hill 2019), host-parasite relationships in the western bluebird (*Sialia mexicana*) and ash-throated flycatcher (*Myiarchus cinerascens*; Musgrave et al. 2019), long-term phenology of two cavity nesters in relation to a changing climate (Wysner et al. 2019), and wildlife mortalities in open-topped pipes (Harris et al. 2019).

Biological Resources Program Reports

LANL biologists supported many projects across the Laboratory with compliance and monitoring activities in 2019. Published reports supporting projects included the following:

- "Biological Evaluation of the Fiber-Optic Line Installation for Improved Communication at the Los Alamos National Laboratory" (LA-UR-19-25861)
- "Biological Assessment for the Modernization and Development of the Weapons and Facility Operations High Explosive Testing and Processing Facilities at LANL" (LA-CP-19-20707)
- "Status of Federally Listed Threatened and Endangered Species at Los Alamos National Laboratory" (LA-UR-19-31659)
- "2018 Results for Avian Monitoring at the Technical Area 36 Minie Site, Technical Area 39 Point 6, and Technical Area 16 Burn Ground at Los Alamos National Laboratory" (LA-UR-19-24156)

Wildland Fire Management

The primary objective of the LANL Wildland Fire Program is to provide wildland fire preparedness through fuels mitigation, integration of wildland fire technology, and interagency planning and training. The program staff are located at the Emergency Operations Center and Technical Area 49 Interagency Fire Center along with personnel from the United States Forest Service and National Park Service. The program collaborates with the Los Alamos Fire Department, National Park Service, United States Forest Service, Bureau of Indian Affairs, Northern Pueblo Agencies, and the New Mexico State Forestry Division to enhance wildland fire preparedness.

The key functions of the LANL Wildland Fire Program are listed as follows:

- Conduct or coordinate the site wildland fire hazard analysis
- Develop wildland fire plans, procedures, and checklists
- Conduct LANL wildfire mitigation projects, such as establishing and maintaining fire breaks, defensible space, and fire roads, and conducting tree thinning

- Update the LANL website to ensure that fire conditions and fire danger ratings are available to the workforce
- Maintain the LANL Wildland Fire Program database, and ensure that the program has map-making capabilities for response
- Conduct training, drills, and exercises with internal and external wildland fire organizations

One notable accomplishment of the LANL Wildland Fire Program in 2019 was the publication of the *LANL Wildland Fire Mitigation and Forest Health Plan* (EMD-PLAN-200). The plan was developed collaboratively with the LANL Wildland Fire Program and LANL Environmental Stewardship Group. The plan provides key components and strategies for wildland fire fuels mitigation and forest health. The LANL Wildland Fire Program also developed a Wildland Fire Annex that was included in the *LANL All-Hazards Emergency Management Plan* (EMD-PLAN-100). The Annex provides additional details for addressing wildland fires as a unique hazard to LANL, using all phases of emergency management (preparedness, response, mitigation, and recovery) and prevention. Lastly, the LANL Wildland Fire Program developed a position and hired a fire management officer in 2019. The position description includes Type 3 or above incident commander capabilities in accordance with National Wildfire Coordinating Group standards, enhancing the Laboratory's ability to respond to wildland fires.

The LANL Wildland Fire Program also conducted several wildland fire mitigation activities, including the following:

- **March 2019 High-Wind Event Recovery:** New Mexico experienced a weather pattern in March 2019 designated by weather experts as a "bomb cyclone." Eighty- to 100-mile-per-hour winds were recorded, and widespread blowdown of trees occurred in some forested areas. Following this event, the LANL Wildland Fire Program evaluated impacted trees on LANL property. Fallen trees were noted for removal, and hazard (leaning or unstable) trees were knocked over. In the vicinity of cultural sites, trees were removed with subject matter expert input to ensure protection of the sites. The remaining blowdown tree removal was subcontracted to the Jemez Pueblo Department of Natural Resources. The subcontracted work included delimbing, cutting, and hauling out trees suitable for lumber. The trees went to the Pueblo of Jemez for sawmill operations. Anything that was not suitable for timber was cut for firewood (approximately 150 cords) (Figure 3-6). The firewood was made available to the Northern Pueblos Association. More than 1,250 trees were removed in fiscal year 2019.

Figure 3-6. Firewood prepared from trees impacted by the 2019 wind event was cut and stacked for removal.

- **Wildland Fire Evacuation Route Maintenance:** The wildland fire roadside mitigation project included conducting maintenance on the wildland fire evacuation routes. See Figures 3-7 and 3-8. The project was conducted in accordance with the treatment standards for evacuation routes detailed in EMD-PLAN-200.

Figure 3-7. Before mowing for wildland fire evacuation route maintenance

Figure 3-8. After mowing for wildland fire evacuation route maintenance

Waste Management

The Laboratory produces several types of regulated wastes, including low-level radioactive wastes, mixed low-level radioactive and hazardous wastes, transuranic wastes, New Mexico special wastes, and others. Transuranic wastes are wastes that contain man-made elements heavier than uranium on the periodic table (such as plutonium). Wastes from current and recent operations at the Laboratory are managed by the management and operating contractor, while legacy wastes—defined as the wastes generated before 1999—are managed by the legacy waste cleanup contractor.

The LANL Enduring Mission Waste Management Plan outlines the strategies employed by the Laboratory to compliantly and efficiently dispose of the wastes produced since January 1, 1999. The plan also incorporates pollution prevention strategies to significantly reduce the volume and toxicity of waste generated going forward. Waste minimization efforts have greatly reduced or eliminated many sources of radioactive and hazardous waste across the Laboratory. Offsite shipping to government and commercial treatment, storage, and disposal facilities has minimized onsite waste disposal. The Laboratory is operating a new Transuranic Waste Facility that stages transuranic waste for offsite shipment. Construction has begun on low-level radioactive and transuranic liquid waste facilities. We submitted a proposal for a new state-of-the-art Consolidated Waste Facility to DOE as part of the long-term strategy to manage waste at the Laboratory safely and effectively.

Environmental Remediation

In accordance with the 2016 Compliance Order on Consent, the Legacy Waste Cleanup Program directed by DOE's Office of Environmental Management and operated by N3B investigates and, where necessary, remediates sites to ensure that chemicals and radionuclides in the environment associated with releases from past operations do not result in an unacceptable chemical risk or radiological dose to human health or the environment. (For more information about the 2016 Compliance Order on Consent, please see the section in Chapter 2, The 2016 Compliance Order on Consent.) Sampling is conducted to determine if releases have occurred and, if so, whether the nature and extent are defined or further sampling is warranted. Using the environmental data obtained for a site, human health and ecological risk assessments are conducted. Sites are remediated if the risk assessments indicate potential adverse impacts to human health, the environment, or both. Corrective actions are complete at a site when we have demonstrated and documented to the regulatory authority's satisfaction that further sampling is not warranted and that the chemicals and radionuclides present do not pose an unacceptable risk or dose to humans, plants, or wildlife. Table 3-3 presents a summary of the reports submitted and site investigations conducted during 2019 by N3B in support of the 2016 Compliance Order on Consent.

Table 3-3. Summary of Reports Submitted and Site Investigations Conducted during 2019 under the N3B Environmental Remediation Program

Document/Activity	Technical Area	Number of Sites	Sampling and Remediation
Addendum to the Middle Los Alamos Canyon Aggregate Area Phase II Investigation Report for Solid Waste Management Unit 02-014	02	1	Characterization data for Solid Waste Management Unit 02-014 consist of results from samples collected in 2007, 2010, 2017, and 2018. Removal of PCB-contaminated soil was conducted to address potentially unacceptable risk for industrial workers and recreational users in the depth interval 0.0–1.0 feet below ground surface and to meet the Toxic Substances Control Act bulk PCB remediation waste cleanup level for low-occupancy areas. Soil was excavated during 2018, and removal areas were expanded both laterally and vertically based on confirmation sampling results. A total of 282 cubic yards of PCB-contaminated soil was excavated and packaged for transportation to an offsite disposal facility. Following completion of investigation sampling and remediation activities, characterization data for Solid Waste Management Unit 02-014 were evaluated. Solid Waste Management Unit 02-014 was determined to not pose an unacceptable human health risk or dose under the industrial, recreational, residential, and construction worker scenarios. Ecological risk was evaluated for all Solid Waste Management Units and Areas of Concern within the Technical Area 02 core area, including Solid Waste Management Unit 02-014, rather than by individual Solid Waste Management Unit or Area of Concern. The Phase II investigation report concluded that no potential ecological risks exist for the Technical Area 02 core area. The Laboratory is recommending to the New Mexico Environment Department that the status of Solid Waste Management Unit 02-014 be certified as complete without controls.
Conclusions/Recommendations: All cleanup objectives were met, and no further corrective actions are required at this site.			

Document/Activity	Technical Area	Number of Sites	Sampling and Remediation
Field Completion Letter Report for Aggregate Area Known Cleanup Sites Campaign: Solid Waste Management Units 39-002(a), 46-004(q), 15-008(b), and 15-007(c)	15	2	Two sites in Technical Area 15 [Solid Waste Management Units 15-008(b) and 15-007(c)] were remediated to address potential unacceptable risk to industrial workers and to ecological receptors. At 15-008(b), copper- and lead-contaminated soil was excavated during 2019. A walkover radiological survey was conducted in and around the planned excavation area to identify areas where radiation values were greater than two times the background. A total of 407 samples at 278 locations were collected. A total of 1,760 cubic yards of copper- and lead-contaminated soil were removed. The excavated material was packaged in waste containers and staged for shipment to an approved, licensed, waste disposal facility for final disposition. At 15-007(c), soil was excavated around existing sampling locations, and additional depth samples were collected at existing sampling locations to define the vertical extent of lead. Additionally, 78 surface grab samples were collected at predetermined 5-foot × 5-foot gridded locations and scanned using a portable X-ray fluorescence analyzer spectrometer to identify any additional areas of elevated lead. Soil that contained lead with concentrations exceeding the industrial limits was removed to 1 foot below ground surface using existing analytical data and field X-ray fluorescence screening data. A total of ~18.9 cubic yards of lead-contaminated soil were removed. The excavated material was packaged in waste containers and staged for shipment to an approved, licensed, waste disposal facility for final disposition.
Conclusions/Recommendations: All cleanup objectives were met, and no further corrective actions are required at these sites. Details and results of the sampling and remediation will be presented in a future aggregate area investigation report.			

Environmental Health Physics Program

The Environmental Health Physics Program provides technical support to the Laboratory for radiation protection of the public and the environment. We use sampling results and radiological assessment models to calculate dose estimates for the public and for plants and animals. These estimates are communicated to regulatory agencies and the public.

DOE Order 458.1, *Radiation Protection of the Public and the Environment*, also requires us to oversee releases to the public of real estate and portable property (such as surplus equipment and wastes) that have the potential to contain residual radioactivity. Examples include land tracts that are transferred to other owners and debris from building demolition activities.

Our environmental health physicists support emergency planning and response by providing technical support and dispersion modeling in the case of an accident and recommendations for protective actions. We also support environmental remediation projects.

Soil, Foodstuffs, and Biota Monitoring

The Soil, Foodstuffs, and Biota Monitoring Program monitors levels of radionuclides, inorganic elements (mostly metals), and organic chemicals (for example, PCBs) in local soil, plants, and animals. The program routinely samples surface soil, native vegetation, foodstuffs (including fruits, vegetables, grains, milk, eggs, fish, meat, and honey); small mammals, such as mice; and other animals that have died due to natural causes or accidents, such as roadkill. These samples are collected from Laboratory property, the surrounding communities, and regional background locations. The data are used to (1) determine whether Laboratory operations are affecting levels of chemicals or radionuclides in the environment, (2) monitor for new releases, (3) calculate estimates of radiation dose for the public and for biota, and (4) conduct risk assessments. We compare levels of chemicals in our samples with background levels, screening levels, and effects levels, and we examine wildlife population and community characteristics. The program is described in detail in Chapter 7.

Accomplishments

In 2019, we sampled foodstuffs from various locations around the Laboratory, in the surrounding communities, and from regional background locations. Foodstuffs samples were analyzed for radionuclides and inorganic elements (mostly metals). Foodstuffs produced by animals, such as milk and eggs, were also tested for PCBs.

Annual sampling was repeated at several locations. Soil and tree samples were collected around the perimeter of Area G and near the boundary between Technical Area 54 and the Pueblo de San Ildefonso and analyzed for radionuclides. Soil, sediment, bees, honey, nonviable bird eggs, and bird nestlings that died of natural causes were collected around the Dual-Axis Radiographic Hydrodynamic Test Facility and analyzed for radionuclides, inorganic elements (mostly metals), and/or organic chemicals. Small mammals and vegetation were collected upstream of the sediment retention structures located in Los Alamos and Pajarito Canyons and analyzed for radionuclides, inorganic elements, and/or organic chemicals.

What is health physics?

Health physics is the branch of radiation science that deals with the effects of ionizing radiation on human health.

Nonviable bird eggs and nestlings that died of natural causes were also collected near Laboratory firing sites and from Bandelier National Monument and were analyzed for metals and/or organic chemicals. We collected and analyzed tissues from mule deer (*Odocoileus hemionus*), elk (*Cervus canadensis*), American badger (*Taxidea taxus*), gopher snake (*Pituophis catenifer*), common raven (*Corvus corax*), American kestrel (*Falco sparverius*), and great horned owl (*Bubo virginianus*), primarily from roadkilled individuals. Results from the program's 2019 foodstuffs monitoring are discussed in Chapter 8, Public Dose and Risk Assessment, and all other monitoring efforts are reported in Chapter 7, Ecosystem Health.

Meteorology Program

DOE Order 458.1, *Radiation Protection of the Public and the Environment*, and DOE Order 151.1D, *Comprehensive Emergency Management System*, require DOE sites to measure weather variables. The variables to be measured are determined by the radiological activities taking place at the site, the topography of the site, and the distances to critical receptors. The LANL Meteorology Program maintains a network of five meteorological towers that measure temperature, wind, humidity, pressure, precipitation, and solar radiation across the site. These data are used for emergency planning in the event of a chemical or radiological release; regulatory compliance in the areas of air quality, water quality, and waste management; and for supporting monitoring programs for surface water and environmental radiation. Weather data can be accessed internally at the Laboratory (https://weather.lanl.gov) or externally to the Laboratory network (https://weathermachine.lanl.gov). No new weather stations were added in 2019. Meteorological conditions at LANL for 2019 are reported in Chapter 4, Air Quality.

Natural Phenomena Hazard Assessment

DOE Order 420.1C, *Facility Safety*, requires that nuclear facility structures, systems, and components must effectively perform their intended safety functions in the face of natural phenomena hazards (for example, earthquakes, floods, and high winds). As a part of this requirement, natural phenomena hazards are reviewed every 10 years to determine if major modifications to nuclear facilities are required by significant increases in risk from natural phenomena. No meteorological assessments were conducted in 2019. The LANL Seismic Engineering Team provides seismic hazard analyses of key Laboratory facilities and is focused on improving seismic monitoring, site characterization, and our understanding of the Pajarito Fault system, path effects, and site effects. The Seismic Hazards Geology program conducts field mapping of the Pajarito Fault system in the vicinity of Los Alamos and performs site-specific hazard studies at current and planned facility sites.

Land Conveyance and Transfer

In 1997, Section 632 of Public Law 105-119 directed DOE to transfer excess land at the Laboratory to Los Alamos County and to the Secretary of the Interior in trust for the Pueblo de San Ildefonso. The 10 original land tracts located at LANL, identified for conveyance or transfer in an Environmental Impact Statement (DOE/EIS 0293), were subdivided into 32 tracts. To date, 26 of these tracts have been conveyed or transferred in the following way: 20 tracts have been conveyed to Los Alamos County, three tracts have been conveyed to the Los Alamos County School District, and three tracts have been transferred to the Bureau of Indian Affairs, to be held in trust for the Pueblo de San Ildefonso.
Tract A-16-b near DP Canyon was conveyed to Los Alamos County in 2019.

Tracts remaining that could be conveyed to Los Alamos County include Tract A-14 in Rendija Canyon, Tracts C-2 and C-4 along New Mexico Route 4, Tract A-18-2 in Bayo Canyon, and additional tracts at Technical Area 21. The Land Conveyance and Transfer Project staff continues to work with the DOE National Nuclear Security Administration Los Alamos Field Office to complete the outstanding compliance activities and requirements needed to convey the remaining tracts.

Conveyances to Los Alamos County support local community economic development by providing lands for housing, commercial uses, and recreation. Nearly 460 housing units, including low-income apartments and about 160 market-rate single-family homes, are being developed on tracts previously conveyed to Los Alamos County.

AWARDS AND RECOGNITION

During 2019, LANL was invited to present its Smart Labs Program progress at the DOE Energy Exchange and Better Buildings Summit and at the International Institute for Sustainable Laboratories conference. The Laboratory received an award for its progress as part of the Better Buildings Smart Labs Accelerator Program. See Figure 3-9.

Figure 3-9. Staff from LANL's Sustainability Program accept an award for implementation of LANL's Smart Labs Program.

DESCRIPTION OF THE QUALITY SYSTEM FOR MANAGEMENT OF ANALYTICAL ENVIRONMENTAL DATA

Data management consists of collecting and maintaining sampling data using procedures that ensure that the data comply with established requirements and that data are suitable for their intended use (for example, compliance monitoring or site characterization). Below, we describe the elements of the quality system for sample and data processing and quality assurance for both the management and operating contractor (Triad) and the legacy waste cleanup contractor (N3B) at the Laboratory.

N3B and Triad have very similar data collection and management programs. Each contractor maintains its own sample management office, but they use the same environmental data management platform (see Environmental Data Management Platform section below). Sample planning and collection is performed by individual programs in coordination with their sample management office. Sample handling, analysis, and data review and evaluation are conducted or overseen by the sample management office. Individual programs are responsible for reporting on data results; the sample management office may assist by providing data sets, but final reports are the responsibility of the program.

N3B and Triad received and reviewed more than 280,000 (N3B) and 110,000 (Triad) analytical results in 2019. Not all of these results were used in this report. Some results may be related to programs that are not included in the Annual Site Environmental Report.

Environmental Data Management Platform

The Environmental Information Management database is the core platform used by both N3B and Triad for managing analytical data. This cloud-based data management platform is used for planning sampling events, tracking the packaging and transportation of samples, and storing the results. This data system is jointly used by N3B, Triad, and the DOE Oversight Bureau of the New Mexico Environment Department for all LANL environmental analytical data. It interfaces with Intellus, a fully searchable database available to the public through the Intellus website (http://www.intellusnm.com).

The database structure is written and maintained by Locus Technologies and consists of a cloud-based SQL Server database platform coupled with a web-based user interface. It is designed to manage the sample collection and analysis from planning through data review and reporting. It includes modules for planning sample collection, tracking samples, uploading field data, uploading electronic data deliverables, and conducting automated data review, as well as tools for notifications and reporting.

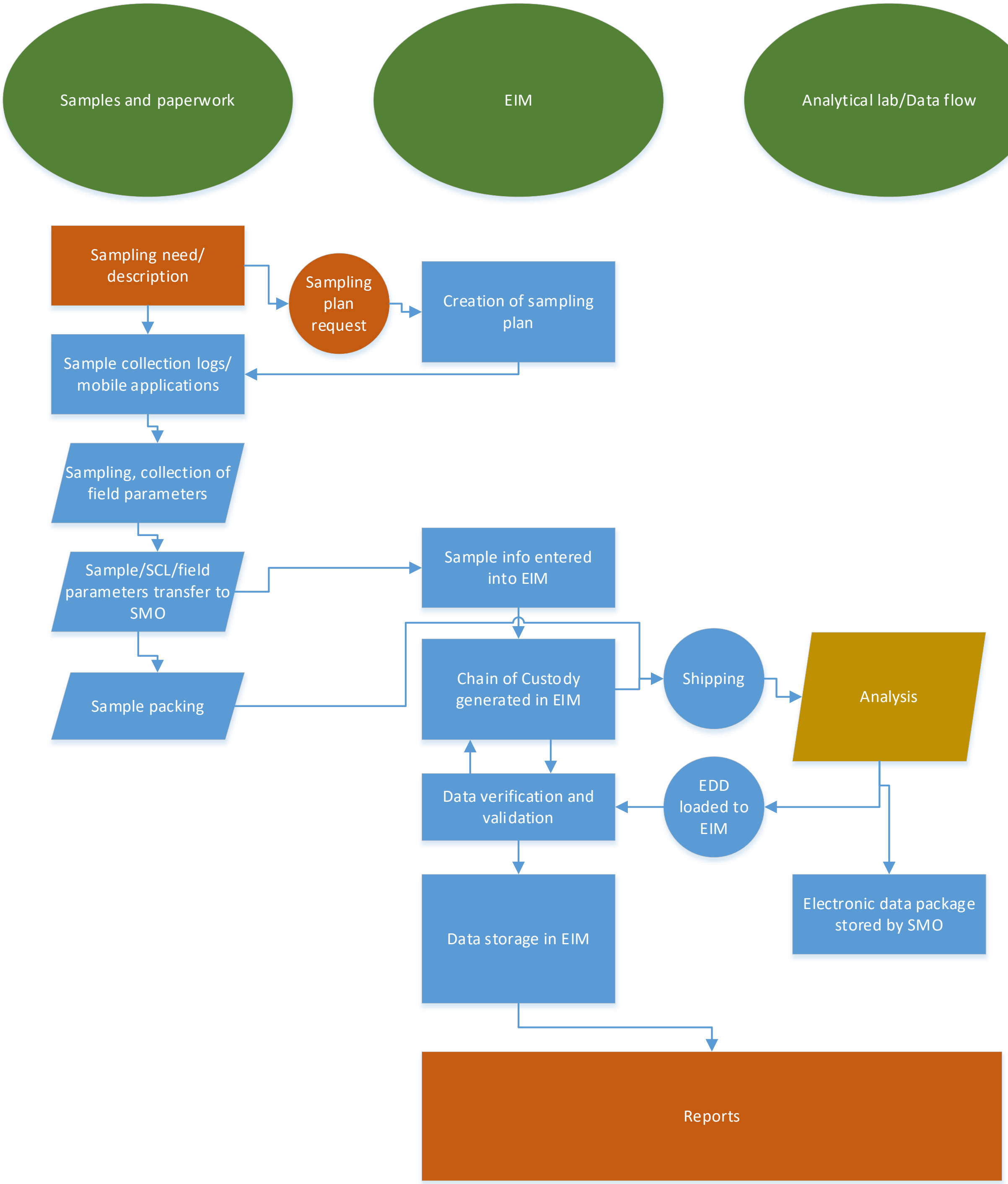
Figure 3-10 illustrates Sample Management Office processes and the role of the Environmental Information Management data system in these processes.

A Software Change Control Board, consisting of N3B, Triad, and New Mexico Environment Department representatives, has oversight responsibility for modifications made to database functionality and user interfaces. This process ensures that changes requested by one organization will not adversely affect the others. To ensure consistency in the database, standardized naming conventions are used for sampling locations to create a single list of shared location names.

Data Quality Objective Process

N3B and Triad ensure that the data reported from the analytical laboratories are of sufficient quality to fulfill their intended purpose and that the data quality is documented so the data can be evaluated for current and future use. The data collected should support defensible decision-making as described in the *Guidance on Systematic Planning Using the Data Quality Objectives Process (EPA QA/G-4)* (U.S. Environmental Protection Agency 2006).

N3B data quality objectives detail minimum quality assurance and quality control on a project-specific basis. Examples of projects include all of the sampling events and samples collected to fulfill a set of permit requirements; all sampling events and samples collected to determine waste disposition; or all



SMO = Sample Management Office
EIM = Environmental Information Management database
SCL = Sample Collection Log; serves as a field chain of custody
EDD = Electronic Data Deliverable text file; used to load analytical data into Environmental Information Management database

Figure 3-10. Functional diagram of the Sample Management Office work. Green ovals represent the three main Sample Management Office functions. Figures with blue background show data collection steps that directly involve the Sample Management Office.

samples and sampling events collected to fulfill a memorandum of understanding or regulated agreement.

The project manager determines the project's specific data quality objectives within the boundaries of contracted services and standard operating procedures. If the project's needs exceed contracted services or standard operating procedures, the Sample Data Management Director may initiate revisions to contracts and standard operating procedures.

Sample Collection and Handling

Sample and data management begins with planning the sampling to ensure that the data will meet the data quality objectives for the project. Sample collection and handling follows established methods. Whenever possible, standard U.S. Environmental Protection Agency methods are used. When federal- or state-approved standard methods are unavailable, LANL-specific procedures are used.

A sampling plan is created in the Environmental Information Management data system. As part of the sampling plan, the system generates sample collection logs and chain-of-custody forms. The sample collection log lists the sampling containers and preservatives needed for each analysis requested. Personnel who conduct the sampling record information on the sample collection log, including location of sampling (if different from planned), sampling date and time (necessary to establish holding time), field parameters if required by the project, and any other comments that may be applicable. Collected samples are placed in coolers, cooled with ice (if required for the analytical method), and delivered to the Sample Management Office. From the time of sampling until delivery to the Sample Management Office, samples are under direct custody of the samplers. At the Sample Management Office, custody is transferred to Sample Management Office staff. Custody transfer is confirmed by signatures. Additionally, before samples are accepted by the Sample Management Office, tamper-indicating devices—also known as custody seals—are placed on every sample container.

Before shipping, Sample Management Office staff store samples as required by the analytical method, including in temperature-controlled refrigerators if needed. Glass sample containers are wrapped in bubble bags to prevent breakage. Samples are packed in coolers with blue ice and/or bagged ice to ensure proper shipping temperature. The signed chain of custody documents are placed inside the coolers. Coolers are taped shut and protected with tamper-indicating devices. Samples are shipped overnight to the designated analytical laboratory. If both the cooler and sample tamper-indicating devices have been damaged or tampered with, the sample is considered unusable. Upon arrival at the designated lab, the integrity of tamper-indicating devices is verified, shipping temperature on arrival is measured, and samples are compared with their respective chain of custody. After the analytical laboratory logs samples into their information management system, the samples are analyzed.

Selection of Analytical Laboratories

Analytical laboratories have been selected through the Request for Proposal process. N3B and Triad have selected laboratories that meet the DOE Consolidated Audit Program – Accreditation Program requirements (see section on *DOE Consolidated Audit Program – Accreditation Program for commercial analytical laboratories* below). For Triad, National Environmental Laboratory Accreditation Program accredited laboratories are chosen when a given analysis is not available from a contracted DOE Consolidated Audit Program–accredited laboratory. Along with the DOE Consolidated Audit Program accreditation, N3B selects laboratories that meet requirements in their Scope of Work Exhibit "D," *Scope* *of Work and Technical Specifications for Off-Site Analytical Laboratory Services*. The Scope of Work Exhibit "D" was developed using the *Department of Defense/Department of Energy Consolidated Quality Systems Manual for Environmental Laboratories*. N3B has contracted with ten analytical laboratories, eight of which performed certifiable analyses for N3B in 2019. When selecting a laboratory to perform a specific analysis, in addition to meeting the minimum requirements of the DOE Consolidated Audit Program and the scope of work, consideration was given to maintaining projects' continuity of data, adding laboratory capabilities to prevent disruptions caused by unforeseen lab closures, instrument failures, or cost. This approach allows for split sampling and data quality comparison.

Sample Analysis

Sample preparation and analyses are performed in the laboratories using industry-standard methods such as those from the U.S. Environmental Protection Agency SW-846, *Clean Water Act*, American Industrial Hygiene Association, Occupational Safety and Health Administration, National Institute of Safety and Health, American Society for Testing and Materials, and American Public Health Association. In the absence of an industry standard method, analyses are performed using performance-based methods that meet the project-specific data quality objectives.

The choice of specific method is determined by program or permit requirements or the desired detection limit. All laboratory quality control samples are reported back to Triad or N3B. Additionally, field quality control samples (blank samples and duplicate samples) are sent periodically for analysis. The frequency of field quality control samples is determined by analytical methods, permits, or LANL procedures.

Data Review and Evaluation

Analytical results are generally returned to LANL in two forms: as an electronic data deliverable and as a data package. An electronic data deliverable is a data file transmitted in a format that can be directly uploaded in database programs. Data packages consist of the combined analytical chain of custody, signed sample collection logs, validation report (if available), and the analytical data report and are usually delivered as a portable document format (pdf) file. Some data users additionally request a hard copy of the data package. For N3B, laboratory data packages and electronic data deliverables adhere to the requirements specified in Exhibit "D," *Scope of Work and Technical Specifications for Off-Site Analytical Laboratory Services*.

Electronic data deliverables are loaded into holding tables in the Environmental Information Management database. Automated programs in the database verify the data in these files by checking for the following:

- Correct format of the electronic data deliverable file, including the number and types of fields (text/numeric/date-time)
- Analyses reported that agree with those ordered
- Data that were already reported (avoiding duplicates)
- The sampling date used by the lab agrees with database sampling date (important for holding time evaluation by the lab)
- Dates listed by the lab are consistent (for example, sampling before preparation date, preparation before analysis date)

Upon verification, a Sample Management Office chemist runs an auto-validation routine in the Environmental Information Management database to validate reported data. Auto-validation follows the U.S. Environmental Protection Agency's National Functional Guidance documents and the *Department of Defense/Department of Energy Consolidated Quality Systems Manual for Environmental Laboratories* for validation of the analytical data. The important exclusions from auto-validation are examination of the spectra (mass spectra, ultraviolet spectra, rad alpha spectra), chromatograms (for methods using confirmation column), and filed blank/duplicate samples. The auto-validation checks and applies proper validation qualifiers and validation reason codes for the following:

- Holding time
- Method blank contamination
- Laboratory control samples and duplicates within limits
- Matrix spike recoveries within limits
- Missing laboratory quality control samples

When verification and auto-validation are completed, data are transferred to production tables in the database.

Data may undergo a manual validation. There are two mechanisms for manual validation: random manual validation of a small percentage of the data or focus validation. For N3B, a minimum of 10 percent of analytical data is manually validated by a chemist. Focus validation is performed on specific data at the request of the data owner or the person preparing reports.

During manual validation, selected samples undergo full validation. Data stored in the Environmental Information Management tables and the data packages are reviewed. All aspects of data quality are evaluated, including spectral data. If manual validation results in a change of the data qualification, the changes are entered into the Environmental Information Management database. A description of the changes and a short explanation of reasons for the changes are included. All such changes are tracked in the Environmental Information Management database's audit tables.

Field quality control samples are evaluated when data sets are prepared for individual programs or data owners. Any detections found in blank samples or large discrepancies in results between duplicated samples are reported back to a Sample Management Office chemist. If the chemist decides that field quality control samples warrant changes in the validation qualifiers or detection status, the changes are entered into the Environmental Information Management database.

The primary purpose of data validation is to assess and summarize the quality and defensibility of analytical data for the end users. The combined guidelines and requirements ensure the necessary level of confidence in data quality and usability for project activities. The entire data validation process includes a description of the reasons for any failure to meet method, procedural, or contractual requirements and an evaluation of the impact of such failure on the associated data or data set.

Environmental Information Management Platform Performance Testing

N3B chemists performed extensive testing of the Automated Data Review Data Validation Module of the Environmental Information Management database, including using electronic data deliverables from actual laboratory analyses. They identified numerous issues and opportunities for enhancements. N3B personnel worked with Locus Technology to implement corrections and improvements to ensure that the outputs meet the requirements in the DOE Quality Systems Manual and the recommendations in the U.S. Environmental Protection Agency's National Functional Guidelines. This work was performed in coordination with Triad and the New Mexico Environment Department.

The validation changes increase transparency and ensure a unified treatment of all data being displayed to the public on Intellus. Testing the system's configuration provided proof of the system's capabilities to perform routine data checks accurately based on analytical methods and regulatory requirements. In addition, the Automated Data Review module was improved for all analytes, particularly radiochemistry data. During this process, N3B chemists manipulated example information to verify that the actual outcomes matched the expected outcomes. The results of this testing were shared with the data system architects, and improvements were identified. Additionally, during this process, N3B identified that the radiochemical capabilities were underutilized and so enhanced the Automated Data Review functionality with respect to radioanalytical assessment.

Records Retention

Original hard copies of chain-of-custody forms and sample collection logs are temporarily stored at the Sample Management Office. Annually, older forms are transferred to the Federal Records Center. The ambient air-monitoring program requires a hard-copy Level IV data package to remain onsite. These records are packaged by fiscal year and transferred to the LANL Records Center, where they remain onsite for 5 years. At the end of 5 years, these records are also transferred to the Federal Records Center.

Analytical records are stored in the Environmental Information Management database. The entire N3B and Triad Environmental Information Management database is backed up at least quarterly on N3B or Triad servers. The analytical results are copied daily to the publicly available Intellus database (www.intellusnm.com). Level IV data packages are also uploaded into the LANL Electronic Records Management System to fulfill the long-term record retention requirement. Approximately once a month, the Level IV data packages are copied to Intellus.

Some data and analytical packages are withheld from public view for up to 90 days from the date of receipt. These packages are usually results from samples collected offsite that LANL shares first with other entities like counties or Native American tribes.

Quality Assurance

N3B's Sample Data Manager and the Sample Management Office are subject to the N3B Quality Assurance and Transformation Audit and Surveillance program and the following:

- Supporting the DOE Consolidated Audit Program audits of analytical laboratories used for environmental sampling (LLCC C.3.7.6 Analytical Laboratories) per the Los Alamos Legacy Cleanup Contract
- Participating in internal audits under the management assessments program
- Supporting Quality Assurance and Transformation in developing project assessment criteria and issues responses in the N3B integrated Contractor Assurance System
- Performing Management Observation and Verifications
- Designating personnel by the Sample Data Management Director to track performance of activities conducted under the scope of this sample and data management plan

DOE's Analytical Services Program

The DOE's Analytical Services Program provides environmental management-related services and products to DOE Program Offices and field sites. The various parts of the Analytical Services Program in which the Laboratory participates are described here.

DOE Consolidated Audit Program – Accreditation Program for commercial analytical laboratories

The DOE Consolidated Audit Program provides for assessments of commercial analytical laboratories that analyze environmental samples. Beginning in fiscal year 2018, use of third-party auditors replaced the traditional DOE Consolidated Audit Program audits, allowing for more in-depth approaches to quality control and oversight of these laboratory facilities in meeting the needs of the DOE. The DOE Consolidated Audit Program has qualified the following three accrediting bodies to perform these audits:

- Perry Johnson Laboratory Accreditation, Inc.
- The American Association for Laboratory Accreditation
- The American National Standards Institute National Accreditation Board

Laboratories are audited against the International Organization of Standardization's Standard 17025, *General Requirements for the Competence of Testing and Calibration Laboratories*; the National Environmental Laboratory Accreditation Conference Standard; and the *Department of Defense/Department of Energy Consolidated Quality Systems Manual for Environmental Laboratories.* N3B uses the results from these third-party accreditation assessment reports as part of its oversight for its subcontracted commercial analytical laboratories. Table 3-4 provides a summary of the DOE Consolidated Audit Program laboratories that are currently subcontracted to perform samples analysis for N3B.

Table 3-4. DOE Consolidated Audit Program – Accreditation Program Audits of Laboratories Contracted by N3B and/or Triad in Fiscal Year 2019

Laboratory	Audit Dates	Accrediting Body	Used in FY19
GEL Laboratories LLC, Charleston, SC	May 20–24, 2019	A2LA[1]	Yes
ARS Aleut Analytical, LLC, Anchorage, AK	August 13–15, 2019	ANAB[2]	Yes
Brooks Applied Labs, Bothell, WA	September 16–18, 2019	ANAB	Yes
Southwest Research Institute, San Antonio, TX	February 12–15, 2019	A2LA	Yes
ALS Environmental, Salt Lake City, UT	September 9–10, 2019	PJLA[3]	Yes
ALS Environmental, Fort Collins, CO	Alternate year desktop surveillance, August 2019	PJLA	No
Desert Research Institute, Reno, NV	Non-DOECAP laboratory[4]	n/a	Yes
EMSL Analytical, Inc.	March 3–8, 2019	A2LA	No
TestAmerica Laboratories, Inc., Arvada, CO	October 11–12, 2018	A2LA	No
Materials and Chemistry Laboratory, Inc., Oak Ridge, TN	May 20–21, 2019	PJLA	No

[1] *The American Association for Laboratory Accreditation*

[2] *The American National Standards Institute National Accreditation Board*

[3] *Perry Johnson Laboratory Accreditation, Inc.*

[4] *Analyses performed at this laboratory do not fall under the DOECAP scope.*

N3B provided support to the DOE Consolidated Audit Program in various ways throughout fiscal year 2019. The team participated in the Analytical Services Program annual training workshop, which consisted of presentations related to the Analytical Services Program activities, future direction of the program, and technical presentations with regard to data quality and data management. N3B supported two DOE Consolidated Audit Program audits by providing audit observers to the GEL Laboratories audit and the Brooks Applied Laboratory audit. Finally, N3B staff played an active role in the DOE Consolidated Audit Program Data Quality Work Group, participating in conference calls and answering questions or requests regarding issues that came up during laboratory audits and general laboratory or data-quality questions from around the complex.

Findings from the third-party audits are reported back to the interested DOE sites through the DOE Consolidated Audit Program administrator. N3B tracks all findings from the laboratories it has under contract. Several findings from fiscal year 2019 are considered to be major findings for the purpose of this report. Some of these findings were recurring between multiple laboratories. The significant findings are outlined here:

- Finding: Laboratories do not document all procedural deviations from standard test methods.
- Finding: The laboratories do not maintain all of the records necessary for re-creation of the data package. Recurring examples included identification of the pH meters, balances, and pipettes used for various processes.
- Finding: Examples were cited where laboratories were not analyzing the quality control samples in the exact same manner as the client samples.
- Finding: Examples were cited where proficiency-testing samples were not being analyzed in the same manner as regular client samples.

Before receiving certificates of accreditation, laboratories are required to submit corrective action reports to the accrediting bodies. The accrediting bodies must accept these corrective actions as sufficient before granting accreditation. All N3B subcontract laboratories received their accreditations in fiscal year 2019, indicating that the corrective actions were determined to be sufficient in fixing the identified issues.

DOE Mixed Analyte Performance Evaluation Program

The Mixed Analyte Performance Evaluation Program provides proficiency testing in various environmental matrices primarily for radionuclide identification and quantification. Results for proficiency testing help to assure field managers of the quality and reliability of environmental data for decisionmaking. Laboratories are required through the National Laboratory Accreditation Conference Standard and the DOE Quality Systems Manual to participate in proficiency testing in all fields of accreditation, where available.

Although not a mandatory requirement of the Quality Systems Manual, the Mixed Analyte Performance Evaluation Program can be a very useful tool in determining a commercial laboratory’s analytical radiological capabilities across most environmental matrices. Participation in the Mixed Analyte Performance Evaluation Program is required for laboratories that perform radiochemical analyses for N3B. In fiscal year 2019, two laboratories fell under this requirement. These laboratories both participated in the two available rounds (Series 40 and Series 41) of the Mixed Analyte Performance Evaluation Program.

In general, Mixed Analyte Performance Evaluation Program results at N3B subcontract laboratories were acceptable, with minor exceptions in the most recent round, Series 41. The labs reported radium-226 results from the water matrix with an unacceptable high bias. In the previous series, radium-226 was spiked at a similar level, and the labs reported an acceptable result. This provides confidence that the failure was an anomaly.

Failures related to the analysis of uranium-234 and uranium-238 in Mixed Analyte Performance Evaluation Program Series 41 with a strong negative bias were noted and considered. Soil matrix samples are known to contain insoluble uranium, which cannot be accurately measured without employing a rigorous sample destruction that many labs do not routinely perform and might not deem necessary, depending on the intent of the analysis. The labs performed well on the Mixed Analyte Performance Evaluation Program Series 40 soils.

DOE Consolidated Audit Program – Treatment, Storage, and Disposal Facility Audits

Treatment, storage, and disposal facility audit reports generated by the DOE Consolidated Audit Program are one tool that DOE Field Office managers can use in performing their DOE O 435.1 annual acceptability reviews for these commercial sites. These audits are conducted by volunteers from the DOE and site contractors who use these sites for the disposal of waste. Table 3-5 provides a summary of the treatment, storage, and disposal facilities that were audited by the DOE Consolidated Audit Program in fiscal year 2019 and were subcontracted to accept radioactive waste from N3B for disposal.

Table 3-5. Audits of Treatment, Storage, and Disposal Facilities Used by N3B in Fiscal Year 2019 under the DOE Consolidated Audit Program

Treatment, Storage, and Disposal Facility	Audit Dates
Waste Control Specialists, LLC	May 7–9, 2019
EnergySolutions, LLC	May 14–16, 2019
Perma-Fix Northwest	June 4– 6, 2019

Findings from all of the treatment, storage, and disposal facilities that N3B uses are reviewed and tracked by the Waste Management Program. Several findings from fiscal year 2019 are considered to be major findings for the purpose of this report. Although there were several issues identified as significant findings, these issues were not of immediate significance to compliance, policy, or performance. The significant findings are outlined as follows:

- Perma-Fix Northwest (Richland, Washington)
  - There were no significant findings identified during this audit.
- Waste Control Specialists (Andrews County, Texas)
  - Finding: Completed quality records are not being stored in a 1-hour, fire-rated cabinet before being scanned.
  - Finding: Commercial Grade Dedication training was not current in the training database for one employee.
  - Finding: The current Waste Controls Specialist Transportation Plan does not reflect all their current practices in the field.

- EnergySolutions (Clive, UT)
  - Finding: Some security signs outside the mixed waste storage pad were faded to the point that they are not legible from 25 feet, as required by regulations and Resource Conservation and Recovery Act permit.
  - Finding: Two satellite accumulation containers in the outside maintenance building were labeled as hazardous waste but were not marked with the hazards of the contents.
  - Finding: An inspection of the new fuel storage and refueling area found that there are not any “No Smoking” signs posted around or near the fueling area.
  - Finding: Several cylinders were observed in the full flammable cylinder storage area adjacent to the outside maintenance shop that were not secured.
  - Finding: Training records in the Energy Solutions Training Management System were not current for all positions that were randomly selected.

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The purpose of the air quality surveillance program at Los Alamos National Laboratory (LANL, or the Laboratory) is to protect public health and the environment. A primary objective is to measure levels of airborne radiological materials in order to calculate radiological doses to humans, plants, and animals. We also conduct meteorological monitoring of the local climate and weather.

Results from radiological monitoring of the air are compared with U.S. Department of Energy and U.S. Environmental Protection Agency standards. During 2019, the emissions from Laboratory operations were below the applicable regulatory limits. The Laboratory uses the data reported here to help address the question, "Are there adverse effects to humans, plants, or animals from Laboratory-produced radioactive airborne materials or direct radiation?" in Chapters 7 and 8, Ecosystem Health *and* Public Dose and Risk Assessment*. Weather data support many Laboratory activities, including emergency management and response, regulatory compliance, safety analysis, engineering studies, and environmental surveillance programs.*

INTRODUCTION

The purpose of the air quality surveillance program at Los Alamos National Laboratory (LANL, or the Laboratory) is to protect public health and the environment. Air quality is monitored by five programs, each described in a section of this chapter: (1) ambient air sampling at public locations, (2) exhaust stack sampling at Laboratory facilities, (3) gamma and neutron direct-penetrating radiation monitoring near radiation sources and in public locations, (4) particulate matter monitoring, and (5) meteorological monitoring of the local climate and weather.

A primary objective is to measure levels of airborne radiological materials in order to calculate radiological doses to humans, plants, and animals. Results are compared with standards from the U.S. Department of Energy and the U.S. Environmental Protection Agency. Radioactivity levels in the air are compared with limits for members of the public provided in DOE Order 458.1 Chg 3, *Radiation Protection of the Public and the Environment*, and in the *National Emission Standards for Hazardous Air Pollutants*, Title 40, Part 61 of the Code of Federal Regulations. Estimates of public doses prepared using these data are provided in Chapter 8, Public Dose and Risk Assessment.

AMBIENT AIR SAMPLING FOR RADIONUCLIDES

To monitor releases from Laboratory operations, the Laboratory's air sampling network measures levels of airborne radionuclides. Radioactivity levels in the air are compared with the U.S. Environmental Protection Agency's concentration levels for environmental compliance, as provided in *National Emission Standards for Hazardous Air Pollutants*, Title 40, Part 61 of the Code of Federal Regulations, Appendix E, Table 2.

During 2019, the Laboratory operated approximately 40 environmental air-monitoring stations to monitor radionuclides in the air (Figures 4-1 and 4-2). Station locations are categorized as regional (away from the Laboratory), perimeter, onsite, or waste site. The waste site locations monitor radionuclides

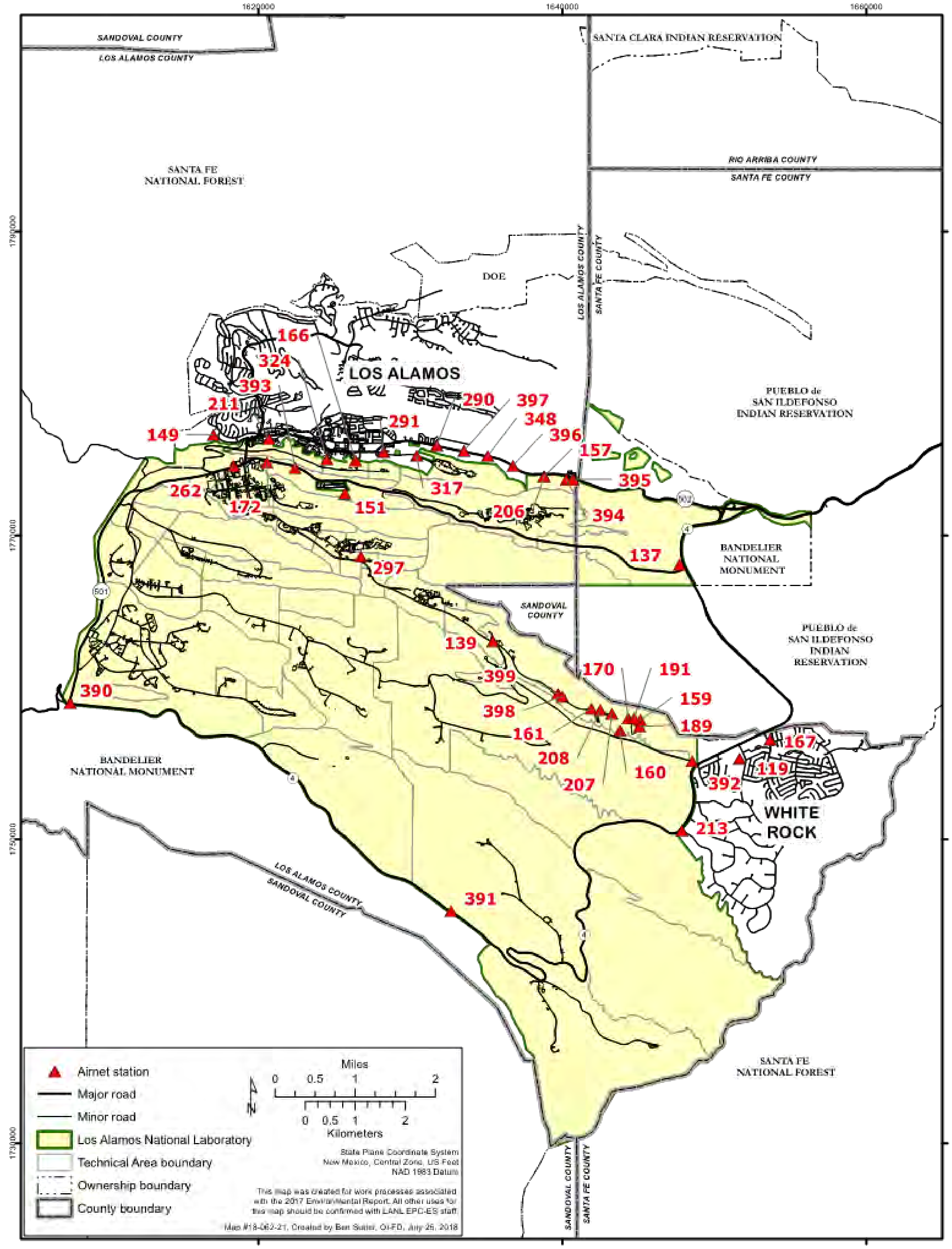
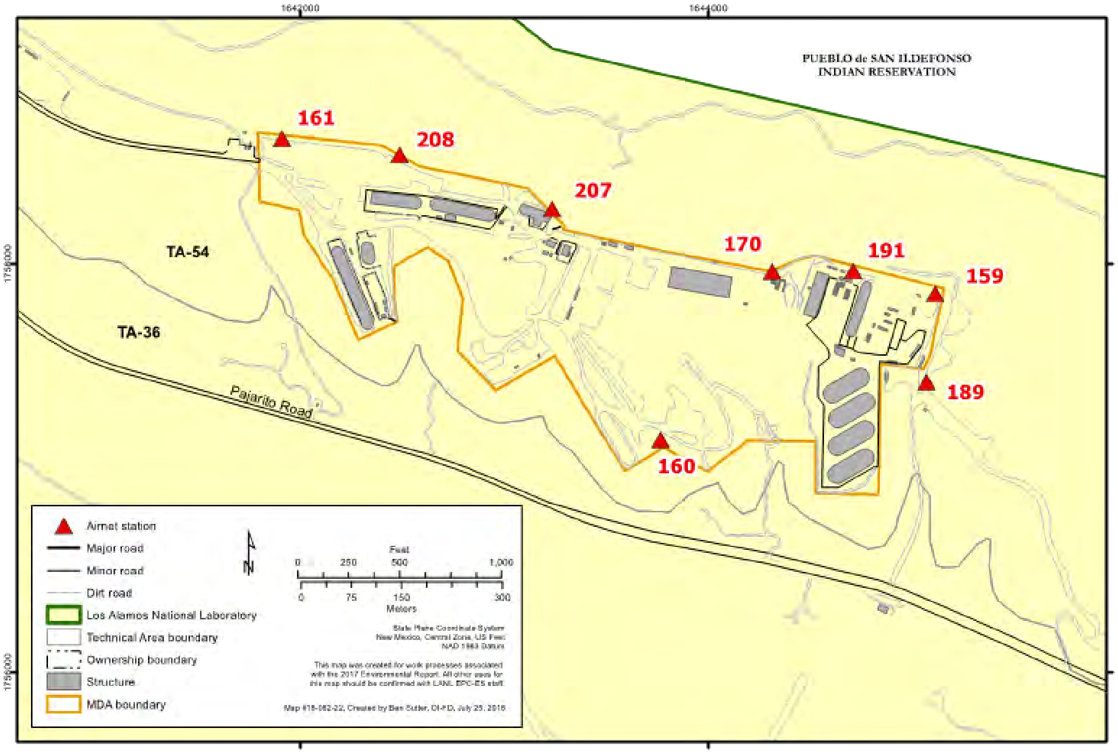


Figure 4-1. Environmental air-monitoring stations at and near the Laboratory



Note: MDA = material disposal area; TA = technical area

Figure 4-2. Environmental air-monitoring stations at the Laboratory's Technical Area 54, Area G

near the Laboratory's low-level radioactive waste disposal area and radioactive waste storage area, Area G, at Technical Area 54. These stations operate continuously by pulling ambient air through a filter to capture airborne particulate matter; the filters are changed out every two weeks and sent to an offsite analytical laboratory.

Regional Background Levels

The atmosphere contains background levels of radioactivity consisting of naturally occurring radionuclides and also radioactive materials from nuclear weapons tests and nuclear accidents. Laboratory staff monitor the air to determine if the Laboratory is adding radioactivity to the atmosphere. Background levels are measured at regional monitoring stations located in the communities of El Rancho, Española, and Santa Fe. The results are summarized in Table 4-1.

What are cosmic rays?

Cosmic rays are fragments of atoms that rain down upon the Earth from outside the solar system.

Table 4-1. Average Background Radionuclide Activities in the Regional Atmosphere

Analyte	Units	U.S. Environmental Protection Agency Concentration Level for Environmental Compliance	Average Regional Background Activities
Tritium	pCi/m^3	1500	1 ± 1
Americium-241	aCi/m^3	1900	0 ± 1
Plutonium-238	aCi/m^3	2100	0 ± 1
Plutonium-239/240	aCi/m^3	2000	0 ± 1
Uranium-234	aCi/m^3	7700	10 ± 4
Uranium-235	aCi/m^3	7100	1 ± 1
Uranium-238	aCi/m^3	8300	7 ± 3

Note: pCi/m^3 = picocuries per cubic meter; aCi/m^3 = attocuries per cubic meter.

Perimeter, Onsite, and Waste Site Radionuclides

Tritium

Tritium is present in the environment primarily as the result of past nuclear weapons tests and cosmic-ray interactions with the air (Eisenbud and Gesell 1997). Measurements of water vapor in the air and tritium in the water vapor are used to calculate the amount of tritium in the air. During 2019, tritium concentrations were similar to recent years and below U.S. Environmental Protection Agency's concentration level for environmental compliance of 1,500 picocuries per cubic meter (Table 4-2). The highest annual tritium activity at any offsite station was 0.2 percent of the concentration level.

Table 4-2. Airborne Tritium as Tritiated Water Activities for 2019—Group Summaries

Station Grouping	Number of Stations	Mean ± 2 Standard Deviations (pCi/m^3)		Maximum Annual Station Activity (pCi/m^3)	U.S. Environmental Protection Agency Concentration Level for Environmental Compliance (pCi/m^3)
Regional	3	1	±1	1	1,500
Perimeter	27	1	±1	3	1,500
Onsite	2	5	n/a	9	1,500
Waste site	1	329	n/a	329	1,500

Note: pCi/m^3 = picocuries per cubic meter, n/a = not applicable.

For the waste site, tritium data are reported for the location at the southern boundary of Area G (station 160, Table 4-2), which is where the tritium concentrations are largest. At the other Area G stations, tritium was monitored only during the last quarter of 2019; therefore, these data were not included in Table 4-2. All of the last-quarter results from these locations were below 329 picocuries per cubic meter. All concentrations are well below the tritium concentration level of 1,500 picocuries per cubic meter.

Analytical methods comply with U.S. Environmental Protection Agency requirements in *National Emission Standards for Hazardous Air Pollutants*, Title 40, Part 61 of the Code of Federal Regulations, Appendix B, Method 114.

Americium-241

Table 4-3 summarizes the 2019 sampling data for americium-241. The results are similar to recent years and about 0.1 percent of the americium-241 concentration level for environmental compliance.

Table 4-3. Airborne Americium-241 Activities for 2019—Group Summaries

Station Grouping	Number of Stations	Mean ± 2 Standard Deviations (aCi/m^3)		Maximum Annual Station Activity (aCi/m^3)
Regional	3	0	±1	0
Perimeter	27	0	±1	2
Onsite	2	0	±1	0
Waste site	8	0	±1	2

Note: aCi/m^3 = attocuries per cubic meter

Plutonium

Table 4-4 summarizes LANL's 2019 plutonium-238 and plutonium-239/240 data, which are similar to previous years.

Table 4-4. Airborne Plutonium-238 and Plutonium-239/240 Activities for 2019—Group Summaries

Station Grouping	Number of Stations	Group Mean ± 2 Standard Deviations (aCi/m^3)		Maximum Annual Station Activity (aCi/m^3)	
		Plutonium-238	**Plutonium-239/240**	**Plutonium-238**	**Plutonium-239/240**
Regional	3	0 ± 1	0 ± 1	0	1
Perimeter	27	0 ± 1	3 ± 13	1	25
Onsite	2	0 ± 1	0 ± 2	0	1
Waste site	8	0 ± 1	1 ± 1	0	1

Note: aCi/m^3 = attocuries per cubic meter

Every year, dust from areas where Manhattan Project–era operations took place results in detectable amounts of plutonium-239 in the air near Technical Areas 01 and 21. Plutonium-239 concentrations at environmental air-monitoring stations 317 (DP Road), 324 (Hillside 138), and 348 (downwind of Technical Area 21) are about 1 percent of the U.S. Environmental Protection Agency's plutonium-239 concentration level for environmental compliance, which is 2,000 attocuries per cubic meter.

Uranium

Table 4-5 summarizes uranium data. The results are consistent with naturally occurring uranium and are below the applicable concentration levels.

Table 4-5. Airborne Uranium-234, -235, and -238 Activities for 2019—Group Summaries

Station Grouping	Number of Stations	Group Mean ± 2 Standard Deviations (aCi/m^3)		
		Uranium-234	**Uranium-235**	**Uranium-238**
Regional	3	10 ± 8	1 ± 1	7 ± 6
Perimeter	27	7 ± 9	1 ± 1	7 ± 7
Onsite	2	5 ± 3	0 ± 1	6 ± 6
Waste site	8	7 ± 6	0 ± 1	7 ± 5

Note: aCi/m^3 = attocuries per cubic meter

Gamma Spectroscopy Measurements

Air samples are analyzed by gamma spectroscopy for the following radionuclides that produce gamma rays: cobalt-60, cesium-134 and -137, iodine-131, sodium-22, and protactinium-234m. These radionuclides were not detected.

Conclusion

All concentrations of airborne radioactive material measured in ambient air samples were below the applicable concentration levels for environmental compliance.

EXHAUST STACK SAMPLING FOR RADIONUCLIDES

Introduction

Radioactive materials are used in some Laboratory operations. Buildings that house those operations may vent radioactive materials into the environment through an exhaust stack or other release point. The Laboratory's stack monitoring team monitors emission points that could cause a public dose greater than 0.1 millirem in a year. Each of these stacks is sampled in accordance with the *National Emission Standards for Hazardous Air Pollutants*, Title 40, Part 61 of the Code of Federal Regulations, Subpart H.

Sampling Methodology

Radioactive stack emissions can be one of four types: (1) particulate matter, (2) activated vapors and volatile compounds, (3) tritium, or (4) gaseous mixed activation products. Activated materials are made radioactive by exposure to neutron radiation. The sampling method is described below for each emission type.

Emissions of particulate matter are sampled using a glass-fiber filter. A continuous sample of air from the stack is pulled through a filter that captures small particles. Filters are collected weekly and shipped to an offsite analytical laboratory.

Charcoal cartridges are used to sample emissions of vapors and volatile compounds generated by operations at the Los Alamos Neutron Science Center at Technical Area 53, the Chemistry and Metallurgy Research Building, and Technical Area 48.

Tritium emissions are measured with collection devices known as bubblers to determine the total amount of tritium released and whether it is in the elemental or oxide form. The bubblers pull a continuous sample of air from the stack. The sample is then "bubbled" through three sequential vials containing ethylene glycol. The ethylene glycol collects any tritium oxide that may be part of a water molecule. The air is then passed through a palladium catalyst that converts the elemental tritium to its oxide form. The sample is then pulled through three additional vials containing ethylene glycol, which collect the newly formed tritium oxide.

The stack monitoring team measures gaseous mixed activation products emissions from Los Alamos Neutron Science Center activities using real-time air-monitoring data. A sample of air from the stack is pulled through an ionization chamber that measures the total amount of radioactivity in the sample.

Data Analysis

Methods

This section discusses analysis methods for each type of Laboratory emission. The methods comply with U.S. Environmental Protection Agency requirements in the *National Emission Standards for Hazardous Air Pollutants*, Title 40, Part 61 of the Code of Federal Regulations, Appendix B, Method 114.

Check of the Total Activity

Each week, the glass-fiber filters are collected, and the total activity is measured before the filters are shipped to an offsite analytical laboratory, where they are analyzed using spectroscopy to identify radionuclides. These data are used to quantify emissions of radionuclides. Results are compared with the total activity measurements to ensure that all radionuclides are identified.

Vaporous Activation Products

Each week, charcoal cartridges are collected and shipped to an offsite analytical laboratory, where they are analyzed using spectroscopy. These data are used to identify and quantify the presence of vaporous material.

Tritium

Each week, tritium bubbler samples are collected and transported to the Laboratory's Health Physics Analysis Laboratory, where the amount of tritium in each vial is determined by liquid scintillation counting.

Gaseous Mixed Activation Products

The Laboratory continuously monitors gaseous mixed activation products at the Los Alamos Neutron Science Center. There are two reasons for using continuous monitoring. First, standard filter paper and charcoal filters will not collect gaseous emissions. Second, the half-lives of these radionuclides are so short that the activity would decay away before any sample could be analyzed offsite. The monitoring system includes a flow-through ionization chamber in series with a gamma spectroscopy system. The real-time current that this ionization chamber measures is recorded on a strip chart, and the total amount of charge collected in the chamber is integrated daily. The gamma spectroscopy system analyzes the composition of these gaseous mixed activation products.

Analytical Results

Table 4-6 provides detailed emissions data for Laboratory buildings with sampled stacks. Table 4-7 provides a detailed listing of the total stack emissions in the groupings of gaseous mixed activation products and particulate matter plus vapor activation products. Table 4-8 presents the half-lives of the radionuclides typically emitted by the Laboratory.

Table 4-6. Airborne Radioactive Emissions from LANL Buildings with Sampled Stacks in 2019
Values are expressed in scientific notation.

Technical Area and Building Number	Tritium (Curies)	Americium-241 (Curies)	Plutonium (Curies)	Uranium (Curies)	Thorium (Curies)	Particulate Matter plus Vapor Activation Products (Curies)	Gaseous Mixed Activation Products (Curies)
TA-03-029		6.3×10^{-8}	7.5×10^{-7}	3.9×10^{-6}	1.5×10^{-7}	1.7×10^{-5}	
TA-16-205/450	38.6						
TA-48-001						1.4×10^{-3}	
TA-50-001			2.5×10^{-8}		2.5×10^{-8}		
TA-50-069					2.4×10^{-10}		
TA-53-003	5.1					1.5×10^{-4}	15
TA-53-007	3.7					2.6×10^{-3}	251
TA-54-231/375/412				1.0×10^{-8}	5.7×10^{-9}		
TA-55-004	0.7		1.2×10^{-8}	3.9×10^{-8}	7.6×10^{-9}		
TA-55-400			2.5×10^{-9}				
Total	48	6.3×10^{-8}	7.9×10^{-7}	4.0×10^{-6}	1.9×10^{-7}	4.2×10^{-3}	266

Table 4-7. Activation Products in 2019

Building No.	Nuclide	Emission (Curies)*	
TA-03-29	Cesium-137	0.000012	1.2×10^{-5}
TA-03-29	Gallium-68	0.0000023	2.3×10^{-6}
TA-03-29	Germanium-68	0.0000023	2.3×10^{-6}
TA-48-001	Arsenic-73	0.0000013	1.3×10^{-6}
TA-48-001	Bromine-77	0.000006	6.0×10^{-6}
TA-48-001	Gallium-68	0.00013	1.3×10^{-4}
TA-48-001	Germanium-68	0.00013	1.3×10^{-4}
TA-48-001	Mercury-197	0.00052	5.2×10^{-4}
TA-48-001	Mercury-197m	0.00052	5.2×10^{-4}
TA-48-001	Osmium-191	0.0000001	1.0×10^{-7}
TA-48-001	Selenium-75	0.000087	8.7×10^{-5}
TA-53-003	Argon-41	0.59	5.9×10^{-1}
TA-53-003	Beryllium-7	0.000022	2.2×10^{-5}
TA-53-003	Bromine-82	0.00013	1.3×10^{-4}
TA-53-003	Carbon-11	14	1.4×10^{1}
TA-53-003	Selenium-75	0.000000068	$6.8x10^{-8}$
TA-53-007	Argon-41	7.8	7.8
TA-53-007	Bromine-76	0.000074	7.4×10^{-5}
TA-53-007	Bromine-77	0.0000031	3.1×10^{-6}
TA-53-007	Bromine-82	0.0021	2.1×10^{-3}
TA-53-007	Carbon-10	0.32	3.2×10^{-1}
TA-53-007	Carbon-11	96	9.6×10^{1}
TA-53-007	Mercury-197	0.00021	2.1×10^{-4}
TA-53-007	Mercury-197m	0.00021	2.1×10^{-4}
TA-53-007	Nitrogen-13	42	4.2×10^{1}
TA-53-007	Nitrogen-16	0.99	9.9×10^{-1}
TA-53-007	Sodium-22	0.00000023	$2.3x10^{-7}$
TA-53-007	Sodium-24	0.000056	5.6×10^{-5}
TA-53-007	Oxygen-14	0.68	6.8×10^{-1}
TA-53-007	Oxygen-15	104	1.04×10^{2}
TA-53-007	Osmium-191	0.000019	$1.9x10^{-5}$
TA-53-007	Selenium-75	0.00000021	$2.1x10^{-7}$

**The emission value for each building and nuclide is listed in both standard and scientific notation.*

Table 4-8. Radionuclide Half-Lives

Nuclide	Half-Life
Tritium	12.3 years
Beryllium-7	53.1 days
Carbon-10	19.3 seconds
Carbon-11	20.4 minutes
Nitrogen-13	10.0 minutes
Nitrogen-16	7.1 seconds
Oxygen-14	70.6 seconds
Oxygen-15	122.2 seconds
Sodium-22	2.6 years
Sodium-24	15.0 hours
Argon-41	1.82 hours
Cobalt-60	5.3 years
Arsenic-73	80.3 days
Arsenic-74	17.8 days
Bromine-76	16.2 hours
Bromine-77	2.4 days
Bromine-82	1.5 days
Selenium-75	119.8 days
Strontium-90	28.8 years
Cesium-134	2.1 years
Cesium-137	30.1 years
Osmium-191	15.4 days
Mercury-197	2.7 days
Mercury-197m	23.8 hours
Uranium-234	245,500 years
Uranium-235	703,800,000 years
Uranium-238	4,468,000,000 years
Plutonium-238	87.7 years
Plutonium-239	24,110 years
Plutonium-240	6,563 years
Plutonium-241	14.4 years
Americium-241	432 years

Conclusions and Trends

Emission-control systems in Laboratory facilities for particulates such as plutonium and uranium continue to work as designed, and particulate emissions remain very low, in the micro-curie range. Emissions of short-lived gases and vapors are slightly higher than last year, as a result of increases in operations at Technical Area 53. During 2019, the radioactive emissions from all Laboratory sources amount to approximately 1 percent of the regulatory limit.

MONITORING FOR GAMMA AND NEUTRON DIRECT-PENETRATING RADIATION

Introduction

Gamma and neutron radiation levels are monitored by the Direct-Penetrating Radiation Network (McNaughton 2018) and supplemented by the Neighborhood Environmental Watch Network. The objectives are to monitor gamma and neutron radiation in the environment as required by DOE Order 458.1.

Devices known as dosimeters measure exposure to ionizing radiation. In 2019, the Laboratory deployed dosimeters at 80 locations to monitor direct-penetrating radiation in the environment. Thermoluminescent dosimeters, which monitor gamma and neutron radiation, are deployed at every environmental air-monitoring station (Figures 4-1 and 4-2). Additional thermoluminescent dosimeters are deployed at Technical Areas 53 and 54, which are potential Laboratory sources of direct-penetrating radiation (Figures 4-3 and 4-4). Together, all these locations make up the Direct-Penetrating Radiation Network. Neighborhood Environmental Watch Network stations, which measure gamma radiation, are situated near these areas but are off Laboratory property. The locations are listed in Supplemental Table S4-1.

Gamma radiation occurs naturally in ranges from 100 millirem to 200 millirem per year, so it is difficult to distinguish the much smaller levels of radiation contributed by the Laboratory. Radiation from the Laboratory is identified by higher radiation levels near the source and reduced radiation levels at greater distances.

Neutron Radiation

Neutron doses are measured near known or suspected sources of neutrons, including Technical Areas 53 and 54. At 52 locations, the accuracy of the neutron measurements is enhanced by the addition of Lucite blocks that reflect neutrons into the dosimeter. The neutron background is measured at locations far from Laboratory sources (Table S4-1).

Quality Assurance

The Radiation Protection Division dosimetry laboratory is accredited by the DOE Laboratory Accreditation Program, and the Radiation Protection Division provides quality assurance for the dosimeters.

Results

Table 4-9 summarizes 2019 gamma radiation data. Laboratory staff compared 2019 results to values recorded in previous years at those stations. At regional locations, the gamma radiation is natural and, as expected, it has not changed. At perimeter stations, the gamma radiation is generally higher than at regional stations because of the increased cosmic radiation at higher altitudes and the increased uranium and thorium in the soil. At these stations, the radiation is mostly natural and, as expected, the 2019 data are similar to previous data. Onsite, the slight decrease likely is not statistically significant. At the accelerator facility located at the Los Alamos Neutron Science Center, there is measurable radiation from the accelerator, which varies from year to year. At the Area G waste site, there is a downward trend as waste is sent to the Waste Isolation Pilot Plant in Carlsbad, New Mexico.

Table 4-9. Gamma Radiation for 2019—Group Summaries

Station Grouping	Number of Stations	Group Mean ± 1 Standard Deviation (millirem)		Maximum Station Activity (millirem)	
		Previous	**2019**	**Previous**	**2019**
Regional	11	118 ± 16	115 ± 15	141	137
Perimeter	25	127 ± 10	124 ± 10	151	150
Onsite	3	130 ± 11	117 ± 9	142	129
LANSCE	8	143 ± 24	134 ± 14	200	160
Waste site	33	208 ± 123	153 ± 31	778	271

Table 4-10 summarizes the neutron radiation data. At regional stations, the radiation is natural and there is no change. Similar to the gamma radiation data, for waste site locations near Area G, there is a decreasing trend as waste is sent offsite.

Table 4-10. Neutron Radiation for 2019—Group Summaries

Station Grouping	Number of Stations	Group Mean ± 1 Standard Deviation (millirem)		Maximum Station Activity (millirem)	
		Previous	**2019**	**Previous**	**2019**
Regional	7	2.6 ± 1.5	2.8 ± 1.6	5	5
Perimeter	3	4.7 ± 4.0	2.1 ± 1.3	9	4
Onsite	10	2.4 ± 0.6	2.5 ± 0.8	3	4
LANSCE	8	3.6 ± 1.1	4.6 ± 1.2	6	7
Waste site	33	148 ± 195	32 ± 32	1,077	124

Detailed results are listed in Supplemental Table S4-1. Locations with a measurable contribution from Laboratory operations are discussed below.

Los Alamos Neutron Science Center at Technical Area 53

Figure 4-3 shows the locations of the dosimeters at Technical Area 53. Previous studies (McNaughton 2013) discuss the possibility that a member of the public on East Jemez Road, south of Technical Area 53, could be exposed to gamma and neutron radiation from the Los Alamos Neutron Science Center in Technical Area 53.

During 2019, dosimeter #115 in Technical Area 53 measured a gamma dose of 160 millirem per year, which is 35 millirem per year above the background of 125 millirem per year. Calculations (McNaughton 2013) show that the gamma dose at East Jemez Road is 0.2 percent of the dose measured by dosimeter #115, so the gamma dose at East Jemez Road was approximately 0.1 millirem per year near this location.

Also, dosimeter #124 at Technical Area 53 measured a neutron dose 7 millirem per year above background. Calculations (McNaughton 2013) show that the neutron dose at East Jemez Road is 10 percent of this value, so the neutron dose at East Jemez Road was 0.7 millirem per year near this location.

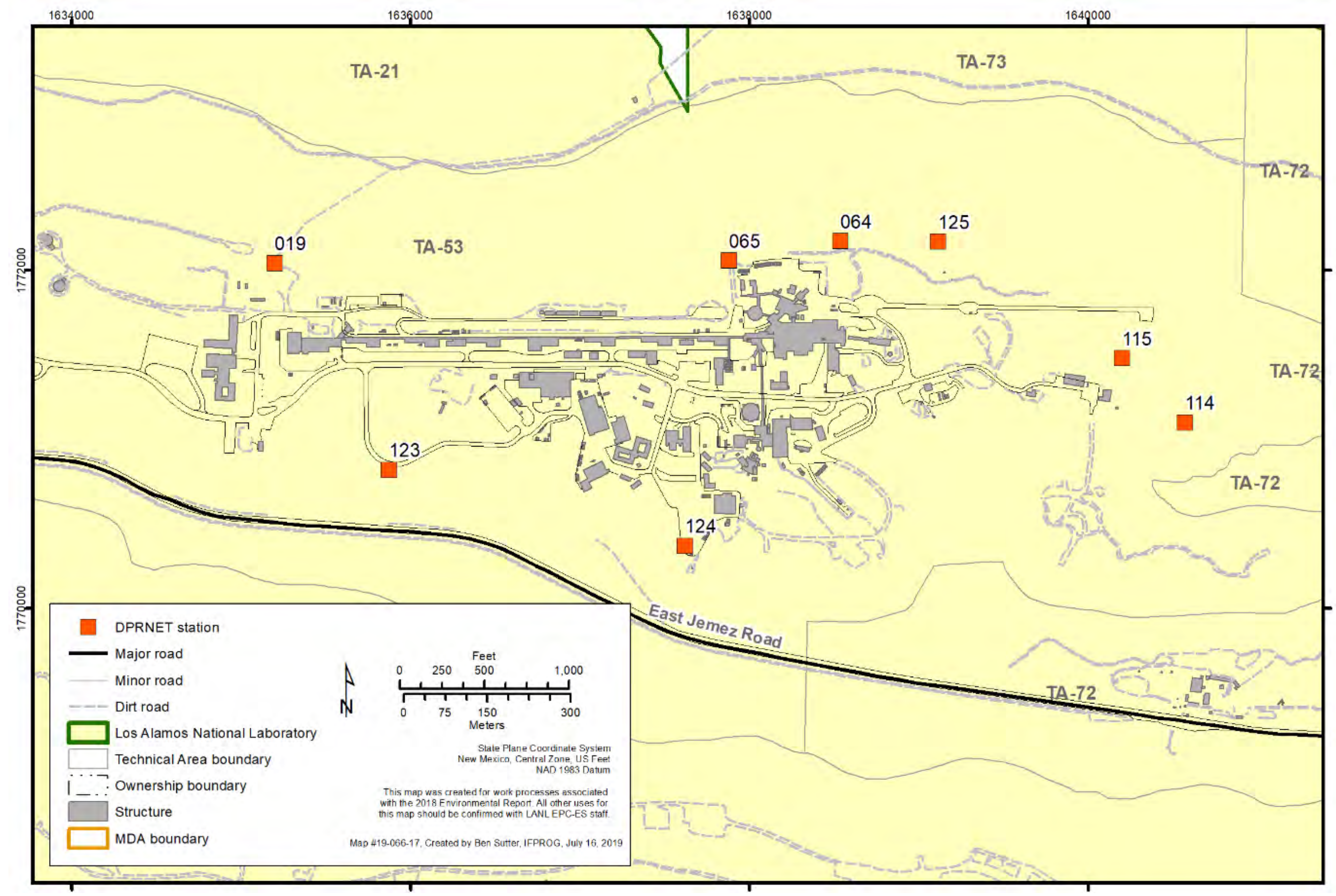


Figure 4-3. Locations of thermoluminescent dosimeters at Technical Area (TA) 53 that are part of the direct-penetrating radiation monitoring network (DPRNET)

Technical Area 54, Area G

Figure 4-4 shows the locations of the dosimeters at Technical Area 54, Area G. Area G is a controlled-access area, so the Area G data do not represent a potential public dose.

Dosimeters #642 through #645 are in Cañada del Buey. After subtracting background, these dosimeters in 2019 measured an annual neutron dose of 2 millirem. This is the dose that would be received by a person who is at the location of the dosimeters 24 hours per day, 365 days per year. As discussed in Chapter 8, an occupancy factor of 1/20 is applied (National Council on Radiation Protection and Measurements 2005), so the dose in Cañada del Buey at the dosimeters is calculated to be 2 millirem multiplied by 1/20, equaling approximately 0.1 millirem per year, which is similar to previous years.

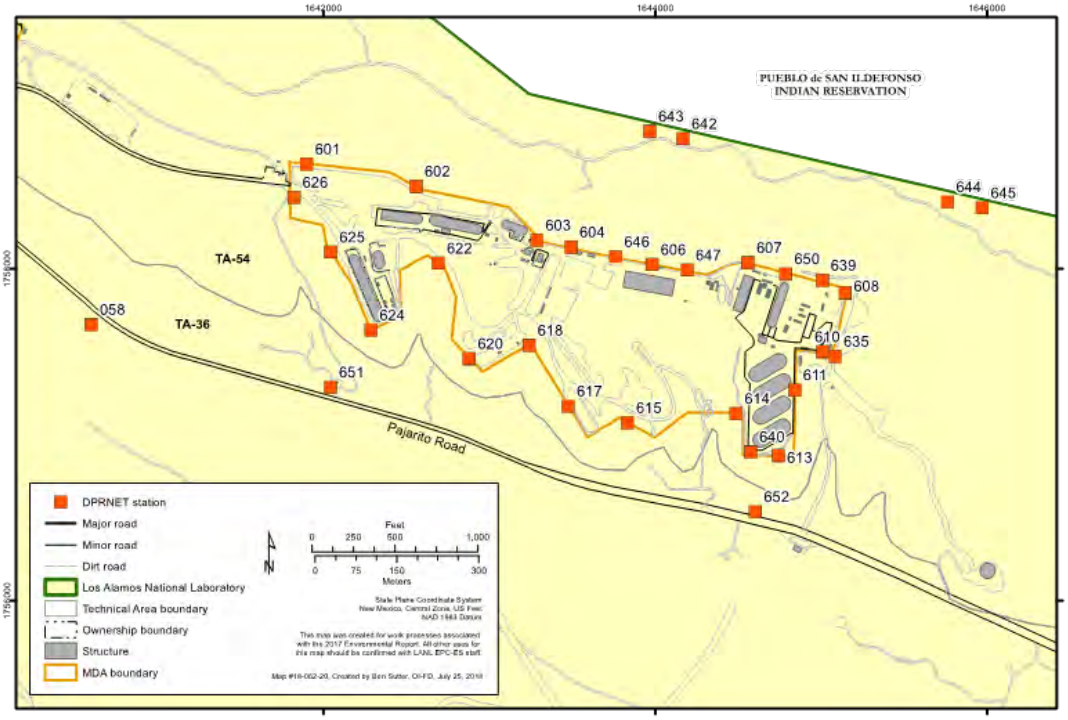


Figure 4-4. Locations of thermoluminescent dosimeters at Area G that are part of the direct-penetrating radiation monitoring network (DPRNET)

Neighborhood Environmental Watch Network

During 2019, the Neighborhood Environmental Watch Network detected gamma-ray emissions from airborne radioactive material on March 19, July 14, and October 26. The total measured dose from these events was less than 0.01 millirem. Although they are not quantitative measurements, these observations indicate that the total dose from gamma-emitting material was far below the annual limit of 10 millirem.

Conclusion

Generally, the data are similar to previous years and show that emissions of direct-penetrating radiation from Laboratory facilities were far below DOE limits.

TOTAL PARTICULATE MATTER AIR MONITORING

Introduction

Particulate matter consists of smoke, dust, and other material that can be inhaled. Generally, it is not radioactive. Particulate matter in the air can be harmful in high concentrations. The total amount of respirable particulate matter is monitored at two locations: near the intersection of New Mexico State Road 4 and Rover Boulevard in White Rock, and at the Los Alamos Medical Center in Los Alamos.

Ambient Air Particulate Matter Concentrations

During 2019, the particulate matter concentrations remained well below the U.S. Environmental Protection Agency standard of 35 micrograms per cubic meter for particulate matter smaller than 2.5 micrometers. Typical concentrations (greater than 95 percent of the time) were less than 10 micrograms per cubic meter. The highest concentrations occurred during the spring from windblown dust and during the summer from wildfires.

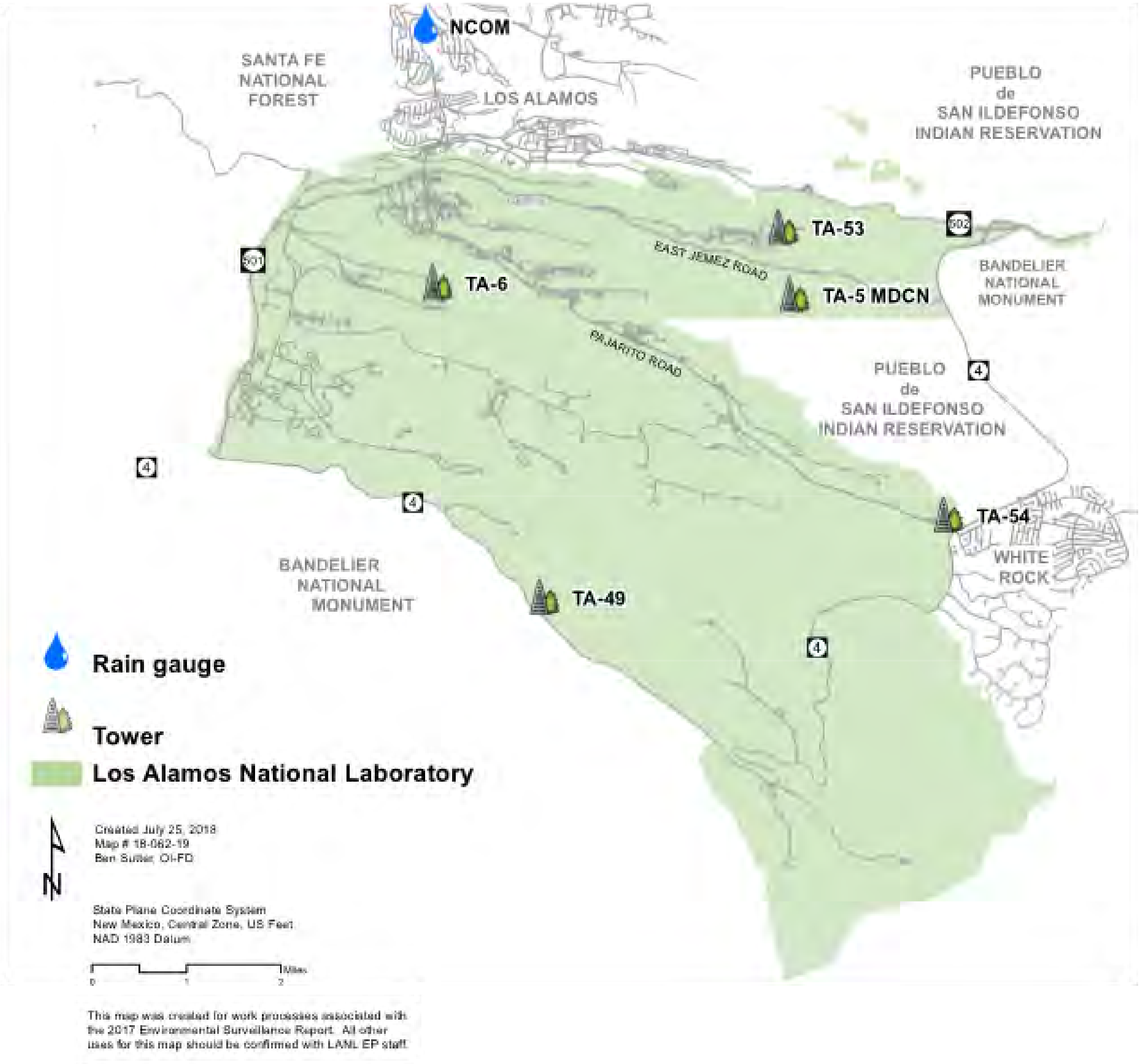
METEOROLOGICAL MONITORING

Introduction

Weather data support many Laboratory activities, including emergency management and response, regulatory compliance, safety analysis, engineering studies, and environmental surveillance programs. The meteorological monitoring program measures wind speed and direction, temperature, pressure, relative humidity, dew point, precipitation, cloud cover, and solar and terrestrial radiation, among other variables. The meteorological monitoring plan (Dewart and Boggs 2014) provides details of the meteorological monitoring program. An electronic copy of the plan is available online at https://weathermachine.lanl.gov.

Monitoring Network

Currently, five meteorological towers gather weather data at the Laboratory (Figure 4-5). Four of the towers are located on mesa tops (Technical Areas 06, 49, 53, and 54) and one is in the bottom of Mortandad Canyon (Technical Area 05). An additional precipitation gage is located in the North Community of the Los Alamos townsite. The Technical Area 06 tower is the Laboratory's official meteorological measurement station.



Note: MDCN = Mortandad Canyon; NCOM = North Community.

Figure 4-5. Locations of five meteorological monitoring towers and a rain gage

Sampling Procedures and Data Management

Laboratory staff place the weather-sensing instruments in areas with good exposure, usually in open fields, to avoid impacts on wind and precipitation measurements. Temperature and wind are measured at multiple height levels on open-lattice towers at Technical Areas 06, 49, 53, and 54. The multiple levels provide a vertical profile important in assessing wind speed and direction at different heights above ground and in assessing air stability conditions. The multiple levels also provide redundant measurements that support data-quality checks. Boom-mounted temperature sensors on the towers are shielded and aspirated (provided with constant air circulation) to minimize effects from direct sunlight. The Mortandad Canyon station includes a 10-meter tripod tower that measures wind only at the top of the tower. Temperature and humidity are measured at near ground level (1.5 meters) at all stations except the North Community station, which only measures precipitation.

Data recorders at the stations read most of the instrument results every three seconds, average the results over a 15-minute period, and transmit the data by network connection, telephone modem, or cell phone to a computer workstation. The workstation program automatically edits measurements that fall outside of realistic ranges. For more than 50 years, the Laboratory has provided these daily weather statistics to the National Weather Service.

Climate

Los Alamos has a temperate, semi-arid mountain climate. Humidity is low, and clear skies are present about 75 percent of the time. These conditions lead to high solar heating during the day and strong radiative cooling at night. Winters are generally mild, with occasional winter storms. Spring is the windiest season. Summer is the rainy season, with frequent afternoon thunderstorms. Fall is typically dry, cool, and calm. The climate statistics summarized here are from analyses of historical meteorological databases maintained by the Laboratory's meteorology program (Bowen 1990 and 1992 and Dewart et al. 2017).

December and January are the coldest months, when 90 percent of minimum temperatures are between 4 °F and 31 °F. Ninety percent of maximum temperatures, which are usually reached in midafternoon, are between 25 °F and 55 °F. Wintertime arctic air masses that descend into the central United States usually warm somewhat before they reach the southern latitude of Los Alamos, so subzero temperatures are not common. Winds during the winter are relatively light, so extreme wind chills are also not common.

Temperatures are highest from June through August, when 90 percent of maximum temperatures are between 67 °F and 89 °F. During the summer months, 90 percent of minimum temperatures are between 45 °F and 61 °F.

Average precipitation is calculated using data from 1981 to 2010 measured at the official Laboratory weather station at Technical Area 06. Other Laboratory stations do not have data going back 30 years, which are necessary for a consistent averaging period. The average annual precipitation, which includes both rain and the water equivalent from frozen precipitation, is 18.97 inches. The average annual snowfall is 57.5 inches. The largest winter precipitation events in Los Alamos are caused by storms approaching from the west to southwest. Snowfall amounts are occasionally enhanced as a result of orographic lifting as the storms travel up the high terrain. Table 4-11 presents the temperature and precipitation records set for Los Alamos from 1924 to 2019.

Table 4-11. Records Set between 1924 and 2019 for Los Alamos

Type of Measurement	Record	Date
Low temperature	–18 °F	January 13, 1963
High temperature	95.5 °F	June 19, 2016
Single-day rainfall	3.52 inches	September 13, 2013
Single-day snowfall	39 inches	January 15, 1987
Single-season snowfall	153 inches	1986–1987

The rainy season typically begins in early July and ends in mid-September. Afternoon thunderstorms form as moist air from the Gulf of California and the Gulf of Mexico is convectively, orographically, or both convectively and orographically lifted by the Jemez Mountains. The thunderstorms yield short, heavy downpours and an abundance of lightning.

The complex topography of Los Alamos influences local wind patterns. Often, a distinct daily cycle of winds occurs. As air close to the ground is heated during the day, it tends to flow uphill. During the night, cool air that forms close to the ground tends to flow downhill. As the daytime breeze flows up the Rio Grande valley, it adds a southerly component to the prevailing westerly winds of the Pajarito Plateau. Nighttime airflow enhances the local westerly winds. Flow in the east-west–oriented canyons of the Pajarito Plateau is generally aligned with the canyons, so canyon winds are usually from the west at night and from the east during the day. Winds on the Pajarito Plateau are faster during the day than at night. This is a result of vertical mixing that is driven by sunshine. During the day, the mixing is strong and brings momentum down to the surface, resulting in fast surface winds.

2019 in Perspective

Table 4-12 presents Los Alamos weather values during 2019. Figure 4-6 presents a graphical summary of Los Alamos temperature for 2019, with the daily high and low temperature at Technical Area 06 compared with the 1981 to 2010 normal values and record values from 1924 to the present. Most months were near or below average, except for the warm months of August and September. Precipitation was above average through April, but the rest of the year had mostly below-average precipitation along with a below-average monsoon season. The last line of Table 4-12 summarizes the year and shows that the overall average temperature was 0.3 °F above the 1981 to 2010 average, total precipitation was 0.98 inches below the average, and snowfall was 9.9 inches below the average. The mean temperature has been above average since 2010, annual precipitation has been below average since 2016, and annual snowfall has been below average since 2011.

A wind gust measured on March 13 of 63 miles per hour was the third highest recorded since Technical Area 06 tower began records in 1990. The strong winds were a result of a quickly developing intense storm called a “bomb cyclone.” This storm resulted in hundreds of trees falling, which caused power outages across the Laboratory.

Table 4-12. Monthly and Annual Climatological Data for 2019 at Los Alamos

Month	Temperatures (°F)[1]								Precipitation (inches)[1]				12-meter[2] Wind (miles per hour)[1]				
	Averages				Extremes						Snowfall				Peak Gusts		
	Daily Maximum	Daily Minimum	Overall	Departure[3]	Highest	Date	Lowest	Date	Total	Departure[3]	Total	Departure[3]	Average Speed	Departure[4]	Speed	From	Date
January	36.0	19.1	27.5	–1.8	46	21	4	3	1.35	0.40	22.1	8.8	4.5	–0.5	49	WNW	21
February	38.6	20.5	29.6	–3.3	51	27	9	20	1.04	0.18	13.2	2.3	6.8	1.0	50	WSW	15
March	49.9	30.7	40.3	1.0	67	27	21	4	3.21	2.01	0.3	–10.1	7.9	1.4	63	W	13
April	61.2	37.1	49.1	2.3	73	20	19	1	1.10	0.04	0	–3.4	7.6	0.0	53	WSW	10
May	63.3	39.9	51.6	–4.4	74	15	30	21	1.09	–0.30	0	–0.3	7.7	0.3	52	SW	26
June	78.1	50.5	64.3	–0.8	86	30	43	24	0.31	–1.20	0	0	7.9	0.8	43	W	4
July	83.6	57.4	70.5	2.3	90	19	51	2	3.15	0.33	0	0	5.8	0.2	38	NNE	13
August	83.6	56.9	70.2	4.4	91	26	52	12	2.33	–1.28	0	0	6.0	0.3	34	N	21
September	77.8	52.1	65.0	5.2	89	3	41	24	0.82	–1.19	0	0	6.2	0.4	35	SSW	19
October	60.5	33.7	47.1	–2.1	75	1	12	31	1.17	–0.38	1.1	–1.1	6.8	0.8	41	WSW	10
November	49.5	26.9	38.2	0.4	62	9	13	30	1.70	0.72	6.7	1.8	5.8	0.5	52	SSW	29
December	40.1	22.0	31.0	1.6	50	21	6	30	0.72	–0.29	4.2	–8.0	5.0	0.5	40	W	15
Year	60.2	37.2	48.7	0.3	91	Aug 26	4	Jan 3	17.99	–0.98	47.6	–9.9	6.5	0.5	63	W	Mar 13

[1] *Data from Technical Area 06, the official Los Alamos weather station*

[2] *Wind data measured at 12 meters above the ground*

[3] *Departure column indicates positive or negative departure from 1981 to 2010 (30-year) climatological average.*

[4] *Departure column indicates positive or negative departure from 1990 to 2010 (21-year) climatological average.*

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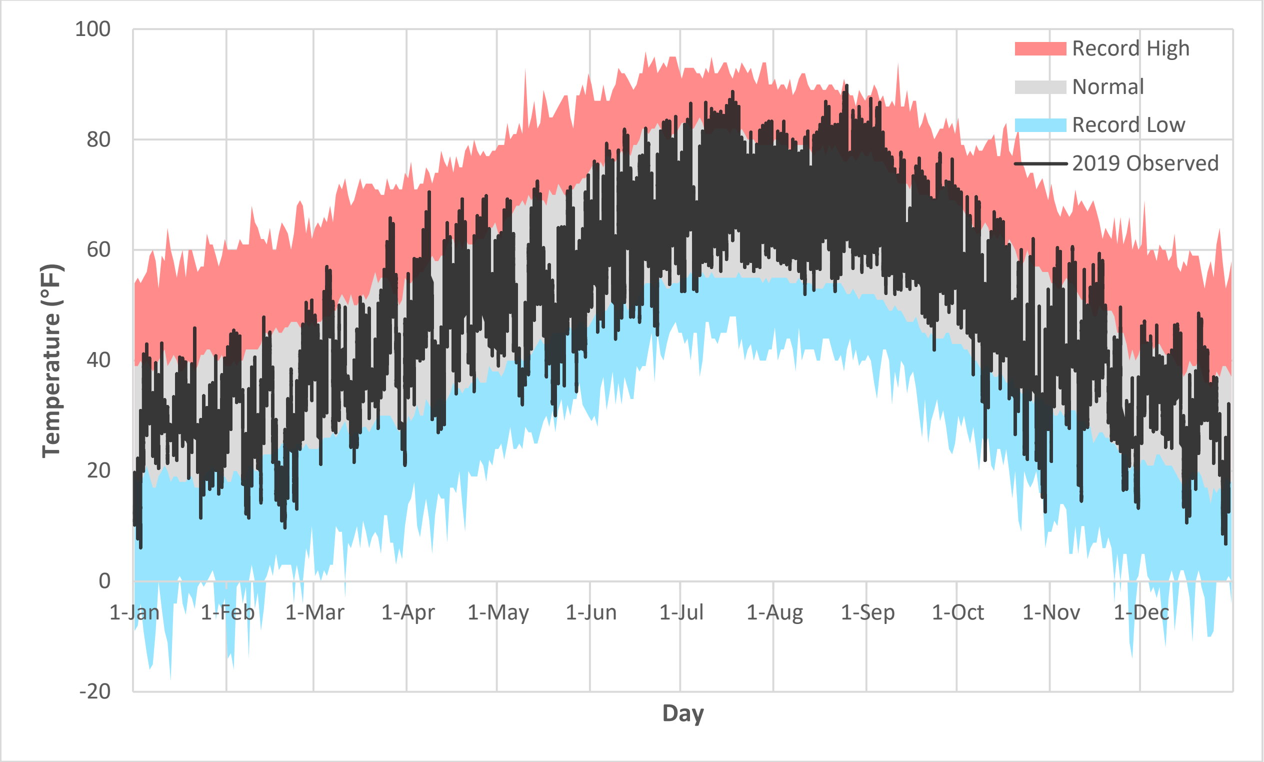

Figure 4-6. Los Alamos 2019 temperatures in degrees Fahrenheit compared with record values and normal values

Figure 4-7 shows a graph of Los Alamos precipitation for 2019. Precipitation started the first half of the year above average, but then a dry monsoon season resulted in slightly below average precipitation for the year. For the year, Los Alamos received near-average precipitation at 17.99 inches (0.98 inches below average). Los Alamos measured nearly 11 inches of above-average snowfall during the first 2 months, but significant dry times during March and December resulted in approximately 10 inches of below-average snowfall for the year. According to the U.S. Drought Monitor, Los Alamos County recovered from exceptional drought conditions at the start of the year to no drought conditions by June, but ended the year with moderate drought conditions (https://droughtmonitor.unl.edu).

At the Laboratory's monitoring stations across Los Alamos, approximately 50 percent of the annual precipitation falls during the summer monsoon season (based on the National Weather Service definition of June 15 to September 30). Typically, more precipitation is measured closer to the Jemez Mountains, and the Technical Area 54 tower near White Rock measures the least precipitation. Although not shown here, more precipitation fell during 2019 at Technical Area 06 and North Community compared to Technical Area 54.

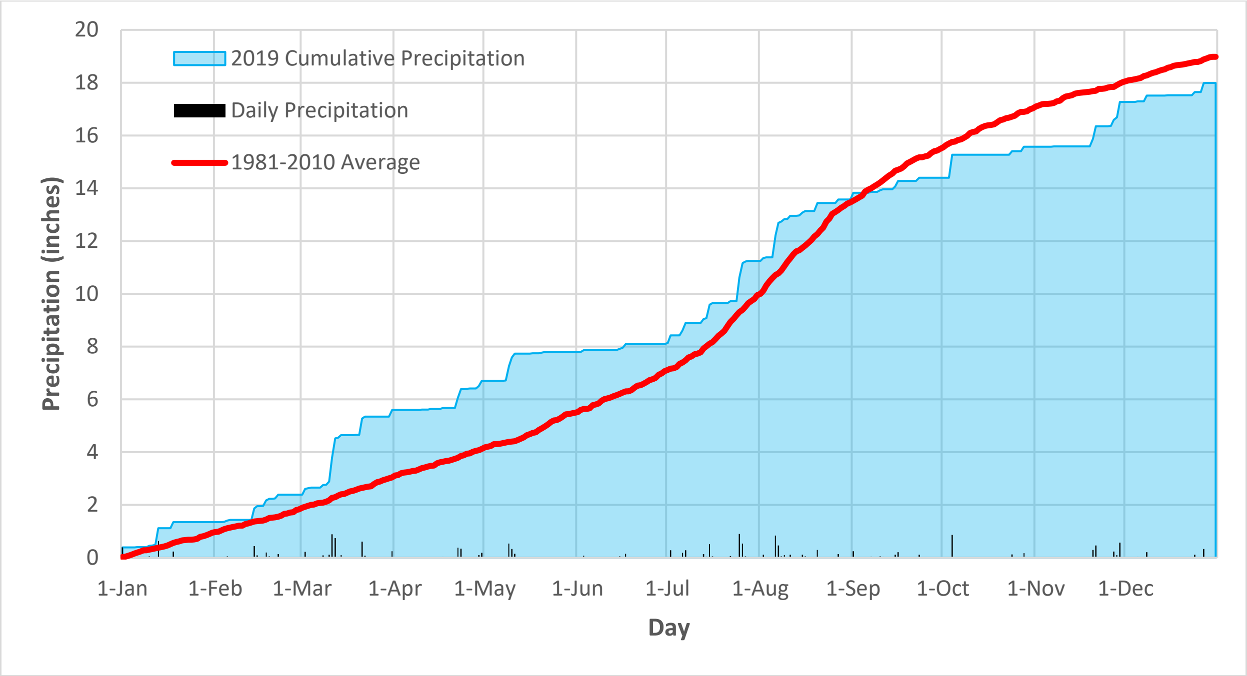

Figure 4-7. Technical Area 06 cumulative precipitation in 2019 versus 30-year average, and the daily precipitation in 2019

Daytime winds (sunrise to sunset) and nighttime winds (sunset to sunrise) are shown in the form of wind roses in Figure 4-8. The wind roses are based on 15-minute average wind observations for 2019 at the four mesa-top stations. Wind roses depict the percentage of time that wind blows from each of 16 directions and the distribution of wind speed. During the day, winds are typically from the south and southwest, while at night the winds are from the west and northwest. Although not shown here, wind roses from different years are almost identical in terms of the distribution of wind directions, indicating that wind patterns are constant when averaged over a year.

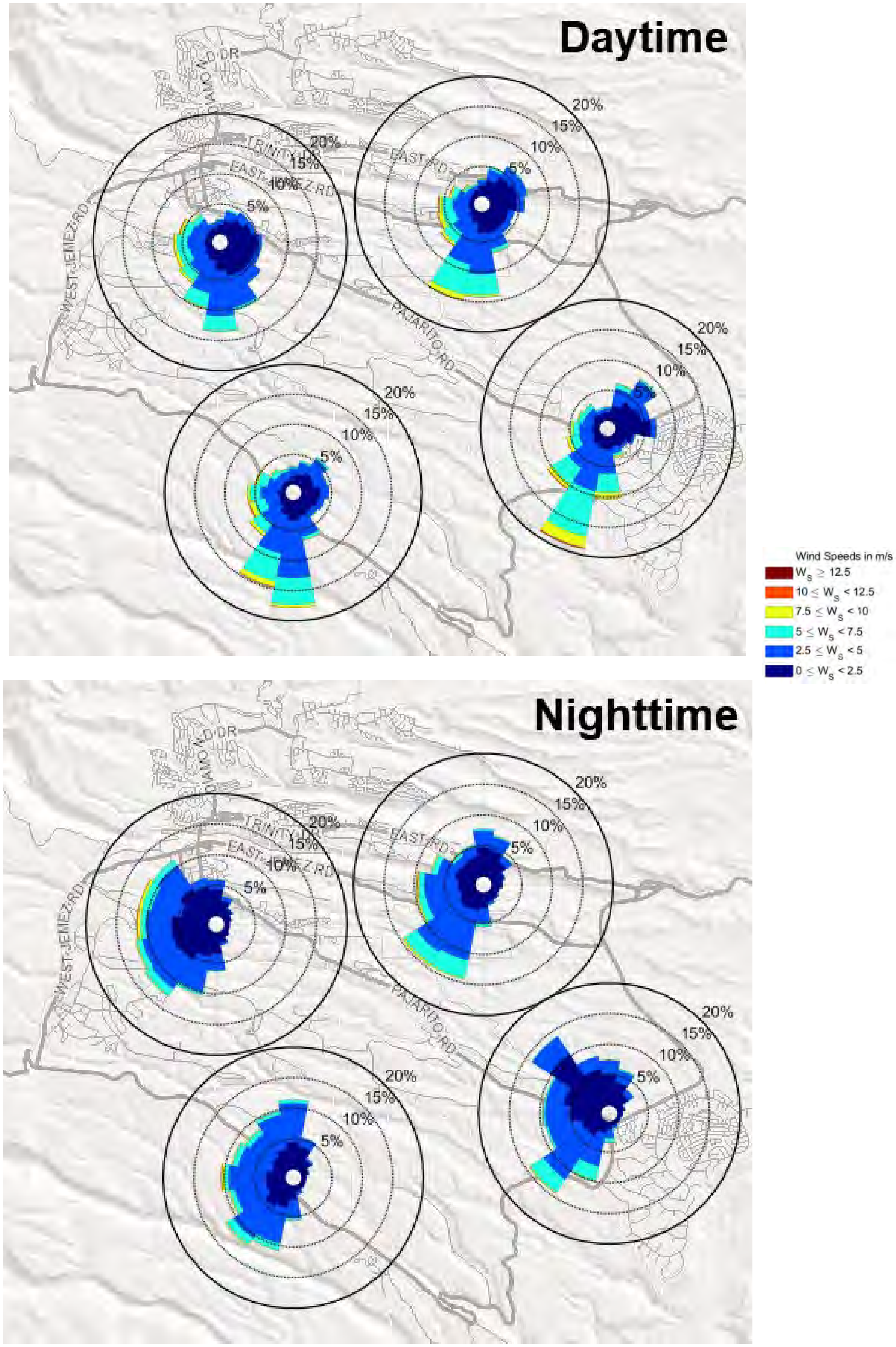

Figure 4-8. Wind roses for 2019 at the four mesa-top meteorological towers

Long-Term Climate Trends

Temperature and precipitation data have been collected in the Los Alamos area since 1910. Figure 4-9 shows the historical record of temperatures in Los Alamos from 1924 through 2019. The annual average temperature is the midpoint between daily high and low temperatures, averaged for the year. One-year averages are shown in green in Figure 4-9. To aid in showing longer-term trends, the 5-year running average is also shown in black. With 5-year averaging, for example, the warm spell during the past 15 years is more extreme than the warm spell during the early-to-mid 1950s and is longer-lived. Five of the hottest summers on record have occurred since 2002. The highest summertime (June, July, and August) average temperature on record was 71.1 °F, recorded during 2011.

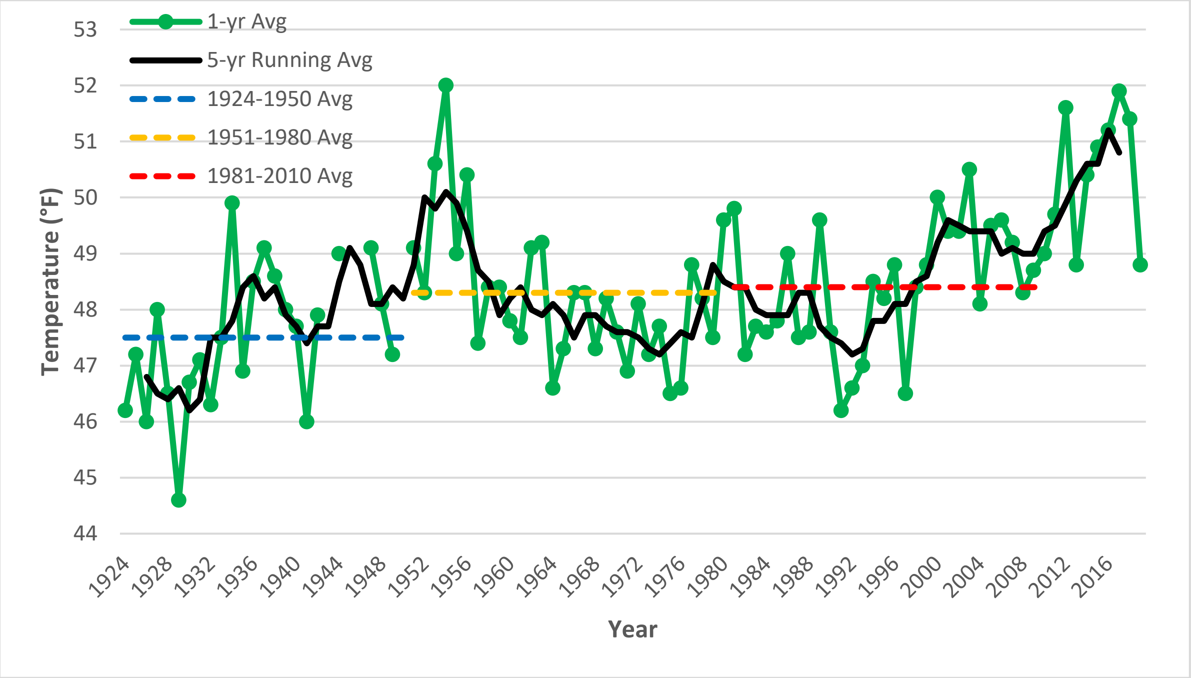

Figure 4-9. Temperature history for Los Alamos with the 1-year average in green and 5-year running average in black. The dashed lines represent long-term averages (25 and 30 years).

The average temperatures per decade, recorded at Technical Area 06, along with two times the standard error, are plotted in Figure 4-10. Ninety-five percent of the annual average temperatures during each decade is found within the error bars. During the decades between 1960 and 2000, the annual average temperatures in Los Alamos varied only slightly from 48 °F. During the 2001–2010 decade, the annual average temperature increased to above 49 °F; this value is statistically significantly higher than previous decades. During the recent 2010–2019 decade, the average temperature increased even more than the previous decade, with annual temperatures above 50 °F. This is consistent with predictions for a warming climate in the southwestern United States (Intergovernmental Panel on Climate Change 2014).

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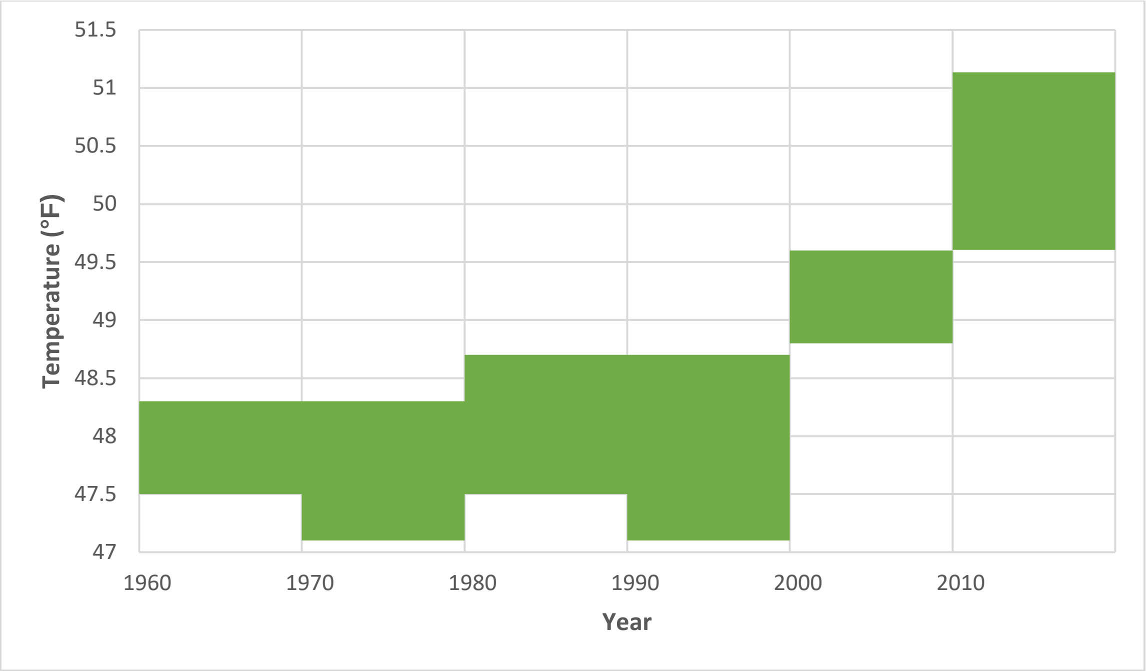

Figure 4-10. Technical Area 06 decadal average temperatures with two times the standard error for 1960 through 2019

Figure 4-11 presents the historical record of the annual precipitation at Technical Area 06. As with the historical temperature profile, the 5-year running average and the 30-year average values are also shown. The most recent drought has essentially spanned the years 1998–2019, although near-average precipitation years occurred from 2004–2010, and above-average precipitation occurred in 2015.

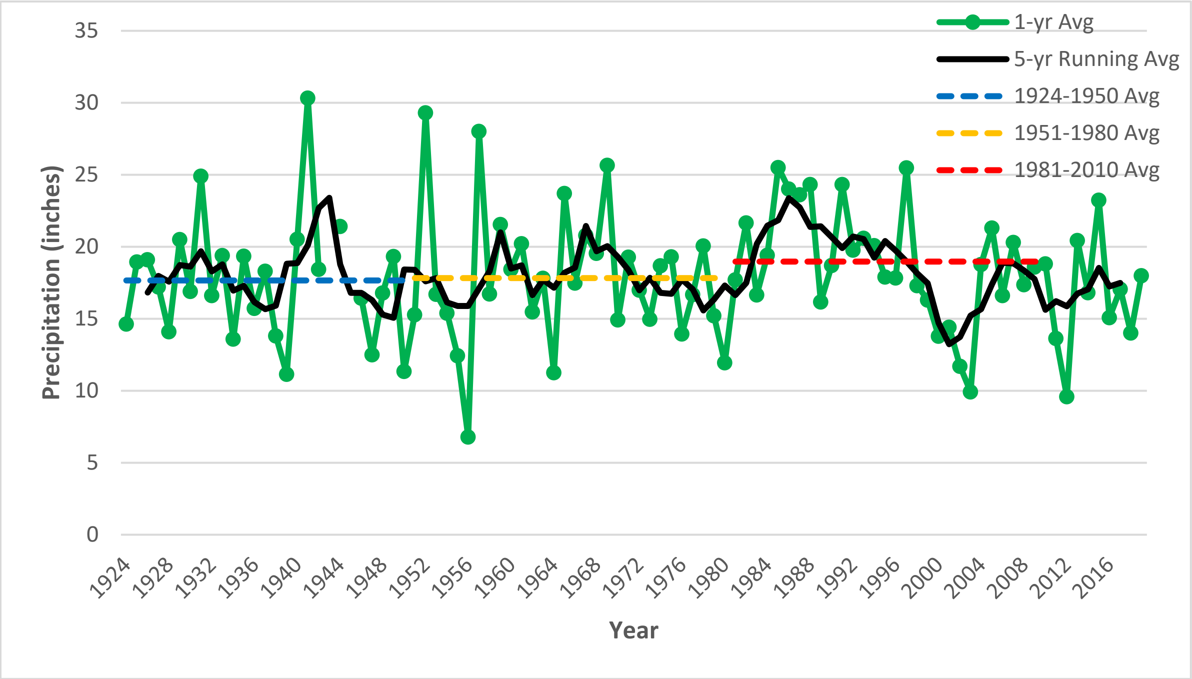

Figure 4-11. Total precipitation history for Los Alamos with the 1-year average in green, 5-year running average in black, and the dashed lines representing long-term averages (25 and 30 years)

QUALITY ASSURANCE

Air Quality Sampling

The quality assurance program satisfies requirements in the U.S. Environmental Protection Agency's *National Emission Standards for Hazardous Air Pollutants*, Title 40, Part 61 of the Code of Federal Regulations, Appendix B, Method 114. The quality assurance project plans and implementing procedures specify the requirements and implementation of sample collection, sample management, chemical analysis, and data management. The requirements follow U.S. Environmental Protection Agency methods for sample handling, chain of custody, analytical chemistry, and statistical analyses of data.

The quality assurance plan for ambient air sampling is described in the procedure "Quality Assurance Project Plan for the Radiological Air Sampling Network," SOP-5140, and 25 supporting procedures. The stack sampling quality assurance plan is described in the procedure "Rad-NESHAP Compliance Program, Program Implementation Plan," EPC-CP-PIP-0101, and 42 supporting procedures.

Direct Radiation Monitoring

The quality assurance plan for direct-penetrating radiation is described in the procedure *Direct Penetrating Radiation Monitoring Network (DPRNET)*, EPC-ES-TPP-007, and the procedure *Obtaining the Environmental Dose from the Model 8823 Dosimeter*, EPC-ES-TP-002. Quality Assurance for the Model 8823 Dosimeter is provided by the Radiation Protection Division dosimetry laboratory, which is accredited by the DOE Laboratory Accreditation Program.

Meteorological Monitoring

Time-series plots of data are generated for a meteorologist to conduct a data-quality review. Daily statistics such as daily minimum and maximum temperatures, daily total precipitation, and maximum wind gust are also generated and checked for quality.

Laboratory staff follow manufacturers' recommendations and consider operating conditions to determine how often to calibrate the weather-sensing instruments. All wind instruments are calibrated every six months. All other sensors are calibrated annually, with the exception of solar radiation sensors, which are calibrated every 5 years. An external audit of the instruments and methods is performed periodically. A subcontractor inspects and performs maintenance on the stations annually.

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Los Alamos National Laboratory (LANL, or the Laboratory) monitors and characterizes groundwater as part of its groundwater protection program and implementation of the Consent Order. We collect and analyze hundreds of groundwater samples each year for a wide range of organic and inorganic constituents and radionuclides. We also implement measures to control contaminant migration.

Chemicals from historical Laboratory operations are present in some locations in perched-intermediate groundwater zones and in the regional aquifer. These chemicals are associated with past liquid effluent releases from Laboratory outfalls (the discharge point of a liquid waste stream into the environment). We use sampling results from some groundwater wells to define the nature and extent of known contaminant plumes and to evaluate and model changes in plume location and concentrations over time. This information guides corrective actions where they are needed. We use other wells to monitor for any new contamination. The results are used to ensure compliance with the requirements of the U.S. Department of Energy orders and New Mexico and federal regulations.

Site-wide groundwater characterization and monitoring indicate that there are only two notable areas of groundwater contamination at the Laboratory: an RDX (hexahydro-1,3,5-trinitro-1,3,5-triazine) plume beneath Cañon de Valle in the vicinity of Technical Area 16 and a chromium plume beneath Sandia and Mortandad Canyons.

RDX, primarily associated with historical machining of high explosives at Technical Area 16, has infiltrated into groundwater beneath Cañon de Valle. In some areas of perched-intermediate groundwater and the regional aquifer, it exceeds the New Mexico tap water screening level of 9.66 micrograms per liter. The RDX plume in the perched-intermediate groundwater and regional aquifer is completely within the LANL boundary and is approximately 3 miles from the nearest public water supply wells.

Hexavalent chromium from releases that occurred from 1956 to 1972 is present in the regional aquifer beneath Sandia and Mortandad Canyons at concentrations above the New Mexico groundwater standard of 50 micrograms per liter. Corrective actions to address the plume are ongoing.

In addition, the groundwater protection program provides monitoring for current Laboratory operations. This includes monitoring required by authorizations issued by the New Mexico Environment Department's Groundwater Quality Bureau such as groundwater discharge permits and monitoring required to meet facility groundwater monitoring plan requirements in accordance with the Laboratory's Hazardous Waste Facility Permit.

INTRODUCTION

Los Alamos National Laboratory (LANL, or the Laboratory) routinely monitors the quality of local groundwater. A regional aquifer is present beneath the Laboratory at depths ranging from 600 to 1,200 feet below the ground surface. Our groundwater monitoring and protection efforts focus on the regional aquifer because of its use for water supply, but also include limited areas of groundwater found within canyon-floor sediments and within rocks and sediments at intermediate depths below the canyon bottoms and above the regional aquifer.

What is an aquifer?

The word aquifer literally means "water bearer" and refers to an underground layer of rock or sediment that contains enough accessible water to be of interest to humans (Buddemeier et al. 2000).

U.S. Department of Energy (DOE) Order 458.1 Chg 3, *Radiation Protection of the Public and the Environment*, requires operators of DOE facilities to ensure that radionuclides from DOE activities do not cause private or public drinking water systems to exceed the drinking water maximum contaminant levels in the *National Primary Drinking Water Regulations*, Title 40, Part 141 of the Code of Federal Regulations. Operators must also ensure that baseline conditions of the groundwater quantity and quality are documented.

In 2016, DOE and the New Mexico Environment Department signed a new Compliance Order on Consent addressing legacy waste cleanup (the previous consent order was signed in 2005). The consent order continues to require the Laboratory to submit an Interim Facility-Wide Groundwater Monitoring Plan to the New Mexico Environment Department for approval each year. The monitoring locations, frequency of monitoring, and substances to be monitored are updated in the plan each year. In April 2018, the legacy waste cleanup contractor Newport News Nuclear BWXT-Los Alamos, LLC (N3B) assumed responsibility for implementing the groundwater program in accordance with the approved Interim Facility-Wide Groundwater Monitoring Plans (N3B 2018, 2019). Some additional groundwater monitoring activities at the Laboratory are required under LANL's Hazardous Waste Facility Permit and groundwater discharge permits (see Chapter 2).

HYDROGEOLOGIC SETTING

The following section describes the distribution and movement of groundwater at the Laboratory and includes a summary of groundwater contaminant sources and distribution. Additional details can be found in reports available at the Laboratory's electronic public reading room, located at http://eprr.lanl.gov.

The Laboratory is located in Northern New Mexico on the Pajarito Plateau. The Pajarito Plateau extends from the Sierra de los Valles range of the Jemez Mountains eastward to the Rio Grande. Rocks composed of Bandelier Tuff are the uppermost layer of the plateau (Figure 5-1). The tuff was formed from ash and other volcanic materials that erupted 1.6 to 1.2 million years ago from the volcanic field of the Jemez Mountains (a volcanic field is an area with a geologic history of volcanic activity). The tuff is more than 1,000 feet thick in the western part of the plateau and thins to about 260 feet above the Rio Grande.

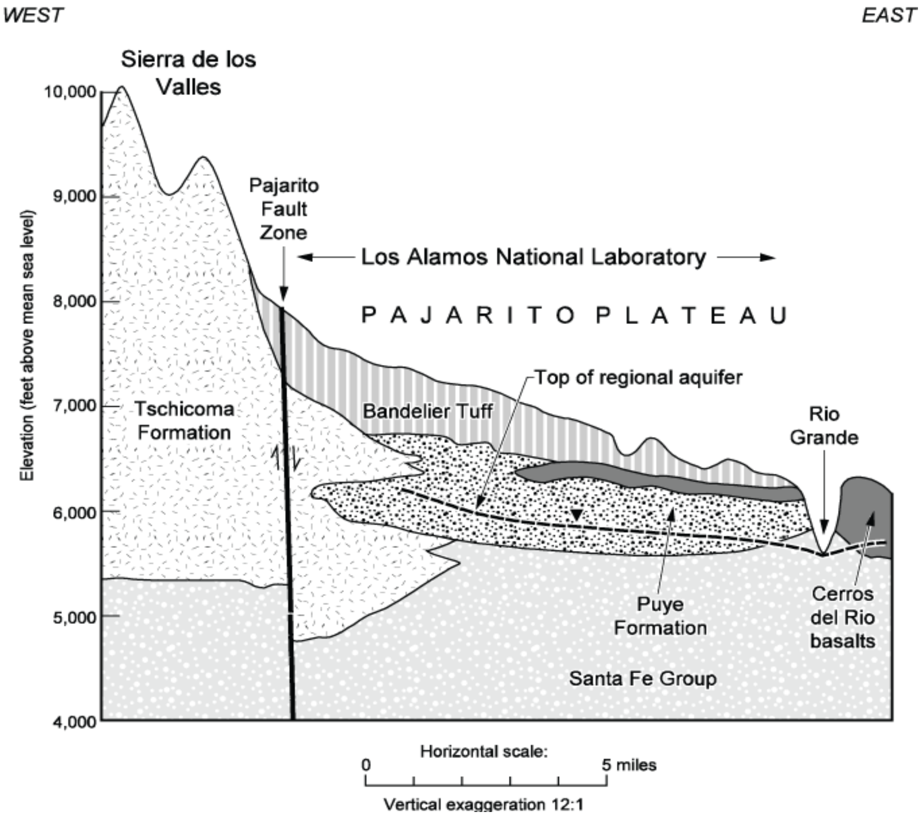


Figure 5-1. Generalized geologic cross-section of the Pajarito Plateau

On the western edge of the Pajarito Plateau, the Bandelier Tuff overlaps the Tschicoma Formation, which consists of older volcanic deposits (Figure 5-1). The Puye Formation, a largely unconsolidated sedimentary deposit, underlies the tuff beneath the central and eastern portion of the plateau. The Puye Formation consists of sand and gravel that washed off the Sierra de los Valles prior to the eruptions producing the Bandelier Tuff. The Cerros del Rio basalt flows, which originated mostly from a volcanic center east of the Rio Grande, extend into the Puye Formation beneath the Laboratory. These formations all overlie the sediments of the Santa Fe Group, which cross the Rio Grande valley and are more than 3,300 feet thick.

The Laboratory sits atop a thick zone of mainly unsaturated rock and sediments. Groundwater beneath the Pajarito Plateau occurs in three modes (Figure 5-2):

(1) perched alluvial groundwater in the bottom of some canyons,
(2) small areas of perched-intermediate groundwater, and
(3) the regional aquifer.

Perched alluvial groundwater is a limited area of saturated rocks and sediments directly below canyon bottoms. Surface water moves through the alluvium until downward flow is disrupted by less-permeable layers of rock, resulting in shallow perched bodies of groundwater. Most of the canyons on the Pajarito Plateau have infrequent surface water flow and, therefore, little or no alluvial groundwater. A few canyons have saturated alluvium in their western ends supported by runoff from the

Hydrogeologic Terms

Saturated rock or sediment is completely wet. **Unsaturated** rock or sediment has air in its pore spaces.

Perched groundwater is a zone of saturation of limited thickness that occurs above the regional aquifer.

Alluvial groundwater is a zone of saturation that exists in sands and gravels in the bottoms of canyons.

Jemez Mountains. In some locations, surface water is supplemented or maintained by discharges from Laboratory outfalls. As alluvial groundwater moves down a canyon, it is used and transpired by plants, or percolates into underlying rock or sediments.

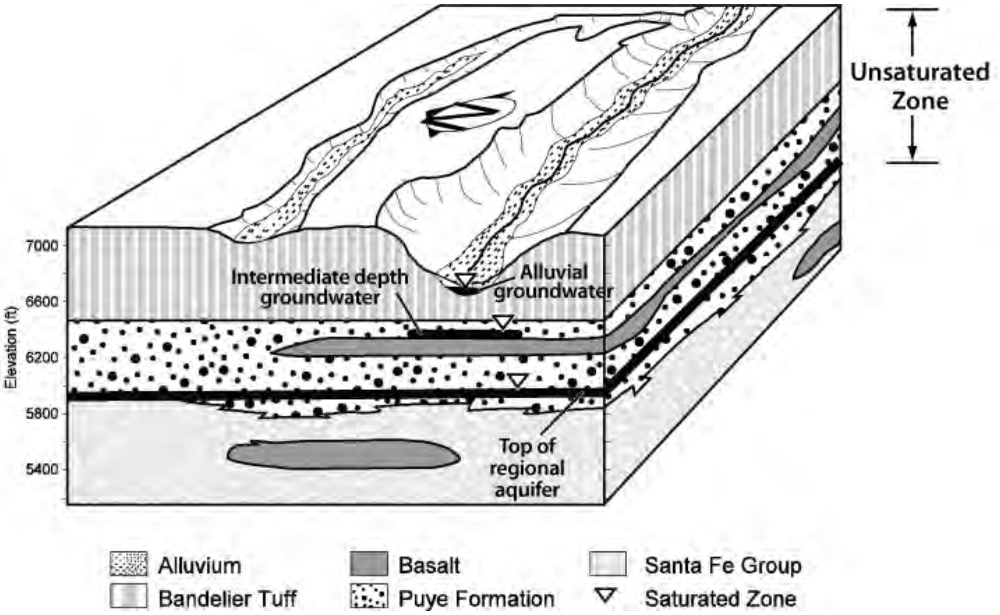
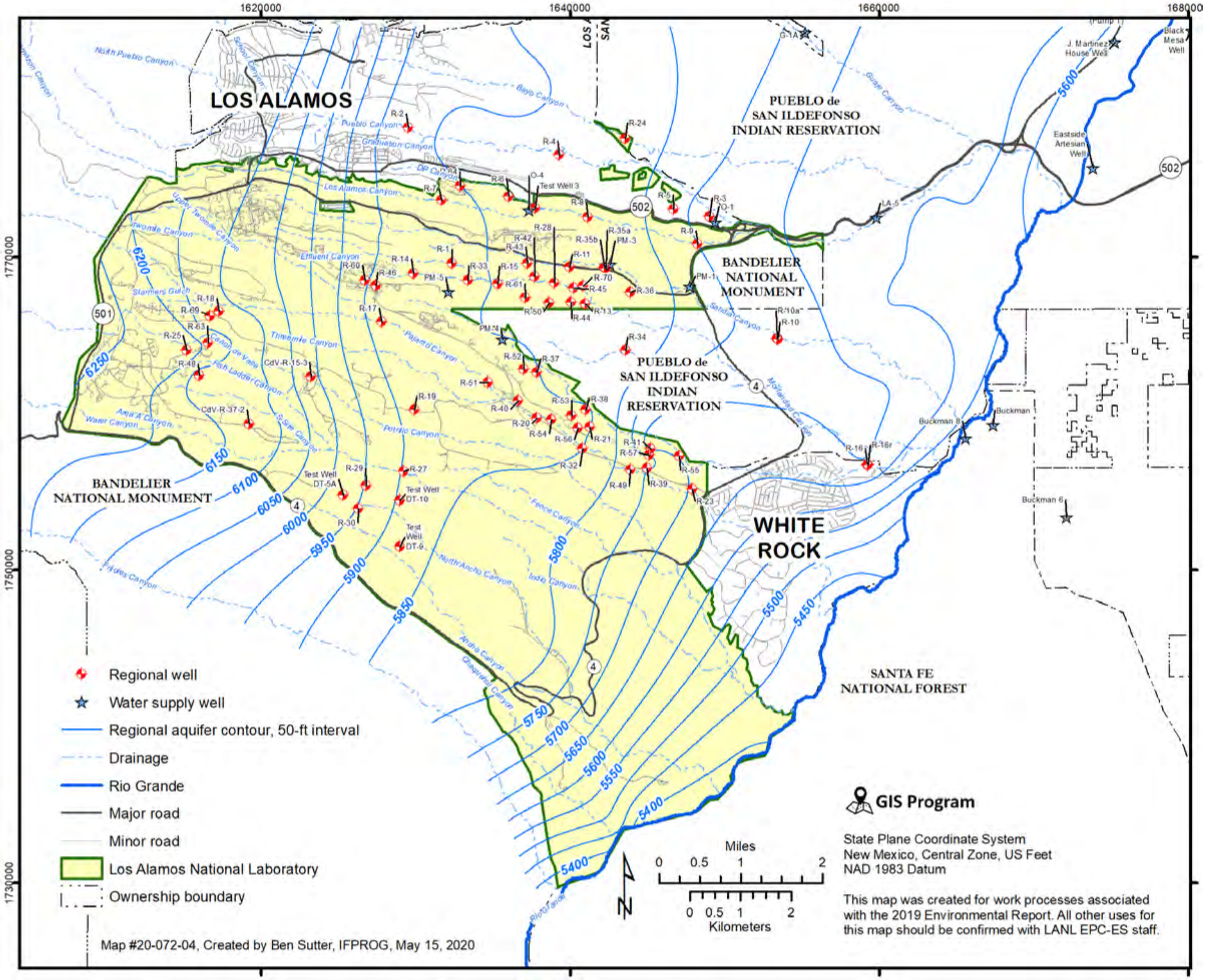


Figure 5-2. Illustration of geologic and hydrologic relationships on the Pajarito Plateau showing the three modes of groundwater occurrence: perched alluvial groundwater, perched-intermediate-depth groundwater, and groundwater within the regional aquifer.

Perched-intermediate groundwater occurs within the lower part of the Bandelier Tuff, within the Puye Formation, and within the Cerros del Rio basalt beneath some canyons. These intermediate-depth groundwater bodies are formed in part by water moving downward from beneath the canyons until it reaches a layer of rock that allows little or no water to pass through. Depths of the perched-intermediate groundwater zones vary. For example, the depth to perched-intermediate groundwater is approximately 120 feet beneath Pueblo Canyon, 450 feet beneath Sandia Canyon, and 500 to 750 feet beneath Mortandad Canyon.

The uppermost level of water in the regional aquifer, known as the water table, occurs at a depth of approximately 1,200 feet below ground surface along the western edge of the plateau and 600 feet below ground surface along the eastern edge (Figures 5-1 and 5-3). Studies indicate that water from the Sierra de los Valles is the main source of recharge for the regional aquifer (LANL 2005a). Groundwater near the water table generally flows east with local northeast or southeast flows observed. The speed of groundwater flow varies but is typically around 30 feet per year. The regional aquifer is separated from alluvial and perched-intermediate groundwater by layers of unsaturated tuff, basalt, and sediment. The limited extent of the alluvial and intermediate groundwater bodies, along with unsaturated rock and sediment that underlies them, restricts their contribution to recharging the regional aquifer, although locally they are important parts of the complete hydrologic pathway to the regional aquifer.



This map was created for work processes associated with the 2019 Environmental Report. All other uses for this map should be confirmed with LANL EPC-ES staff.

Map #20-072-04, Created by Ben Sutter, IFPROG, May 15, 2020

Figure 5-3. Contour map of average water table elevations for the regional aquifer. This map is a generalization of the data.

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GROUNDWATER STANDARDS AND SCREENING LEVELS

Regulatory Overview

The screening levels listed in Table 5-1 are used to evaluate results from groundwater samples reported in this chapter. In general, standards applied to drinking water systems are frequently used as screening criteria for evaluating groundwater quality. Exceedance of a screening level indicates that further evaluation of risk may be needed.

Groundwater standards and screening levels are established by three regulatory agencies. DOE has authority under the Atomic Energy Act of 1954 to set standards for certain nuclear materials. The U.S. Environmental Protection Agency and the New Mexico Water Quality Control Commission set screening levels and standards for other constituents.

DOE Order 458.1 Chg 3, *Radiation Protection of the Public and the Environment*, establishes dose limits for radiation exposure and provides derived concentration technical standards for radionuclide levels in air and water based on those limits. For drinking water, DOE's derived concentration technical standards are calculated based on the U.S. Environmental Protection Agency's 4-millirem-per-year drinking water dose limit.

The U.S. Environmental Protection Agency Safe Drinking Water Act's maximum contaminant levels are the maximum permissible level of a contaminant in water delivered to any user of a public water system.

The New Mexico Water Quality Control Commission groundwater standards, found in *Ground and Surface Water Protection*, Title 20, Chapter 6, Part 2 of the New Mexico Administrative Code, apply to all groundwater with a total dissolved solids concentration of 10,000 milligrams per liter or less. These standards include numeric criteria for many substances. In addition, the standards contain a separate list of toxic pollutants.

The 2016 Compliance Order on Consent requires screening and reporting of groundwater data and describes the screening criteria. In general, the screening levels are the lower of either the New Mexico groundwater quality standard or the federal maximum contaminant level. If neither of these exist for a given chemical, the New Mexico Environment Department's tap water screening levels, provided in the Risk Assessment Guidance for Site Investigations and Remediation: Volume I, Soil Screening Guidance for Human Health Risk Assessments (New Mexico Environment Department 2019), are applied. These values are available in Table A-1 of that document. If no New Mexico Environment Department tap water screening level has been established for the chemical, then the U.S. Environmental Protection Agency's regional human health medium-specific screening level for tap water, adjusted to a 1×10^{-5} excess risk for carcinogenic contaminants, is used. The U.S. Environmental Protection Agency updates the regional screening levels for tap water several times each year; 2018 values were used to prepare this chapter. Updated New Mexico Water Quality Control Commission groundwater standards went into effect in December 2018 with revised standards for some additional constituents becoming effective in July 2020.

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Table 5-1. Application of Screening Levels to LANL Groundwater Monitoring Data

Sample Type	Constituent	Screening Levels	References	Notes
Water supply wells	Radionuclides	• New Mexico groundwater standards • Concentration technical standards derived from DOE's 4-millirem-per-year drinking water dose limit • U.S. Environmental Protection Agency maximum contaminant levels	• 20.6.2 New Mexico Administrative Code • DOE Order 458.1 Chg 3 • Code of Federal Regulations Title 40, Parts 141–143	This sampling is in addition to the regulatory compliance sampling conducted by the water supply system operator (see Water Supply Monitoring section below).
Water supply wells	Nonradionuclides	• New Mexico groundwater standards • U.S. Environmental Protection Agency maximum contaminant levels	• 20.6.2 New Mexico Administrative Code • Code of Federal Regulations Title 40, Parts 141–143	This sampling is in addition to the regulatory compliance sampling conducted by the water supply system operator (see Water Supply Monitoring section below).
Non-water–supply groundwater samples	Radionuclides	• New Mexico groundwater standards • Concentration technical standards derived from DOE's 4-millirem-per-year drinking water dose limit • U.S. Environmental Protection Agency maximum contaminant levels	• 20.6.2 New Mexico Administrative Code • DOE Order 458.1 Chg 3 • Code of Federal Regulations Title 40, Parts 141–143	New Mexico groundwater standards apply to all groundwater. The concentration technical standards (derived from DOE's 4-millirem-per-year drinking water dose limit) and U.S. Environmental Protection Agency maximum contaminant levels are for comparison only.
Non-water–supply groundwater samples	Nonradionuclides	• New Mexico groundwater standards • U.S. Environmental Protection Agency maximum contaminant levels • U.S. Environmental Protection Agency regional screening levels for tap water	• 20.6.2 New Mexico Administrative Code • Code of Federal Regulations Title 40, Parts 141–143 • 2016 Compliance Order on Consent	A hierarchy of levels applies as screening levels for groundwater. See text for explanation.

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The New Mexico Water Quality Control Commission numeric criteria for contaminant concentrations mostly apply to filtered water samples, which represent the concentration of a constituent dissolved in groundwater. However, the standards for mercury, organic compounds, and nonaqueous phase liquids apply to unfiltered samples, which represent both the dissolved concentration of the constituent and the concentration associated with suspended sediments in the groundwater sample. The U.S. Environmental Protection Agency maximum contaminant levels and regional screening levels for tap water are applied to both filtered and unfiltered sample results.

For radioactivity in groundwater, we screen sample results by comparing them with the New Mexico Water Quality Control Commission groundwater standards for combined radium-226 and radium-228, DOE's drinking water concentration technical standards (derived from DOE's 4-millirem-per-year dose limit), and with the U.S. Environmental Protection Agency maximum contaminant level drinking water standards.

POTENTIAL SOURCES OF CONTAMINATION

Historical discharges from Laboratory operations have affected all three groundwater zones. Figure 5-4 shows the key locations of historical effluent discharges.

Drainages that received effluent in the past include Mortandad Canyon, Pueblo Canyon from its tributary Acid Canyon, and Los Alamos Canyon from its tributary DP Canyon (Figure 5-4). Rogers (2001) and Emelity (1996) summarize effluent discharge history at the Laboratory.

Sandia Canyon has received discharges of power plant cooling water, other cooling tower water, and water from the Laboratory's current Sanitary Waste Water Systems Plant. Water Canyon and its tributary Cañon de Valle have received effluents produced by high-explosives processing and experimentation. Over the years, Los Alamos County has operated several sanitary waste water treatment plants in Pueblo Canyon. The Laboratory also had several sanitary treatment plants.

Since the early 1990s, the Laboratory has significantly reduced both the number of industrial outfalls and the volume of water discharged. The quality of the remaining discharges has been improved through treatment process improvements so that they meet applicable standards.

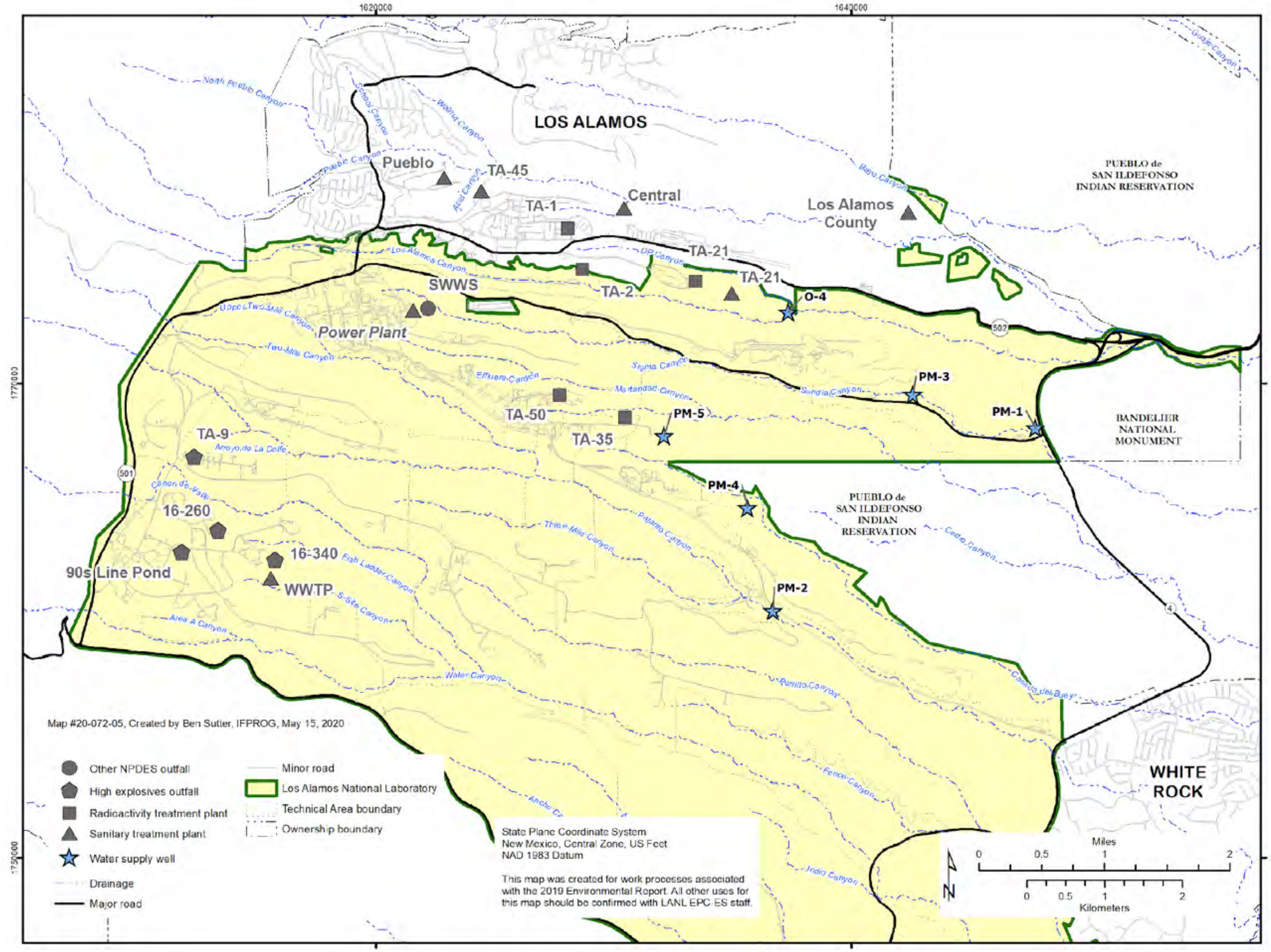
A site-wide sampling program is underway for the emerging contaminants known as per- and polyfluoroalkyl substances (PFAS). Initial results show no detections above screening levels. Further information will be provided in next year's report.

GROUNDWATER MONITORING NETWORK

We monitor water quality and other characteristics at alluvial, perched-intermediate, and regional aquifer wells and at springs that represent perched-intermediate and regional aquifer groundwater. These wells and springs are primarily grouped into area-specific monitoring groups to address the unique monitoring objectives of each group. Area-specific monitoring groups include Technical Area 54, Technical Area 21, Material Disposal Area AB, Material Disposal Area C, the Chromium Investigation, and the Technical Area 16 260 outfall (Figure 5-5). Locations that are not included within one of these six area-specific monitoring groups are assigned to the General Surveillance monitoring group (Figure 5-6). Numerous springs along the Rio Grande are also monitored (Figure 5-7; Purtymun et al. 1980).

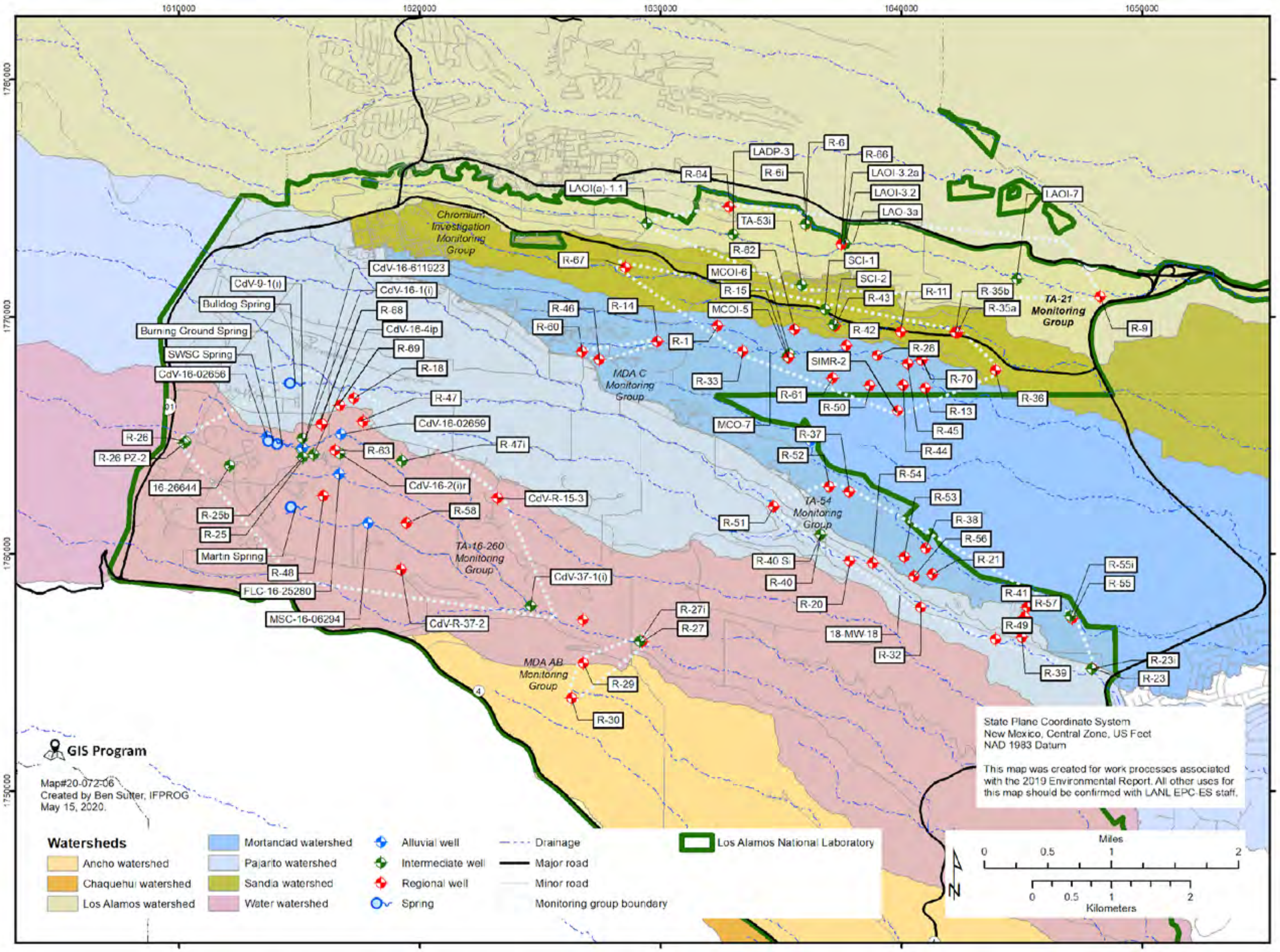
We also monitor groundwater quality at three alluvial, two intermediate, and four regional aquifer wells for Laboratory operations that have groundwater discharge permits (see Chapter 2, New Mexico Water Quality Act: Groundwater Discharge Regulations). Alluvial wells SCA-3, MCA-RLW-1, and MCA-RLW-2 are operated for discharge permit compliance purposes only, and results are summarized in the section Groundwater Discharge Permit Monitoring below. Operational monitoring required under LANL's Hazardous Waste Facility Permit is currently included within the annually approved Interim Facility-Wide Groundwater Monitoring Plan and results are reported throughout this chapter.

We collect samples from 12 Los Alamos County water supply wells (Figure 5-7), from wells located on Pueblo de San Ildefonso lands, and from the Buckman well field operated by the city of Santa Fe. Groundwater monitoring locations on the Pueblo de San Ildefonso lands are shown in Figure 5-7; they mainly discharge from the regional aquifer. However, Vine Tree Spring (near the former sampling location Basalt Spring) and Los Alamos Spring discharge from perched-intermediate groundwater, and wells LLAO-1b and LLAO-4 monitor alluvial groundwater.



Note: NPDES = National Pollutant Discharge Elimination System; SWWS = sanitary waste water system; TA = technical area; WWTP = waste water treatment plant

Figure 5-4. Major liquid release outfalls potentially affecting groundwater; most outfalls shown are currently inactive.



GIS Program

Map#20-072-06
Created by Ben Sulter, IFPROG
May 15, 2020.

State Plane Coordinate System
New Mexico, Central Zone, US Feet
NAD 1983 Datum

This map was created for work processes associated with the 2019 Environmental Report. All other uses for this map should be confirmed with LANL EPC-ES staff.

Note: MDA = Material disposal area

Figure 5-5. Groundwater monitoring wells and springs assigned to area-specific monitoring groups

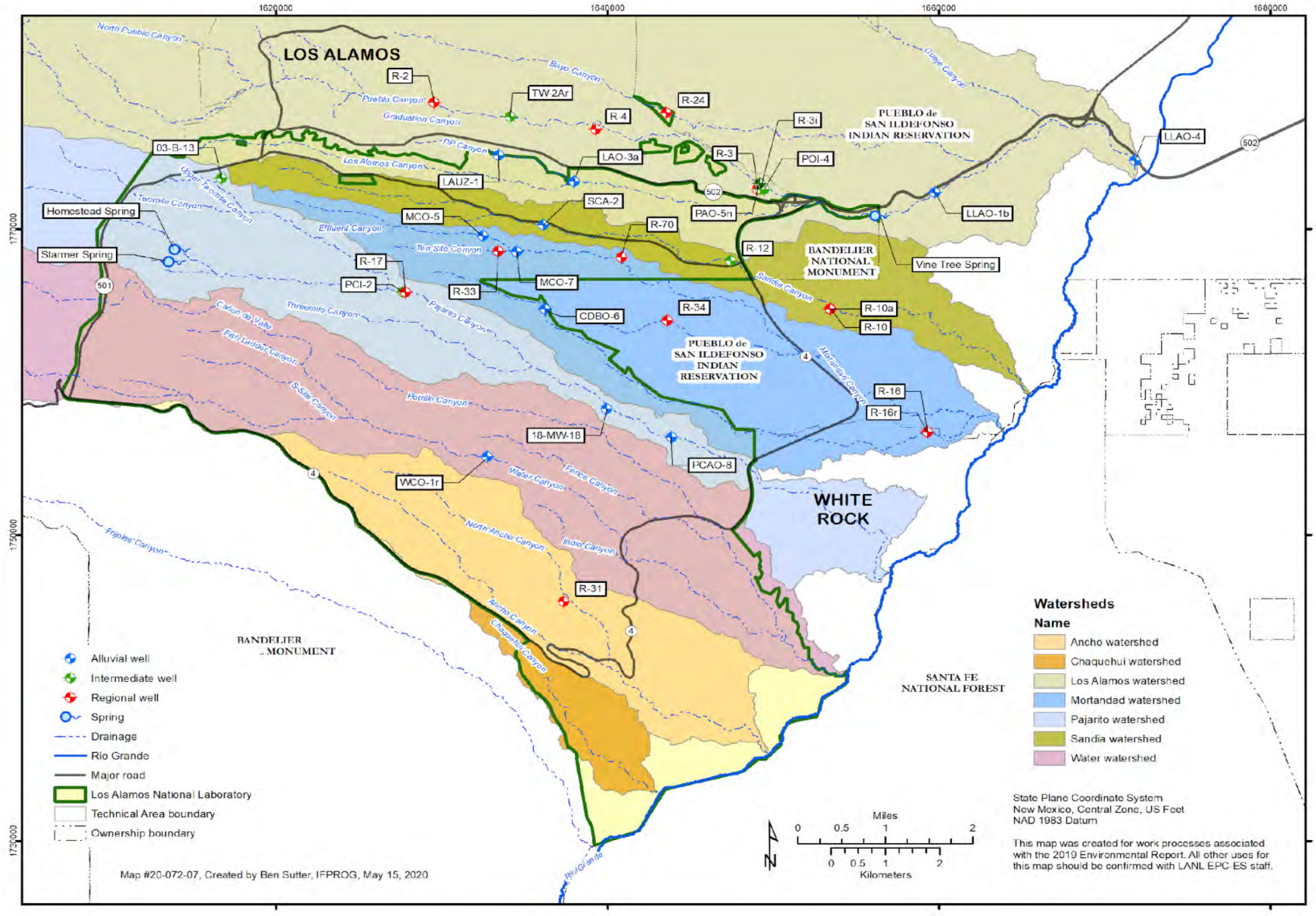


Figure 5-6. Groundwater monitoring wells and springs assigned to watershed-specific portions of the General Surveillance monitoring group

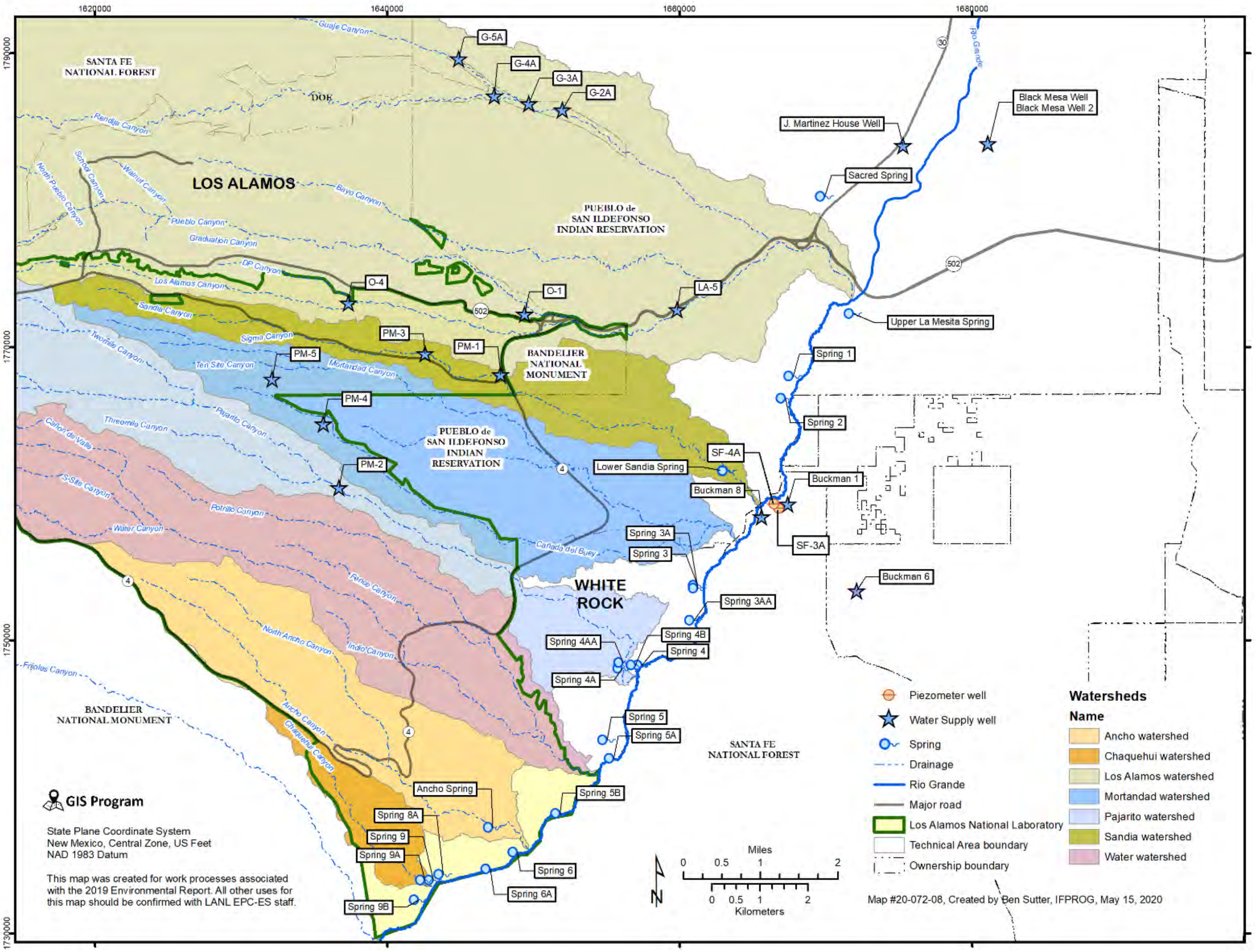


Figure 5-7. Water supply wells and piezometers used for monitoring at Los Alamos County, the city of Santa Fe Buckman well field, and Pueblo de San Ildefonso, and springs used for groundwater monitoring in White Rock Canyon

GROUNDWATER DATA INTERPRETATION

The groundwater monitoring data for 2019 are available from the Intellus New Mexico website at https://www.intellusnm.com.

Analytical laboratory results are reported in relation to several limits. The method detection limit is the lowest concentration of a substance in a sample that the laboratory can state with 99 percent confidence is greater than zero. The method detection limit is determined from analysis of a set of standardized samples containing the substance. A second limit reported by analytical laboratories is the practical quantitation limit. The practical quantitation limit is the lowest concentration of a substance in a sample that can be measured with a high degree of confidence. The practical quantitation limit is approximately (but not always) three times the method detection limit. Concentrations measured between the method detection limit and the practical quantitation limit are identified as estimated concentrations and marked with a "J" qualifier in the analytical report and in the results from the Intellus website.

A nondetect result indicates that the analytical laboratory did not detect the substance in the sample. These results are marked with a "U" qualifier. In the past, the Laboratory sometimes reported nondetect results at the practical quantitation limit value. Therefore, for older results, the detected but estimated results (results between the method detection limit and the practical quantitation limit) may have a lower reported value than nondetect results for the same substance. Recent groundwater sample nondetect results are reported at the method detection limit.

The method detection limit and practical quantitation limit do not apply to radiological measurements. For radiological measurements, the minimum detectable activity is similar to the method detection limit. To be considered a detected activity, a radiological measurement must be greater than the minimum detectable activity.

GROUNDWATER SAMPLING RESULTS BY MONITORING GROUP

The following sections discuss groundwater sampling results for the six area-specific monitoring groups, the General Surveillance monitoring group, springs along the Rio Grande, and Los Alamos County and City of Santa Fe water supply wells. The tables and discussions are grouped according to groundwater mode, proceeding from deepest (the regional aquifer) to shallowest (the alluvial groundwater). The accompanying tables and text mainly address constituents found at levels above screening levels. Other constituents that are below screening levels, such as tritium, are discussed in a few cases to track trends where potential Laboratory influences are observed. The discussion addresses radionuclides, inorganic compounds, inorganic elements (primarily metals), and organic compounds for each groundwater zone. The accompanying plots and maps provide temporal and spatial context.

Water Supply Monitoring

Los Alamos County

We collected samples from 12 Los Alamos County water supply wells that produce water for the community and the Laboratory (Figure 5-7). These samples supplement Los Alamos County's regular monitoring and specifically address potential Laboratory contaminants. All drinking water produced by the Los Alamos County water supply system meets federal and state drinking water standards as reported in the county's annual drinking water quality report (available at https://www.losalamosnm.us/common/pages/DisplayFile.aspx?itemId=16814219). No water supply wells showed detections of Laboratory-related constituents above applicable drinking water standards.

City of Santa Fe

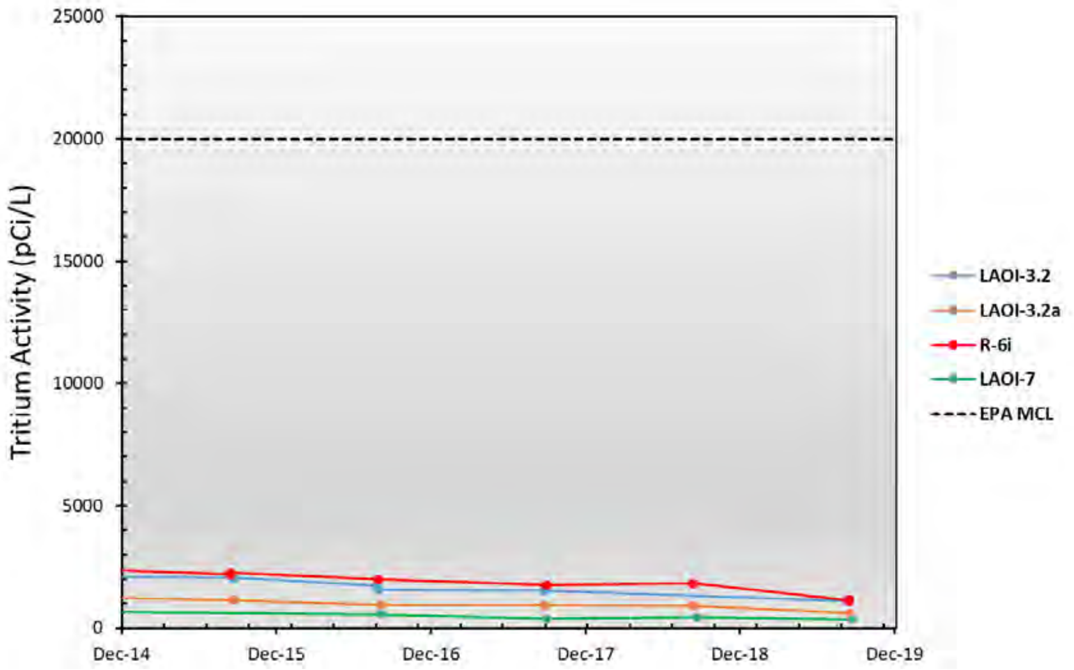
In 2019, we sampled three water supply wells (Buckman-1, Buckman-6, and Buckman-8) in the City of Santa Fe's Buckman well field. Samples were also collected from four piezometers (wells typically used to measure water levels) in the well field (LANL 2012a). These samples supplement the City of Santa Fe's regular monitoring and specifically address potential Laboratory contaminants. No Laboratory-related constituents were present above standards for these locations. The City of Santa Fe publishes an annual water quality report that provides additional information (https://www.santafenm.gov/water_quality).

Technical Area 21 Monitoring Group

Technical Area 21 is located on a mesa bordered by Los Alamos Canyon on the north and DP Canyon on the south. Technical Area 21 contains two past operational areas, DP West and DP East, both of which produced liquid and solid radioactive wastes. The operations at DP West included plutonium processing, while the operations at DP East included the production of weapons initiators and tritium research. From 1952 to 1986, a liquid waste treatment plant discharged effluent containing radionuclides from the plutonium processing facility at Technical Area 21 into DP Canyon (Figure 5-4).

Sources of potential groundwater pollutants in the vicinity of the Technical Area 21 monitoring group wells include the former liquid waste treatment plant outfall (Solid Waste Management Unit 21-011[k]), adsorption beds and disposal shafts at Material Disposal Area T, adsorption beds at Material Disposal Area U, the former Omega West reactor cooling tower (Solid Waste Management Unit 02-005), DP West, DP East, waste lines, an underground diesel fuel line, and sumps. The Technical Area 21 monitoring group includes wells in perched-intermediate groundwater and in the regional aquifer.

Samples from several wells that monitor perched-intermediate groundwater in the Technical Area 21 monitoring group have tritium that likely originated from the former liquid waste treatment plant, the Omega West Reactor, or both. Tritium concentrations in perched-intermediate wells R-6i, LAOI-3.2, LAOI-3.2a, and LAOI-7 in 2019 are generally consistent with concentrations measured in recent years (Figure 5-8; see Figure 5-5 for well locations). The highest tritium concentration among these wells in 2019 is 1,140 picocuries per liter in R-6i, down from 1,820 picocuries per liter in 2018. For comparison purposes, the U.S. Environmental Protection Agency maximum contaminant level for tritium in drinking water is 20,000 picocuries per liter.



EPA MCL = The U.S. Environmental Protection Agency maximum contaminant level for tritium in drinking water.

Figure 5-8. Tritium concentrations in sampled perched-intermediate groundwater from wells in the Technical Area 21 monitoring group in Los Alamos Canyon

Chromium Investigation Monitoring Group

The Chromium Investigation monitoring group is located in Sandia and Mortandad Canyons. Chromium is present in the regional aquifer below these canyons at levels above the New Mexico Environment Department groundwater standard of 50 micrograms per liter in an area that is estimated to be approximately one mile in length and about a half-mile wide (Figures 5-9 and 5-10).

Through National Pollutant Discharge Elimination System Outfall 001, Sandia Canyon receives treated sanitary effluent from the Technical Area 46 sanitary waste water system plant as well as discharges from cooling towers for computing facilities and the Technical Area 03 power and steam plants. Groundwater monitoring related to current Laboratory operations discharging through National Pollutant Discharge Elimination System Outfall 001 is discussed in Chapter 2.

From 1956 to 1972, potassium dichromate was used as a corrosion inhibitor in the cooling system at the power plant (LANL 1973) and was present in the effluent discharged through the outfall. These discharges of potassium dichromate are the source of the hexavalent chromium observed in groundwater beneath Sandia and Mortandad Canyons. A conceptual model for the sources and spatial distribution of chemicals and radionuclides in groundwater in this area is presented in the Investigation Report for Sandia Canyon, the Phase II Investigation Report for Sandia Canyon (LANL 2009a, 2012b), and in the Compendium of Technical Reports Conducted Under the Work Plan for Chromium Plume Center Characterization (LANL 2018a). The conceptual model indicates that chromium originated from releases into Sandia Canyon and then migrated in the subsurface along geologic perching horizons to locations in the regional aquifer beneath Mortandad Canyon.

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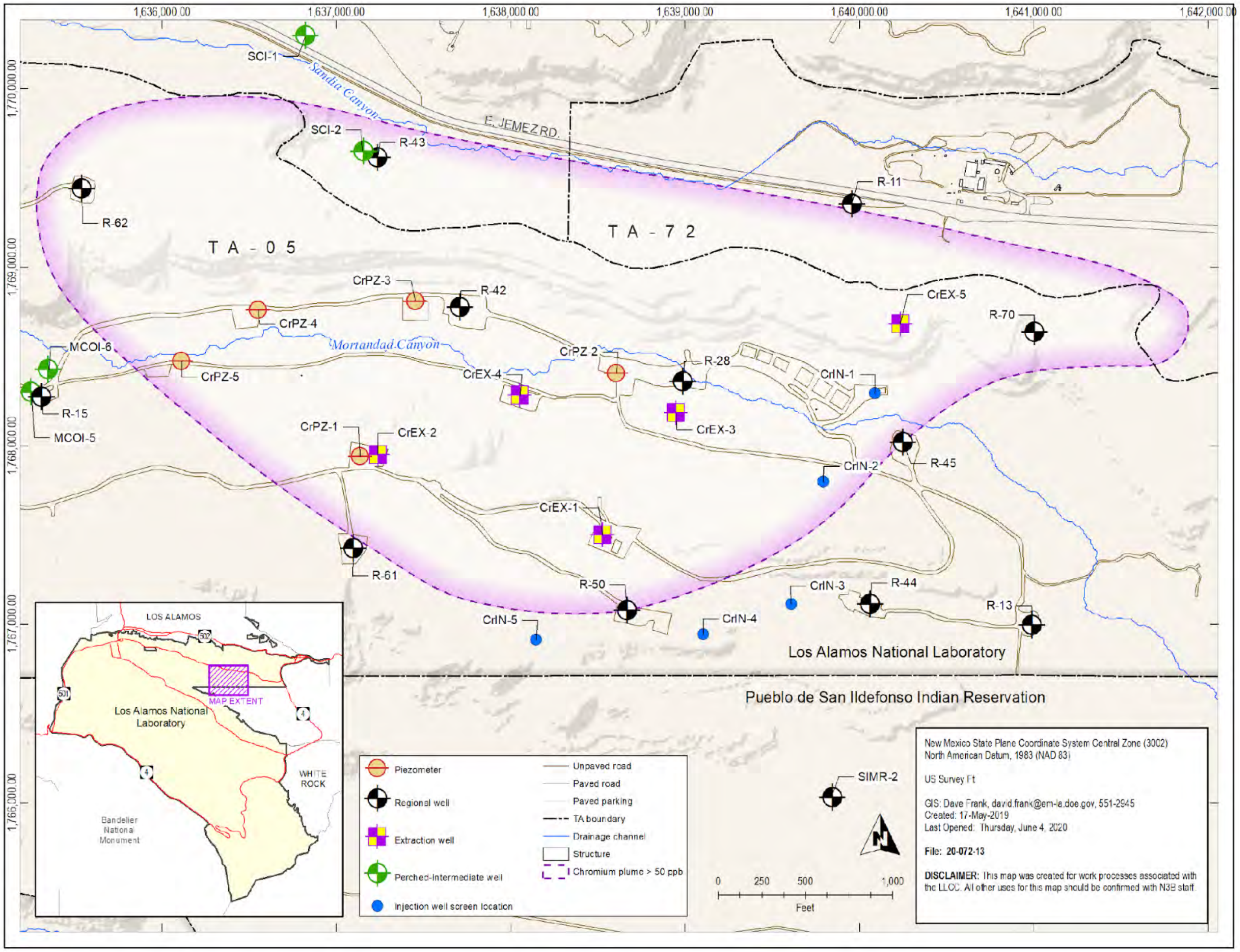

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Figure 5-9. Approximation of the chromium plume footprint in the regional aquifer, as defined by the 50-microgram-per-liter New Mexico Environment Department groundwater standard, and locations of the chromium interim measures injection and extraction wells in 2019

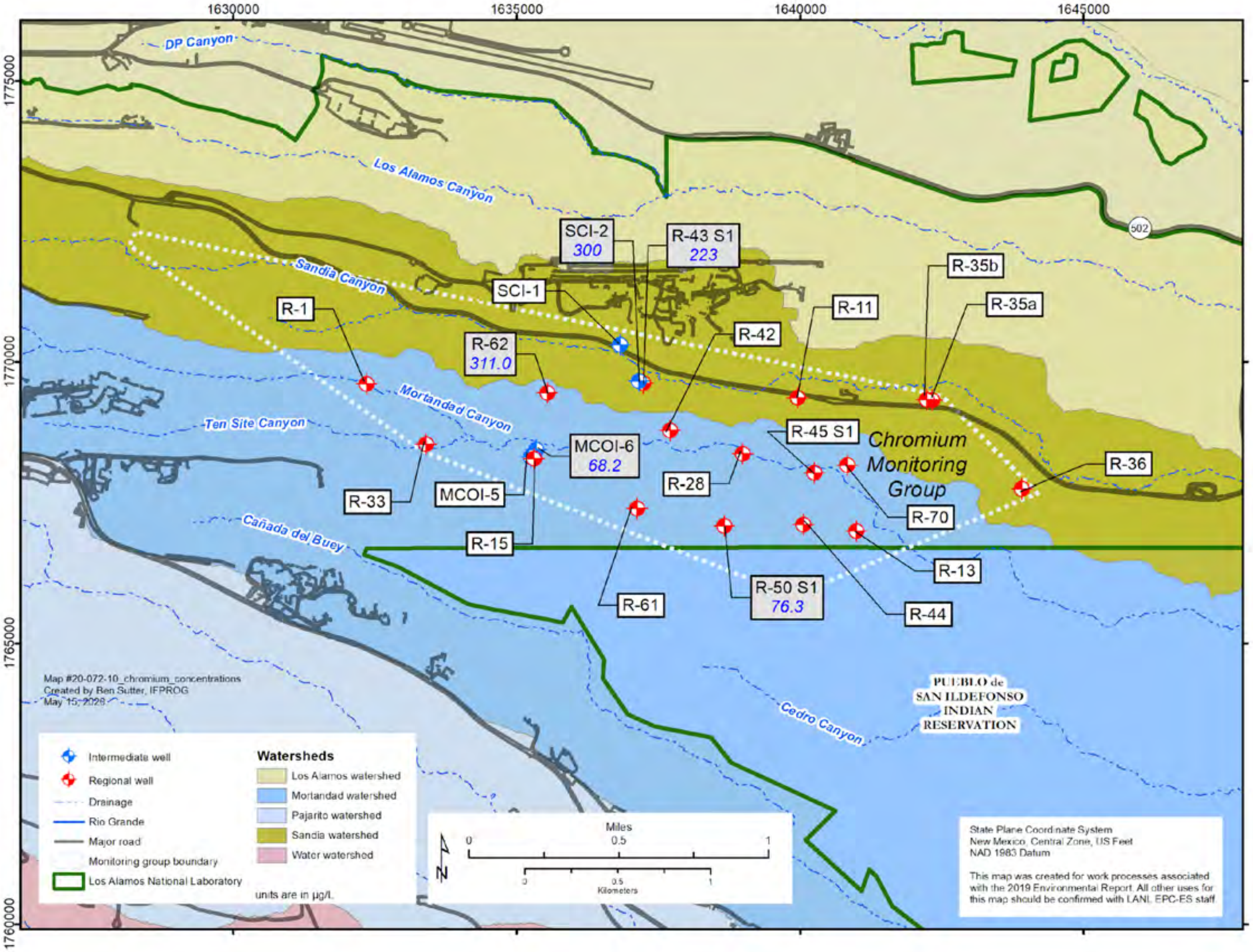


Figure 5-10. The Chromium Investigation monitoring group perched-intermediate groundwater and regional aquifer monitoring wells. The white dashed outline encompasses the wells included in the monitoring group. Labels for the wells include maximum chromium concentrations in 2019 at wells with recorded concentrations greater than the New Mexico groundwater standard of 50 micrograms per liter (µg/L).

The chromium is found within 50 to 100 feet of the surface of the regional aquifer (LANL 2009a, 2012b, 2017, 2018b). The 2019 chromium concentrations exceeded the New Mexico groundwater standard of 50 micrograms per liter in three regional aquifer wells: R-62, R-50 screen 1, and R-43 screen 1 (Figure 5-11). Monitoring in 2019 primarily focused on characterizing and understanding the transport and fate of chromium and related contaminants in perched-intermediate groundwater and within the regional aquifer. We also evaluated the performance of interim measures being conducted to mitigate the chromium plume migration while alternatives for a final remedy for the plume are evaluated.

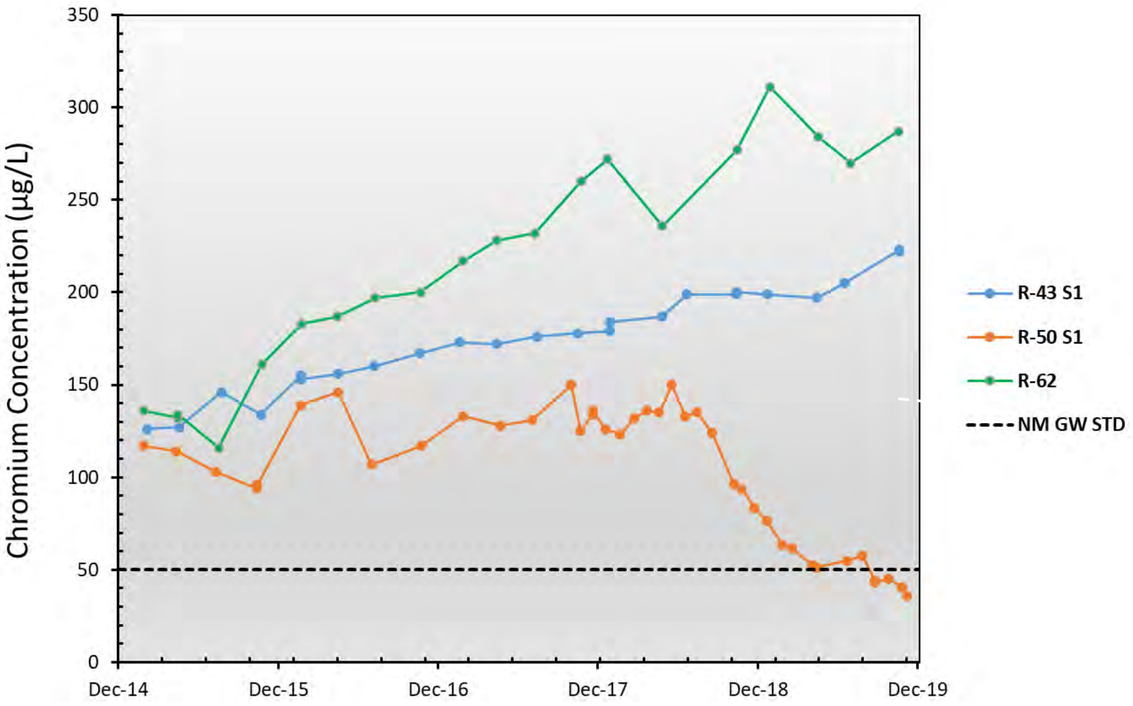


Figure 5-11. Trends in chromium concentrations for three of the regional aquifer wells that exceeded the New Mexico Groundwater Standard (NM GW STD) for chromium of 50 micrograms per liter (µg/L)

The Laboratory's Interim Measures Work Plan for Chromium Plume Control (LANL 2015) presented an approach using extraction wells and injection wells to control plume migration. The Laboratory's objective for the interim measures operations is to establish and maintain the portion of the plume containing 50 micrograms per liter or more of chromium completely within the Laboratory boundary. To accomplish this, we are currently extracting contaminated groundwater from five extraction wells, piping the extracted water to an aboveground ion exchange treatment system, and, following treatment, injecting the treated water back into the regional aquifer through five injection wells located in the downgradient portion of the area of contamination. Interim measures operations began in late 2016. During 2019, extraction and injection activities were conducted from January through early May and from July through December.

To date, the interim measures operations have focused along the northern boundary between the Laboratory and the Pueblo de San Ildefonso west of State Route 4 (Figure 5-9). Two regional aquifer wells, R-50 and R-44, monitor the effectiveness of the interim measure at the downgradient plume edge along that boundary. Well R-50 has 2 screens, one near the water table and one approximately 100 feet below the water table. The deeper of the two screens has shown consistent chromium concentrations within naturally occurring (background) levels, indicating that the chromium contamination at that location is less than 100 feet thick (Figure 5-12). The levels of chromium in R-50 screen 1 continue to steadily decrease over time in response to the interim measures, but showed a slight increase during the summer of 2019 when the interim measures operations were shut down for maintenance activities (Figure 5-12). Chromium concentrations in R-44 screen 1 and screen 2 have historically been below the New Mexico groundwater standard for chromium and are dropping further in response to the interim measures (Figure 5-12).

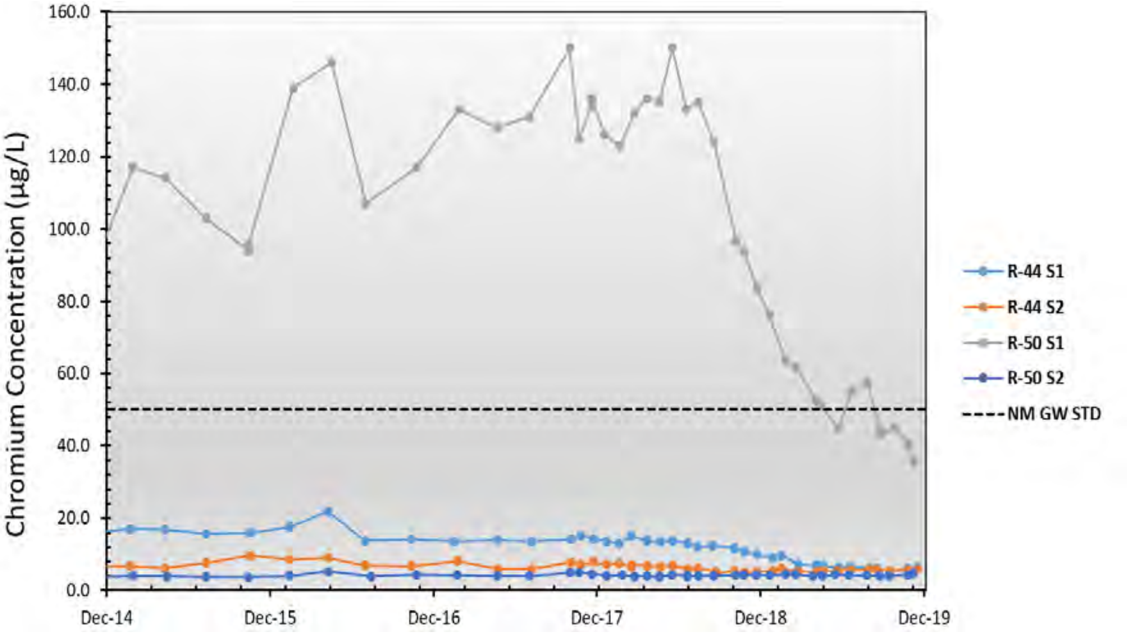


Figure 5-12. Trends in the chromium concentrations for four of the regional aquifer wells that monitor the effectiveness of the interim measure at the downgradient plume edge. The New Mexico Groundwater Standard (NM GW STD) for chromium is 50 micrograms per liter (µg/L).

Interim measures operations along the northeastern portion of the plume began in late 2019. Therefore, chromium concentration data from monitoring wells in that portion of the plume, specifically R-11 and R-45 (2 screens), do not yet reflect the effects of the interim measures. Instead, data from those wells represent other factors that may affect trends in chromium concentrations, such as changes in chromium levels in water recharging the regional aquifer. Both R-11 and R-45 screens 1 and 2 showed decreasing concentrations in chromium independent of the interim measures (Figure 5-13).

Two wells located along the northwestern upgradient portion of the chromium plume, R-62 and R-43 (2 screens), continued to show increases in chromium concentrations in 2019 (Figure 5-14). A new monitoring well is scheduled for installation in this area to further characterize the extent of chromium contamination. Data from these wells will be used to evaluate whether mitigation actions are necessary in this area.

Two perched-intermediate groundwater wells had chromium concentrations above the standard: SCI-2 and MCOI-6. Chromium concentrations continue to decline in SCI-2 and remain steady in MCOI-6 (Figure 5-15).

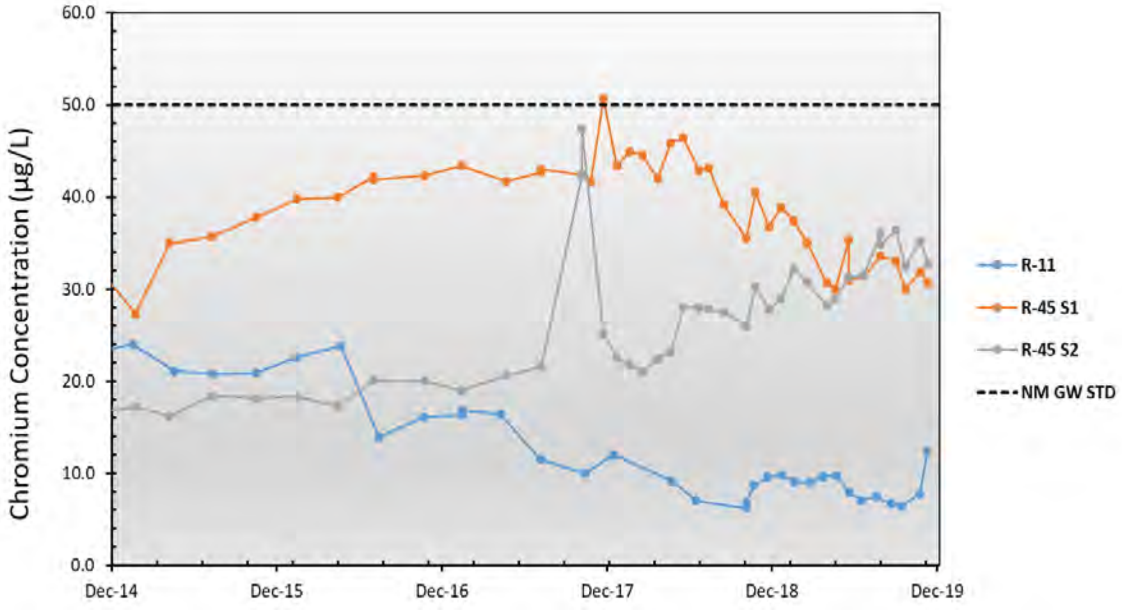
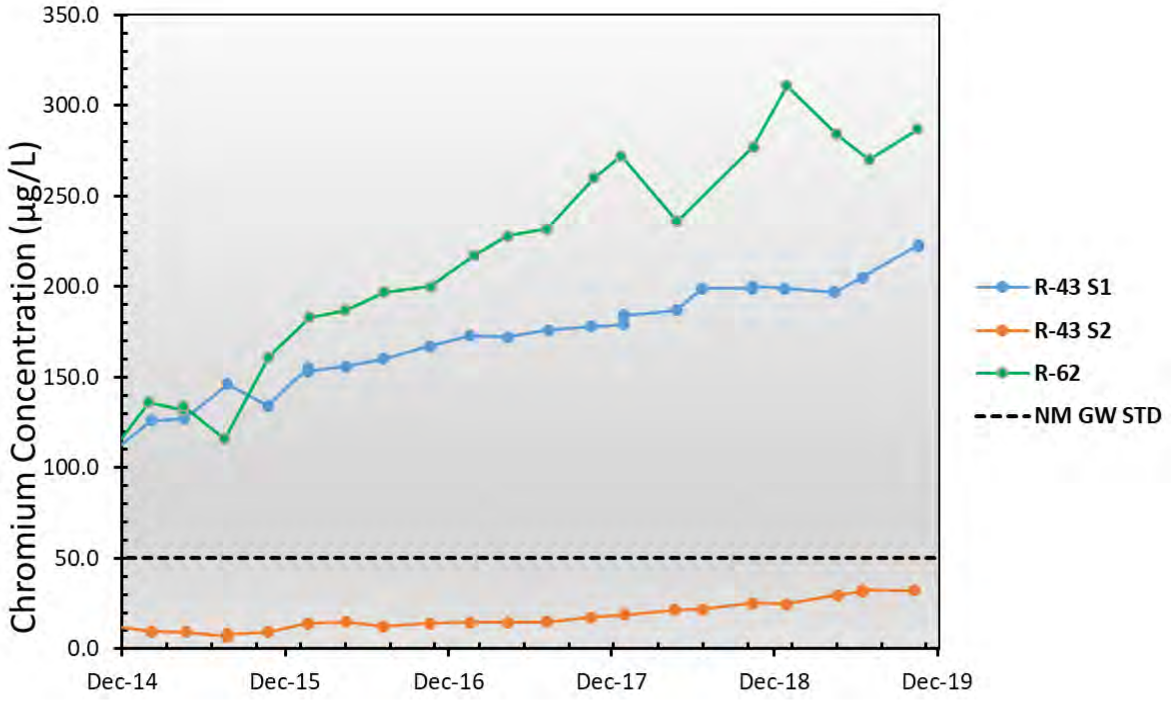


Figure 5-13. Trends in chromium concentrations of two regional wells (R-11 and the two screens of R-45) in the Chromium Investigation monitoring group located along the northeast edge of the plume; these trends are not a reflection of the interim measure, but rather a trend in chromium concentrations in water recharging the regional aquifer. The New Mexico Groundwater Standard (NM GW STD) for chromium is 50 micrograms per liter (µg/L).



NM GW STD = New Mexico groundwater standard

Figure 5-14. Regional monitoring wells R-43 (two screens) and R-62 are located on the northwestern portion of the chromium plume. These two wells show a continued increase in chromium concentrations in 2019.

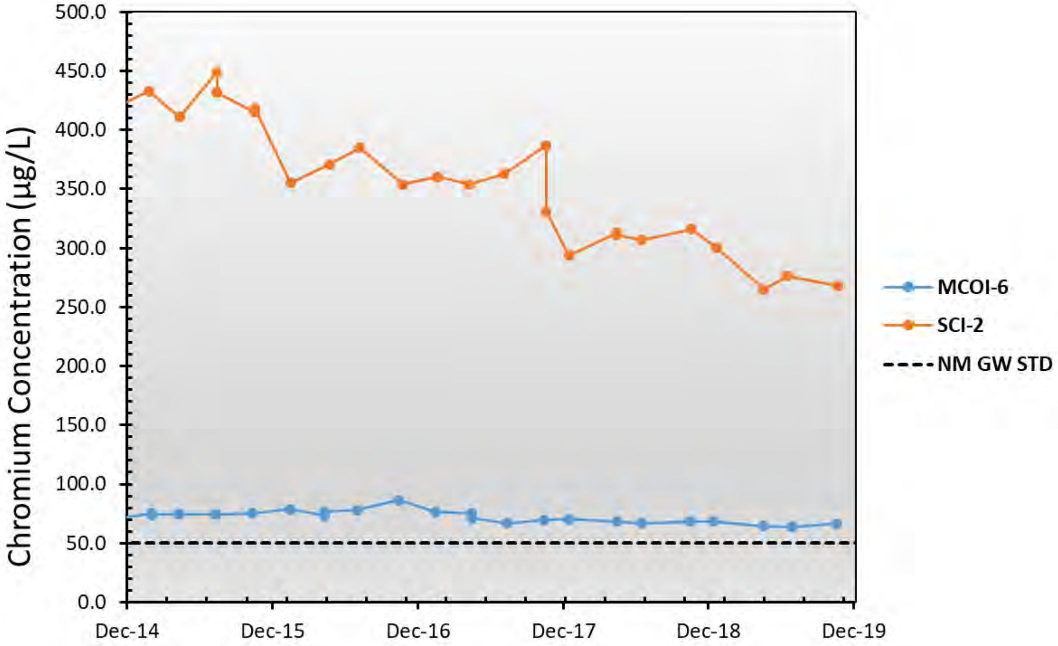
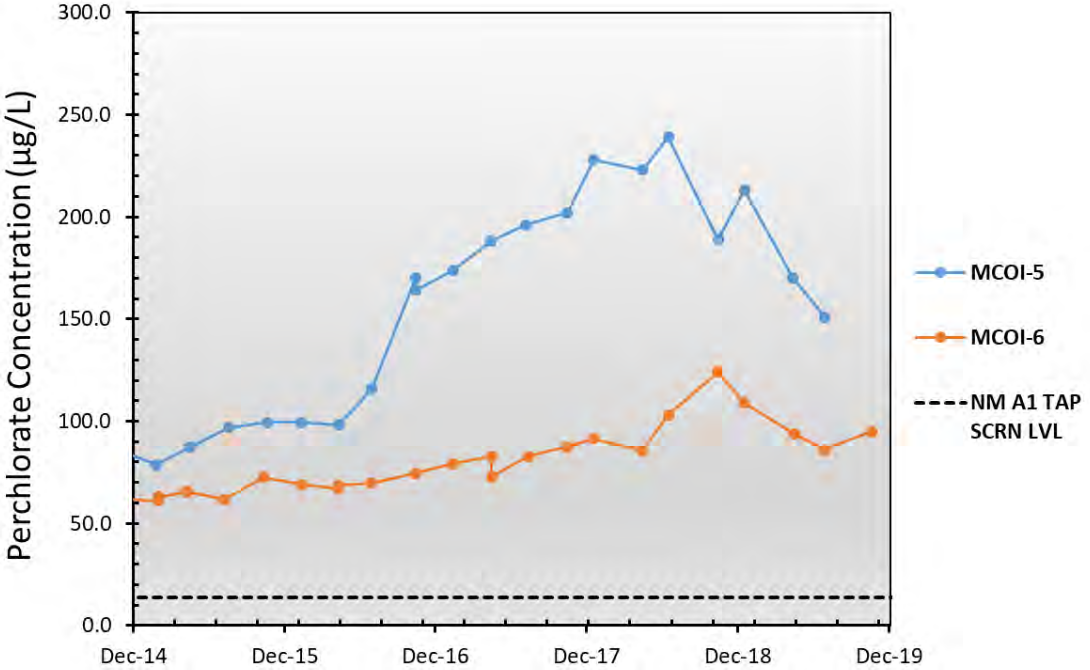


Figure 5-15. Trends in chromium concentrations for perched-intermediate groundwater monitoring wells in the Chromium Investigation monitoring group with chromium concentrations that exceeded the New Mexico Groundwater Standard (NM GW STD) of 50 micrograms per liter (µg/L)

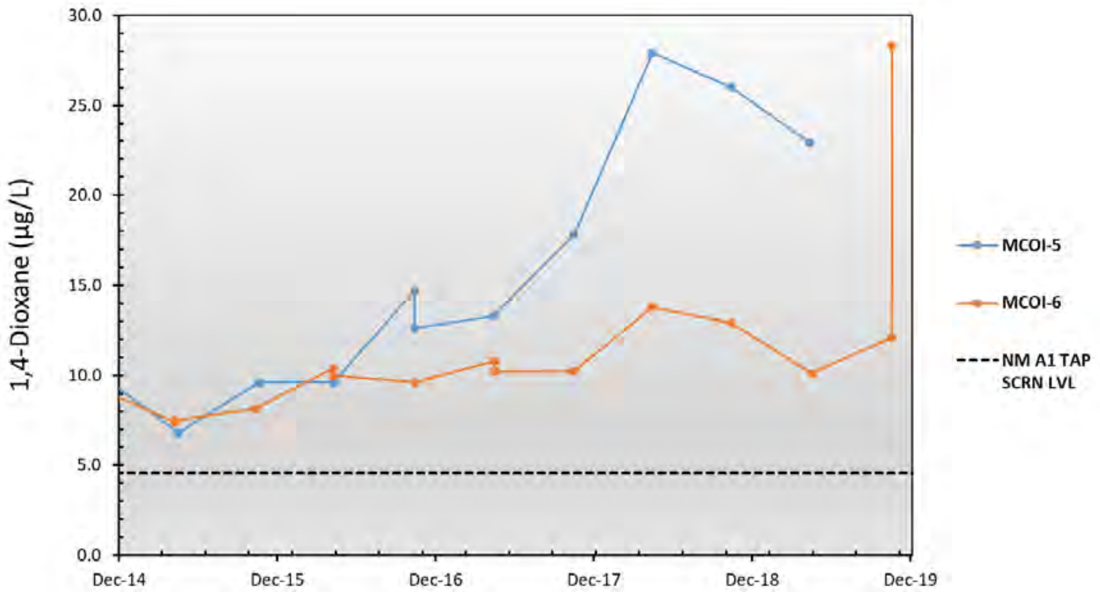
A small area with perchlorate contamination is also present in groundwater beneath Mortandad Canyon. The primary source of perchlorate was effluent discharges from the Radioactive Liquid Waste Treatment Facility from 1963 until March 2002. Perchlorate is present above the New Mexico tap water screening level of 13.8 parts per billion in two perched-intermediate groundwater wells, MCOI-5 and MCOI-6 (Figure 5-16). In perched-intermediate well MCOI-6, the perchlorate concentration trends are relatively stable. Perchlorate concentrations at MCOI-5 have been decreasing. Perchlorate is also present in the regional aquifer, specifically at wells R-61 and R-15. Although R-15 perchlorate levels are below 13.8 parts per billion, the R-61 screen 1 has historically shown concentrations slightly above 13.8 parts per billion. We continue to monitor perchlorate and will incorporate necessary remedial actions as part of the chromium project because of their joint location in groundwater beneath Mortandad Canyon.

Other constituents detected in the Chromium Investigation monitoring group include 1,4-dioxane and tritium in perched-intermediate wells MCOI-5 and MCOI-6 (Figures 5-17 and 5-18). The trend for 1,4-dioxane has been primarily flat at MCOI-6, but it has recently shown an upward trend. Well MCOI-5 has had a continued increasing trend in 1,4-dioxane over the last few years, though between 2018 and 2019 we see a decrease in concentration from 27.9 micrograms per liter to 22.9 micrograms per liter. Concentrations of 1,4-dioxane are not present above the screening level of 4.59 micrograms per liter in the regional aquifer. Perched-intermediate wells MCOI-5 and MCOI-6 have tritium concentrations far below the U.S. Environmental Protection Agency maximum contaminant level for tritium in drinking water of 20,000 picocuries per liter.



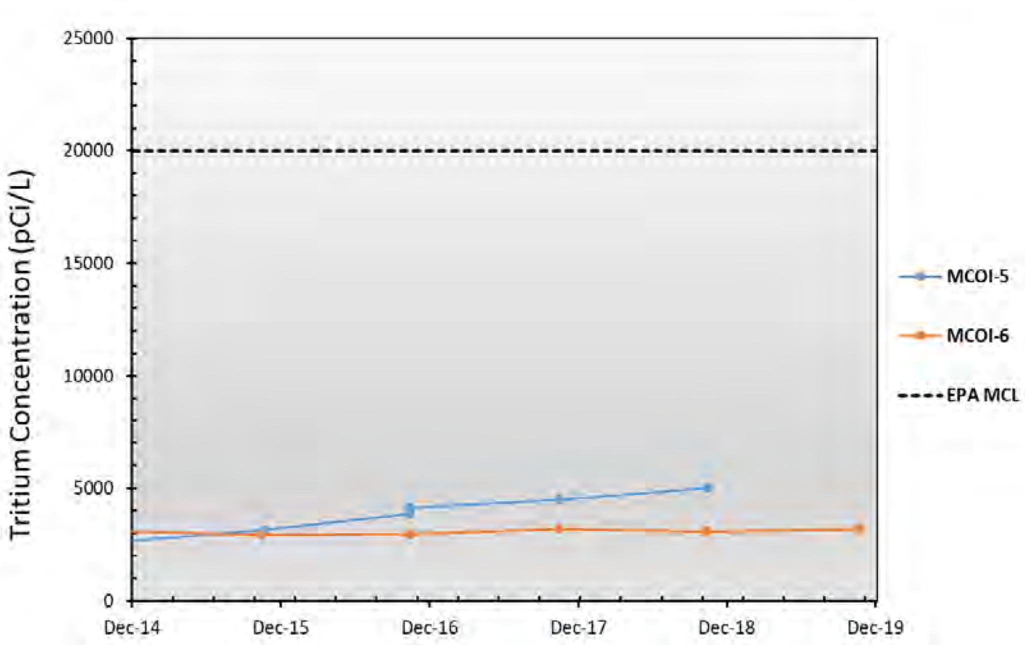
NMED A1 TAP SCRN LVL = New Mexico Environment Department tap water screening level

Figure 5-16. Trends in perchlorate concentrations for perched-intermediate groundwater monitoring wells in the Chromium Investigation monitoring group with perchlorate detections above the New Mexico tap water screening level of 13.8 micrograms per liter (µg/L)



NMED A1 TAP SCRN LVL = New Mexico Environment Department tap water screening level

Figure 5-17. Concentrations of 1,4-dioxane in perched-intermediate groundwater monitoring wells with detections of 1,4-dioxane in the Chromium Investigation monitoring group. The New Mexico groundwater standard for 1,4-dioxane is 4.59 micrograms per liter (µg/L). Note: Samples collected in November were analyzed by two different methods. Additional samples will be collected to verify the trends.



EPA MCL = The U.S. Environmental Protection Agency maximum contaminant level for tritium in drinking water

Figure 5-18. Tritium concentrations in perched-intermediate groundwater monitoring wells in the Chromium Investigation monitoring group. The U.S. Environmental Protection Agency maximum contaminant level for tritium in drinking water is 20,000 picocuries per liter (pCi/L).

Material Disposal Area C Monitoring Group

Material Disposal Area C is located on Mesita del Buey in Technical Area 50, at the head of Ten Site Canyon. It is an inactive landfill where solid low-level radioactive wastes and chemical wastes were disposed of between 1948 and 1974. Vapor-phase volatile organic compounds and tritium are present in the upper 500 feet of the unsaturated soil and rock beneath Material Disposal Area C (LANL 2011a). The primary volatile organic compound is trichloroethene. The Material Disposal Area C monitoring group includes nearby regional aquifer monitoring wells (Figure 5-5). Monitoring data indicate no contamination is present in the groundwater in the regional aquifer immediately downgradient of Material Disposal Area C. No perched-intermediate groundwater is present beneath Material Disposal Area C.

Technical Area 54 Monitoring Group

Technical Area 54 is situated in the east-central portion of the Laboratory on Mesita del Buey. The technical area includes four material disposal areas designated as Areas G, H, J, and L; a waste characterization, storage, and transfer facility (Technical Area 54 West); active radioactive waste storage operations at Area G; hazardous and mixed-waste storage operations at Area L; and administrative and support areas.

At Technical Area 54, groundwater monitoring is conducted to support both (1) monitoring of solid waste management units and areas of concern (particularly Areas G, H, and L) under the Compliance Order on Consent and (2) the Laboratory's Hazardous Waste Facility Permit. The Technical Area 54 monitoring group includes both perched-intermediate groundwater and regional wells (Figure 5-5).

Monitoring data show vapor-phase volatile organic compounds are present in the upper portion of the unsaturated zone beneath Areas G and L. The primary vapor-phase volatile organic compounds at Technical Area 54 are 1,1,1-trichloroethane; trichloroethene; and Freon-113. Tritium is also present (LANL 2005b, 2006, 2007).

There are a small number of detections of a variety of substances, including several volatile organic compounds, from the groundwater monitoring network around Technical Area 54. Tritium was not detected in any of the regional aquifer groundwater monitoring wells in the Technical Area 54 monitoring group. The chemical 1,4-dioxane was detected above the U.S. Environmental Protection Agency maximum contaminant level of 4.59 micrograms per liter at well R-37 screen 1. This is a first detection of this compound above the screening level at this well, and we will continue to monitor the trend here. The sporadic and limited spatial nature of the volatile organic compound detections and the lack of tritium suggest that Technical Area 54 may not be the source of the detected compounds (LANL 2009b).

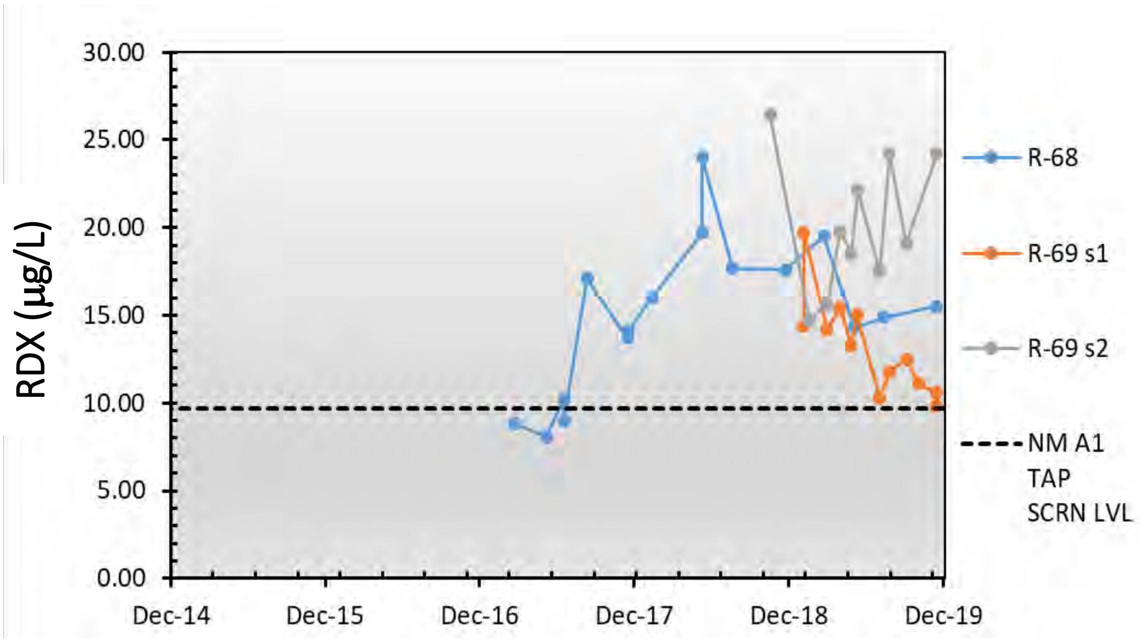
Technical Area 16 260 Monitoring Group

Water Canyon and Cañon de Valle (a tributary of Water Canyon) cross the southwest portion of LANL where the Laboratory develops and tests explosives. In the past, the Laboratory released waste water into both canyons from several high-explosives processing facilities in Technical Areas 16 and 09 (Figure 5-4). The Technical Area 16 260 monitoring group was established for the upper Water Canyon/Cañon de Valle watershed to monitor substances released from Consolidated Unit 16-021(c)-99, which includes the Technical Area 16 260 outfall and associated solid waste management units. The Technical Area 16 260 outfall discharged high-explosives-bearing water from a high-explosives machining facility to Cañon de Valle from 1951 through 1996. These discharges served as a primary source of high-explosives and inorganic element contamination in the area (LANL 1998, 2003, 2011b). Current evidence indicates that over time, the effluent from the Technical Area 16 260 outfall, sometimes mixed with naturally occurring surface water and alluvial groundwater in Cañon de Valle, infiltrated from Cañon de Valle and percolated through unsaturated rock layers to perched-intermediate groundwater zones and ultimately into the regional aquifer.

Data indicate that springs, surface water, alluvial groundwater, and perched-intermediate groundwater in the area contain explosive compounds, including RDX (hexahydro-1,3,5-trinitro-1,3,5-triazine); HMX (octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine); TNT (2,4,6-trinitrotoluene); and barium. RDX has been detected in the regional aquifer in wells R-18, R-63, R-68, and R-69 screens 1 and 2 (Figure 5-19 and Figure 5-20).

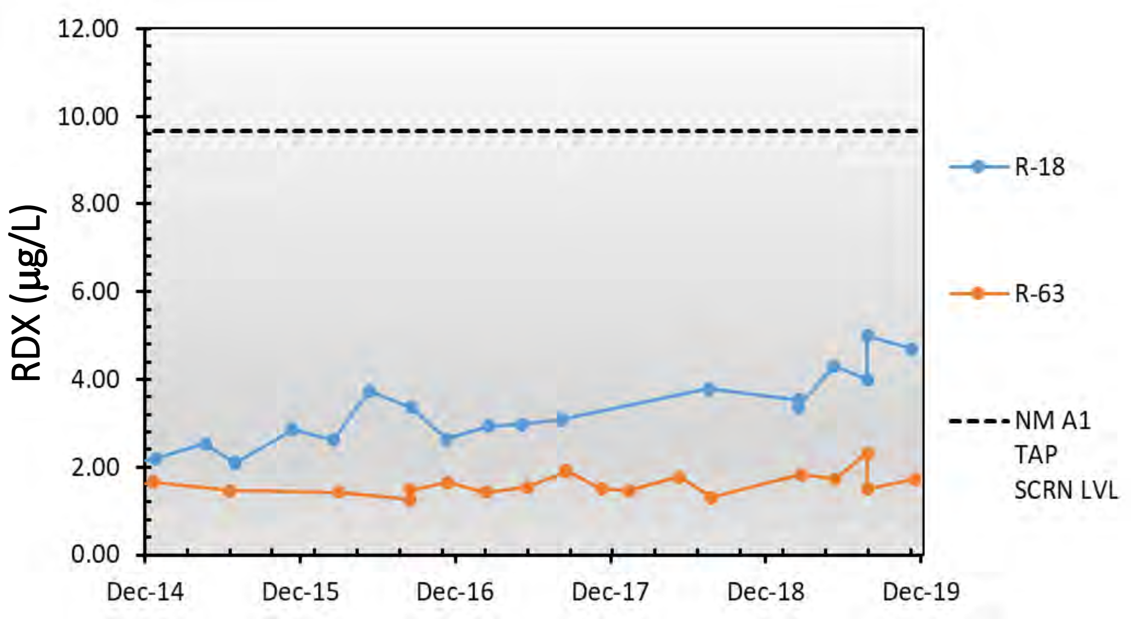
In addition, the volatile organic compounds tetrachloroethene and trichloroethylene, and boron have been detected in springs, alluvial groundwater, and perched-intermediate groundwater. Low concentrations of tetrachloroethene have been detected in the regional aquifer in wells R-25 screen 5, R-18, R-68, and R-69 screens 1 and 2.

RDX is the primary groundwater contaminant in this area and the only contaminant that exceeds its groundwater standard (9.66 micrograms per liter) in the regional aquifer. Two regional aquifer wells, R-68 and R-69 screens 1 and 2, have had RDX concentrations above the tap water screening level of 9.66 micrograms per liter. RDX concentrations in regional monitoring wells R-63 and R-18 were below the groundwater standard, but are exhibiting stable to increasing trends (Figure 5-20).



NMED A1 TAP SCRN LVL = New Mexico Environment Department tap water screening level

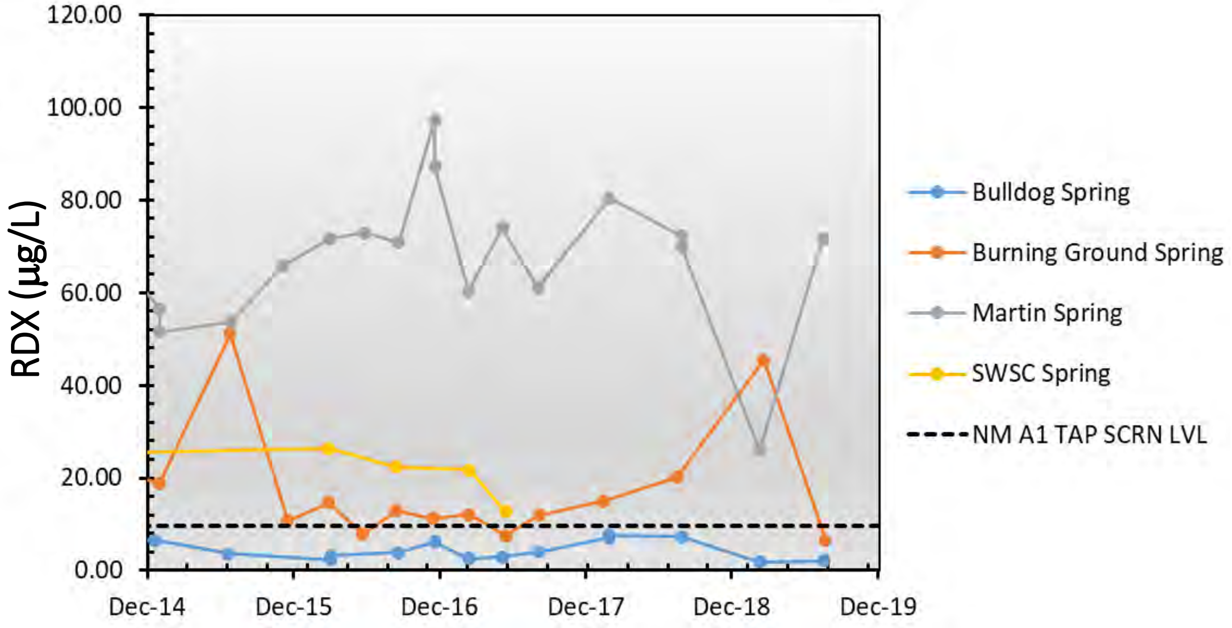
Figure 5-19. RDX concentrations in regional aquifer well R-68 and R-69 screens 1 and 2. The New Mexico groundwater standard for RDX is 9.66 micrograms per liter (µg/L).



NMED A1 TAP SCRN LVL = New Mexico Environment Department tap water screening level

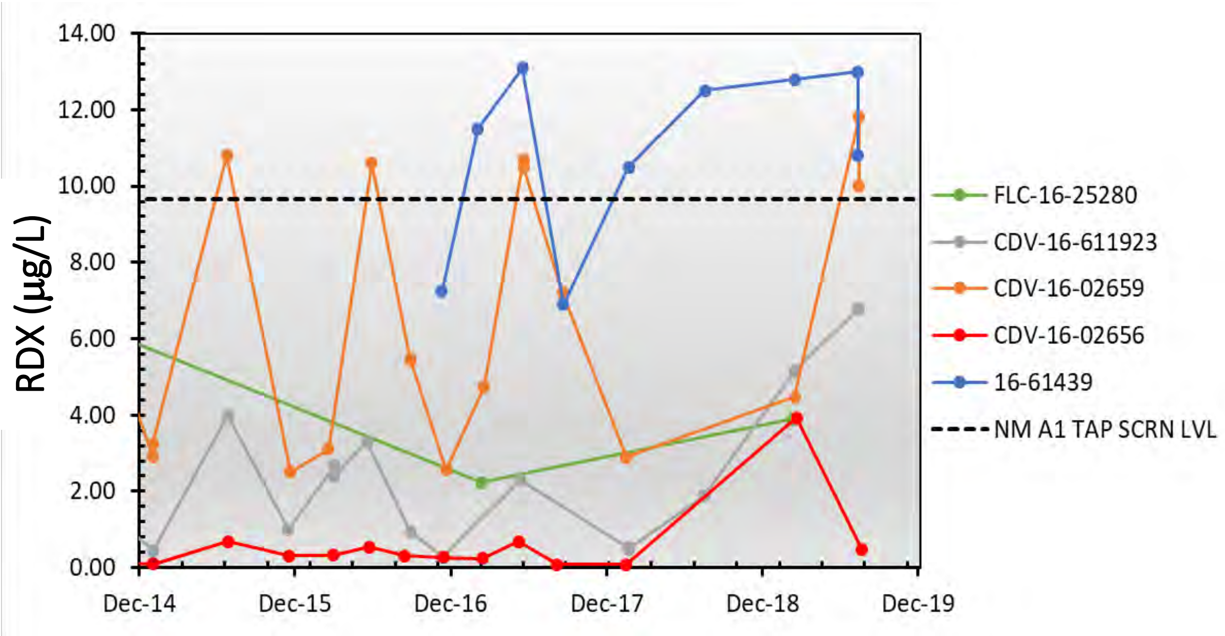
Figure 5-20. RDX concentrations in regional aquifer wells R-18 and R-63. The New Mexico groundwater standard for RDX is 9.66 micrograms per liter (µg/L).

Figures 5-21, 5-22, and 5-23 show RDX concentrations in springs, alluvial wells, and perched-intermediate groundwater wells, respectively. The springs discharge from perched-intermediate groundwater zones.



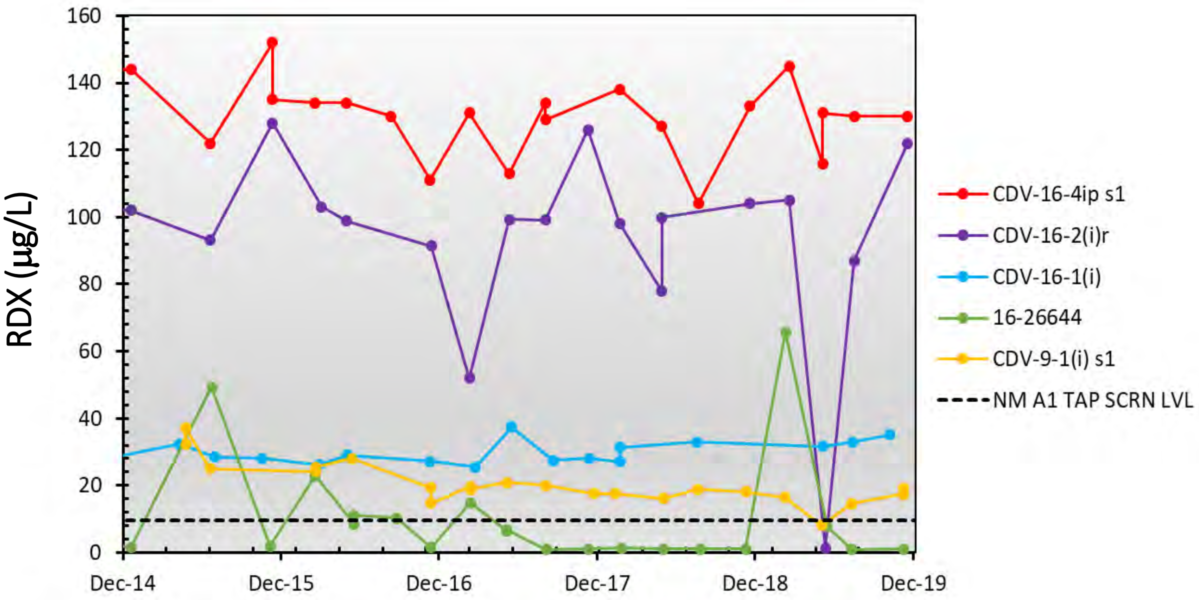
NMED A1 TAP SCRN LVL = New Mexico Environment Department tap water screening level

Figure 5-21. RDX concentrations in two springs in Cañon de Valle, one spring in Martin Spring Canyon, and one spring in Bulldog Gulch, in Technical Area 16 (see locations in Figure 5-5). The New Mexico groundwater standard for RDX is 9.66 micrograms per liter (µg/L).



NMED A1 TAP SCRN LVL = New Mexico Environment Department tap water screening level

Figure 5-22. RDX concentrations in alluvial groundwater wells in Cañon de Valle and Fishladder Canyon. The New Mexico groundwater standard for RDX is 9.66 micrograms per liter (µg/L).



NMED A1 TAP SCRN LVL = New Mexico Environment Department tap water screening level.

Figure 5-23. RDX concentrations in perched-intermediate groundwater wells. The New Mexico groundwater standard for RDX is 9.66 micrograms per liter (µg/L).

Of the springs sampled, the concentrations of RDX are highest in Martin Spring (Figure 5-21). RDX concentrations at Burning Ground Spring have been relatively steady over the last five years (Figure 5-21), with the exception of samples collected in July 2015 and March 2019. SWSC Spring, near the former location of the Technical Area 16 260 outfall, does not have consistent flow, and it was not sampled in 2019.

RDX concentrations in alluvial monitoring wells show significant variability because of seasonal influences, but remain relatively low (Figure 5-22). RDX concentrations in each of the perched-intermediate groundwater wells show some variability (Figure 5-23). Long-term monitoring of some of these springs and alluvial wells is now included in the annual Interim Facility-Wide Groundwater Monitoring Plan (N3B 2018).

Other substances, including tetrachloroethene, trichloroethene, boron, and barium, are present in all groundwater zones but are well below applicable standards in the regional aquifer. We are currently investigating the extent and implications of RDX contamination in perched-intermediate and regional groundwater. A report on this investigation is scheduled for completion in 2020.

Material Disposal Area AB Monitoring Group

The Material Disposal Area AB monitoring group is located in Technical Area 49. Technical Area 49, also known as the Frijoles Mesa Site, is located on a mesa in the upper part of the Ancho Canyon drainage. Part of the area drains into Water Canyon. The canyons in the Ancho watershed are mainly dry with no known persistent alluvial groundwater zones and no known perched-intermediate groundwater.

Material Disposal Area AB was the site of nuclear weapons component testing from 1959 to 1961 (Purtymun and Stoker 1987, LANL 1988). The testing involved isotopes of uranium and plutonium; lead and beryllium; explosives such as TNT, RDX, and HMX; and barium nitrate. Some of this material remains in shafts in the mesa top. Further information about activities, solid waste management units, and areas of concern at Technical Area 49 can be found in earlier Laboratory reports (LANL 2010a, 2010b).

In 2019, no constituents were found in Material Disposal Area AB monitoring group wells at concentrations above standards or screening levels.

White Rock Canyon Monitoring Group

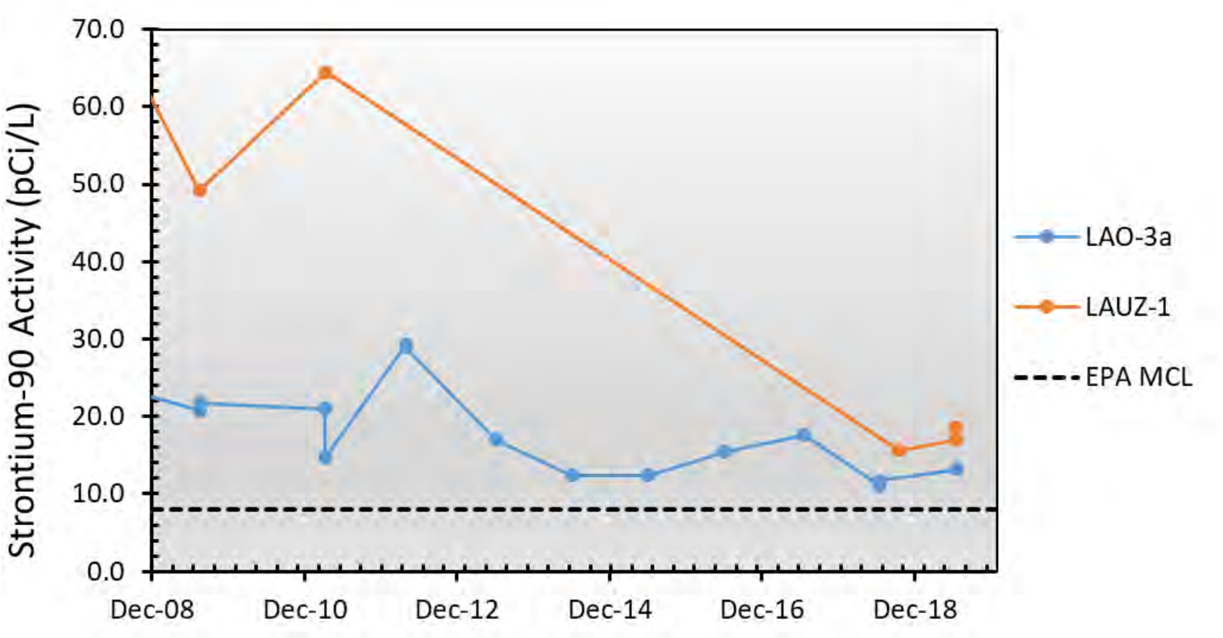
The springs that flow along and near the Rio Grande in White Rock Canyon discharge predominantly regional aquifer groundwater (Purtymun et al. 1980). A few springs appear to represent discharge of perched-intermediate groundwater. Some other springs may discharge a mixture of regional aquifer groundwater, perched-intermediate groundwater, and percolation of recent precipitation (Longmire et al. 2007).

The White Rock Canyon springs serve as important monitoring points for evaluating the Laboratory's potential impact to the Rio Grande (Figure 5-7). Consistent with prior years' data, no springs that discharge groundwater from beneath the Laboratory into White Rock Canyon had any constituent concentrations above applicable groundwater standards or screening levels in 2019.

General Surveillance Monitoring

Los Alamos Canyon on Laboratory Property

Alluvial well LAO-3a in Los Alamos Canyon (Figure 5-6) continues to show strontium-90 concentrations above the U.S. Environmental Protection Agency's 8 picocuries per liter maximum contaminant level (Figure 5-24). Alluvial well LAUZ-1 had not been sampled since 2011, but was sampled in 2018 and 2019. In 2019, the concentration of strontium-90 was 18.6 picocuries per liter, which is below the 2011 concentration of 64.5 picocuries per liter. The source of the strontium-90 is Solid Waste Management Unit 21-011(k), which was an outfall from industrial waste treatment at Technical Area 21. Strontium-90 is persistent at this location and in several downgradient alluvial wells near the confluence of DP Canyon with Los Alamos Canyon, but it has not been migrating to alluvial locations further down Los Alamos Canyon (LANL 2004).

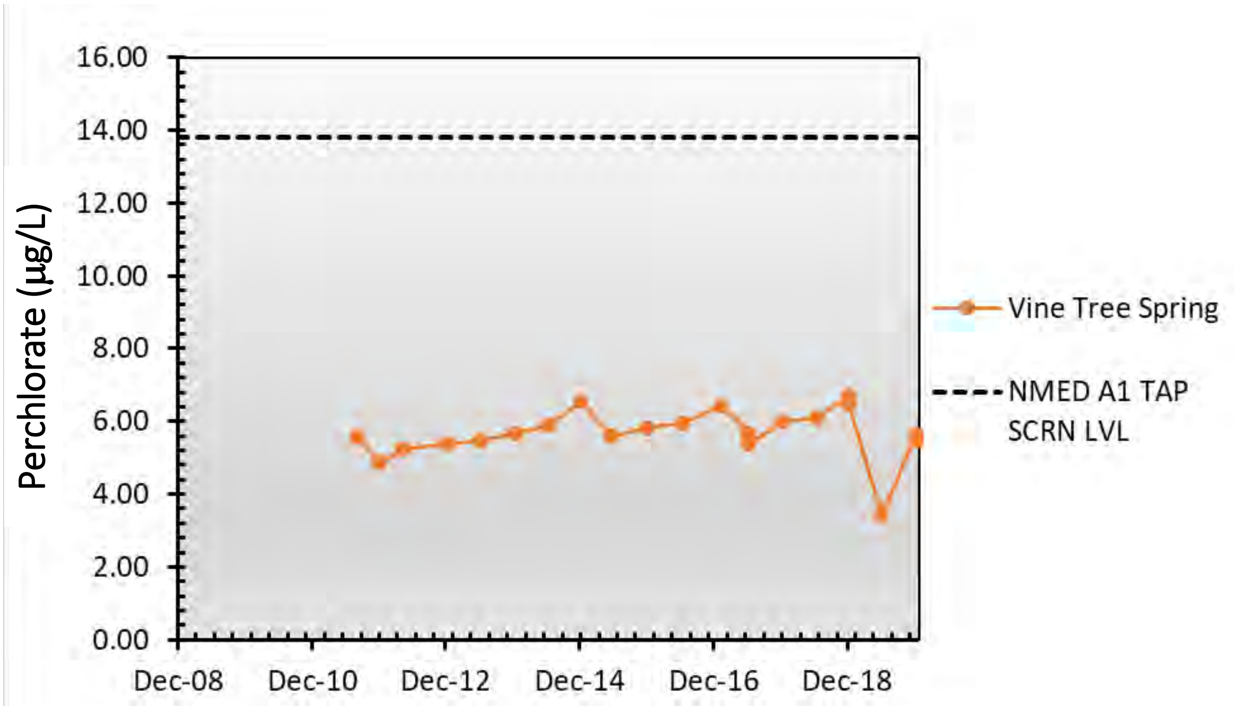


EPA MCL = U.S. Environmental Protection Agency maximum contaminant level for drinking water

Figure 5-24. Strontium-90 concentrations at alluvial monitoring wells LAO-3a and LAUZ-1. The U.S. Environmental Protection Agency maximum contaminant level for strontium-90 in drinking water is 8 picocuries per liter (pCi/L).

Lower Los Alamos Canyon

Vine Tree Spring on Pueblo de San Ildefonso land represents discharge of perched-intermediate groundwater. Sampling at Vine Tree Spring began as a replacement for nearby Basalt Spring, which had been sampled since the 1950s until it dried up around 2010. The perchlorate concentration in Vine Tree Spring for 2019 is consistent with prior years' data. The perchlorate contamination may be associated with historical Laboratory operations. For context, the perchlorate values are below the risk-based screening level of 13.8 micrograms per liter (Figure 5-25). The screening level for perchlorate is determined according to a hierarchical data-screening process required under the 2016 Consent Order.



NMED A1 TAP SCRN LVL = New Mexico Environment Department tap water screening level

Figure 5-25. Perchlorate concentrations at Vine Tree Spring. The New Mexico risk-based screening level for perchlorate is 13.8 micrograms per liter (µg/L).

Sandia Canyon

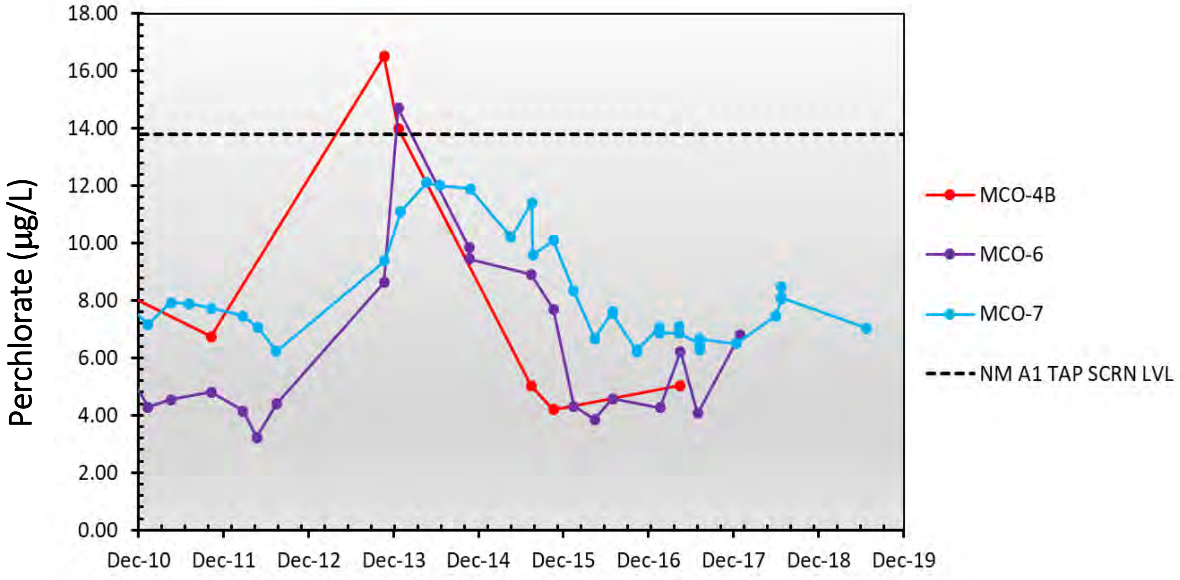
The General Surveillance monitoring group wells located in Sandia Canyon that are not part of the Chromium Investigation monitoring group include regional aquifer wells R-10 and R-10a and perched-intermediate well R-12; wells R-10 and R-10a are on Pueblo de San Ildefonso land. No constituents were measured near or above standards or screening levels in these wells during 2019.

Mortandad Canyon

Several regional aquifer wells in Mortandad Canyon are part of the General Surveillance monitoring group. No constituents were measured near or above standards or screening levels in these wells during 2019.

Under the groundwater discharge plan application for the Technical Area 50 Radioactive Liquid Waste Treatment Facility outfall, quarterly and annual samples are collected from seven alluvial, perched-intermediate, and regional aquifer wells to monitor Laboratory operational impacts from discharges to the outfall in Mortandad Canyon, as discussed in Chapter 2 and later in this chapter. Effluent treatment at the Radioactive Liquid Waste Treatment Facility was upgraded in 2002.

Historically, perchlorate has been detected in alluvial monitoring wells MCO-4B, MCO-6, and MCO-7 (Figure 5-26). Since the 2002 Radioactive Liquid Waste Treatment Facility upgrades, the perchlorate concentrations from the wells remain low relative to past perchlorate concentrations in Mortandad Canyon alluvial groundwater. All 2019 results are below the perchlorate groundwater screening level. Nitrate, fluoride, and total dissolved solids are also far below applicable standards in these alluvial wells.



NMED A1 TAP SCRN LVL = New Mexico Environment Department tap water screening level

Figure 5-26. Perchlorate concentrations at General Surveillance monitoring group and groundwater discharge plan monitoring wells MCO-4B, MCO-6, and MCO-7 in Mortandad Canyon alluvial groundwater. The New Mexico tap water screening level for perchlorate is 13.8 micrograms per liter (µg/L).

Cañada del Buey

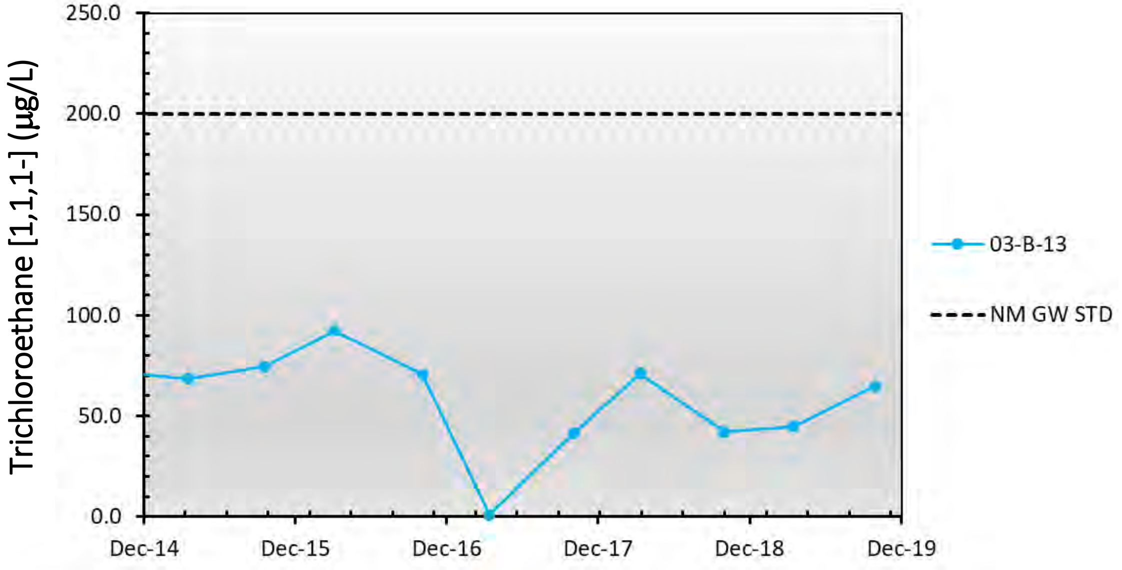
Alluvial well CDBO-6 in Cañada del Buey was dry in 2019 and therefore not sampled.

Pajarito Canyon

Pajarito Canyon has a watershed that begins in the Sierra de los Valles west of the Laboratory. Twomile and Threemile Canyons at the Laboratory are tributaries of Pajarito Canyon. Saturated alluvium is present in portions of Pajarito Canyon, including a reach in lower Pajarito Canyon, but does not extend beyond the Laboratory’s eastern boundary. In the past, the Laboratory released small amounts of waste water into tributaries of Pajarito Canyon from several high-explosives processing sites at Technical Area 09. A nuclear materials experimental facility occupied the floor of Pajarito Canyon at Technical Area 18. Waste management areas at Technical Area 54 occupy the mesa north of the lower part of the canyon.

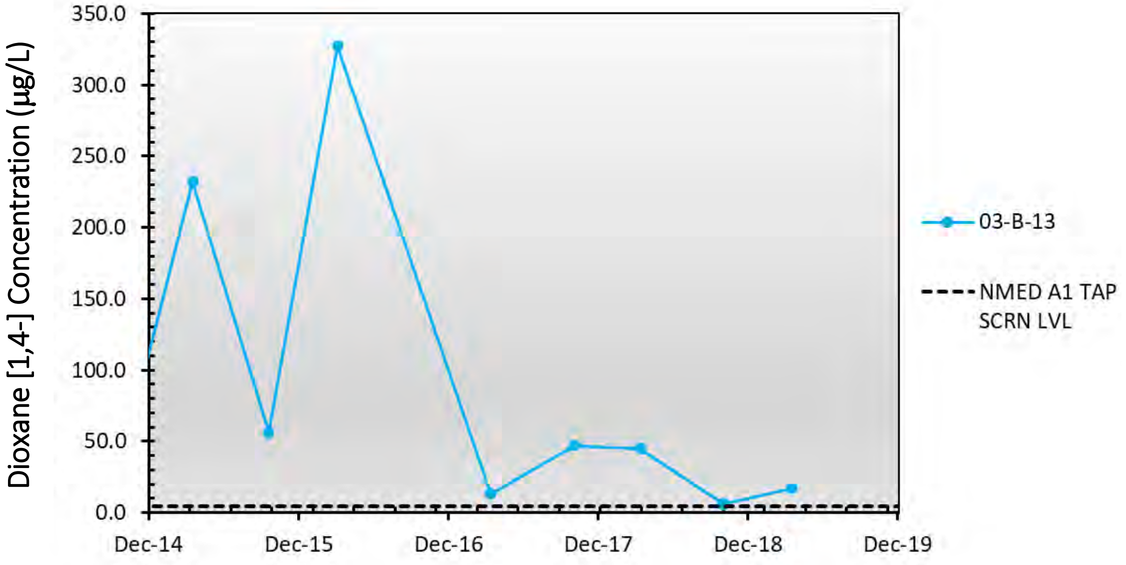
Solid Waste Management Unit 03-010(a) is the outfall area from a former vacuum repair shop behind the warehouse at Technical Area 03. The outfall area is located on a small tributary to Twomile Canyon. A small zone of shallow perched-intermediate groundwater is present and is apparently recharged by runoff from adjacent parking lots and building roofs. This perched groundwater is sampled at a depth of approximately 21 feet by well 03-B-13. In 2019, samples from this well contained 1,1,1-trichloroethane at concentrations below the New Mexico groundwater standard (Figure 5-27). Concentrations of 1,4-dioxane in 03-B-13 were the lowest ever recorded (Figure 5-28).

Several other alluvial and perched-intermediate groundwater and regional aquifer wells in Pajarito Canyon are part of the General Surveillance monitoring group. No constituents were measured near or above applicable standards or screening levels in these wells during 2019.



NM GW STD = New Mexico groundwater standard

Figure 5-27. Concentrations of 1,1,1-trichloroethane in Pajarito Canyon perched-intermediate groundwater at General Surveillance monitoring group well 03-B-13. The New Mexico groundwater standard for 1,1,1-trichloroethane is 200 micrograms per liter (µg/L).



NMED A1 TAP SCRN LVL = New Mexico Environment Department tap water screening level

Figure 5-28. Concentrations of 1,4-dioxane in Pajarito Canyon perched-intermediate groundwater at General Surveillance monitoring group well 03-B-13. The New Mexico groundwater standard for 1,4-dioxane is 4.59 micrograms per liter (µg/L).

Water Canyon

Water Canyon has only one General Surveillance monitoring group location, alluvial well WCO-1r. For the March 15, 2019, sampling event, iron was detected at 1,560 micrograms per liter, which is above the 1,000 micrograms per liter New Mexico groundwater standard.

Groundwater Discharge Permit Monitoring

Groundwater monitoring completed in support of groundwater discharge permits (wells MCA-RLW-1, MCA-RLW-2, SCA-3, MCOI-6, SCI-1, R-1, R-14 Screen 1, R-46, and R-60) contained no constituents detected above applicable standards or screening levels in 2019. Alluvial wells MCA-RLW-1 and SCA-3 were dry during the monitoring period. It should be noted several analytes related to historical operations were detected in perched-intermediate aquifer well MCOI-6 above applicable standards or screening levels as presented in the Chromium Investigation monitoring group portion of this report.

SUMMARY

The Laboratory has been monitoring groundwater for many years. The groundwater monitoring network has been significantly expanded over the last decade. This expanded network has improved our understanding of the nature and extent of groundwater contamination. As described in this chapter, only two areas are showing groundwater contaminants that are of sufficient concentration and extent to warrant an action such as interim measures, further characterization, and potential remediation under the 2016 Consent Order: RDX contamination in the vicinity of Technical Area 16 and chromium contamination beneath Sandia and Mortandad Canyons. We will continue to implement interim measures in the chromium plume in 2020 and beyond. Further characterization work and studies to evaluate groundwater risks and potential remediation strategies are ongoing in both of these areas.

QUALITY ASSURANCE

All methods and procedures used to perform the field activities associated with this data are documented in the 2019 Interim Facility-Wide Groundwater Monitoring Plan (N3B 2018).

Sampling and data validation were conducted using Standard Operating Procedures that are a part of a comprehensive quality assurance program. Standard Operating Procedures include the following:

- "WCSF-Interim Facility-Wide Groundwater Monitoring" (LANL 2016, 601812)
- "Groundwater Sampling" (IWD-TPMC-LA-16-049)
- "Wireless Connect/Non-connected Component Plan – Standalone Wireless System Name: Groundwater Monitoring Well Data Acquisition System" (N3B-SD-016-CP-032/L2)
- "Locus Mobile Application for Groundwater Data Collection" (N3B-ER-SOP-20324)
- "Groundwater Sampling IPC-6" (N3B-ER-SOP-20032)
- "Groundwater Sampling and Sample Preservation" (N3B-ER-IWD-20088)
- "Manual Groundwater Level Measurements" (N3B-ER-SOP-20243)
- "Groundwater Level Data Processing, Review, and Validation" (N3B-ER-SOP-20231)
- "Validation of Volatile Organic Compound (VOC) Analytical Data" (N3B-ER-AP-20309)
- "Validation of Semi-volatile Organic Compound Analytical Data" (N3B-ER-AP-20310)
- "Validation of LC-MS/MS High Explosive Analytical Data" (N3B-ER-AP-20316)
- "Validation of Organochlorine Pesticide and Polychlorinated Biphenyl Analytical Data" (N3B-ER-AP-20311)
- "Validation of Metals and Cyanide Analytical Data" (N3B-ER-AP-20313)
- "Validation of Gamma Spectroscopy, Chemical Separation Alpha Spectrometry, Gas Proportional Counting, and Liquid Scintillation Analytical Data" (N3B-ER-AP-20314)
- "Validation of General Chemistry Analytical Data" (N3B-ER-AP-20315)

- “Validation of High Explosive Analytical Data by LC-MS/MS” (N3B-ER-AP-20316)
- “Validation of Dioxin and Furan Analytical Data” (N3B-ER-AP-20320)
- “Validation of Chlorinated Biphenyl Congener Analytical Data” (N3B-ER-AP-20318)
- “Validation of Total Petroleum Hydrocarbons Gasoline Range Organics/Diesel Range Organics Analytical Data” (N3B-ER-AP-20319)
- “Validation of LC-MS/MS Perchlorate Analytical Data” (N3B-ER-AP-20320)

Procedures for Collecting Groundwater Samples

The Laboratory has several standard operating procedures for collecting groundwater samples and samples from springs that discharge groundwater. These procedures (or their equivalent used by sampling subcontractors) are used in accordance with the “Interim Facility-Wide Groundwater Monitoring Plan for the 2019 Monitoring Year, October 2018–September 2019” and the “Interim Facility-Wide Groundwater Monitoring Plan for the 2020 Monitoring Year, October 2019–September 2020” (N3B 2018, 2019).

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Los Alamos National Laboratory (LANL, or the Laboratory) collects and analyzes storm water runoff to check for a variety of substances and characteristics, such as chemical and radionuclide levels, the volume and duration of flow, and the total amount of suspended sediment. We compare these sampling results with New Mexico water quality standards, target action levels, and radiological dose guidelines. The State of New Mexico uses our surface water data in updating its determinations of impaired waters on and near the Laboratory every two years.

We also analyze newly deposited sediment samples each year for chemical and radionuclide levels. We compare sediment-sampling results with human and ecological health screening criteria.

The data collected in 2019 and presented in this chapter are used to verify that during 2019, the storm water–related transport of chemicals or radionuclides did not cause levels of those substances to exceed the levels found during the canyons investigations of 2004–2011. We have found that over time, at any given sampling location, storm water–related transport of sediments generally results in similar or lower levels of Laboratory-released chemicals and radionuclides at that location than previously existed because of the deposit of new sediments. The results of the sediment and surface water data collected in 2019 support the conclusion that the risk assessments presented in the canyons investigation reports represent an upper bound of risks from these substances in the canyons for the foreseeable future. The Laboratory continues to have several impaired stream reaches, as defined by the New Mexico Environment Department. Laboratory industrial outfalls and dredge and fill activities are regulated to help minimize these impairments.

INTRODUCTION

Effluents (liquid discharges from industrial operations) containing radionuclides, inorganic chemicals, and organic chemicals were released into canyons around Los Alamos National Laboratory (LANL, or the Laboratory) during the early years of its operations. Treatments to reduce contaminants in effluents began in the 1950s. Effluent discharges at the Laboratory have been conducted under permits from regulatory agencies since 1978.

There are also natural and non-Laboratory but human-related sources of chemicals and radionuclides, such as the natural composition of rocks and soils, substances associated with trees burned during forest fires, atmospheric fallout of radionuclides and of chemicals such as polychlorinated biphenyls (PCBs), and releases from other developed areas on the Pajarito Plateau. All of the above sources contribute to the measured levels of chemicals and radionuclides in surface water and sediment across the plateau.

We monitor chemical and radionuclide levels in surface water and sediment in and around the Laboratory to (1) document the water quality in streams within and downstream of the Laboratory and (2) evaluate risks to human and ecosystem health. Sampling results are compared with New Mexico water quality standards, target action levels, radiological dose guidelines, and human and ecosystem health screening criteria.

The data presented in this chapter originate from three Laboratory programs:

- Annual environmental surveillance sampling (N3B 2019a, N3B 2020a)
- The annual Interim Facility-Wide Groundwater Monitoring Plan (N3B 2018, N3B 2019b), which includes sampling of springs and persistent surface water in streams
- Storm water runoff monitoring associated with the Individual Permit (Permit No. 0030759; the authorization to discharge [from solid waste management units and areas of concern] under the National Pollutant Discharge Elimination System) (N3B 2020b)

The legacy waste cleanup contractor Newport News Nuclear BWXT–Los Alamos (N3B) assumed responsibility for implementing the Laboratory's surface water and sediment surveillance programs, groundwater protection program, and the Individual Permit in April 2018.

At the Laboratory, we consider any soil that is either suspended in water or that has been deposited by surface water flows as sediment. Many of our sediment samples are collected from dry stream channels or adjacent floodplains, and not from aquatic habitats.

STANDARDS, SCREENING LEVELS, AND DESIGNATED USES FOR STREAM REACHES

The New Mexico Water Quality Control Commission establishes surface water quality standards for New Mexico in *Standards for Interstate and Intrastate Surface Waters*, Title 20, Chapter 6, Part 4 of the New Mexico Administrative Code. The current standards were approved by the Environmental Protection Agency on March 2, 2017, and can be found online at https://www.env.nm.gov/surface-water-quality/2013-triennial-review/. We use the New Mexico Environment Department’s protocol for assessing attainment of surface water quality standards (New Mexico Environment Department 2019a). Hardness-dependent aquatic life criteria for metals are calculated using water hardness values of concurrent samples where available, and 30 milligrams calcium carbonate per liter (mg $CaCO_3$/L) where hardness values are not available (U.S. Environmental Protection Agency 2006a, New Mexico Water Quality Control Commission 2017).

U.S. Department of Energy (DOE) Order 458.1 Chg 3, *Radiation Protection of the Public and the Environment*, sets total dose limits for radioactivity released during Laboratory operations. Limits apply to members of the public, plants, and animals. There are no drinking water systems relying on surface water that deliver water to people on the Pajarito Plateau. Therefore, our radiological assessment of surface water looks at the potential exposures of aquatic organisms as well as animals living on land (collectively called "biota"). We compare radionuclide activities in surface water with the DOE biota concentration guides (DOE 2002, 2004) with site-specific modifications by McNaughton et al. (2013). Biota concentration guides for either aquatic, riparian, or terrestrial animals are used for evaluation, depending on how often surface water is present at each location being evaluated. Perennial reaches are screened using aquatic and riparian animal biota concentration guides; intermittent reaches are screened using aquatic, terrestrial, and riparian biota concentration guides; ephemeral reaches are screened using terrestrial animal biota concentration guides. Biota dose results are provided in Chapter 7.

We compare surface water results for gross alpha radioactivity and isotopes of radium with the New Mexico water quality standards. The gross alpha standard does not apply to source, special nuclear, or byproduct material regulated by DOE under the Atomic Energy Act of 1954. The gross alpha radioactivity data discussed in this chapter were not adjusted to remove these sources of radioactivity.

We compare surface water results from the Individual Permit site monitoring areas with the target action levels specified in the Individual Permit. Additional details for site monitoring area results are provided in the Individual Permit Annual Report (N3B 2020c).

State of New Mexico Assessments of Stream Reaches

The New Mexico Environment Department Surface Water Quality Bureau uses surface water sampling results to evaluate impairment of the state's stream reaches under Section 303(d) of the Clean Water Act. They update the list of impaired stream reaches, including those on Laboratory property, every two years.

Under *Standards for Interstate and Intrastate Surface Waters*, Title 20, Chapter 6, Part 4 of the New Mexico Administrative Code, stream reaches within the Laboratory boundary are classified as perennial (having water throughout the year), or ephemeral and intermittent (having water for extended periods only at certain times of the year or having water briefly only in direct response to precipitation) (New Mexico Water Quality Control Commission 2017). Based on their type of stream flow and other characteristics, the stream reaches are assigned one or more of the following designated uses: cold water aquatic life, marginal warm water aquatic life, limited aquatic life, livestock watering, wildlife habitat, primary (human) contact, and secondary (human) contact.

Terms related to surface water

Surface water – water on the surface of a continent, such as in a river, lake, or wetland

Watershed – the area of land that contributes water flow to a particular stream or river

Stream reach – a section of a stream or river along which similar hydrologic conditions exist, such as discharge, depth, area, geology, and slope

Storm water – water that comes as runoff from rain and snowmelt events

Floodplain – an area of land adjacent to a stream that may receive water when the stream floods

Effluent – water resulting from industrial processes that is discharged to the environment

Base flow – the portion of a perennial stream's flow that is sustained between precipitation events

Stream reaches within the Laboratory boundary are divided into assessment units. An assessment unit is considered impaired when one or more of the New Mexico surface water quality standards are not being met for one or more pollutants. The standards that are applied to each assessment unit depend on the designated use(s) of that assessment unit.

The locations of assessment units on and around the Laboratory are shown in Figure 6-1. The current status of each designated use (supported, not supported, or not assessed) for each assessment unit, and the identified cause of impairment, if any, are listed in Table 6-1.

Sediment Screening Levels

We compare levels of chemicals in sediment with the New Mexico Environment Department's risk-based soil screening levels (New Mexico Environment Department 2019b) and levels of radionuclides with the Laboratory's risk-based screening action levels (LANL 2015a). If there are no New Mexico soil screening levels for a particular chemical, the U.S. Environmental Protection Agency's regional screening levels are used (U.S. Environmental Protection Agency 2016). Soil screening levels for inorganic and organic chemicals and screening action levels for radionuclides are levels considered safe for industrial, construction worker, or residential exposure scenarios. If concentrations of substances are below screening action levels or soil screening levels, then adverse human health effects are highly unlikely. In addition, we use sediment background values from Ryti et al. (1998) for reference. (Note: The New Mexico surface water quality standards only address total PCBs, while the soil screening levels address individual PCB congeners, but not total PCBs.)

For evaluation of biota, we compare levels of radionuclides in sediment with the DOE biota concentration guides (DOE 2002, 2004) with site-specific modifications by McNaughton et al. (2013). Biota concentration guides for riparian and terrestrial animals are used for evaluation.

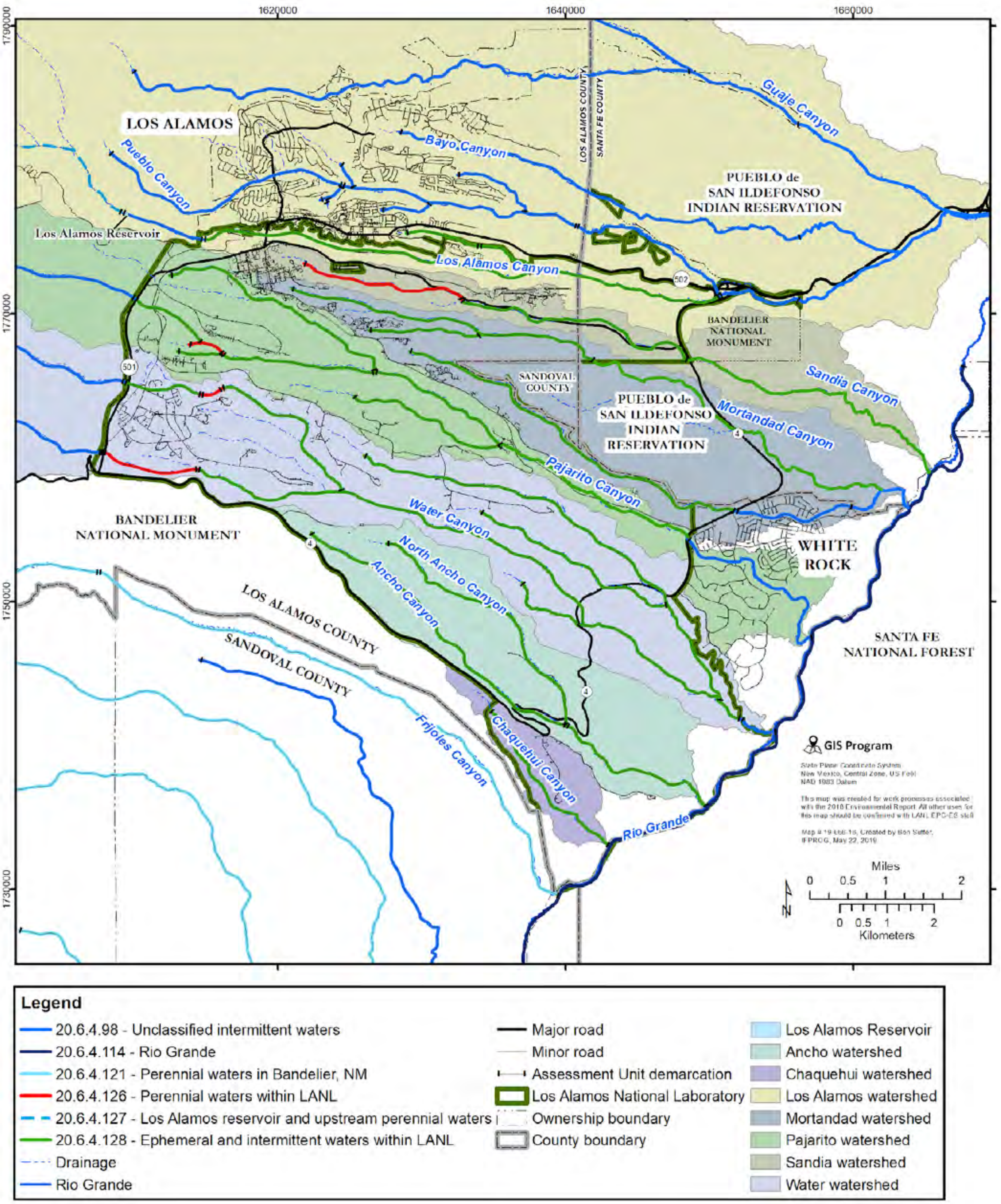

Figure 6-1. Stream reaches and watersheds within and around the Laboratory. Map shows the classifications of streams from *Standards for Interstate and Intrastate Surface Waters*, Title 20, Chapter 6, Part 4 of the New Mexico Administrative Code (20.6.4 NMAC; New Mexico Water Quality Control Commission 2017).

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Table 6-1. LANL Assessment Units, Impairment Cause, and Designated Use(s) that Are Supported, Not Supported, or Not Assessed

Assessment Unit Name	Impairment Cause	Designated Use Supported	Designated Use Not Supported	Designated Use Not Assessed
Acid Canyon (Pueblo Canyon to headwaters)	Gross alpha[1], aluminum, PCBs[2], copper	None	Wildlife habitat, livestock watering, marginal warm water aquatic life	Primary contact
Ancho Canyon (North Fork to headwaters)	PCBs	Wildlife habitat	Limited aquatic life	Secondary contact, livestock watering
Ancho Canyon (Rio Grande to North Fork Ancho)	PCBs, mercury	Livestock watering	Limited aquatic life, wildlife habitat	Secondary contact
Arroyo de la Delfe (Pajarito Canyon to headwaters)	Copper, PCBs, aluminum, gross alpha	None	Limited aquatic life, livestock watering, wildlife habitat	Secondary contact
Cañada del Buey (within LANL)	PCBs, gross alpha	None	Limited aquatic life, livestock watering	Secondary contact, wildlife habitat
Cañon de Valle (below LANL gage E256)	Gross alpha	Wildlife habitat, limited aquatic life	Livestock watering	Secondary contact
Cañon de Valle (LANL gage E256 to Burning Ground Spring)	PCBs	Livestock watering	Cold water aquatic life, wildlife habitat	Secondary contact
Cañon de Valle (upper LANL boundary to headwaters)	Gross alpha, PCBs	Wildlife habitat	Marginal warm water aquatic life, livestock watering	Primary contact
Cañon de Valle (within LANL above Burning Ground Spring)	Not assessed	Not applicable	Not applicable	Livestock watering, limited aquatic life, wildlife habitat, secondary contact
Chaquehui Canyon (within LANL)	PCBs	Wildlife habitat, livestock watering	Limited aquatic life	Secondary contact
DP Canyon (Grade Control to upper LANL boundary)	Copper, PCBs, aluminum, gross alpha	None	Livestock watering, limited aquatic life, wildlife habitat	Secondary contact
DP Canyon (Los Alamos Canyon to grade control)	PCBs, aluminum, gross alpha	None	Livestock watering, limited aquatic life, wildlife habitat	Secondary contact
Fence Canyon (above Potrillo Canyon)	Not assessed	Not applicable	Not applicable	Livestock watering, limited aquatic life, wildlife habitat, secondary contact
Graduation Canyon (Pueblo Canyon to headwaters)	Copper, PCBs	Livestock watering	Wildlife habitat, marginal warm water aquatic life	Primary contact

Assessment Unit Name	Impairment Cause	Designated Use Supported	Designated Use Not Supported	Designated Use Not Assessed
Indio Canyon (above Water Canyon)	Not assessed	Not applicable	Not applicable	Livestock watering, limited aquatic life, wildlife habitat, secondary contact
Kwage Canyon (Pueblo Canyon to headwaters)	Not assessed	Not applicable	Not applicable	Primary contact, wildlife habitat, livestock watering, marginal warm water aquatic life
Los Alamos Canyon (DP Canyon to upper LANL boundary)	PCBs, cyanide, selenium, gross alpha, mercury	None	Livestock watering, limited aquatic life, wildlife habitat	Secondary contact
Los Alamos Canyon (NM-4 to DP Canyon)	Aluminum, PCBs, cyanide, radium, gross alpha, mercury	None	Livestock watering, limited aquatic life, wildlife habitat	Secondary contact
Mortandad Canyon (within LANL)	Copper, PCBs, gross alpha, mercury	None	Livestock watering, limited aquatic life, wildlife habitat	Secondary contact
North Fork Ancho Canyon (Ancho Canyon to headwaters)	Gross alpha, PCBs	None	Livestock watering, limited aquatic life, wildlife habitat	Secondary contact
Pajarito Canyon (Arroyo de La Delfe to Starmers Spring)	None	Livestock watering, cold water aquatic life wildlife habitat	None	Secondary contact
Pajarito Canyon (lower LANL boundary to Twomile Canyon)	Aluminum, PCBs, copper, gross alpha, cyanide	Wildlife habitat, limited aquatic life livestock watering	None	Secondary contact
Pajarito Canyon (Twomile Canyon to Arroyo de La Delfe)	PCBs, silver, copper, gross alpha	Wildlife habitat	Livestock watering, limited aquatic life	Secondary contact
Pajarito Canyon (upper LANL boundary to headwaters)	Gross alpha, cyanide, PCBs, aluminum, mercury	None	Warm water aquatic life, livestock watering, wildlife habitat	Primary contact
Pajarito Canyon (within LANL above Starmers Gulch)	Aluminum, gross alpha	Wildlife habitat	Livestock watering, limited aquatic life	Secondary contact
Potrillo Canyon (above Water Canyon)	Gross alpha	Limited aquatic life, wildlife habitat	Livestock watering	Secondary contact
Pueblo Canyon (Acid Canyon to headwaters)	Gross alpha, PCBs, copper, aluminum	None	Marginal warm water aquatic life, livestock watering, wildlife habitat	Primary contact

Assessment Unit Name	Impairment Cause	Designated Use Supported	Designated Use Not Supported	Designated Use Not Assessed
Pueblo Canyon (Los Alamos Canyon to Los Alamos Wastewater Treatment Plant)	Gross alpha, aluminum, PCBs, selenium	None	Marginal warm water aquatic life, livestock watering, wildlife habitat	Primary contact
Pueblo Canyon (Los Alamos Wastewater Treatment Plant to Acid Canyon)	Gross alpha, PCBs	None	Marginal warm water aquatic life, livestock watering, wildlife habitat	Primary contact
Sandia Canyon (Sigma Canyon to National Pollutant Discharge Elimination System Outfall 001)	PCBs, aluminum, copper, temperature	Livestock watering	Wildlife habitat, cold water aquatic life	Secondary contact
Sandia Canyon (within LANL below Sigma Canyon)	PCBs, aluminum, gross alpha, mercury	None	Livestock watering, limited aquatic life, wildlife habitat	Secondary contact
South Fork Acid Canyon (Acid Canyon to headwaters)	Gross alpha, copper, PCBs	None	Marginal warm water aquatic life, livestock watering, wildlife habitat	Primary contact
Ten Site Canyon (Mortandad Canyon to headwaters)	PCBs, gross alpha	None	Livestock watering, limited aquatic life, wildlife habitat	Secondary contact
Threemile Canyon (Pajarito Canyon to headwaters)	Gross alpha	Limited aquatic life, wildlife habitat	Livestock watering	Secondary contact
Twomile Canyon (Pajarito to headwaters)	PCBs, aluminum, copper, gross alpha	None	Livestock watering, limited aquatic life, wildlife habitat	Secondary contact
Walnut Canyon (Pueblo Canyon to headwaters)	PCBs, copper	Livestock watering, wildlife habitat	Marginal warm water aquatic life	Primary contact
Water Canyon (Area-A Canyon to New Mexico 501)	None	Cold water aquatic life, livestock watering, wildlife habitat	None	Secondary contact
Water Canyon (within LANL above New Mexico 501)	Not assessed	Not applicable	Not applicable	Livestock watering, limited aquatic life, wildlife habitat, secondary contact
Water Canyon (within LANL below Area-A Canyon)	PCBs, aluminum, gross alpha, mercury	None	Livestock watering, limited aquatic life, wildlife habitat	Secondary contact

[1] *Gross alpha levels in surface water samples are currently not adjusted to remove sources of radioactivity from source, special nuclear, or byproduct material regulated by DOE under the Atomic Energy Act of 1954.*

[2] *PCBs are total PCBs in the water column.*

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HYDROLOGIC SETTING

Laboratory lands contain all or parts of seven watersheds that drain into the Rio Grande basin (Figure 6-1). Listed from north to south, the major canyons for these watersheds are Los Alamos, Sandia, Mortandad, Pajarito, Water, Ancho, and Chaquehui Canyons. Each of these watersheds includes tributary canyons of various sizes. Los Alamos, Pajarito, and Water Canyons have their headwaters west of the Laboratory in the eastern Jemez Mountains, mostly within the Santa Fe National Forest. The remainder of the watersheds have their headwaters on the Pajarito Plateau. Only the Ancho Canyon watershed is located entirely on Laboratory land.

In 2019, snowmelt runoff crossed the downstream (eastern) boundary of the Laboratory at gaging stations in Los Alamos, Pajarito, Pueblo, and Water Canyons and Cañada del Buey. Total snowmelt runoff for 2019 measured at these stations is estimated at 460 acre-feet, with most of the runoff occurring in Los Alamos and Pueblo Canyons. Total storm water runoff for June to October 2019 measured at the downstream Laboratory boundary is estimated at 44 acre-feet. Most of this runoff occurred in Los Alamos and Water Canyons; minimal runoff (less than 1.5 acre-feet) occurred in Pueblo, Sandia, Mortandad, Pajarito, Ancho, and Chaquehui Canyons, and Cañada del Buey; and no runoff occurred in Potrillo Canyon or Fence Canyon. No effluent from the Los Alamos County Treatment Facility reached the gaging station in lower Pueblo Canyon during storm events in 2019. Figure 6-2 shows the precipitation and storm water runoff volume for the Laboratory for the monsoonal period of June through October during the years 1995 to 2019.

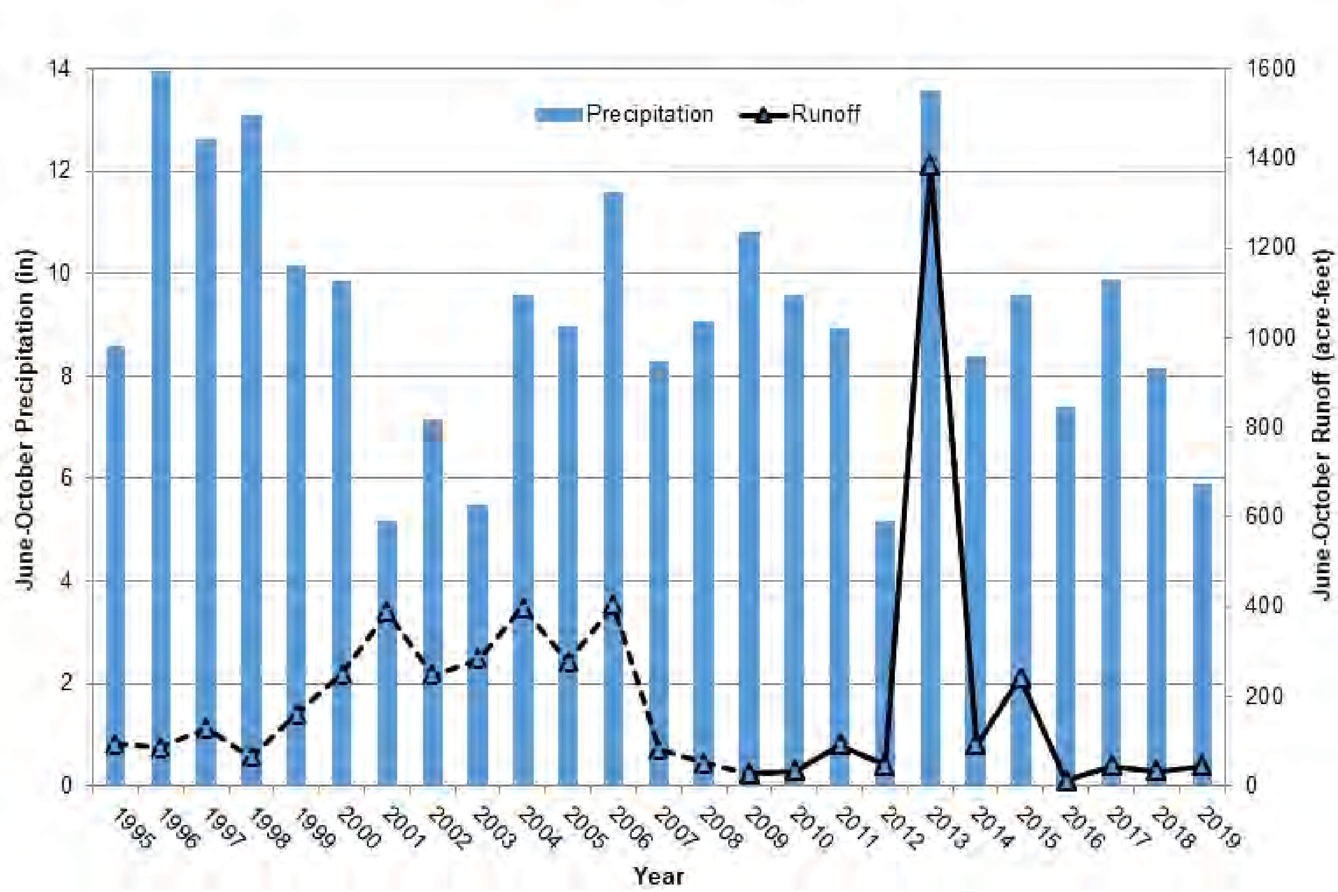

Figure 6-2. Total June–October precipitation from 1995 to 2019 averaged across the Laboratory's meteorological tower network (Technical Area 06, Technical Area 49, Technical Area 53, Technical Area 54, and North Community), and estimated June–October storm water runoff volume in Laboratory canyons from 1995 to 2019. Dashed line indicates data with potential quality issues.

SURFACE WATER AND SEDIMENT SAMPLING

Surface Water Sampling Locations and Methods

We sample surface water in all major canyons and tributaries on current or former Laboratory lands. This includes an emphasis on monitoring close to and downstream of potential sources of Laboratory-released substances, including monitoring at the downstream Laboratory boundaries and east of New Mexico State Road 4.

We currently maintain 37 stream gaging stations on and near the Laboratory, all of which are equipped with automated samplers that activate at the start of storm water runoff events. Storm water samples are also collected at eight additional stream channel locations that do not have active gaging stations. The number of gaging stations and stream channel sampling locations remains fairly constant over time. However, not all gaging stations or channel sampling locations experience storm water flow in any given year, so the number of locations with samples varies from year to year. The sampling locations are chosen to monitor surface water flow onto and off of Laboratory and former Laboratory lands and at the confluence of canyons.

The automated samplers at gaging stations are programmed to start collecting water ten minutes after the peak flow during a runoff event, referred to as “Peak + 10.” The year 2019 was the ninth year that the Peak + 10 sampling method was employed at the gaging stations. This method was implemented based on comments by the New Mexico Environment Department that results from water samples collected before the peak of the storm flow were highly variable and therefore not ideal for monitoring contaminant and sediment transport. Programming the automated samplers to sample 10 minutes after the peak ensures that samples are not collected on the rising limb of the hydrograph. Previously, from 2004–2010, samples were collected right at the peak of the runoff event. As a result, current storm water sampling results are not directly comparable with data collected prior to the 2011 monitoring season.

To meet monitoring requirements under the Individual Permit, we have also installed samplers in 250 site monitoring areas to sample storm water runoff directly from 405 solid waste management units and areas of concern. These samplers are not kept on during months with freezing temperatures. Because rain storms on the Pajarito Plateau are frequently very localized and not all rainfall events produce storm water runoff, not all active Individual Permit sampling locations collect samples each year.

Water discharged from springs is a type of base flow (the portion of stream flow that is not runoff). We collected grab samples of surface water below springs that discharge groundwater at locations identified in the “Interim Facility-Wide Groundwater Monitoring Plan for the 2019 Monitoring Year, October 2018–September 2019” and the “Interim Facility-Wide Groundwater Monitoring Plan for the 2020 Monitoring Year, October 2019–September 2020” (N3B 2018, N3B 2019b).

Figure 6-3 shows locations where samples were collected in 2019 for storm water at stream gaging stations and at sediment-detention basins and for base flow below springs, and Figure 6-4 shows Individual Permit site monitoring areas where compliance samples were collected in 2019.

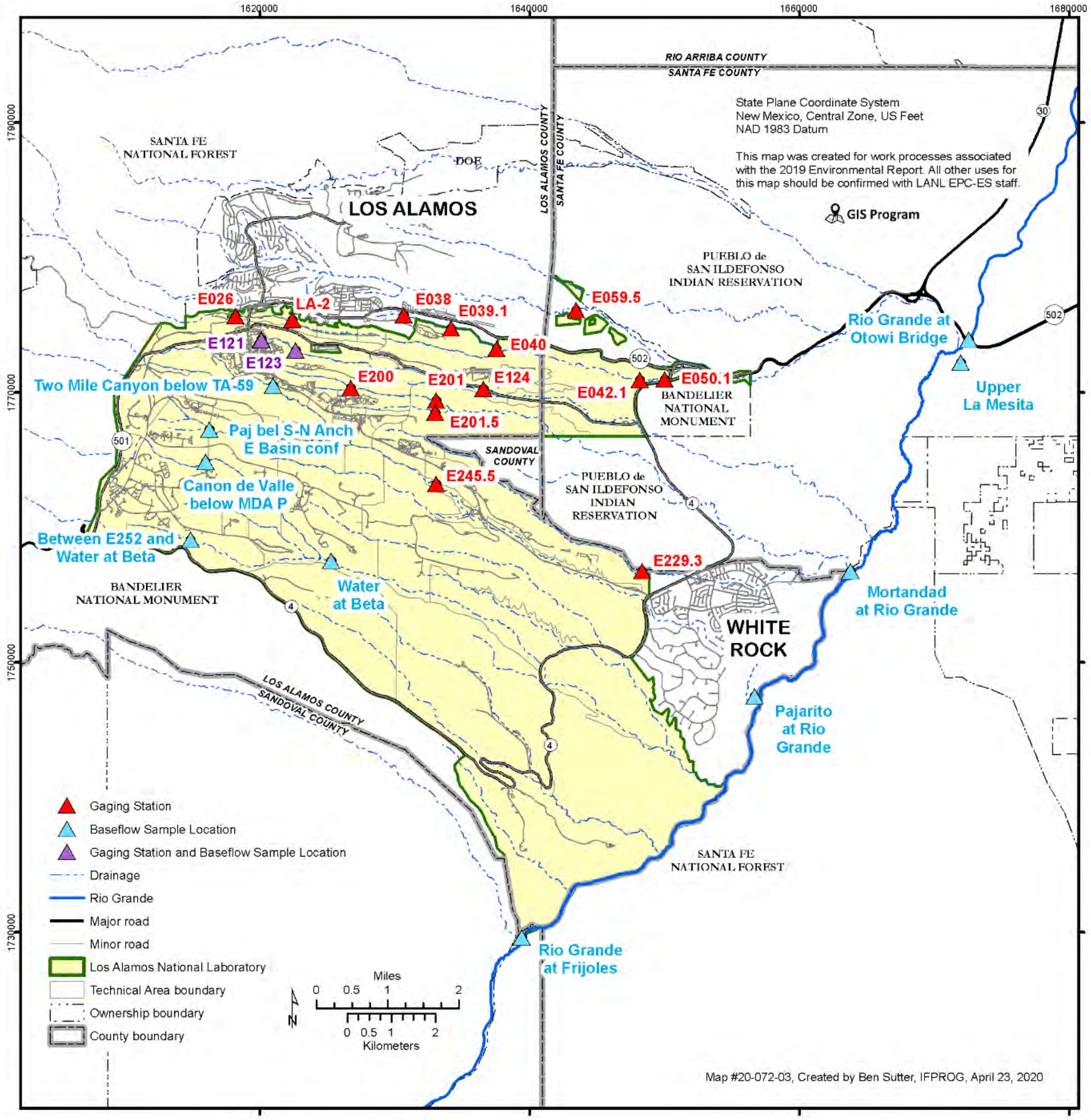

Figure 6-3. Locations sampled for storm water in 2019 at stream gaging stations and at sediment-detention basins in upper Los Alamos Canyon and for base flow below springs

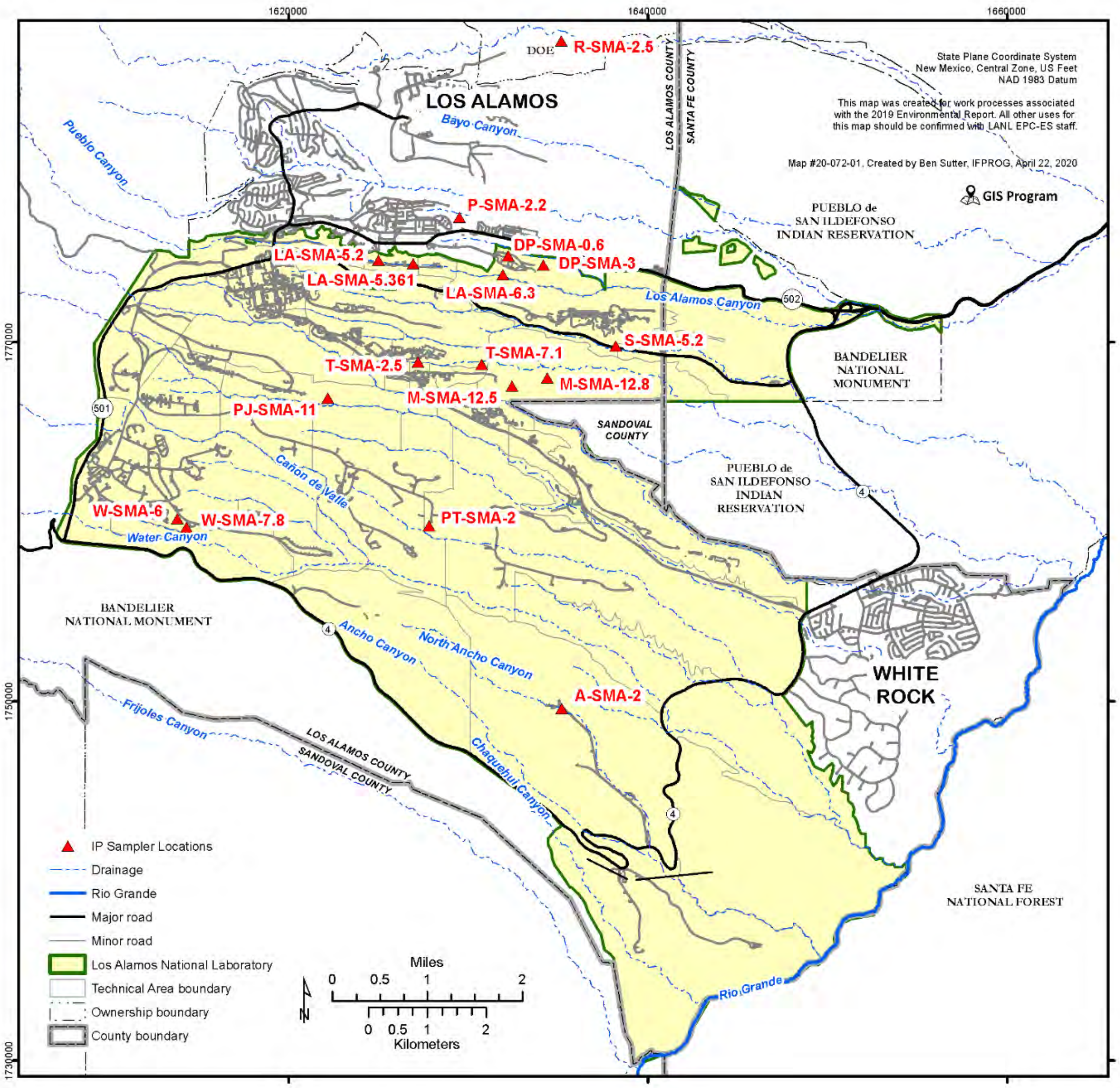

Figure 6-4. Individual Permit (IP) site monitoring areas where automated samplers collected compliance storm water samples in 2019

Sediment Sampling Locations and Methods

Figure 6-5 shows locations sampled for sediment in 2019 as part of the annual environmental surveillance program. Sediment samples were collected at a depth of between 0 and 6 inches, depending on the thickness of the uppermost sediment layer. We collected samples from stream channels and floodplains where new sediment was deposited during 2019. For streams with flowing water, sediment samples were collected near the edge of the main channel adjacent to, but not in, the water. During 2019, storm water runoff flowed in every canyon on Laboratory property except for Fence Canyon and Potrillo Canyon, both in the Water Canyon watershed; therefore, sediment samples were collected from most watersheds.

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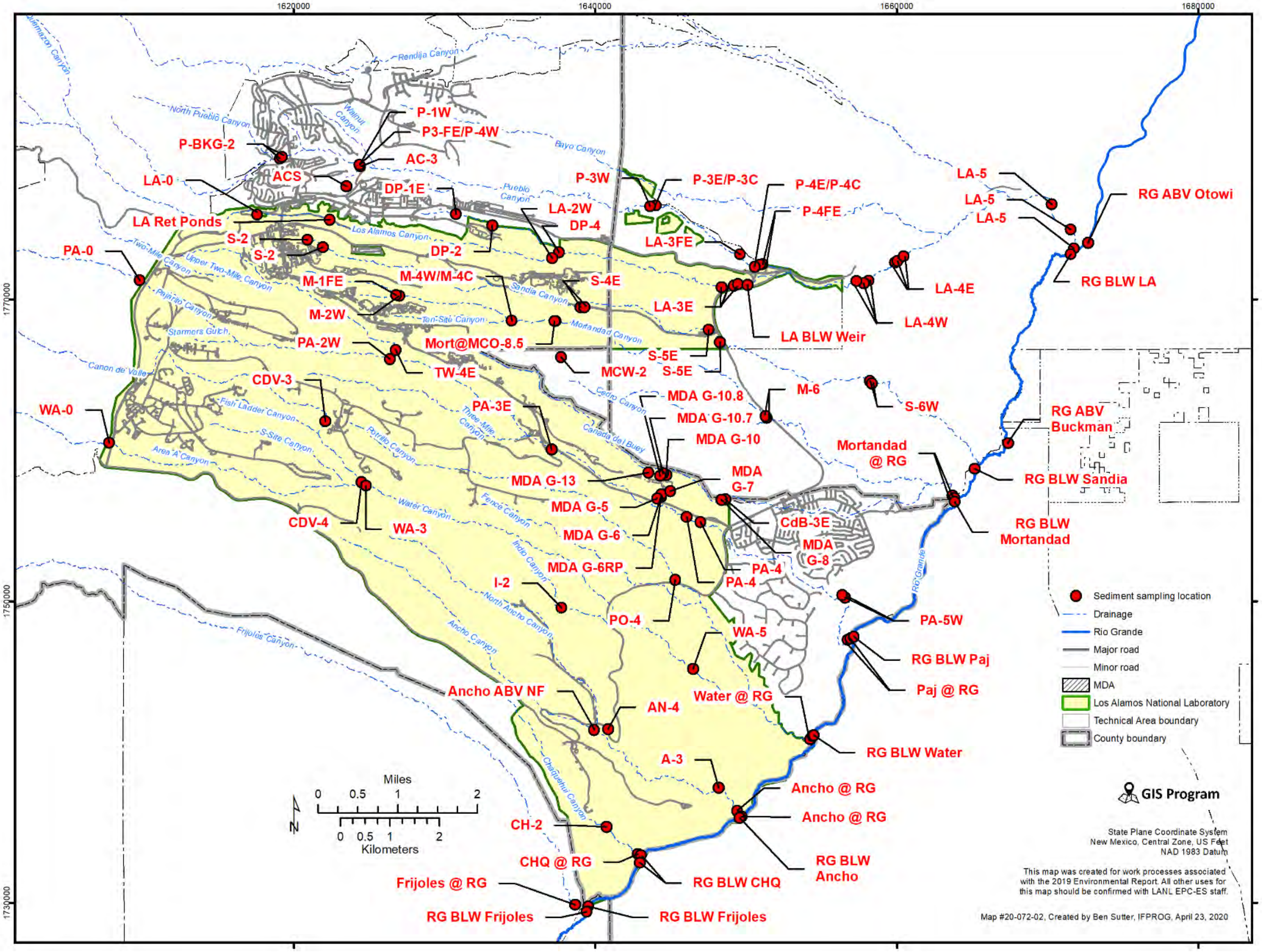

State Plane Coordinate System
New Mexico, Central Zone, US Feet
NAD 1983 Datum

This map was created for work processes associated with the 2019 Environmental Report. All other uses for this map should be confirmed with LANL EPC-ES staff.

Map #20-072-02, Created by Ben Sutter, IFPROG, April 23, 2020

Note: MDA = Material disposal area; RG = Rio Grande; BLW = below; @ = at; LA = Los Alamos Canyon; P = Pueblo Canyon; AC = Acid Canyon; ACS = Acid Canyon South, S = Sandia Canyon; WA = Water Canyon; CDV = Cañon de Valle; ABV = above; CH or CHQ = Chaquehui Canyon; CdB = Cañada del Buey; PA = Pajarito Canyon; M or Mort = Mortandad Canyon; MCW = Mortandad Canyon West; PO = Potrillo Canyon; BKG = background; TW = Twomile Canyon; I = Indio Canyon

Figure 6-5. Locations sampled in 2019 for sediment as part of the annual environmental surveillance program

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Sampling Results

Table 6-2 summarizes inorganic chemical results for 2019 storm water and base flow samples and Table 6-3 summarizes organic chemical and radionuclide results for 2019 storm water and base flow samples. Table 6-4 summarizes chemical results for 2019 sediment samples at locations that exceeded screening levels for at least one chemical. The surface water monitoring data for 2019 and previous years are available through the Intellus New Mexico website (https://intellusnm.com).

Results from compliance sampling for the Individual Permit are not presented in the tables below, but are discussed in the text and included in the following figures. Tables of the Individual Permit sampling results for 2019 are available in the Storm Water Individual Permit Annual Report (N3B 2020c). Tests are not performed for every substance in every Individual Permit sample; the analyses that are requested vary depending on the chemicals or radionuclides present in the solid waste management units and areas of concern within a site monitoring area.

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Table 6-2. 2019 Storm Water and Base Flow Results for Inorganic Chemicals

Location Description	Stream Gage Number	Total Aluminum[1]			Dissolved Copper			Dissolved Lead			Total Selenium			Dissolved Zinc		
		Analyses[2]	Detects[3]	Exceedances[4]	Analyses	Detects	Exceedances	Analyses	Detects	Exceedances	Analyses	Detects	Exceedances	Analyses	Detects	Exceedances
Between E252 and Water at Beta	n/a	2	2	0	2	0	0	2	0	0	2	0	0	2	0	0
Canon de Valle below MDA P	E256	1	1	1	1	0	0	1	0	0	1	0	0	1	1	0
CO111041	n/a	2	2	2	2	2	2	2	1	0	2	0	0	2	1	0
DP above TA-21	E038	1	1	1	1	1	0	1	1	0	1	1	0	1	1	0
DP below grade control structure	E039.1	2	2	2	2	2	1	2	2	0	2	1	0	2	1	0
E059.5 Pueblo below LAC WWTF	E059.5	1	1	1	1	1	1	1	1	1	1	1	0	1	1	0
Los Alamos above low-head weir	E042.1	2	2	2	2	2	0	2	0	0	2	2	1	2	1	0
Los Alamos below Ice Rink	E026	1	1	1	1	1	0	1	1	0	1	1	1	1	0	0
Los Alamos below low-head weir	E050.1	3	3	3	3	3	0	3	1	0	3	3	2	3	1	0
Mortandad above Ten Site	E201	1	1	1	1	1	1	1	1	0	1	1	0	1	0	0
Mortandad at Rio Grande	n/a	1	1	0	1	1	0	1	0	0	1	0	0	1	1	0
Mortandad below Effluent Canyon	E200	2	2	2	2	2	1	2	1	0	2	2	0	2	2	0
Pajarito below S-N transect of East Anchor Basin	n/a	2	2	2	2	0	0	2	1	0	2	0	0	2	1	0
Pajarito above Threemile	E245.5	1	1	1	1	1	0	1	0	0	1	1	0	1	0	0
Pajarito at Rio Grande	n/a	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0
Rio Grande at Frijoles	n/a	1	1	0	1	0	0	1	0	0	1	0	0	1	0	0
Rio Grande at Otowi Bridge	n/a	1	1	1	1	0	0	1	0	0	1	0	0	1	0	0
Sandia above Firing Range	E124	1	1	1	1	1	0	1	0	0	1	1	1	1	0	0
Sandia below Wetlands	E123	4	4	4	4	4	4	4	3	3	4	0	0	4	4	1
Sandia below Wetlands	E123	4	1	0	4	0	0	4	0	0	4	0	0	4	3	0
Sandia left fork at Asphalt Plant	E122	4	4	3	4	4	4	4	2	2	4	0	0	3	3	3
South Fork of Sandia at E122	E122	3	1	0	3	0	0	3	0	0	3	0	0	3	2	0
Sandia right fork at Power Plant	E121	5	5	5	5	5	5	5	3	3	5	1	0	5	5	5
Sandia right fork at Power Plant	E121	4	2	0	4	3	0	4	0	0	4	0	0	4	4	0
Ten Site above Mortandad	E201.5	1	1	1	1	1	1	1	1	0	1	1	1	1	1	0

Location Description	Stream Gage Number	Total Aluminum[1]			Dissolved Copper			Dissolved Lead			Total Selenium			Dissolved Zinc		
		Analyses[2]	Detects[3]	Exceedances[4]	Analyses	Detects	Exceedances	Analyses	Detects	Exceedances	Analyses	Detects	Exceedances	Analyses	Detects	Exceedances
Twomile Canyon below TA-59	n/a	1	1	1	1	0	0	1	1	0	1	0	0	1	1	0
Water at Beta	n/a	1	1	1	1	0	0	1	1	0	1	0	0	1	1	0

[1] *Unfiltered aluminum is screened for base flow samples and aluminum filtered to 10 µm is screened for storm water samples.*

[2] *Analyses are the number of samples analyzed for that constituent.*

[3] *Detects are the number of samples in which that constituent was detected.*

[4] *Exceedances are the number of results that were detected above the screening level.*

Gray highlighting indicates base flow sampling locations, whereas no gray highlighting indicates storm water sampling locations.

Table 6-3. 2019 Storm Water and Base Flow Results for Organic Chemicals and Radionuclides

Location Description	Stream Gage Number	Total PCB			Gross Alpha		
		Analyses[1]	Detects[2]	Exceedances[3]	Analyses	Detects	Exceedances
CDB above SR-4	E229.3	0	0	0	1	1	1
CO111041	n/a	2	2	2	2	2	2
DP above Los Alamos Canyon	E040	1	1	1	0	0	0
DP above TA-21	E038	1	1	1	1	1	1
DP below grade control structure	E039.1	2	2	2	2	2	2
E059.5 Pueblo below LAC WWTF	E059.5	1	1	1	1	1	1
Los Alamos above low-head weir	E042.1	2	2	2	2	2	2
Los Alamos below Ice Rink	E026	1	1	1	1	1	1
Los Alamos below low-head weir	E050.1	3	3	3	3	3	3
Mortandad above Ten Site	E201	1	1	1	1	1	1
Mortandad at Rio Grande	n/a	0	0	0	1	0	0
Mortandad below Effluent Canyon	E200	3	3	3	5	5	4
Pajarito above Threemile	E245.5	1	1	1	1	1	1
Rio Grande at Otowi Bridge	n/a	0	0	0	1	1	0
Sandia above Firing Range	E124	1	1	1	1	1	1
Sandia below Wetlands	E123	4	4	4	4	3	0
Sandia below Wetlands||	E123	2	1	1	1	0	0
Sandia left fork at Asphalt Plant	E122	4	4	4	4	4	0
South Fork of Sandia at E122	E122	2	2	1	0	0	0
Sandia right fork at Power Plant	E121	5	5	5	5	5	0
Sandia right fork at Power Plant	E121	2	2	1	1	0	0
Ten Site above Mortandad	E201.5	1	1	1	1	1	1
Twomile Canyon below TA-59	n/a	0	0	0	1	0	0

[1] Analyses are the number of samples analyzed for that constituent.

[2] Detects are the number of samples in which that constituent was detected.

[3] Exceedances are the number of results that were detected above the screening level.

Gray highlighting indicates base flow sampling locations, whereas no gray highlighting indicates storm water sampling locations.

Table 6-4. 2019 Sediment Locations Where at Least One Sample Result Exceeded Screening Levels

Location ID	Canyon	Reach Name	Iron			Manganese		
			Analyses[1]	Detects[2]	Exceedances[3]	Analyses	Detects	Exceedances
CH-61326	Chaquehui	Chaquehui at Rio Grande	1	1	0	1	1	1
LA-61586	Los Alamos	LA below Weir	1	1	0	1	1	1
PA-61534	Pajarito	PA-4	1	1	0	1	1	1
PA-61535	Pajarito	PA-4	1	1	0	1	1	1
PU-61537	Pueblo	P-4E/P-4C	1	1	1[4]	1	1	1
SA-61629	Sandia	S-6W	1	1	0	1	1	1
WA-61546	Water	WA-3	1	1	0	1	1	1
WA-61550	Water	Water at Rio Grande	1	1	0	1	1	1
WR-61528	White Rock	Rio Grande below Frijoles	1	1	0	1	1	1
WR-61522	White Rock	Rio Grande below Mortandad	1	1	0	1	1	1
WR-61521	White Rock	Rio Grande below Sandia	1	1	0	1	1	1
WR-61524	White Rock	Rio Grande below Water	1	1	0	1	1	1

[1] *Analyses are the number of samples analyzed for that constituent.*
[2] *Detects are the number of samples in which that constituent was detected.*
[3] *Exceedances are the number of results that were detected above the construction worker non-cancer screening level except where noted.*
[4] *Exceeds residential soil non-cancer screening level.*

Discussion of Sampling Results

The screening levels provide a high level of confidence in determining a low probability of risk to human health. They are not designed or intended to provide definitive estimates of actual risk and are not based on site-specific information (U.S. Environmental Protection Agency 2001). For example, onsite data are compared with residential screening levels, though there are no residences nearby. We evaluate human health effects from exposure to storm water in Chapter 8, Public Dose and Risk Assessment.

Sediment data presented in this report are used to determine if the following conceptual model is still accurate: the process of sediment transport by storm water runoff observed in Laboratory canyons generally results in the same or lower levels of LANL-released substances in new sediment deposits than previously existed in a given reach. The results from 2019 verify this conceptual model and support the idea that the risk assessments presented in the canyons investigation reports (LANL 2004, 2005, 2006, 2009a, 2009b, 2009c, 2009d, 2011a, 2011b, 2011c) represent an upper bound of potential human health risks in the canyons for the foreseeable future.

What is the Human Health–Organism Only Surface Water Quality Standard?

This is one of the surface water quality standards used by the State of New Mexico to identify whether a water body or stream reach has adequate water quality for its designated use(s). The intent of this standard is to protect the health of humans who eat fish or other aquatic wildlife (such as crayfish) that live in a lake, river, or stream.

For sediment samples collected in 2019, there were minimal exceedances of screening levels. Out of 101 sediment samples collected, only 12 samples had any exceedances. Construction worker non-cancer soil screening levels were exceeded for manganese in twelve sediment samples. Exceedances primarily occurred in samples collected near the Rio Grande and two of these values were below the sediment background value for manganese (LANL 1998). One of the samples with a manganese exceedance, from Pueblo Canyon, also had an iron exceedance of the residential non-cancer soil screening level.

Table 6-5 provides a summary of all storm water and base flow sampling locations that had exceedances in 2019. Exceedances for each analyte are categorized by applicable New Mexico water quality standards. The percent of locations exceeding is also included.

Table 6-5. Number of Locations where New Mexico Water Quality Standards were Exceeded for Storm Water or Base Flow Results in 2019 for Constituents with at Least One Exceedance

Analyte	Livestock Watering	Wildlife Habitat	Acute Aquatic Life	Chronic Aquatic Life	Human Health-Organism Only
Total Aluminum	—[‡]	—	19 (79%)	6 (25%)	—
Dissolved Copper	—	—	9 (38%)	4 (17%)	—
Dissolved Lead	—	—	0	4 (17%)	—
Total Selenium	—	5 (21%)	1 (4%)	5 (21%)	—
Dissolved Zinc	—	—	3 (13%)	3 (13%)	—
Gross alpha	13 (68%)	—	—	—	—
Total PCB	—	15 (94%)	1 (6%)	15 (94%)	16 (100%)

[‡] A dash indicates there is no standard for this chemical or radionuclide in this category.
Note: The percentage in parentheses represents the percent of locations that have an exceedance for that analyte.

Constituents Related to Background Sources

Some chemicals and radionuclides may come from both naturally occurring sources and human-derived sources. Chemicals that are mainly or completely naturally occurring are discussed below, but results are not presented in figures. Chemicals from human sources that exceeded screening levels more than once in 2019 at a particular location for water samples are shown in Figures 6-6 through 6-11. Because of the smaller number of samples, the sediment data are not presented in figures, but exceedances are reported in Table 6-4.

In Figures 6-6 through 6-11, the points in the top panel show the locations of the stream gaging stations, sediment detention basins, base flow, and Individual Permit sites where surface water samples have been collected. For each constituent, the color of a point corresponds to the percentile in which the median concentration at that location falls. The median values and the percentiles were calculated from data collected from 2011 through 2019. The percentiles were calculated from a data set of the median values of the constituent at each sampled location in the watershed. The range in concentrations represented by each percentile is provided at the top of the figure. The plots in the bottom panel(s) show all results in the watershed for the constituent of interest for each year, with different colors for Individual Permit samples and gage samples.

Aluminum: Storm water samples collected on the Pajarito Plateau in 2019 commonly contained aluminum concentrations above New Mexico water quality standards. However, most or all of this aluminum is likely naturally occurring (Reneau et al. 2010, Ryan et al. 2019). Aluminum is a natural component of soil and Bandelier Tuff, and it is not known to be derived from Laboratory operations in any significant quantity. In 2019, total aluminum concentrations in storm water exceeded the acute aquatic life standard at 19 sampling locations (79 percent of locations) and the chronic aquatic life standard at 6 sampling locations (25 percent of locations). There were three exceedances of the target action level for total aluminum concentrations in 20 Individual Permit–related runoff samples in 2019. Fourteen of the 39 assessment units, or stream reaches, on Laboratory or former Laboratory lands are listed as impaired for aluminum (Table 6-1). However, the New Mexico Environment Department Surface Water Quality Bureau has stated that "the large number of exceedances" for aluminum in surface water on the Pajarito Plateau "may reflect natural sources associated with the geology of the region," and that aluminum also exceeds 658 micrograms per liter (the acute aquatic life standard for a hardness of 30 mg $CaCO_3$/L) in other parts of the Jemez Mountains area (New Mexico Environment Department 2009).

In 2019, no sediment samples exceeded soil screening levels for aluminum.

Arsenic: Arsenic has both natural and human-derived sources. Coal-fired power plants emit gaseous arsenic. While the Four Corners Generating Station coal-fired power plant has contributed to arsenic contamination, the Laboratory also operated coal-fired power plants historically. Arsenic is also found naturally in the local volcanic rocks. In 2019, none of the filtered gaging station storm water or base flow results exceeded the surface water quality standards for arsenic. One of the 20 Individual Permit-related samples exceeded the target action level for arsenic in 2019. None of the 39 assessment units, or stream reaches, on Laboratory or former Laboratory lands are listed as impaired for arsenic (Table 6-1).

In 2019, no sediment samples exceeded soil screening levels for arsenic.

Copper: Copper is naturally occurring and it is also associated with explosives firing sites, forest fires, and developed areas, such as buildings and parking lots. Copper sources in developed landscapes include brake pad abrasion and building materials, such as flashing, plumbing pipes, and electrical components (TDC Environmental 2004, Göbel et al. 2007). In 2019, copper concentrations in filtered storm water were detected above the acute aquatic life standard at 9 sampling locations (38% of locations) and above the chronic aquatic life standard at 4 sampling locations (17% of locations).

Historically, every watershed across the Laboratory has recorded elevated copper concentrations in storm water at some time, including all of the Laboratory's upstream boundary gaging stations. Twelve of the 39 assessment units, or stream reaches, on Laboratory or former Laboratory lands are listed as impaired for copper (Table 6-1). Since the 2006 implementation of the Individual Permit, every watershed has had a target action level exceedance for copper in Individual Permit–related runoff samples. In 2019, there were 6 exceedances of the target action level for filtered copper concentrations in 20 Individual Permit-related runoff samples. Figures 6-6 and 6-7 show copper concentrations in filtered storm water and base flow for Los Alamos/Pueblo and Sandia/Mortandad Canyons. Concentrations measured in 2019 were similar to those measured in previous years.

In 2019, no sediment samples exceeded soil screening levels for copper.

Note: µg/L = microgram per liter

Figure 6-6. Los Alamos Canyon copper concentrations in filtered storm water from Individual Permit samplers and gaging stations and base flow from 2011–2019. Top panel: median storm water copper values for each sampling location from 2011–2019. Bottom panels: dissolved copper concentrations from Individual Permit and gage station samples from 2011 and 2019.

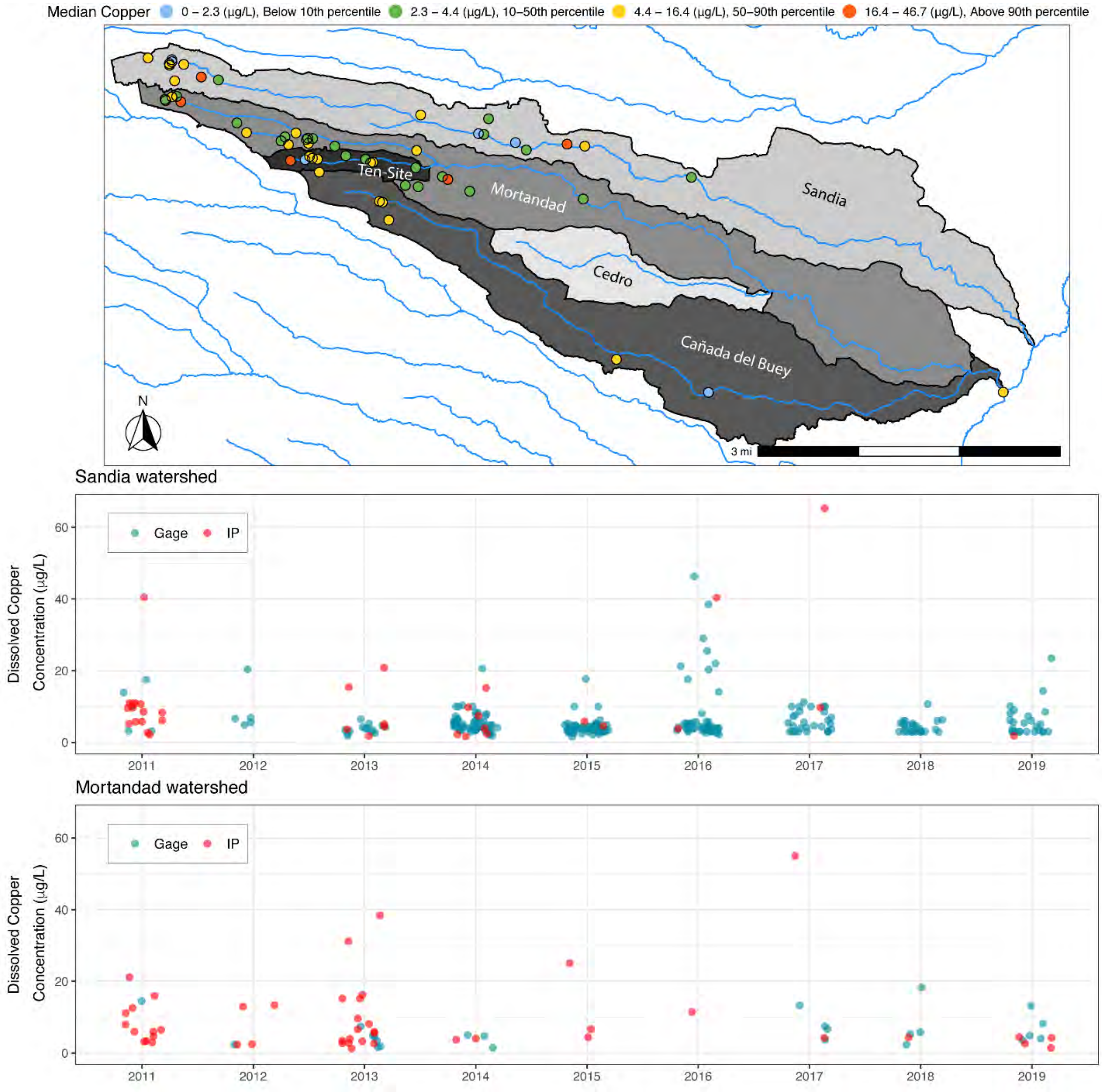


Figure 6-7. Sandia Canyon and Mortandad Canyon watershed copper concentrations in filtered storm water from Individual Permit samplers and gaging stations and base flow from 2011 to 2019. Top panel: median storm water copper values for each sampling location between 2011 and 2019. Bottom panels: dissolved copper concentrations from Individual Permit and gage station samples from 2011 and 2019.

Lead: Lead is associated with developed areas, such as buildings and parking lots (Göbel et al. 2007). The major lead sources in developed landscapes are lead-based paints, building sidings, and the operation of automobiles (Davis and Burns 1999). Lead concentrations in filtered storm water in 2019 were detected above the chronic aquatic life standard at four sampling locations (17% of locations). None of the 39 assessment units, or stream reaches, on Laboratory or former Laboratory lands are listed as impaired for lead (Table 6-1). There were no exceedances of the target action level for filtered lead concentrations in the 20 Individual Permit-related runoff samples in 2019. Figure 6-8 shows lead concentrations in filtered storm water and base flow in Sandia and Mortandad Canyons. Concentrations measured 2019 were similar to those measured in previous years.

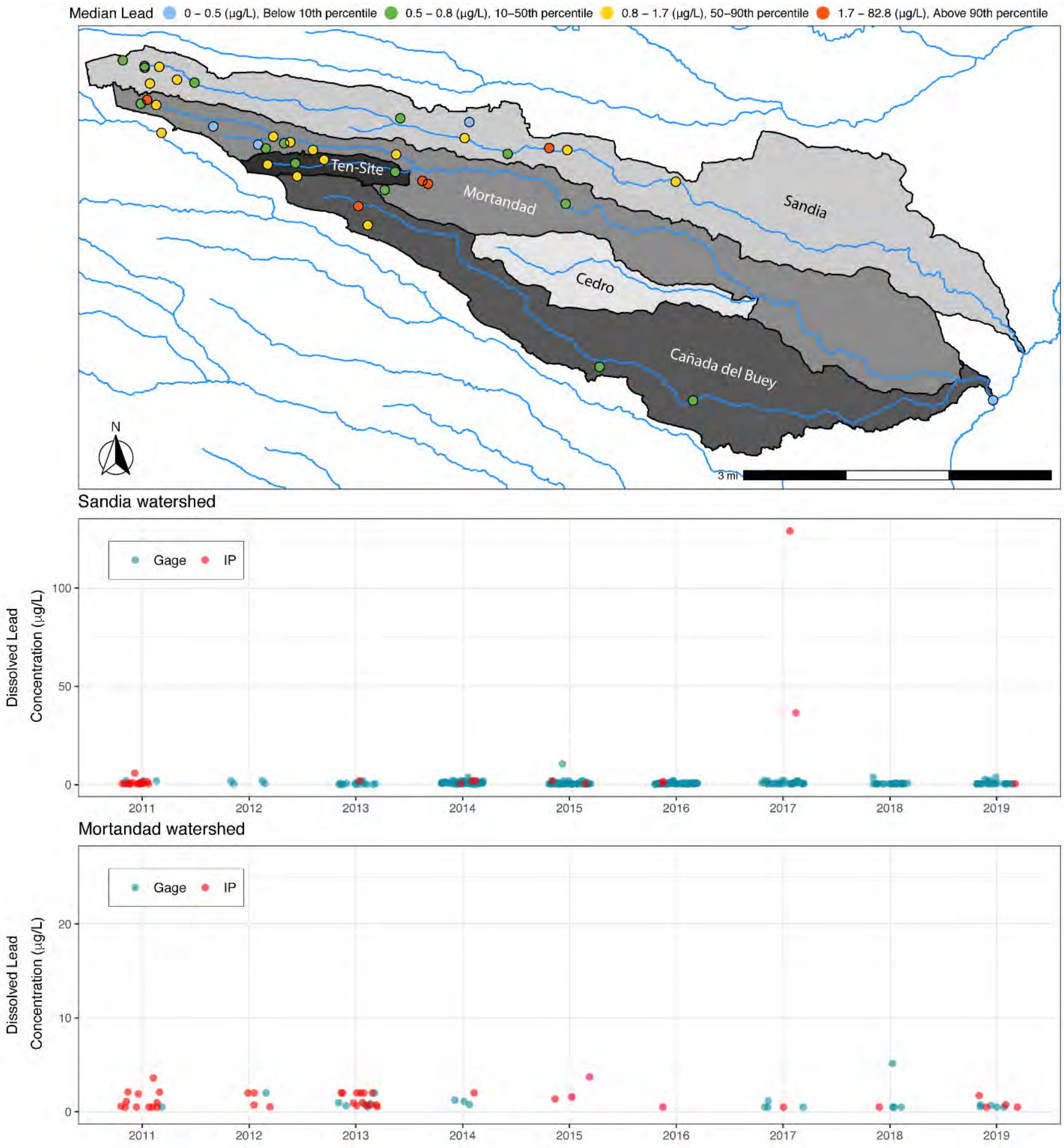
In 2019, no sediment samples exceeded soil screening levels for lead.

Manganese: Manganese is naturally occurring on the Pajarito Plateau. Laboratory operations have not generated or released significant quantities of manganese. Dissolved manganese concentrations were elevated following the Cerro Grande fire and then decreased quickly in subsequent years (Gallaher and Koch 2004, 2005). Filtered manganese concentrations were not detected above the acute or chronic aquatic life standards in storm water samples collected in 2019. None of the 39 assessment units, or stream reaches, on Laboratory or former Laboratory lands are listed as impaired for manganese (Table 6-1).

In 2019, manganese concentrations in sediment exceeded the construction worker non-cancer soil screening level in 12 samples.

Selenium: Selenium is naturally occurring on the Pajarito Plateau. Laboratory operations have not generated or released significant quantities of selenium. Total selenium concentrations were elevated following the Cerro Grande fire and then decreased quickly in subsequent years (Gallaher and Koch 2004, 2005). In 2019, total selenium concentrations in storm water were detected above the wildlife habitat standard at 5 sampling locations (21% of locations), above the acute aquatic life standard at 1 sampling location (4% of locations), and above the chronic aquatic life standard at 5 sampling locations (21% of locations). Total selenium concentrations exceeded the Individual Permit target action level in 6 of the 20 Individual Permit-related storm water samples collected in 2019. Two of the 39 assessment units, or stream reaches, on Laboratory or former Laboratory lands are listed as impaired for selenium (Table 6-1).

In 2019, no sediment samples exceeded soil screening levels for selenium.



Note: Two Individual Permit samples from 2017 in the Sandia watershed are not shown in the bottom panel due to the scale of the plot (concentrations of 129 µg/L and 36.5 µg/L).

Figure 6-8. Sandia Canyon watershed lead concentrations in filtered storm water from Individual Permit samplers, gaging stations, and base flow from 2011– 2019. Top panel: median storm water lead values for each sampling location from 2011–2019. Bottom panels: dissolved lead concentrations of Individual Permit and gage station samples from 2011–2019.

Zinc: While naturally occurring, zinc can also be associated with developed areas. Zinc sources include automobile tires, galvanized materials, motor oil, and hydraulic fluid (Rose et al. 2001, Washington State Department of Ecology 2006, Councell et al. 2004). In 2019, filtered zinc concentrations in storm water samples were detected above the acute aquatic life standard at three sampling locations (13% of locations) and above the chronic aquatic life standard at three sampling locations (13%). None of the 39 assessment units, or stream reaches, on Laboratory or former Laboratory lands are listed as impaired for zinc (Table 6-1). Filtered zinc concentrations exceeded the Individual Permit target action level in two of the 20 Individual Permit-related storm water samples collected in 2019. Figure 6-9 shows zinc concentrations in filtered storm water and base flow for Sandia and Mortandad Canyons. The scatter plots in the lower two panels of Figure 6-10 show that zinc concentrations were generally higher in Sandia Canyon in 2019 compared with the previous 2 years, although still within range of what has been observed in the past.

In 2019, no sediment samples exceeded soil screening levels for zinc.

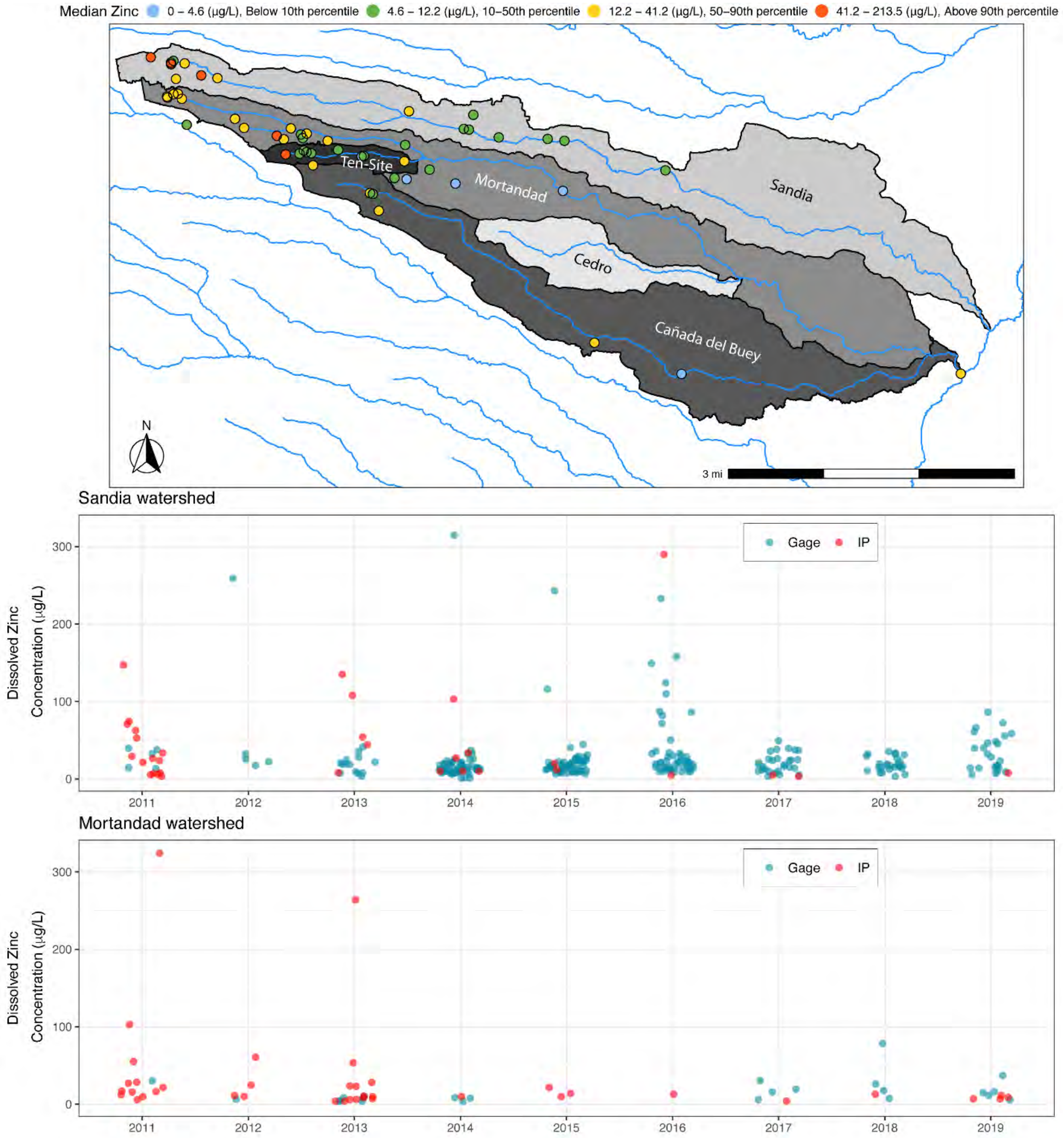


Figure 6-9. Sandia Canyon watershed zinc concentrations in filtered storm water from Individual Permit samplers and gaging stations and base flow from 2011 to 2019. Top panel: median storm water zinc values for each sampling location between 2011 and 2019. Bottom panels: dissolved zinc concentrations from Individual Permit and gage station samples from 2011 to 2019.

Gross Alpha: The gross alpha activity is the sum of the radioactivity from alpha particle emissions from radioactive materials. Alpha particles are released by many naturally occurring radionuclides, such as isotopes of radium, thorium, and uranium, and their decay products. In 2019, 13 sampling locations (68% of locations) had gross alpha activities above the livestock watering standard. In 2011, 2012, and 2013, the highest gross alpha activities in storm water were measured in samples containing ash and sediment from the 2011 Las Conchas fire. Also, gross alpha activities were particularly high in runoff samples from the large September 2013 flood event. For sampling under the Individual Permit in 2019, gross alpha activity was above the target action level in 19 of 20 samples. Twenty-five of the 39 assessment units, or stream reaches, on Laboratory or former Laboratory lands are listed as impaired for gross alpha radioactivity (Table 6-1). However, the analytical results from 2019 support earlier conclusions that the majority of the alpha radioactivity in storm water on the Pajarito Plateau is from the decay of naturally occurring isotopes in sediment and soil and that Laboratory impacts are relatively small (for example, see Gallaher 2007).

Sediment is not analyzed for gross alpha levels because sediment sampling is targeted to specific radionuclides of concern at a particular location.

Constituents Related to Los Alamos National Laboratory Operations

Several constituents were measured in storm water and sediment that were known to be released during historical Laboratory operations. The nature and extent of the constituents in sediment are described in detail in the canyons investigation reports referenced in the Discussion of Sampling Results section.

The following discussion describes the occurrences of key constituents in 2019 storm water and sediment samples. Results for constituents that exceeded screening levels or standards more than once in 2019 at a particular sample location for storm water and base flow are shown in the figures associated with each chemical below.

Cadmium: Cadmium is associated with combustion of fossil fuel; industrial use such as refinement for nickel-cadmium batteries, metal plating, pigments, and plastics; and activities such as sewage sludge disposal and application of phosphate fertilizers (Agency for Toxic Substances and Disease Registry 2012). In 2019, there were no exceedances observed for filtered storm water samples or base flow samples. There were no exceedances of the target action level for filtered cadmium concentrations in the 20 Individual Permit-related runoff samples in 2019. None of the 39 assessment units, or stream reaches, on Laboratory or former Laboratory lands are listed as impaired for cadmium (Table 6-1).

In 2019, no sediment results exceeded soil screening levels for cadmium.

Cesium-137: Cesium-137 is a radionuclide that is a byproduct of nuclear fission processes in nuclear reactors and nuclear weapons testing. In 2019, cesium-137 was not detected in any gaging station storm water samples or base flow samples. Individual Permit–related storm water samples are not analyzed for radionuclides.

In 2019, cesium-137 activity in sediment samples did not exceed the relevant screening action level.

Chromium: Chromium is associated with potassium dichromate that was used as a corrosion inhibitor in the cooling system at the Technical Area 03 power plant (LANL 1973) and was discharged through Outfall 001 from 1956 to 1972. Filtered storm water and base flow results did not exceed surface water quality standards in 2019 for chromium or chromium (III). There were no exceedances of the target action level for filtered chromium concentrations in the 20 Individual Permit-related runoff samples in 2019. None of the 39 assessment units, or stream reaches, on Laboratory or former Laboratory lands are listed as impaired for chromium (Table 6-1).

In 2019, no sediment samples exceeded soil screening levels for chromium.

Dioxins and Furans: Dioxins and furans are associated with the incineration of medical, industrial, municipal, and private wastes; municipal waste water treatment sludge; coal-fired boilers; and diesel fuel emissions (U.S. Environmental Protection Agency 2006b). Forest fires are also a major, natural source of dioxins (Gullett and Touati 2003). Toxic equivalents are used to report the toxicity-weighted masses of mixtures of dioxins and furans. This is more meaningful than reporting the number of grams of dioxins or furans because toxic equivalents provide information on toxicity (U.S. Environmental Protection Agency 2010). In addition, there are surface water quality standards for a total dioxin toxic equivalent, whereas there are no standards for individual dioxins or furans. In 2019, no storm water gaging station results exceeded the human health–organism only standard. There were no Individual Permit–related samples tested for 2,3,7,8-tetrachlorodibenzodioxin (one of the more toxic compounds) in 2019. In base flow samples analyzed for dioxins and furans (along the Rio Grande at the Otowi Bridge and at Frijoles Canyon, and Mortandad and Pajarito Canyons where they meet the Rio Grande), results were below surface water quality standards. None of the 39 assessment units, or stream reaches, on Laboratory or former Laboratory lands are listed as impaired for dioxins or furans (Table 6-1).

In 2019, no sediment samples exceeded soil screening levels for dioxins or furans.

Mercury: Natural sources of mercury include forest fires and fossil fuels such as coal and petroleum. Human activities such as mining and fossil fuel combustion have led to widespread global mercury pollution. While the Four Corners Generating Station coal-fired power plant has contributed to mercury contamination in the surrounding areas, the Laboratory also operated coal-fired power plants historically. In 2019, none of the filtered or unfiltered storm water or base flow samples had exceedances for mercury. Two of the 20 Individual Permit–related samples exceeded the target action level for mercury in 2019. Seven of the 39 assessment units, or stream reaches, on Laboratory or former Laboratory lands are listed as impaired for mercury (Table 6-1).

In 2019, no sediment samples exceeded soil screening levels for mercury.

Polychlorinated biphenyls (PCBs): PCBs are stable, persistent organic compounds that break down slowly in the environment. They were commonly used as plastic and paint stabilizers and coolants in electrical appliances before they were banned in the United States in 1979. Many older construction materials, including caulking, paints, window putty, and electrical components, used PCBs (Durell and Lizotte 1998, Kakareka and Kukharchyk 2006). As these building components weather, PCBs accumulate on the landscape and are redistributed. PCBs are remobilized and distributed throughout the globe, including through atmospheric deposition (Chevreuil et al. 1996, Duinker and Bouchertail 1989, Grainer et al. 1990, LANL 2012).

PCBs are associated with materials used historically by the Laboratory, including transformers; oils, solvents, and paints used in industrial activities; and a former asphalt batch plant in Sandia Canyon.

In 2019, 16 sampling locations (100% of locations) had PCB concentrations above the human health–organism only standard, 15 sampling locations (94 percent of locations) had concentrations above both the chronic aquatic life standard and wildlife standard (which are numerically equal), and one sampling location (6% of locations) had concentrations above the acute aquatic life standard. In 2019, two of two Individual Permit storm water samples exceeded the target action level for total PCBs. Twenty-eight of the 39 assessment units on Laboratory or former Laboratory lands are listed as impaired for PCBs (Table 6-1). Figures 6-10 and 6-11 show total PCB concentrations in unfiltered storm water and base flow for Los Alamos/Pueblo and Sandia/Mortandad Canyons. One Individual Permit sample in Pueblo Canyon was notably high in 2019. This location, P-SMA-2.2 will have enhanced controls installed in 2020 to initiate corrective action monitoring (N3B 2020c).

In 2019, no sediment results exceeded soil screening levels for PCBs.

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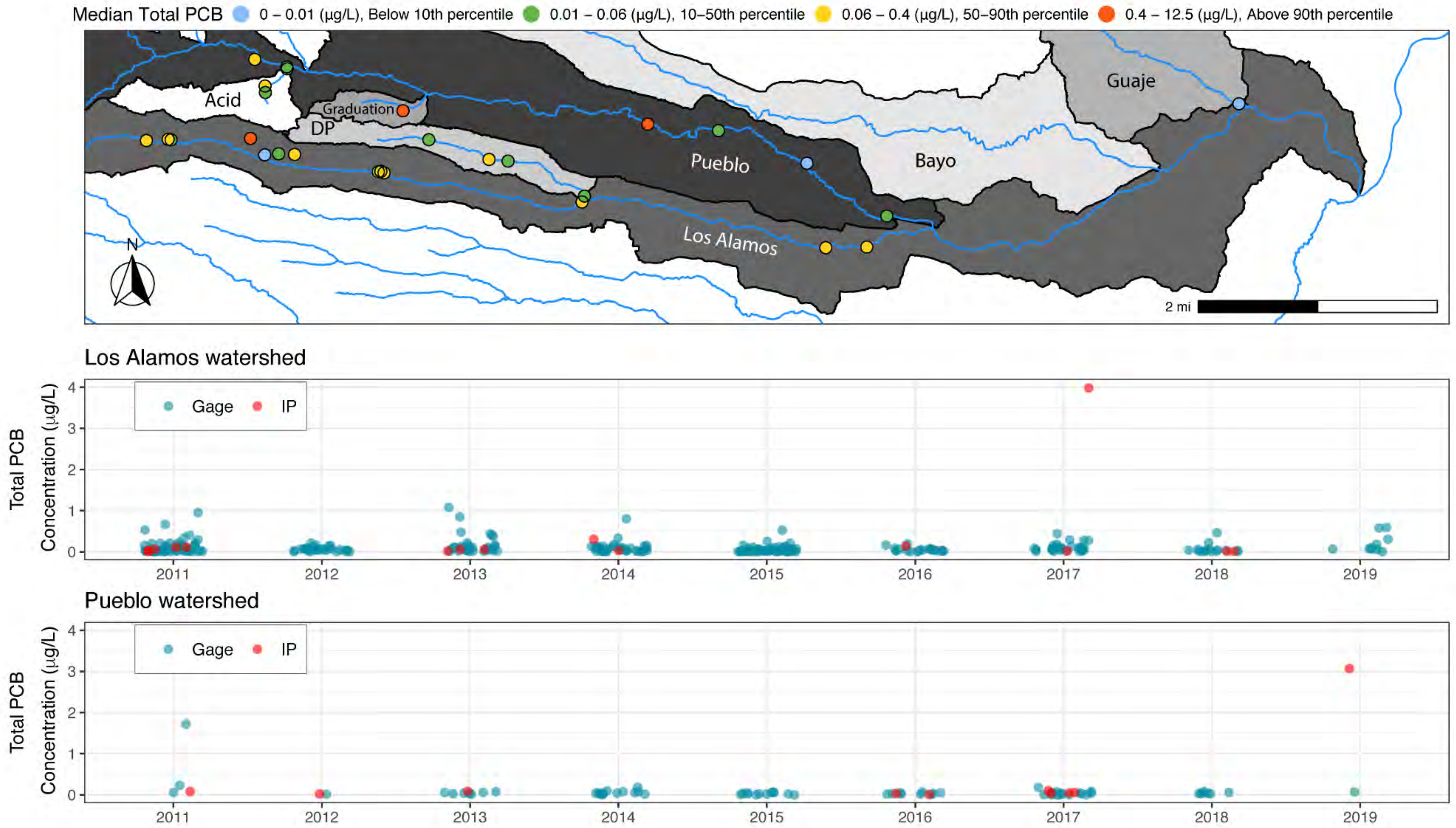

Note: one Individual Permit sample from 2013 in the Los Alamos watershed is not shown in the bottom panel due to the scale of the plot (concentration 21.1 �g/L).

Figure 6-10. Los Alamos Canyon watershed total PCB concentrations in unfiltered storm water from Individual Permit samplers and gaging stations and base flow from 2011 to 2019. Top panel: median storm water total PCB values for each sampling location between 2011 and 2019. Bottom panels: total PCB concentrations from Individual Permit and gage station samples from 2011 to 2019.

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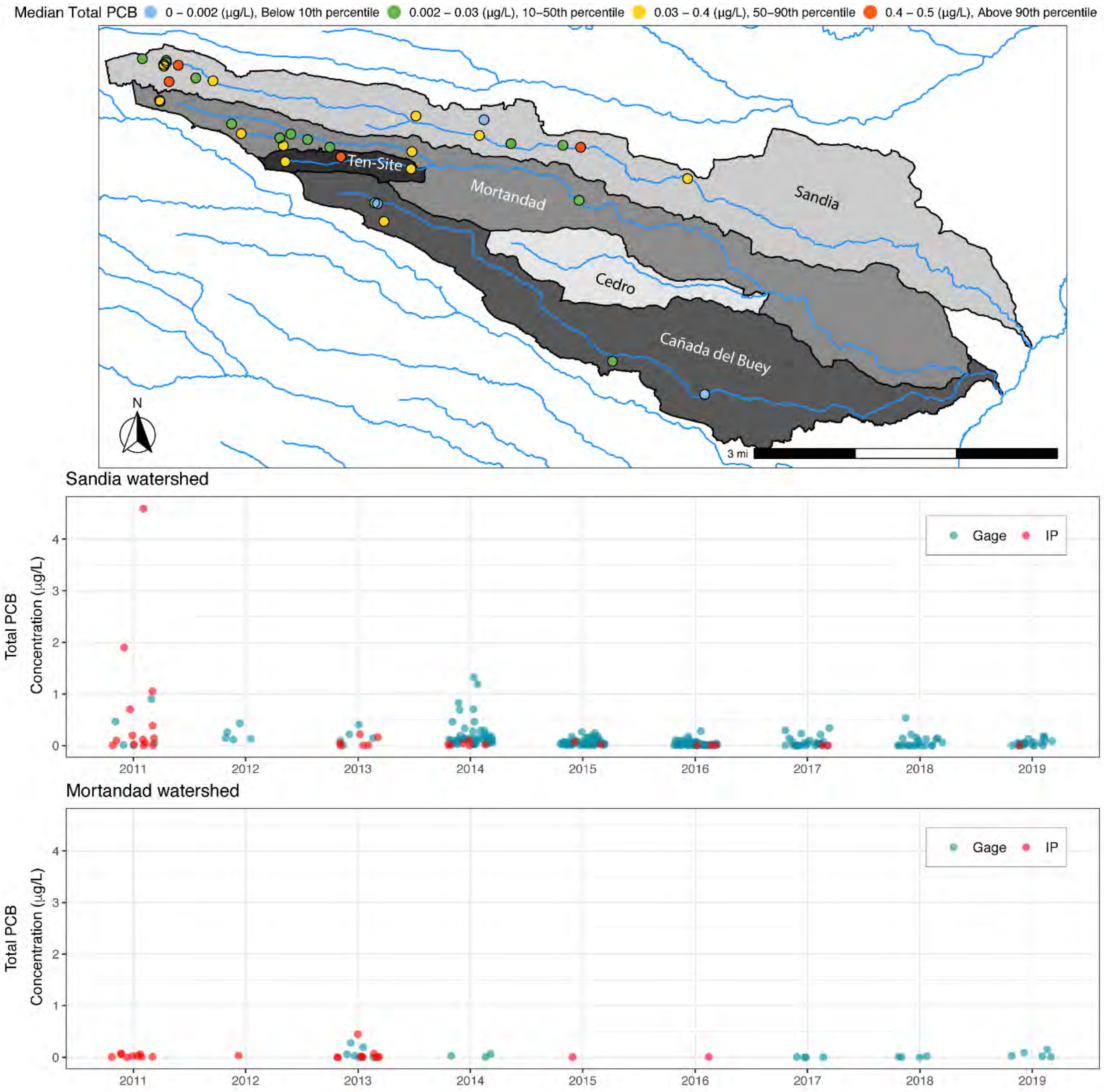

Figure 6-11. Sandia Canyon and Mortandad Canyon watershed total PCB concentrations in unfiltered storm water from Individual Permit samplers and gaging stations and base flow from 2011 to 2019. Top panel: median storm water total PCB values for each sampling location between 2011 and 2019. Bottom panels: total PCB concentrations from Individual Permit and gage station samples from 2011 to 2019.

Polycyclic Aromatic Hydrocarbons: Asphalt is prepared using petroleum products that contain polycyclic aromatic hydrocarbons, and operations at the former asphalt batch plant in Sandia Canyon released effluent from operations to the stream. In 2019, no storm water results at the gaging stations or base flow results exceeded the water quality standards for polycyclic aromatic hydrocarbons. There were no Individual Permit–related exceedances in 2019. None of the 39 assessment units, or stream reaches, on Laboratory or former Laboratory lands are listed as impaired for polycyclic aromatic hydrocarbons (Table 6-1).

For the 12 of 18 polycyclic aromatic hydrocarbon compounds that have screening levels, none of the sediment results from 2019 exceeded these screening levels.

Thallium: Gaseous emissions from cement factories and coal-fired power plants have led to thallium pollution. While the Four Corners Generating Station coal-fired power plant has contributed to thallium contamination in the surrounding areas, the Laboratory also operated coal-fired power plants historically. In 2019, none of the filtered gaging station storm water or base flow results exceeded the surface water quality standards for thallium. None of the 20 Individual Permit-related samples exceeded the target action level for thallium in 2019. None of the 39 assessment units, or stream reaches, on Laboratory or former Laboratory lands are listed as impaired for thallium (Table 6-1).

In 2019, no sediment samples exceeded soil screening levels for thallium.

CONCLUSIONS

Through the human health risk assessments in the canyons investigation reports, the biota dose assessment (Chapter 7), and human health risk assessment (Chapter 8) in this report, we have concluded that levels of chemicals and radionuclides present in storm water, base flow, and sediments are below levels that would impact human or biota health.

The scatter plots in Figures 6-6 through 6-11 show that the concentrations of chemicals exceeding screening levels in storm flow and base flow samples in 2019 fall within or below the ranges recorded in previous years, with the exception of an Individual Permit sample from Pueblo Canyon with a high total PCB concentration. This location will have enhanced controls installed in 2020.

We continue to observe very few sediment exceedances in 2019. All sediment exceedances were for manganese, except for one iron exceedance in Pueblo Canyon. Unlike other years, we did not observe any chromium or PCB exceedances.

The results of the storm water, base flow, and sediment data comparisons from samples collected in 2019 verify the conceptual model that storm water–related sediment transport observed in Laboratory canyons generally results in lower concentrations of Laboratory-released chemicals in the new sediment deposits than previously existed in deposits in a given reach. The results also support the idea that the risk assessments presented in the investigation reports represent an upper bound of potential human and ecological health risks in the canyons for the foreseeable future. Although some chemicals had concentrations in storm water, base flow, and sediment that were above screening levels in 2019, these transient events do not significantly affect human or biota health.

QUALITY ASSURANCE

Sampling of storm flow, base flow, and sediment, as well as measuring stream flow, is performed according to written quality assurance and quality control procedures and protocols. Current versions of all procedures and guides are listed at https://ext.em-la.doe.gov/EPRR/ReadingRoom.aspx?room=2. These procedures ensure that the collection, processing, and chemical analysis of samples and the validation and verification of analytical data are consistent from year to year.

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Chapter 7 – ECOSYSTEM HEALTH

We monitor ecosystem health to determine whether operations at Los Alamos National Laboratory (LANL, or the Laboratory) affect plant or animal populations. We collect samples of soil, sediment, plants, and animals on Laboratory property, near the Laboratory perimeter, and from background locations. We test these samples for levels of radionuclides, inorganic elements (such as metals), and organic chemicals (for example, polychlorinated biphenyls [PCBs], dioxins, furans, and high explosives). We also conduct radiation dose assessments for plants and animals occupying areas around specific Laboratory facilities and around sediment retention structures in canyon bottoms. The calculated doses are compared with background levels of radiation, screening levels, and federal standards for radiation doses to plants and animals.

During 2019, soil and vegetation samples were collected around the perimeter of Material Disposal Area G at Technical Area 54. Soil, sediment, honey, honeybee, bird egg, and nestling samples were collected around the Dual-Axis Radiographic Hydrodynamic Test Facility at Technical Area 15. Bird egg and nestling samples were collected at open detonation sites and an open burning ground. Small mammals and vegetation samples were collected in Los Alamos and Pajarito Canyons. Deceased animals (primarily from animal-vehicle collisions) were collected opportunistically from various sites on and off Laboratory property. We report the sampling results here. We also report the results from avian monitoring projects and from surveys for threatened and endangered species.

Most radionuclide activities and chemical concentrations in soil, sediment, plants, and animals from onsite and perimeter locations were either not detected, were similar to background, or were below screening levels that are protective of biota. Biota dose assessments indicate that the radiation doses are far below the levels observed to have adverse effects on plants and animals. Six years of bird banding data at the Sandia wetlands were analyzed. The overall number of birds and species captured was variable; however, we observed no decreases over time in bird species diversity, abundance, or the percentage of breeding birds. Low recapture rates should be explored further. In 2019, the fall bird banding in the Pajarito wetlands captured almost three times the highest total from previous years. Surveys of birds found no differences in species richness (the number of different bird species present) around open firing sites at Technical Areas 36 and 39 and an open burning site at Technical Area 16 compared with control areas. Species diversity (which includes both the number of species and their relative abundances) was higher at the firing sites and the open burning site compared with their control areas. Endangered species surveys in 2019 confirmed that two Mexican spotted owl habitats were again occupied and that both produced young.

INTRODUCTION

An ecosystem includes living organisms, such as plants, animals, and bacteria; nonliving physical environmental factors, such as soil, air, and water; and the interactions among these components (Smith and Smith 2012). The health of an ecosystem can be affected by environmental disturbances, including wildfire, flooding, drought, invasive species, climate shifts, chemical spills, construction projects, vegetation removal, and a host of other factors (Rapport 1998). Los Alamos National Laboratory (LANL, or the Laboratory) provides habitat to many species of plants and animals (collectively called "biota"). The primary objective of the Laboratory's ecosystem health monitoring is to determine if past or current releases of radionuclides and chemicals from Laboratory operations are affecting local plants and animals.

The monitoring program conducts two specific types of monitoring: institutional and facility-specific. Institutional monitoring occurs site-wide and is conducted on Laboratory property, around the perimeter of the Laboratory, and at regional background locations. Institutional monitoring is used to measure the levels of radionuclides and chemicals in areas outside of designated solid waste management units and to compare predictions of chemical and radionuclide transport models with actual results. Facility-specific monitoring is used to measure the nature and extent of radionuclides and chemicals associated with specific facilities and operations at the Laboratory.

Both institutional and facility-specific results are used to assess the effects of Laboratory-released chemicals and radionuclides on ecosystem health. This is accomplished by the following:

- measuring levels of radionuclides and other chemicals in soil, plants, and animals from areas on Laboratory property and near the perimeter of the Laboratory, and then comparing these levels with
  - levels measured from background locations that are not affected by Laboratory operations,
  - levels that scientists have determined should trigger further investigation, such as screening levels, and
  - levels that may cause adverse health effects;
- evaluating trends in radionuclide and chemical levels in soil, plants, and animals over time;
- assessing population parameters and species diversity of animals in areas that are potentially affected by Laboratory operations; and
- estimating radiation dose and chemical risk to biota based on the collected information.

The Laboratory also monitors migratory bird species to meet regulatory commitments.

This chapter reports on levels of radionuclides, inorganic elements (mostly metals), and organic chemicals in soil and biota samples that were collected onsite at the Laboratory from perimeter locations and from regional background locations. Specifically, we report on terrestrial ecosystem health for 2019, including (1) facility-specific results, such as monitoring around Area G, the Dual-Axis Radiographic Hydrodynamic Test Facility, and around two sediment retention structures; (2) results for chemical levels in mammals, birds, and snakes that were collected opportunistically; and (3) bird population abundance and diversity monitoring results. Finally, we calculated an overall biota radiation dose for organisms occupying mesa tops and canyon bottoms. We compared our results with background levels, screening levels, and federal dose standards.

TERRESTRIAL HEALTH ASSESSMENT

One way we assess terrestrial ecosystem health is by monitoring levels of constituents in a variety of environmental media including soil, native vegetation, honey bees (*Apis mellifera*) or honey, small mammals, bird eggs, and other animals collected opportunistically (as roadkills, for example). Environmental samples are routinely analyzed for radionuclides, inorganic elements such as metals, and organic chemicals such as polychlorinated biphenyls (PCBs), high explosives, dioxins, furans, volatile organic compounds, and semi-volatile organic compounds. In 2019, select samples were also analyzed for per- and polyfluoroalkyl substances (PFAS).

Soil is useful for monitoring because it receives substances that are released in air emissions and particles that are transported by wind and water. Soil data can thus provide information about several modes of chemical and radionuclide transport. Monitoring soil over time also directly measures long-term trends of radionuclide and other chemical concentrations around nuclear facilities (DOE 2015).

Levels of constituents in soil collected at and near the Laboratory are compared with regional statistical reference levels calculated from samples collected at regional background locations. Radionuclides and other chemicals in soil collected from regional background locations come from naturally occurring elements in the soil or from man-made sources that are not attributed to the Laboratory. These sources include worldwide fallout of radioactive particles from nuclear facility accidents or testing of atomic weapons and chemical releases from non-Laboratory sources, such as power plants and automobile emissions. The regional statistical reference level for a chemical or radionuclide is the level below which 99 percent of the regional background locations results fall. As required by the U.S. Department of Energy (DOE), all background locations are at a similar elevation to the Laboratory, are more than 9.3 miles away from the Laboratory, and are beyond the range of potential influence from normal Laboratory operations (DOE 2015).

What are PFAS?

Per- and polyfluoroalkyl substances (PFAS) are a class of synthetic compounds that are found in many manufactured items such as cookware, food packaging, stain repellents, and fire-fighting foams. They can repel oil, stains, grease, and water, and are fire-resistant. There are nearly 6,000 types of PFAS compounds known, some of which have been more widely used and studied than others.

The widespread use of PFAS and their ability to persist in the environment means that past and current uses may result in increasing PFAS levels in the environment and bioaccumulation in animal tissue. PFAS also have possible impacts on human health.

Currently, neither the U.S. Environmental Protection Agency nor the State of New Mexico regulate PFAS compounds. In 2016, the U.S. Environmental Protection Agency issued a health advisory level of 70 parts per trillion in drinking water for three individual PFAS compounds. This health advisory level is nonenforceable and nonregulatory. In the beginning of 2020, the U.S. Environmental Protection Agency added specific PFAS to the list of reportable compounds under the Toxic Release Inventory. In addition, specific PFAS have been proposed to be added to the Comprehensive Environmental Response, Compensation, and Liability Act list of hazardous substances.

Levels of constituents in soil are also compared with ecological screening levels (LANL 2017a). Ecological screening levels include the highest level of a radionuclide or chemical in the soil that is known to not affect selected animals or plants (the no-effect ecological screening level) and the lowest level known to have caused an adverse effect on selected animals or plants (the low-effect ecological screening level) (LANL 2017a). Soil ecological screening levels exist for the following terrestrial ecological receptors: generic plant; earthworm—representing soil-dwelling invertebrates; desert cottontail (*Sylvilagus* *audubonii*)—representing mammalian herbivores; deer mouse (*Peromyscus maniculatus*)—representing mammalian omnivores; montane shrew (*Sorex monticolus*)—representing mammalian terrestrial insectivores; Botta's pocket gopher (*Thomomys bottae*)—representing burrowing mammals; gray fox (*Urocyon cinereoargenteus*)—representing mammalian carnivores; occult little brown bat (*Myotis lucifugus occultus*)—representing mammalian aerial insectivores; American robin (*Turdus migratorius*)—representing avian omnivores, herbivores, and insectivores; violet-green swallow (*Tachycineta thalassina*)—representing avian aerial insectivores; and American kestrel (*Falco sparverius*)—representing avian carnivores (LANL 2017a).

Monitoring levels of constituents in biological tissues provides information regarding whether chemicals in the environment are being taken up by plants and animals and allow us to compare observed levels with levels that scientists have determined are potentially associated with adverse health effects to the individual plant or animal. Levels of chemicals in biological tissues are compared with the lowest observable adverse effect levels, if available. A lowest observable adverse effect level is the lowest concentration measured in an animal's tissues that has produced an adverse effect in a population of animals or plants (U.S. Environmental Protection Agency 2014). Levels of radionuclides in tissues are compared with biota dose screening levels, which are set at 10 percent of the DOE limit for radiation doses to biota (DOE 2019, McNaughton 2006).

If a radionuclide in soil or in biota is detected at an activity that is higher than the screening levels, then—using all of the available data—the dose to biota is calculated using RESRAD-BIOTA software (version 1.8) (http://resrad.evs.anl.gov/codes/resrad-biota/), which is DOE's methodology for evaluating radiation doses to aquatic and terrestrial biota. This calculated dose is compared with DOE limits: 1 rad per day for terrestrial plants and aquatic animals, and 0.1 rad per day for terrestrial animals (DOE 2019).

We perform statistical tests to evaluate differences in constituents among sites and to examine trends in constituent levels over time. Examples of these tests include *t*-tests, analysis of variance, Kruskal-Wallis tests, Kendall's Tau tests, linear regressions, and generalized linear models. Samples collected within approximately the last 10 years are used to look at trends over time because the samples are directly comparable: they were analyzed with similar analytical methods and instruments and have similar detection limits. We test a null hypothesis for each set of data, typically that there are no differences among locations or that there are no increasing trends over time. For each test, we select a probability level, or p-value, of the null hypothesis being correct at which we accept or reject the null hypothesis. We use a p-value of less than 5 percent ($p < 0.05$) as our threshold to reject the null hypothesis of no difference among locations or no trend over time. If the p-value is greater than 5 percent ($p > 0.05$), we accept the null hypothesis of no difference or no trend.

Facility Soil and Vegetation Monitoring

Area G at Technical Area 54

Area G was established in 1957 and is the Laboratory's primary low-level radioactive solid waste burial and storage site (Figure 7-1) (DOE 1979, Martinez 2006). Tritium, plutonium, americium, and uranium are the main radionuclides in waste materials at Area G (Mayfield and Hansen 1983). The Laboratory has conducted soil, vegetation, and small mammal monitoring at Area G since 1980 to determine whether radionuclides are migrating beyond the waste burial area (LANL 1981, Mayfield and Hansen 1983).

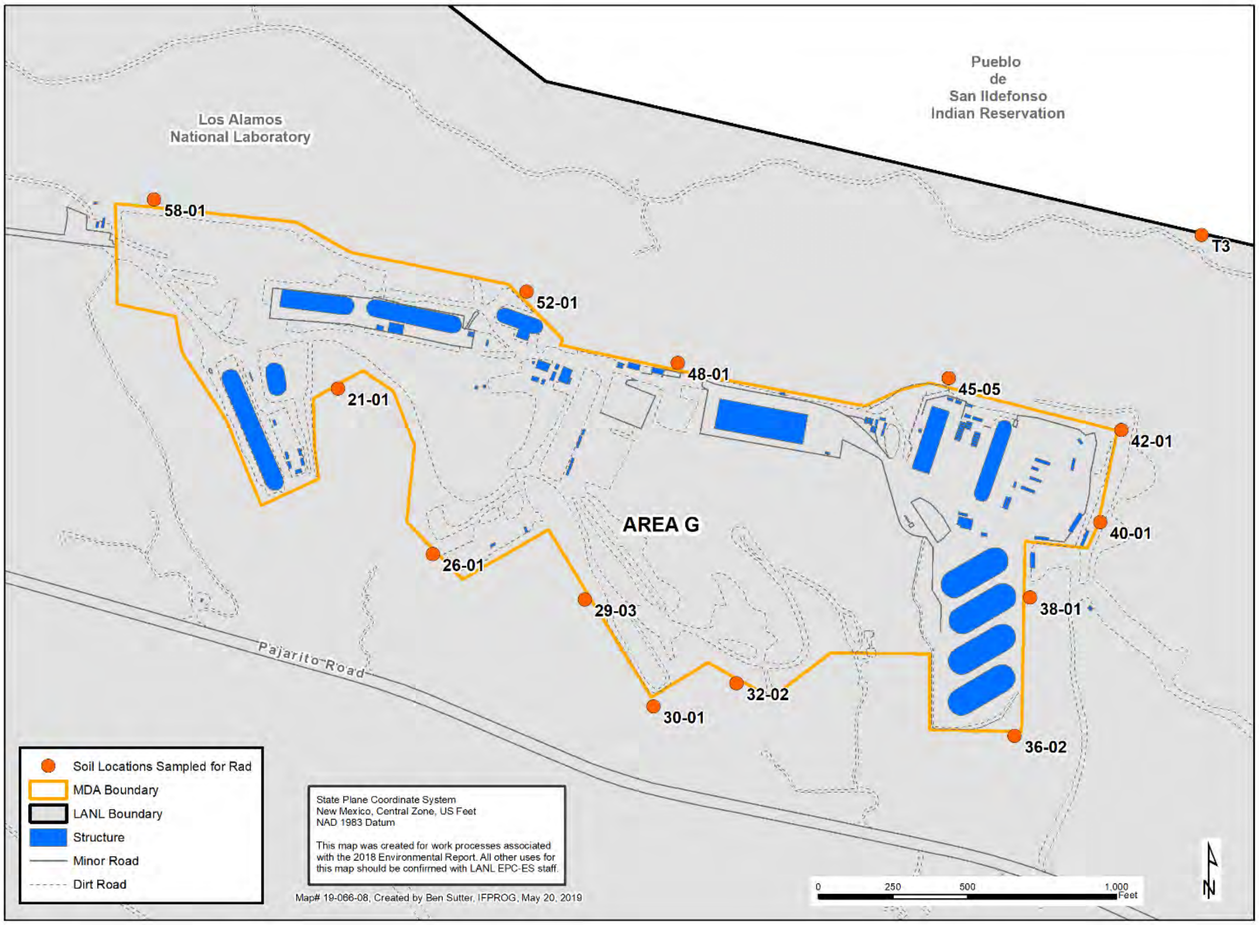


Figure 7-1. Locations of soil and vegetation samples collected around Area G in 2019. Note: MDA is Material Disposal Area.

We collect surface soil and vegetation at Area G each year for testing. Surface soil grab samples (0 to 6 inches deep) and composite tree samples, primarily of one-seed juniper (*Juniperus monosperma*), were collected in June 2019 at 13 designated locations around the perimeter of Area G. Soil and one composite tree sample were collected at the bottom of Cañada del Buey near the boundary between the Laboratory and the Pueblo de San Ildefonso (Figure 7-1). All samples were analyzed for tritium, americium-241, cesium-137, plutonium-238, plutonium-239/240, strontium-90, uranium-234, uranium-235/236, and uranium-238.

Radionuclides in Soil and Vegetation at Area G

In 2019, cesium-137, strontium-90, uranium-234, and uranium-238 activities were below, and uranium-235/236 activity was similar to or below regional statistical reference levels in all soil samples collected around the perimeter of Area G. Similar to previous years, americium-241, plutonium-238, plutonium-239/240, and tritium were detected above the regional statistical reference levels in many soil locations around the perimeter of Area G in 2019 (Supplemental Table S7-1).

Americium-241, plutonium-238, and plutonium-239/240 in soil samples collected on the north, northeastern, and eastern side of Area G were above the regional statistical reference level. These concentrations are similar to previous years and are not increasing over time (Kendall's Tau, $p > 0.05$; see Figure 7-2). Plutonium-239/240 activities are decreasing over time at both the 40-01 and 42-01 sampling locations (Kendall's Tau, $p < 0.05$). Levels of tritium in soil samples collected on the southern side of Area G were above the regional statistical reference level, which are consistent with data from previous years. Tritium levels are not statistically increasing over time (Kendall's Tau, $p > 0.05$; see Figure 7-2).

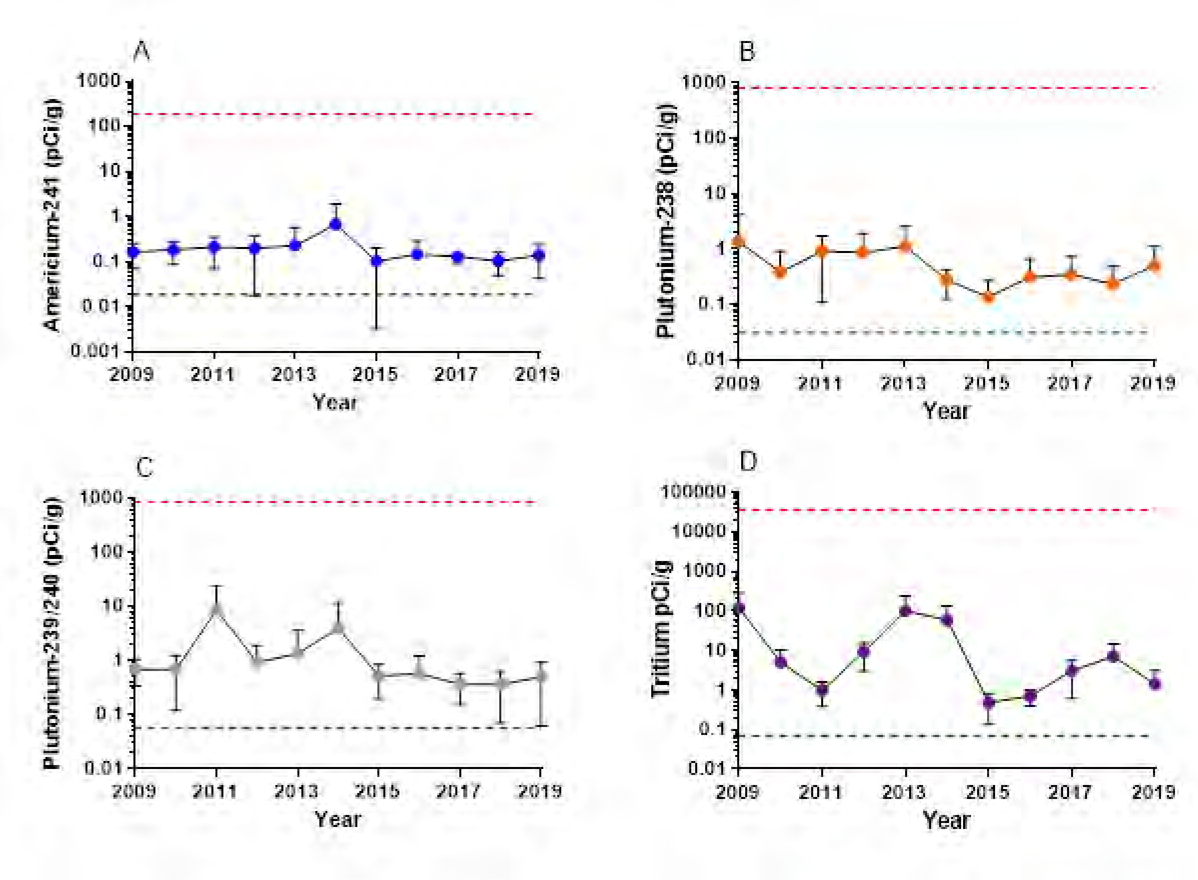


Figure 7-2. (A) Americium-241, (B) plutonium-238, (C) plutonium-239/240 activities in surface soil samples collected from five locations on the northern, northeastern, and eastern side (locations 38-01, 40-01, 42-01, 45-05, and 48-01), and (D) tritium activities in surface soil samples collected from two locations on the southern side (locations 29-03 and 30-01) of Area G at Technical Area 54 from 2009 to 2019. Data are compared with the regional statistical reference level (green dashed line) and the lowest no-effect ecological screening level (red dashed line). Note the logarithmic scale on the vertical axis. Points represent mean and error bars represent standard deviation. Bottom error bars are absent on some points as the error would have been a negative value; however, negative values cannot be shown on a logarithmic axis. Note: pCi/g = picocuries per gram.

Results from native trees (primarily one-seed juniper) can be an indicator of both uptake by roots and of deposition of radionuclides on the surfaces of leaves and branches. Tree samples were collected at the same general locations as the soil samples (Figure 7-1); however, because of a firebreak along the fence line, some of the trees were located more than 30 feet away from the fence around Area G, particularly on the northern and eastern sides.

The majority of radionuclides in overstory vegetation samples were either not detected or were below the regional statistical reference levels and all activities were below the biota dose screening levels (Supplemental Table S7-2). The majority of radionuclides in vegetation are not changing over time (Kendall's Tau, $p > 0.05$). Results for americium-241 between 2009 and 2018, reported in last year's Annual Site Environmental Report (which included four locations), had a decreasing trend; however, after including the 2019 results, there was no significant trend in americium-241 values at the north, northeastern, and eastern sides of Area G (which included five locations; Figure 7-3).

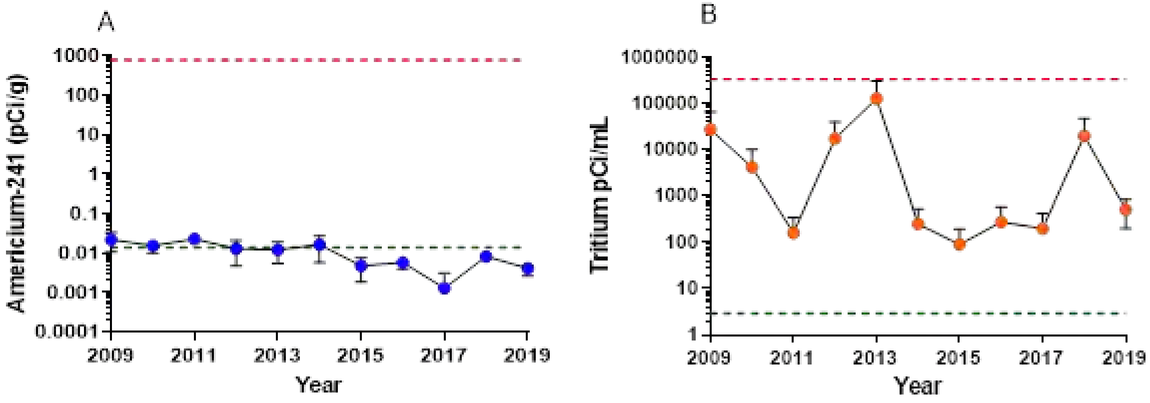


Figure 7-3. (A) Americium-241 activities in overstory vegetation samples collected from five locations on the northeastern corner of Area G (locations 38-01, 40-01, 42-01, 45-05, and 48-01), and (B) tritium activities in overstory vegetation samples collected from two southern locations (locations 29-03 and 30-01) around Area G at Technical Area 54 from 2009 to 2019. Data are compared with the regional statistical reference level (green dashed line) and biota dose screening level for overstory vegetation (red dashed line). Note the logarithmic scale on the vertical axis. Points represent mean and error bars represent standard deviation. Bottom error bars are absent on some points as the error would have been a negative value; however, negative values cannot be shown on a logarithmic axis. Note: pCi/g = picocuries per gram and pCi/mL = picocuries per milliliter.

Similar to previous years, tritium in overstory vegetation was highest (up to 748 picocuries per milliliter) in trees growing in the southern sections near the tritium disposal shafts. The overall trend in plant tritium is highly variable from year to year but the levels have not been increasing over time (Kendall's Tau, $p > 0.05$; Figure 7-3). Variability in plant tritium levels may be a result of any, or a combination, of the following: soil moisture, depth of roots, time of sampling, distance from the perimeter fence, temperature, or barometric pressure.

Radionuclides in Soil and Vegetation near the Laboratory/Pueblo de San Ildefonso Boundary in Cañada del Buey

In 2019, a duplicate-split soil sample (where soil is thoroughly mixed in a bag and split into two sample containers) was collected at a location known as T3-B near the Technical Area 54 and Pueblo de San Ildefonso boundary and near T3 in Figure 7-1. This location was sampled during 2016 through 2019.

From 2006 through 2015, soil was collected near a location known as T3-E, which is near a fence that roughly divides the two properties.

The majority of radionuclide activities in soil were not detected or were below the regional statistical reference level. All activities were below the ecological screening levels (Supplemental Table S7-1). Americium-241 was detected at 0.0191 and 0.0220 picocuries per gram, slightly above the regional statistical reference level of 0.0187 picocuries per gram. Plutonium-239/240 was detected at 0.1000 and 0.1050 picocuries per gram, above the regional statistical reference level of 0.0571 picocuries per gram. These observations are on Laboratory property and are well below the no-effect ecological screening levels for americium-241 and plutonium 239/240 of 190 and 870 picocuries per gram, respectively. Between 2016 and 2019, concentrations of radionuclides in soil near the Technical Area 54 and Pueblo de San Ildefonso boundary did not show any trends over time (Kendall's Tau, $p > 0.05$; Figure 7-4).

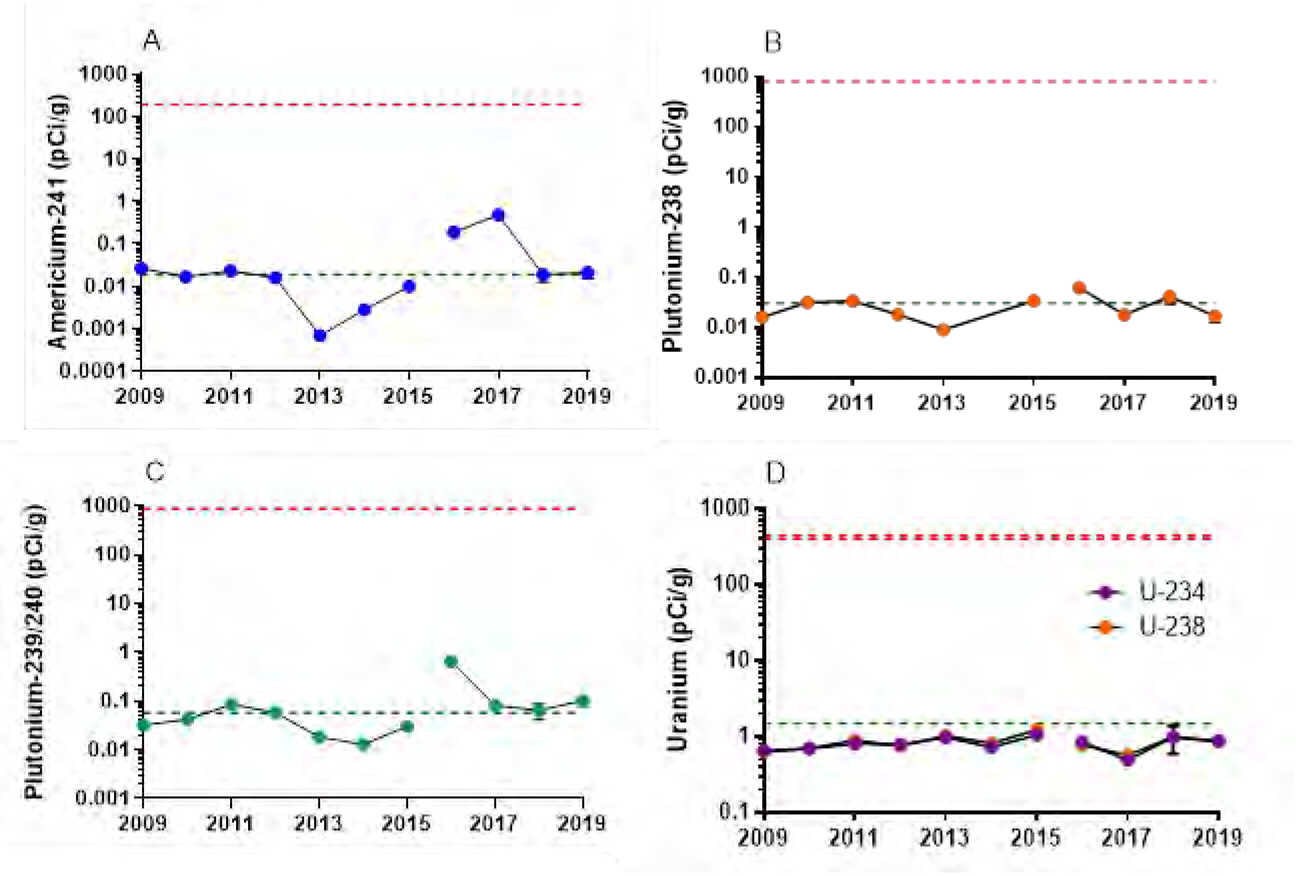


Figure 7-4. (A) Americium-241, (B) plutonium-238, (C) plutonium-239/240, and (D) uranium-234 and uranium-238 activities in soil collected near the Technical Area 54 and Pueblo de San Ildefonso border from 2009 through 2019. Results from 2009 through 2015 were at the T3-E location (near the fence); results from 2016 through 2019 were at the T3-B location (near the road). Results from 2018 and 2019 are the average of duplicated samples. Data are compared with the regional statistical reference level (green dashed line) and the lowest no-effect ecological screening level (red dashed line). Note the logarithmic scale on the vertical axis. Points represent true values (between 2009 and 2017, n = 1 each) or represent mean values (between 2018 and 2019, n = 2 each), and error bars represent standard deviation. Note: pCi/g = picocuries per gram.

All three uranium isotopes were detected in all soil samples collected near the Technical Area 54 and Pueblo San Ildefonso boundary and were all below the regional statistical reference level (Table S7-1). The near 1:1 ratio of uranium-234 to uranium-238 activities (Figure 7-4) indicates that these uranium activities are from naturally occurring sources (U.S. Nuclear Regulatory Commission 2019) and the concentrations observed here are within the range of Laboratory background concentrations (Ryti et al. 1998).

Radionuclides in overstory vegetation collected near the Technical Area 54 and Pueblo de San Ildefonso boundary were all below the regional statistical reference level, except for plutonium-239/240, which was observed at 0.0186 picocuries per gram (the regional statistical reference level is 0.0118 picocuries per gram). All radionuclides are far below the biota dose screening level, which are protective of biota, and no radionuclide levels are trending over time in vegetation (Table S7-2).

Dual-Axis Radiographic Hydrodynamic Test Facility at Technical Area 15

The Dual-Axis Radiographic Hydrodynamic Test Facility at Technical Area 15 is a principal Laboratory explosives firing site. Soil, sediment from drainages, plants, and animals are monitored at the facility to determine whether constituents released from operations may be affecting plants or animals and if the levels are consistent with our expectations of radionuclide and chemical uptake. Environmental monitoring has occurred annually since 1996. The firing site began operations in 2000. Open-air detonations occurred from 2000 to 2002, detonations using foam mitigation were conducted from 2003 to 2006, and detonations within closed steel containment vessels have been conducted since 2007.

Monitored constituents in soil and sediment include radionuclides, beryllium (and other inorganic elements), and organic chemicals such as high explosives, dioxins, and furans. Routine biological samples collected around the Dual-Axis Radiographic Hydrodynamic Test Facility have included overstory branches, small mammals, honey bees and/or honey, and bird eggs and nestlings. Samples of soil, sediment, and one type of biota are collected annually; typically, vegetation, honey or honey bees, and small mammals sampling is rotated annually so that each is sampled once in a 3-year period. Bird samples are collected opportunistically when abandoned or infertile eggs or deceased nestlings are found in local nest boxes.

In 2019, we collected soil, sediment, honey bees, and honey at the facility. For soil sampling, five surface soil subsamples were collected at each location at a depth from 0 to 2 inches, combined, and mixed. The samples were collected in May 2019 on the north, east, south, and west sides of the Dual-Axis Radiographic Hydrodynamic Test Facility perimeter along the fence line (Figure 7-5). An additional composite soil sample was collected about 75 feet north of the firing point along the side of the protective berm. Sediment grab samples were collected at depths from 0 to 6 inches on the north, east, south, and southwest sides within drainages around the facility (Figure 7-5). All soil and sediment samples were analyzed for radionuclides, including americium-241, cesium-137, plutonium-238, plutonium-239/240, strontium-90, tritium, uranium-234, uranium-235/236, and uranium-238; inorganic elements, including aluminum, antimony, arsenic, barium, beryllium, cadmium, calcium, chromium, cobalt, copper, iron, lead, magnesium, manganese, mercury, nickel, potassium, selenium, silver, sodium, thallium, vanadium, and zinc; and high explosives. The sample nearest to the firing point was also analyzed for dioxins and furans.

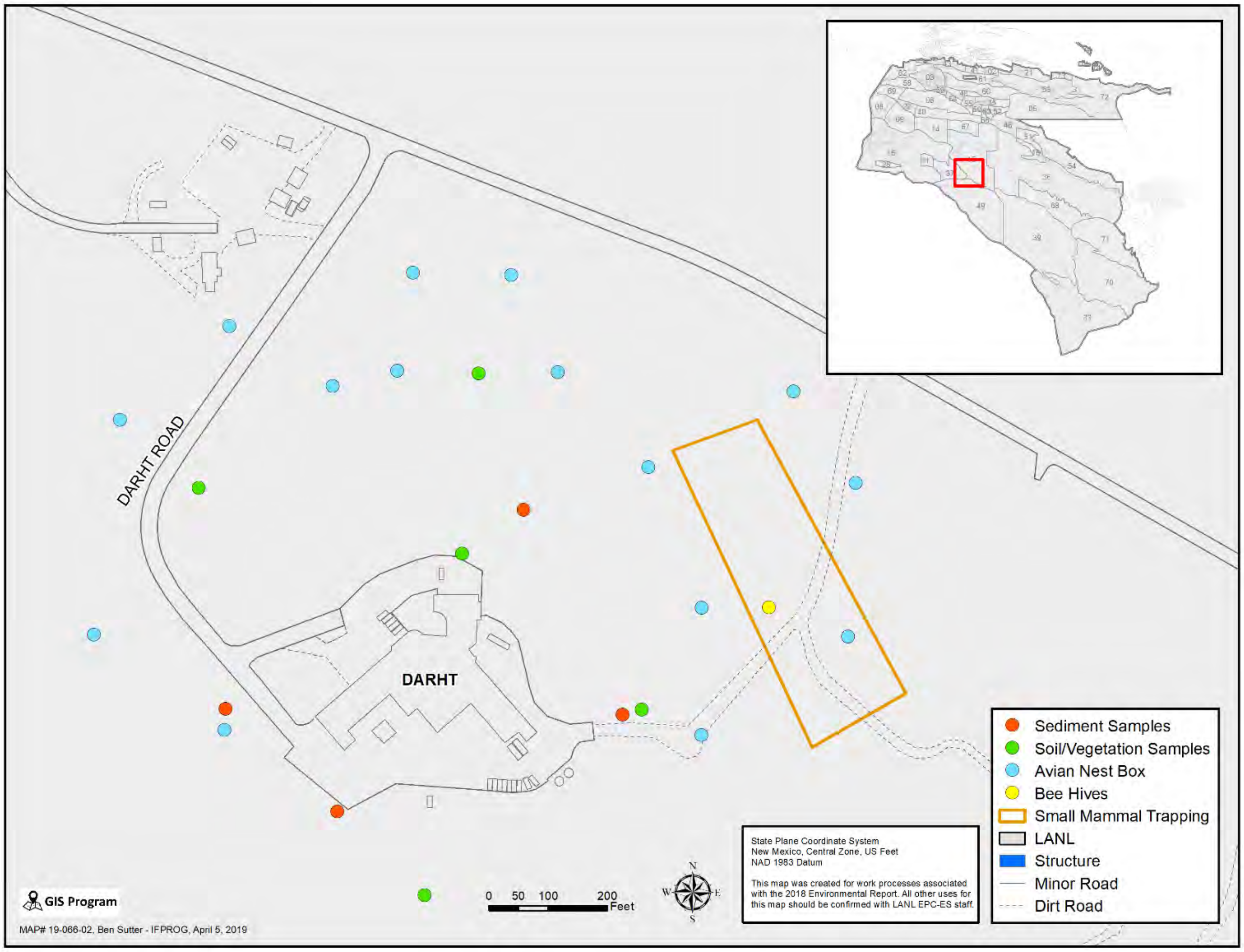


Figure 7-5. Soil, sediment, and biota sample locations at the Dual-Axis Radiographic Hydrodynamic Test Facility (DARHT) at Technical Area 15

Constituent results in soil samples are compared with the baseline statistical reference levels. The baseline statistical reference levels for the Dual-Axis Radiographic Hydrodynamic Test Facility are based on samples collected at the facility during 1996 to 1999, before the beginning of firing site operations. The baseline level for each constituent is the level below which 99 percent of samples from this time occurred (Nyhan et al. 2001). In cases where there are no baseline statistical reference levels (mostly inorganic elements like aluminum, calcium, cobalt, iron, magnesium, manganese, potassium, sodium, vanadium, and zinc), the soil and biota chemical results are compared with regional statistical reference levels.

Beehives were established north of the Dual-Axis Radiographic Hydrodynamic Test Facility and bees were consistently collected and chemically analyzed through 2013. In 2019, three old beehives were replaced with three new beehives and bees. One of the old hives still contained live bees, which were collected for inorganic element and radionuclide analyses. Honey was also collected from the old active hive and was analyzed for inorganic elements, radionuclides, high explosives, and PFAS.

Wild bird eggs have sometimes been shown to reflect chemical exposures from the location where a female bird feeds during egg formation (Dauwe et al. 2005). However, chemicals from the female's previous exposures, such as on migration routes or wintering grounds, can also be deposited into eggs (Bustnes et al. 2010). Nestlings tend to reflect local chemical exposures due to their limited mobility. Eggs that did not hatch and nestlings that died of natural causes were collected from nest boxes surrounding the Dual-Axis Radiographic Hydrodynamic Test Facility and chemically analyzed (Figure 7-5). One egg sample, consisting of an individual mountain bluebird (*Sialia currucoides*) egg, was collected and analyzed for inorganic elements. Two nestling samples, consisting of an individual western bluebird (*Sialia mexicana*) and an individual mountain bluebird nestling, were collected and analyzed for plutonium and uranium isotopes.

Results for Radionuclides and Chemicals in Soil, Sediment, Honey Bees, Honey, Bird Eggs, and Nestlings at the Dual-Axis Radiographic Hydrodynamic Test Facility

Soil and sediment samples collected around the Dual-Axis Radiographic Hydrodynamic Test Facility did not contain detectable levels of americium-241 or tritium, and the majority of samples did not contain detectable levels of cesium-137, plutonium-238, or strontium-90 (Table S7-3). Detectable activities of cesium-137, plutonium-238, plutonium-239/240, and strontium-90 were all were below the baseline regional statistical reference level, and/or regional statistical reference level (Table S7-3).

In 2019, soil and sediment samples contained all three isotopes of uranium. This observation is consistent with previous years. Several samples contained activities of uranium that were higher than the regional statistical reference level and the baseline statistical reference level. The relative isotopic abundance of uranium-234, uranium-235, and uranium-238 activities indicate that the uranium in these samples is depleted uranium (uranium from testing activities) rather than natural uranium (e.g., 84.7 percent uranium-238, 1.1 percent uranium-235, and 15.2 percent uranium-234 [International Atomic Energy Agency 2019a]). The highest level of uranium-238, 21.2 picocuries per gram, was observed in a sediment sample collected on the south side of the Dual-Axis Radiographic Hydrodynamic Test Facility and is higher than typical observations. The majority (97 percent) of uranium-238 activities are less than 10 picocuries per gram in soil and sediment collected at the Dual-Axis Radiographic Hydrodynamic Test Facility. All radionuclide activities are far below ecological screening levels that are protective of biota (Table S7-3).

Operations at the Dual-Axis Radiographic Hydrodynamic Test Facility have changed since 2007 to include the use of closed containment vessels. Since 2008, uranium-238 activity near the firing point has mostly been similar to the baseline statistical reference level (Figure 7-6). Levels of radionuclides in soil and sediment samples collected around the Dual-Axis Radiographic Hydrodynamic Test Facility are not increasing over time (Kendall's Tau, $p > 0.05$).

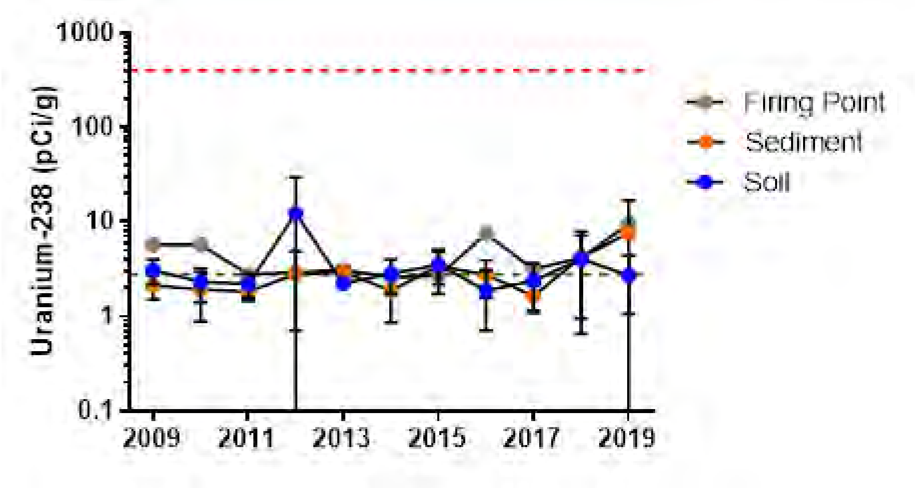


Figure 7-6. Uranium-238 activities in surface soil and sediment samples collected around the Dual-Axis Radiographic Hydrodynamic Test Facility and in the firing point soil samples from 2009 to 2019 compared with the baseline statistical reference level (mean plus 3 standard deviations of soil uranium-238 pre-operations; green dashed line) and the lowest no-effect ecological screening level for the generic plant as an ecological receptor (red dashed line). Note the logarithmic scale on the vertical axis. Points represent true values (firing point) or represent means (sediment and soil) and error bars represent standard deviation. Bottom error bars are absent on some points as the error would have been a negative value; however, negative values cannot be shown on a logarithmic axis. Note: pCi/g = picocuries per gram.

All inorganic elements, except for mercury, were found at detectable concentrations in all soil and sediment samples collected in 2019. Mercury was found at detectable concentrations in some samples. Concentrations of aluminum, antimony, arsenic, barium, beryllium, cadmium, calcium, chromium, cobalt, iron, lead, magnesium, nickel, potassium, and silver were below all reference and screening levels, including the baseline statistical reference levels, regional statistical reference levels, and both the no- and low-effect ecological screening levels of select elements (Table S7-4). Consistent with observations from previous years, in some soil and sediment samples concentration of manganese (four samples), mercury (one sample), thallium (six samples), and vanadium (nine samples) exceeded the no-effect ecological screening level for the plant, montane shrew, or American robin and/or the low-effect ecological screening level for the American robin. This included the soil sample collected at the firing point; however, all concentrations of these elements were below the regional statistical reference level and the baseline statistical reference level (when available). As a note, the regional statistical reference level of these elements is also above the no-effect ecological screening level (Table S7-4).

The soil sample collected at the firing site contained copper (19 milligrams per kilogram) that was higher than regional statistical reference level (17 milligrams per kilogram) and the no-effect ecological screening level for the American robin (14 milligrams per kilogram), but was below the baseline statistical reference level (86 milligrams per kilogram; Table S7-4). Six soil and sediment samples contained selenium concentrations (range 0.75 to 0.95 milligrams per kilogram) that were above the baseline statistical reference level (0.68 milligrams per kilogram) and the no-effect ecological screening level for the plant (0.52 milligrams per kilogram) and montane shrew (0.70 milligrams per kilogram), but were below the regional statistical reference level (1.79 milligrams per kilogram; Table S7-4). Three sediment samples contained zinc concentrations (range 53 to 90 milligrams per kilogram) that were higher than the regional statistical reference level (50 milligrams per kilogram) and were above the no-effect ecological screening level for the American robin (47 milligrams per kilogram; Table S7-4). Three sediment samples also exceeded the regional statistical reference level for sodium (140 milligrams per kilogram; range of exceedances 170 to 230 milligrams per kilogram), although no other reference values for sodium are available (Table S7-4). Although concentrations of some inorganic chemicals exceeded the no-effect ecological screening levels, the majority were below the low-effect ecological screening levels. The number of locations with concentrations potentially associated with adverse effects at an individual level are minimal, and no impacts to populations or communities of plants and animals are expected.

Consistent with data in previous years, selenium (Figure 7-7) and copper concentrations were increasing over time in the sediment sample collected from the east side of the Dual-Axis Radiographic Hydrodynamic Test Facility; in 2019, zinc in sediment was also increasing at this sampling location (Kendall’s Tau, $p < 0.05$). Arsenic, cadmium, and selenium were increasing over time in soil collected from the east side of the Dual-Axis Radiographic Hydrodynamic Test Facility, and arsenic was increasing over time in soil collected from the south side (Kendall’s Tau, $p < 0.05$). These trends will be monitored closely in future sampling. No other elements are increasing over time around the Dual-Axis Radiographic Hydrodynamic Test Facility.

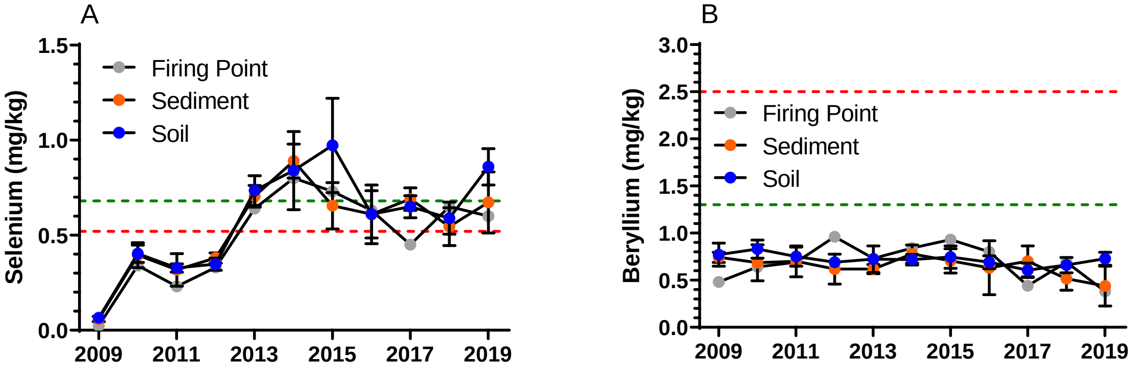


Figure 7-7. (A) Selenium and (B) beryllium concentrations in surface soil and sediment samples collected around the Dual-Axis Radiographic Hydrodynamic Test Facility and near the firing point soil sample from 2009 to 2019, compared with the baseline statistical reference level (mean plus 3 standard deviations of soil concentrations pre-operations; green dashed line) and the lowest no-effect ecological screening level (red dashed line). Note the linear scale on the vertical axis. Points represent true values (firing point) or represent means (sediment and soil, n = 4 each) and error bars represent standard deviation. Note: mg/kg = milligrams per kilogram.

Beryllium, listed as a chemical of potential concern before the start-up of operations at the facility (DOE 1995), was not detected above the baseline statistical reference level (1.3 milligrams per kilogram) in any of the soil or sediment samples during 2019. Beryllium concentrations in all soil and sediment samples from 2009 to 2019 have been below the baseline statistical reference level (Figure 7-7).

Consistent with previous years, no high-explosives chemicals or furans were detected in any of the soil or sediment samples collected within or around the perimeter of the Dual-Axis Radiographic Hydrodynamic Test Facility in 2019, including the sample closest to the firing point (Table S7-5). Most dioxins, including 2,3,7,8-tetrachlorodibenzodioxin (TCDD), were also not detected in the soil sample collected at the firing site (Table S7-6). The only detected dioxin congeners were 1,2,3,4,6,7,8-heptachlorodibenzodioxin and 1,2,3,4,6,7,8,9-octachlorodibenzodioxin at concentrations of 0.001 and 0.007 nanograms per kilogram, respectively. There are no ecological screening levels for these dioxin congeners; however, toxic equivalent factors for TCDD-like compounds can be used to calculate the TCDD toxic equivalent for dioxin-like compounds. The toxic equivalent factor is 0.01 for 1,2,3,4,6,7,8-heptachlorodibenzodioxin and 0.0003 for 1,2,3,4,6,7,8,9-octachlorodibenzodioxin (Van den Berg et al. 2006). Multiplying the detectable concentrations of these congeners by their respective toxic equivalent factors yields a value that is orders of magnitude less than the no-effect ecological screening level for TCDD.

In the mountain bluebird egg, several inorganic elements were not detected, including aluminum, arsenic, beryllium, cadmium, chromium, cobalt, lead, nickel, silver, thallium, and vanadium; these observations are similar to previous years. All detectable concentrations of elements were below the regional statistical reference level (Table S7-7).

Plutonium-238 and plutonium-239/240 were not detected in either of the nestling samples collected around the Dual-Axis Radiographic Hydrodynamic Test Facility (Table S7-7). Uranium-234, uranium-235/236, and uranium-238 were detected in nestlings and were similar to previous results; uranium-238 was detected (0.225 and 0.270 picocuries per gram) above the regional statistical reference level (0.197 picocuries per gram; Figure 7-8). Although not enough data are available for a trend analysis, there is no difference of uranium-234 or uranium-238 isotopes in nestlings collected from the Dual-Axis Radiographic Hydrodynamic Test Facility ($n = 4$) when compared with background ([$n = 3$], unpaired *t*-test, $p > 0.05$, Figure 7-8). All radionuclide levels were far below the biota dose screening level (DOE 2019). Uranium isotopes 234, 235/236, and 238 have been detected in soils, sediments, and small mammals collected around the Dual-Axis Radiographic Hydrodynamic Test Facility at levels that have exceeded the regional statistical reference levels in the recent past (Gaukler et al. 2018, Fresquez et al. 2016). These results suggest that uranium is bioavailable and is being incorporated into nestling tissues but is below levels associated with harmful effects.

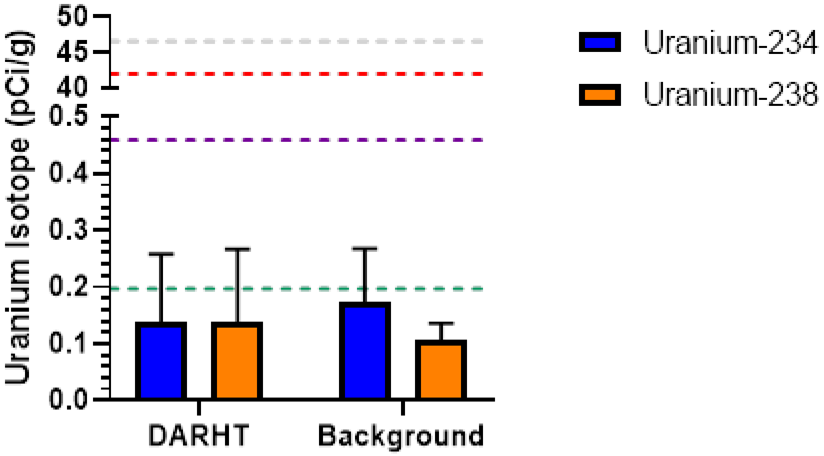


Figure 7-8. Uranium-234 and uranium-238 activities in nestling samples collected around the Dual-Axis Radiographic Hydrodynamic Test (DARHT) Facility and from the background location located at Bandelier National Monument from 2017 to 2019. Data are compared with the regional statistical reference level (the mean plus 3 standard deviations of background concentrations; purple dashed line for uranium-234 and green dashed line for uranium-238) compared with the biota dose screening level for the generic plant as an ecological receptor (red dashed line for uranium-234 and gray dashed line for uranium-238). Note the linear scale on the vertical axis. Columns represent mean values and error bars represent standard deviation. Note: pCi/g = picocuries per gram.

Honey bees were analyzed for inorganic elements and radionuclides. The majority of inorganic elements were below the regional statistical reference level (Table S7-8) and no inorganic elements in honey bees are changing over time. Tritium, uranium-234, and uranium-238 were the only radionuclides that were detected (Table S7-8). No radionuclides are increasing in bees over time and uranium-238 was found to be decreasing over time (Kendall's Tau, $p < 0.05$). As only one sample from background is available, a regional statistical reference level could not be calculated; however, comparisons between the honey bee sample collected from the Dual-Axis Radiographic Hydrodynamic Test Facility were made with the honey bee sample collected from a background location. Uranium isotopes in the honey bee sample from the Dual-Axis Radiographic Hydrodynamic Test Facility were less than background and tritium levels were similar. All radionuclide activities were below the biota dose screening levels.

The honey sample was analyzed for inorganic elements, radionuclides (Table S7-8), high explosives, and PFAS. No radionuclides, high explosives, or PFAS were detected. Because only one honey sample from background is available for inorganic elements, a regional statistical reference level could not be calculated; however, comparisons between the honey sample collected from the Dual-Axis Radiographic Hydrodynamic Test Facility were made with the honey sample collected from a background location. The majority of inorganic elements were similar in concentrations and detection patterns (Table S7-8). No constituent levels found in honey collected near the Dual-Axis Radiographic Hydrodynamic Test Facility are of ecological concern.

Chemicals in Bird Eggs and Nestlings at Open Detonation and Open Burning Firing Sites

Bird eggs and nestlings are useful for monitoring chemicals, radionuclide exposures, and uptake in biological systems because different species occupy many trophic levels. Additionally, the collection of nonviable eggs and/or nestlings that die of natural causes is noninvasive and nondestructive to populations. Inorganic elements and organic chemicals can pose risks of adverse effects to birds if exposed at high enough concentrations (Jones and de Voogt 1999). Sources of inorganic elements include both releases from human activities and natural geological sources. Birds can be exposed through a number of routes including diet, ingestion of soil, drinking water, and inhalation. Avian nest boxes have been placed at two firing sites located at Technical Area 36 (Minie) and Technical Area 39 Point 6, and at the burning grounds located at Technical Area 16 for monitoring purposes. Inorganic elements (mostly metals), dioxins, and furans are of interest at open detonation firing sites (Minie and Technical Area 39) and at the burning grounds at Technical Area 16 (Fresquez 2011).

Nonviable eggs and nestlings that die from natural causes were collected and analyzed for chemicals. In 2019, weather conditions led to higher than usual numbers of nonviable eggs due to warm temperatures in the early spring and then a period of very cold temperatures. We collected 31 nonviable eggs on Laboratory property and 39 nonviable eggs at background locations located at Bandelier National Monument. Chemical concentrations were evaluated in 26 nonviable western bluebird and five nonviable mountain bluebird eggs that were collected from eight nest boxes at the Laboratory near the open detonation firing sites and near the burning grounds. Because of limited sample mass, nonviable eggs were evaluated for inorganic elements only. Results were compared with the regional statistical reference levels calculated from nonviable eggs of western bluebirds and ash-throated flycatchers (*Myiarchus cinerascens*) from background locations between 2016 and 2019 (n = 23 samples).

One deceased ash-throated flycatcher nestling was obtained from the Technical Area 16 open burning site in 2019. The nestling was collected from a nest box and had died of natural causes. The nestling was analyzed for dioxins, furans, and total PCBs. Results were compared with 2,3,7,8-tetrachlorodibenzodioxin toxic equivalents values and the regional statistical reference levels calculated from deceased nestlings of western bluebirds and ash-throated flycatcher nestlings from background locations between 2018 and 2019 (n = 4 samples). Nonviable egg and nestling results were also compared with the lowest observable adverse effect levels from peer-reviewed literature when available.

Results of Chemical Concentrations in Bird Eggs

The majority of inorganic elements were either not detected or were below the regional statistical reference levels in bird eggs collected from Technical Area 16 (six samples), Technical Area 36 (one sample), and Technical Area 39 (one sample; Table S7-9). Of the elements containing detectable concentrations in eggs collected from Technical Area 16, antimony, barium, and selenium were detected at concentrations above the regional statistical reference levels (Table S7-9). These results are described in detail below.

Two samples from Technical Area 16 contained barium concentrations (68 and 210 milligrams per kilogram; Table S7-9) that were above the regional statistical reference level of 31 milligrams per kilogram. Legacy barium in the canyon sediment is known to occur in the area and has been detected in water samples near Cañon de Valle (LANL 2003), which may suggest that birds may be exposed by direct ingestion of water and then the constituent was transferred to their eggs. No reliable screening levels are available for barium; thus, it is unknown at what concentrations adverse effects could be expected. However, of the nonviable egg samples collected at Technical Area 16 since 2016 (n = 17), only five of them contained concentrations above their respective regional statistical reference level. Additionally, percentages of eggs hatched in nest boxes at Technical Area 16 (n = 48) compared with nest boxes at background locations (n = 120) were not statistically different (Kruskal-Wallis test; $p > 0.05$). The hatching success in nest boxes at Technical Area 16 (n = 48) was 74.5 percent and was consistent with those reported previously for the area (Fair and Myers 2002). Barium did not have a negative impact on eggshell thickness when we compared data from Technical Area 16 (n = 40) and background locations (n = 54) from 2016 through 2019 (mixed-effects regression model; $p > 0.05$). These results suggest that adverse effects from barium at the population level is unlikely.

Antimony was detected slightly above the regional statistical reference level of 0.26 milligrams per kilogram in one sample from Technical Area 16 (0.27 milligrams per kilogram; Table S7-9). No reliable screening levels are available for antimony. One other sample at Technical Area 16 had levels of selenium (3.5 milligrams per kilogram) that exceeded the regional statistical reference level for selenium (3.3 milligrams per kilogram). Selenium is an essential micronutrient and needed by living organisms. The selenium concentration was far below 8.0 milligrams per kilogram, which is the lowest observable adverse effect level (Ohlendorf and Heinz 2011).

The overall results indicate that the levels of inorganic elements in the eggs of western and mountain bluebirds at the open detonation firing sites and at the burning grounds are not likely to cause adverse effects in breeding bird populations. Many constituents were not detected in the nonviable egg samples. Most constituents that were detected were below regional statistical reference levels, and all were below the lowest observable effect levels (when available).

Results of Chemical Concentrations in Bird Nestlings

Most dioxins and furans were not detected in the nestling sample collected from Technical Area 16. The sample contained detectable concentrations of 1,2,3,4,6,7,8,9-octachlorodibenzodioxin at 7.65 picograms per gram and 1,2,3,4,6,7,8-heptachlorodibenzodioxin at 4.08 picograms per gram, which exceeds the regional statistical reference levels of 2.42 picograms per gram and 1.48 picograms per gram, respectively. Lowest observable adverse effect levels are not available for each dioxin and furan congener. However, in eastern bluebird eggs, 2,3,7,8-tetrachlorodibenzodioxin, which is the most potent dioxin congener, induced toxic effects in concentrations between 1,000 to 10,000 picograms per gram wet weight (Harris and Elliott 2011). Toxic equivalent factors can be used to calculate the toxic equivalent values of dioxin-like compounds. The toxic equivalent factor for 1,2,3,4,6,7,8,9-octachlorodibenzodioxin for avian species is 0.0001 (Van den Berg et al. 1998); multiplying the detectable concentration of 7.65 picograms per gram by the toxic equivalency factor yields a value of 0.000765, which is many orders of magnitude less than the lowest observable adverse effect level for 2,3,7,8-tetrachlorodibenzodioxin seen in eastern bluebird eggs.

PCBs were detected at 0.0126 milligrams per kilogram and were above the regional statistical reference level of 0.0045 milligrams per kilogram. The lowest observable adverse effect level in avian eggs is 1.0 milligrams per kilogram (Harris and Elliott 2011). Thus, even though the PCB concentrations are higher than the regional statistical reference level, these levels are not expected to negatively impact the bird population.

Many constituents were not detected and most constituents were below regional statistical reference levels, lowest observable adverse effect levels, and toxic equivalents. These findings suggest that the detectable concentrations are not of ecological concern. More data are needed, including additional nestling samples from firing sites, to make robust assessments and to evaluate trends over time.

Biota Monitoring at Sediment and Flood-Retention Structures

The Laboratory has constructed flood- and sediment retention structures to reduce flood risks and to stop or slow the movement of sediments and associated chemicals and radionuclides off Laboratory property. Many chemicals and radionuclides in waste products adhere to soil and sediment particles. Storm water flows can transport these soil and sediment particles downstream in canyon bottoms.

The Los Alamos Canyon weir and the Pajarito Canyon flood-retention structure were built following the Cerro Grande fire in 2000. As part of an environmental analysis of actions taken in response to the Cerro Grande fire, DOE identified various measures to minimize impacts resulting from the fire (DOE 2000). One of the measures is monitoring soil, surface water, groundwater, and biota upstream of flood-control structures within sediment retention basins and within sediment traps to determine if constituent concentrations in these areas adversely affect plants or animals.

To this end, we collect native grasses and forbs and wild mice in the retention basins of the Los Alamos Canyon weir and the Pajarito Canyon flood-retention structure on an annual basis for environmental monitoring purposes.

We attempt to collect the following samples from each location annually: (1) a composite understory vegetation sample for radionuclide and inorganic element analyses; (2) a composite sample of approximately 100 grams of whole-body deer mice for radionuclide analyses; (3) three individual wild mice for inorganic elements analyses; and (4) three individual wild mice for PCB analysis. The following two sections report the 2019 results of this monitoring.

Los Alamos Canyon Weir

The Los Alamos Canyon weir is a water-control structure made of rock-filled wire cages called gabions. The weir was built in Los Alamos Canyon near the northeastern boundary of the Laboratory. The retention basin upstream of the weir covers more than one acre. Accumulated sediment was excavated from the retention basin in 2009, 2011, 2013, and 2014. Sediment excavated in 2009 was placed on the west side of the basin and stabilized, whereas sediment excavated in 2011, 2013, and 2014 was analyzed, placed on a plastic liner, contained within a berm, compacted, and seeded approximately 0.5 miles west of the weir in Los Alamos Canyon.

A composite understory vegetation sample was collected within the retention basin and submitted for radionuclide and inorganic element analyses in June 2019. Plants we collected include an unknown species of Brome grass (*Bromus sp.),* cheatgrass (*Bromus tectorum*), curly dock (*Rumex crispus)*, kochia (*Bassia scoparia*), lambsquarters (*Chenopodium album*), little sagebrush (*Artemisia arbuscula*), common mullein (*Verbascum thapsus*), mustard species (*Brassicaceae sp.*), rubber rabbitbrush (*Ericameria nauseosa*), redtop (*Agrostis gigantea*), tarragon *(Artemisia dracunculus),* yellow salsify (*Tragopogon dubius*), yellow sweetclover (*Melilotus officinalis*), thistle species (*Asteraceae sp*.), and vetch (*Fabacea sp.)*. Several inorganic elements were not detected in understory vegetation and all concentrations of elements were below the regional statistical reference levels (Table S7-10). Antimony, beryllium, selenium, and silver were found to be increasing over time (Kendall's Tau, $p < 0.05$); however, the percentage of nondetects in these vegetation samples is high, and therefore these trends are likely to be arbitrary. All other levels of inorganic elements in vegetation are not changing over time (Kendall's Tau, $p > 0.05$).

Most radionuclides in understory vegetation were either not detected or were below the regional statistical reference levels (Table S7-11). Strontium-90 was detected (3.81 picocuries per gram) above the regional statistical reference level of 3.18 picocuries per gram, but the level was far below biota dose screening levels (Table S7-11). Americium-241 and plutonium-239/240 activities vary from year to year but are not increasing over time (Kendall's Tau, $p > 0.05$; Figure 7-9). The high variability may be a result of disturbances due to soil excavation at the weir or due to sampling variability; plants are collected at different locations within the basin each year. In addition, because of high-runoff events and water ponding, the stems and leaves of the plants may retain different amounts of sediment each year; sediment on plant material can influence radionuclide results.

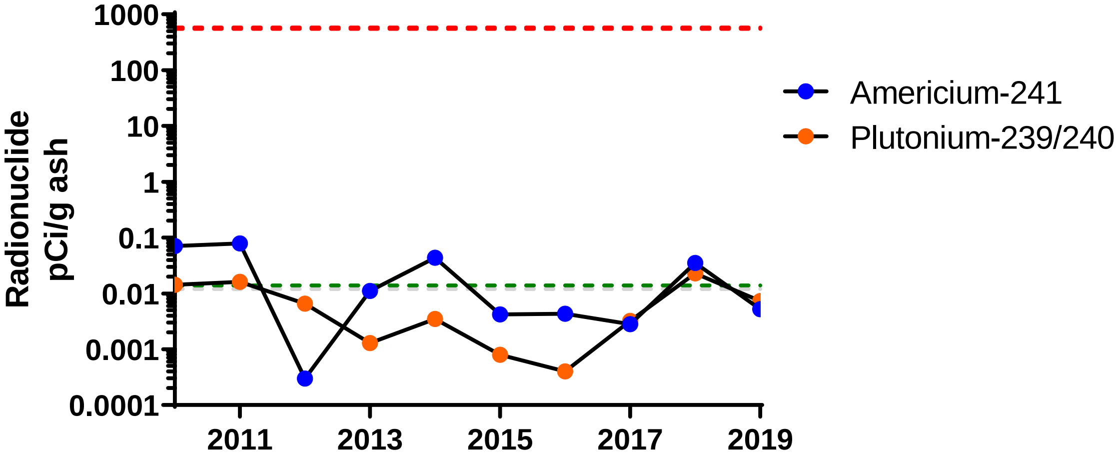


Figure 7-9. Americium-241 and plutonium-239/240 in understory vegetation collected on the upstream side (retention basin) of the Los Alamos Canyon weir from 2010 to 2019 compared with the biota dose screening level (red dashed line), and with the regional statistical reference level (green dashed line for americium-241 and gray dashed line for plutonium-239/240; the gray dashed line is underneath the green dashed line). Note the logarithmic scale on the vertical axis. Points represent true values; error bars are not available as only one sample was collected per year. Note: pCi/g = picocuries per gram.

Small mammals, such as wild mice, are ideal for monitoring chemicals and radionuclide exposures and uptake in biological systems because of their close contact with soil, burrowing behavior, and their omnivorous diets (Smith et al. 2002, Talmage and Walton 1991). Small mammals were collected from the retention basin in June 2019 using Sherman® live traps. All animal handling procedures were approved by LANL's Institutional Animal Care and Use Committee. We captured one individual Mexican woodrat (*Neotoma mexicana*) for radionuclide analyses, one individual deer mouse and two individual western harvest mice (*Reithrodontomys megalotis*) for inorganic element analyses, and three individual deer mice for PCB congeners.

Most radionuclides in small mammals were either not detected or were below the regional statistical reference levels (Table S7-12). Plutonium-239/240 was detected (0.0179 picocuries per gram) above the regional statistical reference level of 0.0128 picocuries per gram and was also well below the biota dose screening level (Table S7-12). Strontium-90 was detected (3.43 picocuries per gram) above the regional statistical reference level of 0.432 picocuries per gram; however, it was far below the biota dose screening level (Table S7-12). Interestingly, strontium-90 activity in small mammals is decreasing over time from 2010 through 2019 (Kendall's Tau, $p < 0.05$, Figure 7-10). No other radionuclides are changing over time.

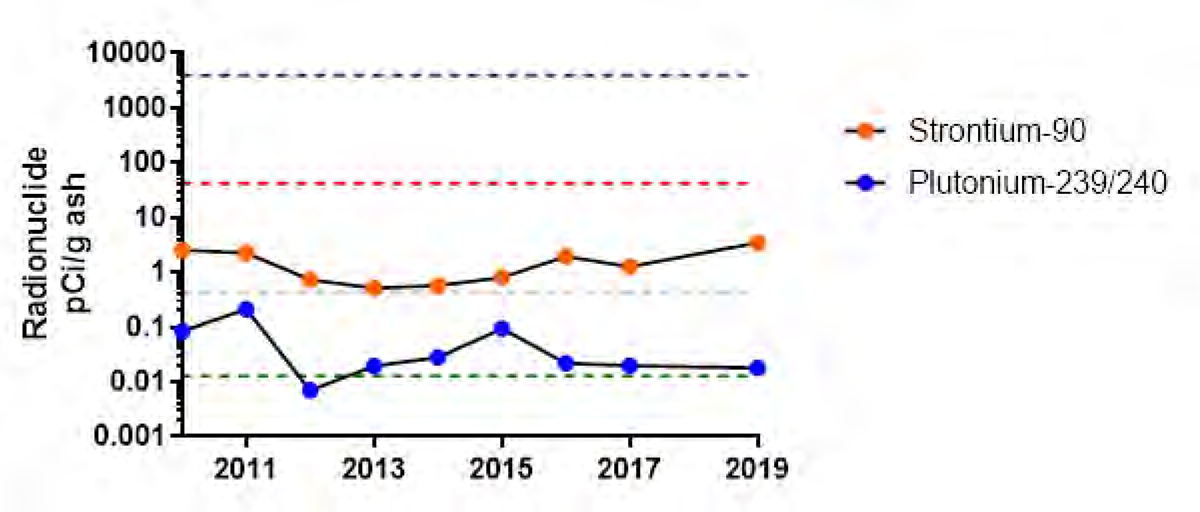


Figure 7-10. Strontium-90 and plutonium-239/240 in small mammals collected on the upstream side (retention basin) of the Los Alamos Canyon weir from 2010 to 2019 compared with the biota dose screening level (red dashed line for plutonium-239/240 and purple dashed line for strontium-90), and with the regional statistical reference level (green dashed line for plutonium-239/240 and gray dashed line for strontium-90). Note the logarithmic scale on the vertical axis. Points represent true values; error bars are not available as only one sample was collected per year.
Note: pCi/g = picocuries per gram.

Results of inorganic element analyses in whole-body small mammals are in Table S7-13. Many elements were detected in small mammals and concentrations of mercury and selenium slightly exceeded the regional statistical reference levels. Most inorganic elements were not changing over time; however, antimony, cadmium, silver, and zinc were increasing (Kendall's Tau, $p < 0.05$). Zinc has shown an increasing trend in previous years that could suggest this is a true trend and not a result of environmental variability (Figure 7-11). Although zinc is increasing over time, the overall concentration is similar to or below the regional statistical reference level and thus is not of ecological concern. The increasing trends of antimony, cadmium, and silver are likely arbitrary as cadmium and silver were not detected in small mammals in 2019 and antimony was only detected in one of three individuals. These trends will continue to be monitored in the future.

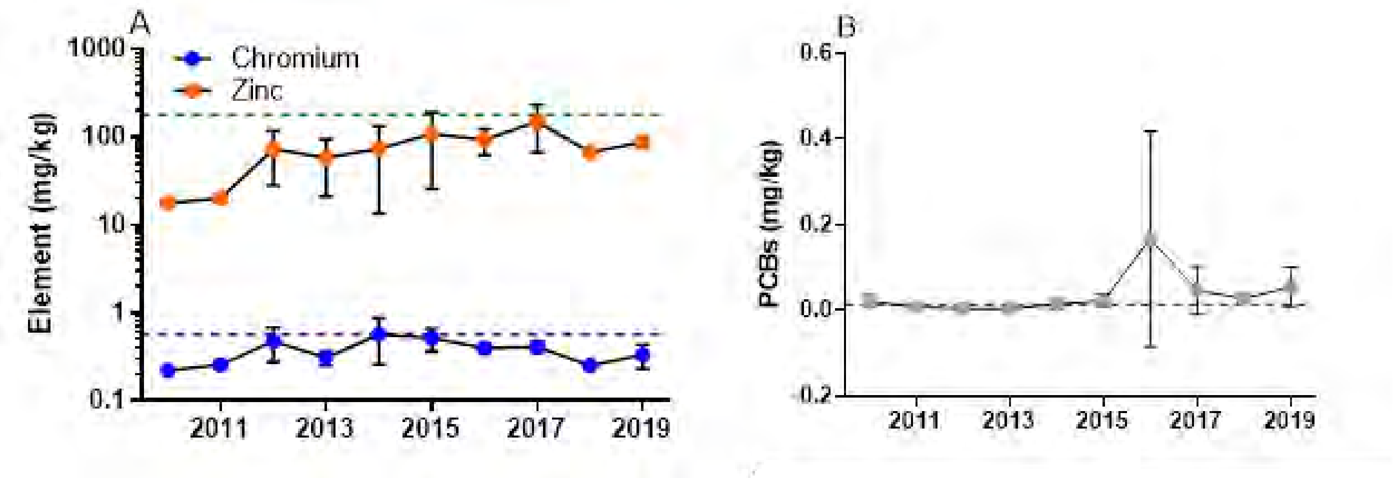


Figure 7-11. (A) Chromium and zinc and (B) PCB concentrations in individual whole-body mice samples collected upstream (in the retention basin) of the Los Alamos Canyon weir from 2010 to 2019 compared with the regional statistical reference level (mean plus 3 standard deviations of small mammals collected from background locations; green dashed line for zinc and PCBs; purple dashed line for chromium). Note vertical axis is a logarithmic scale for chromium and zinc and a linear scale for PCBs. Points represent true values or the mean when multiple results were available; error bars represent standard deviation. Note: mg/kg = milligrams per kilogram.

PCBs were detected in three deer mice collected upstream from the Los Alamos Canyon weir at concentrations of 0.018, 0.039, and 0.107 milligrams per kilogram. These values were higher than the regional statistical reference level of 0.013 milligrams per kilogram (Table S7-14). All concentrations observed here are 2 orders of magnitude below the lowest observable adverse effect level observed in mice (2.5 milligrams per kilogram) reported from PCB-contaminated sites where wild mouse populations were negatively affected (Batty et al. 1990). Thus, these levels are not expected to negatively affect the wild mouse population near the retention basin.

The levels of PCBs in small mammals collected from the upstream side of the retention basin are increasing over time (Kendall's Tau, $p < 0.05$; Figure 7-11). The variability in PCB concentrations may be related to the removals of sediment from the basin between 2009 and 2014 and accumulation of sediment since that time.

Pajarito Canyon Flood-Retention Structure

The Pajarito Canyon flood-retention structure is located upstream of Technical Area 18. The structure extends 390 feet across the canyon and is about 70 feet high. The bottom of the retention structure is equipped with one 42-inch-diameter drainage culvert, which allows storm water to drain. Accumulated water is retained no longer than 96 hours behind the retention structure; water drains naturally into the existing streambed.

In June 2019, a composite understory vegetation sample was collected on the upstream side of the Pajarito Canyon flood-retention structure and analyzed for radionuclides and inorganic elements. Plants we collected include bottlebrush squirreltail (*Elymus elymoides*), cheatgrass (*Bromus tectorum*), curly dock (*Rumex crispus*), field bindweed (*Convolvulus arvensis*), Canadian horseweed (*Erigeron canadensis*), lambsquarters (*Chenopodium album*), common mullein (*Verbascum thapsus*), mustard species

(*Brassicacecae* sp.), orchardgrass (*Dactylis glomerata*), redtop (*Agrostis gigantea*), ryegrass (*Lolium perenne*), and yellow sweetclover (*Melilotus officinalis*). Results from analysis of the composite vegetation sample show that all radionuclides were either not detected or were below the regional statistical reference levels, and all radionuclide activities were below the biota dose screening level (Table S7-15). No trends over time in radionuclide activities in vegetation collected upstream of the Pajarito Canyon flood-retention structure were observed from 2009 to 2019 (Kendall's Tau, $p > 0.05$).

Several inorganic elements were not detected in the composite vegetation sample, and all elements, except for lead, were below the regional statistical reference level (Table S7-16). Lead was detected in the vegetation sample at 1.90 milligrams per kilogram, which was slightly above the regional statistical reference level of 1.27 milligrams per kilogram, but is far below the levels that are considered toxic to plants (LeFebvre 2016). Beryllium and selenium were found to be increasing in vegetation over time (Kendall's Tau, $p < 0.05$); however, the percentage (65–91 percent) of nondetects in these vegetation samples are high, and therefore these increasing trends are likely to be arbitrary.

Small mammals were also collected from the Pajarito Canyon flood-retention structure in June 2019. Small mammals were captured using Sherman® live traps. All animal handling procedures were approved by LANL's Institutional Animal Care and Use Committee. We captured four brush mice (*Peromyscus boylii*) and one deer mouse that we composited for radionuclide analyses, one individual deer mouse and two individual western harvest mice were used for inorganic element analyses, and one deer mouse and two individual brush mice were used for PCB congener analysis.

Most radionuclides were either not detected or were below the regional statistical reference levels in the composite mouse sample (Table S7-17). Strontium-90 was observed at 0.629 picocuries per gram, which was above the regional statistical reference level of 0.432 picocuries per gram, but is well below the biota dose screening level and therefore not of ecological concern. Additionally, no radionuclides are changing over time (Kendall's Tau, $p > 0.05$).

Most inorganic element concentrations in whole-body mice were detected and were below the regional statistical reference levels (Table S7-18). Chromium and zinc exceeded the regional statistical reference level in the deer mouse. Most inorganic elements in wild mice are not changing over time; however, in 2019, trends of increasing chromium and lead were observed and were consistent with 2018; zinc continues to increase over time (Kendall's Tau, $p < 0.05$, Figure 7-12). As the majority of these constituents are below the regional statistical reference levels and because chromium and zinc are essential minerals, these observations are not of ecological concern. Trends over time will continue to be monitored.

PCBs were detected in all three individuals (Table S7-19) collected upstream of the Pajarito Canyon flood-retention structure. The deer mouse sample contained PCBs at a concentration of 0.0185 milligrams per kilogram, which was above the regional statistical reference level of 0.0129 milligrams per kilogram but is 2 orders of magnitude below the lowest observable adverse effect level observed in mice (2.5 milligrams per kilogram) reported from PCB-contaminated sites where wild mouse populations were negatively affected (Batty et al. 1990). Thus, the current PCB levels are not expected to negatively affect the wild mouse population near the retention basin. Additionally, PCB concentrations in whole-body wild mice collected upstream of the Pajarito Canyon flood-retention structure are not changing over time (Kendall's Tau, $p > 0.05$; Figure 7-12).

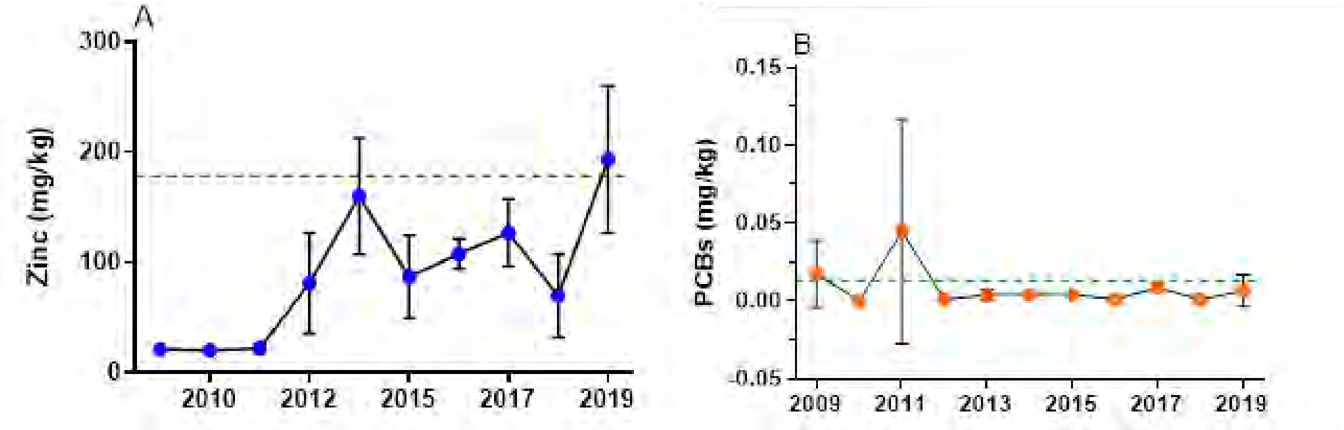


Figure 7-12. (A) Zinc and (B) PCB concentrations in individual whole-body mouse samples collected upstream (in the retention basin) of the Pajarito Canyon flood-retention structure from 2009 to 2019 compared with the regional statistical reference level (mean plus 3 standard deviations of small mammals collected from background locations, green dashed line). Note the vertical axis is linear. Points represent the mean. Error bars represent standard deviation. Note: mg/kg = milligrams per kilogram.

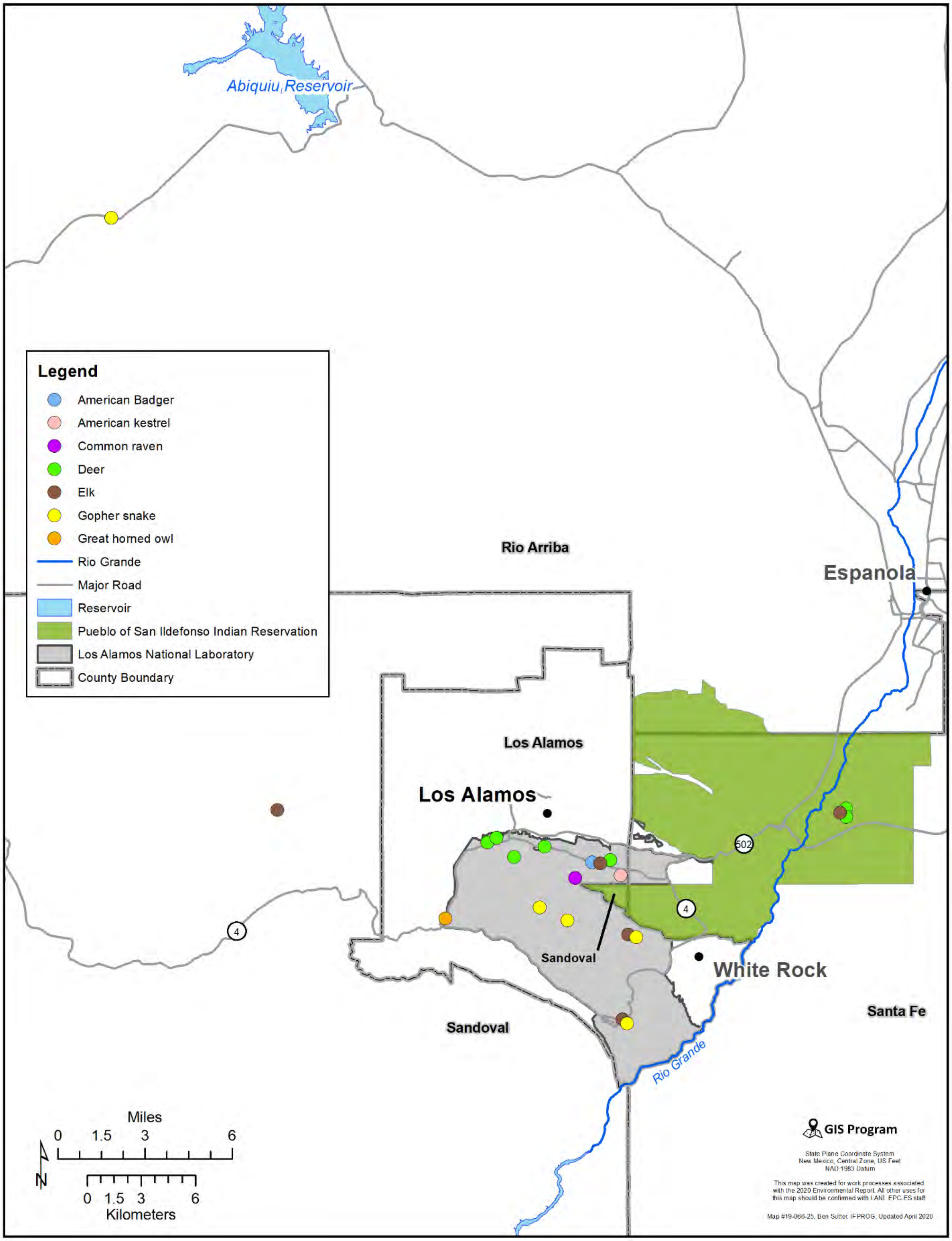
Large Animal Monitoring

Monitoring Network

The environmental monitoring and surveillance program has opportunistically collected road-killed mule deer (*Odocoileus hemionus*) and elk (*Cervus canadensis*) from onsite, perimeter, and background sites since the 1970s (LASL 1973). To date, the program has collected and analyzed approximately 55 deer and 60 elk.

In 2015, the program expanded and began collecting other species including mountain lion (*Puma concolor*), bobcat (*Lynx rufus*), black bear (*Ursus americanus*), coyote (*Canis latrans*), gray fox, great horned owl (*Bubo virginianus*), western screech-owl (*Megascops kennicottii*), red-tailed hawk (*Buteo jamaiciensis*), gopher snake (*Pituophis catenifer*), and more that were killed by vehicles or by other accidents.

In 2019, we collected seven mule deer, five elk, one American badger (*Taxidea taxus*), six gopher snakes, two common ravens (*Corvus corax*), one American kestrel (*Falco sparverius*), and one great horned owl from onsite, perimeter, and background locations (Figure 7-13). The majority of animals collected were casualties of vehicle strikes, although others came from different sources, such as hunter donations and animals that had died of electrocution or by drowning. Animal tissue samples were analyzed for concentrations of radionuclides, inorganic elements, PCBs, and some of the animals were analyzed for PFAS. Leg muscle and leg bone were harvested from the deer, elk, and badger; muscle was analyzed for radionuclides, inorganic elements, PCBs, and PFAS, and bone was analyzed for radionuclides. Unwashed whole-body birds (feathers included) and snakes were analyzed for all constituents.



State Plane Coordinate System
New Mexico, Central Zone, US Feet
NAD 1983 Datum

This map was created for work processes associated with the 2020 Environmental Report. All other uses for this map should be confirmed with LANL EPC-ES staff

Map #19-066-25, Ben Sutter, IFPROG, Updated April 2020

Figure 7-13. Locations of animals collected opportunistically from within and around the Laboratory in 2019

Radionuclide Monitoring in Large Animals

Most radionuclides in deer and elk (muscle and bone) were either below the minimum detectable activity (most results) or below the regional statistical reference levels. Strontium-90 in one perimeter elk muscle sample (0.1030 picocuries per gram) exceeded the regional statistical reference level of 0.0746 picocuries per gram (Tables S7-20 and S7-21). Radionuclide levels are not changing over time in either deer or elk muscle or bone collected onsite. Levels are also not changing in muscle or bone in deer collected from perimeter locations (Kendall's Tau, $p > 0.05$). Too few elk samples from perimeter locations were available for trend analyses ($n = 2$). These data are similar to previous years.

Most radionuclides in gopher snakes were not detected or were below the regional statistical reference level (Table S7-22). Tritium levels (2.73 and 8.21 picocuries per milliliter) in two gopher snakes collected onsite exceeded the regional statistical reference level of 2.13 picocuries per milliliter, but all levels of radionuclides were below the biota dose screening levels. However, the regional statistical reference level is based on a small sample size ($n = 2$) and more data from background locations are needed to make robust assessments.

All radionuclides were either not detected or were below the regional statistical reference level in the badger (Table S7-23). Most radionuclides in birds were not detected or were below the regional statistical reference levels (Table S7-23). Similar to gopher snakes, three birds collected onsite contained tritium levels (range 2.29 to 4.47 picocuries per milliliter) that were above the regional statistical reference level of 0.4481 picocuries per milliliter. The regional statistical reference level for birds is also based on a small sample size ($n = 2$), and more data from background locations are needed to make robust assessments. Levels of radionuclides observed in all animals were below the biota dose screening level, which is protective of biota.

Inorganic Elements in Large Animals

Most inorganic elements in deer were below the regional statistical reference levels. Aluminum, antimony, barium, cadmium, calcium, lead, manganese, nickel, and silver were higher than the regional statistical reference levels in one or more of the deer. All inorganic elements observed in elk, except for manganese in one elk, were below the regional statistical reference levels (Tables S7-24 and S7-25). Antimony is increasing in both deer and elk collected onsite (Kendall's Tau, $p < 0.05$) and was above the regional statistical reference level. Currently there is no reliable lowest observable adverse effect level for antimony in ungulates. These trends will continue to be monitored. Silver is also increasing over time in deer collected onsite; however, silver was not detected in 86 percent of samples, and nondetects could be affecting this observation. Zinc is increasing in deer collected from perimeter locations (Kendall's Tau, $p < 0.05$); however, the majority of samples contain zinc concentrations that are below the regional statistical reference level and thus are not of concern. Too few elk samples are available from perimeter locations to conduct trend analyses of inorganic elements ($n = 4$).

Several inorganic elements were not detected in gopher snakes and most detections were below the regional statistical reference levels (Table S7-26). Iron concentrations in two snakes (90 and 112 milligrams per kilogram) were detected above the regional statistical reference level of 69 milligrams per kilogram. In birds, one raven and the great horned owl contained levels of iron, magnesium, manganese, silver, and/or vanadium that were above the regional statistical reference level (Table S7-27). However, as many of these elements are essential elements, they are unlikely to cause adverse effects to the population level at the concentrations observed here. Additionally, as previously mentioned, the regional statistical reference levels for these groups of animals are based on small sample sizes, and more data are needed to make robust assessments. Inorganic element analyses were requested on the badger; however, the sample was inadvertently ashed for radionuclide analyses before inorganic element analyses. The analyses were not conducted following the ashing as we need inorganic element results reported on a wet weight basis for meaningful comparisons.

PCB Monitoring in Large Animals

PCBs were detected in all animal samples. Deer PCB concentrations ranged from 0.000016 to 0.000734 milligrams per kilogram and elk concentrations ranged from 0.0000067 to 0.00048 milligrams per kilogram; most concentrations were above the regional statistical reference levels of 0.000017 and 0.000021 milligrams per kilogram, respectively (Tables S7-28 and S7-29). Our observations in both deer and elk are well below the U.S. Food and Drug Administration standard of 3 milligrams per kilogram for red meat consumption by humans (U.S. Food and Drug Administration 1987). Total PCBs are not changing over time in deer or elk muscle collected onsite or in deer muscle collected from perimeter locations (Kendall's Tau, $p > 0.05$). Too few elk samples from perimeter locations were available for trend analyses ($n = 3$).

PCBs were detected in all gopher snakes and ranged from 0.000793 to 0.00271 milligrams per kilogram and all were above the regional statistical reference of 0.000474 milligrams per kilogram (Table S7-30). In birds, PCBs ranged from 0.024 to 0.642 milligrams per kilogram and all, except for the great horned owl, were below the regional statistical reference level of 0.1001 milligrams per kilogram (Table S7-31). PCB concentrations are typically higher in predator species, such as the owls reported here, because these organic chemicals are lipophilic (absorbed by fats) and increase in concentration in animals that eat other animals (Eisler and Belisle 1996, Hornbuckle et al. 2006). The lowest observable adverse effect level of PCBs is between 1 and 30 milligrams per kilogram in avian eggs and 2 to 4 milligrams per kilogram in avian adult plasma (Harris and Elliott 2011). All levels observed here are well below the lowest observable adverse effect level for birds. The total PCB concentrations in all animals monitored and reported here are overall quite low, and while there are not specific lowest observable adverse effect levels of PCBs for deer, elk, snakes, and badgers, adverse effects in other animals are not observed until concentrations are above 1 milligram per kilogram (Batty et al. 1990, Harris and Elliott 2011).

Per- and Polyfluoroalkyl Substances Monitoring in Large Animals

A total of 14 animal tissue samples were analyzed for 14 PFAS compounds. Samples collected onsite include one American kestrel, two common ravens, one great horned owl, four gopher snakes, and three mule deer. Samples collected from background locations include two gopher snakes and one elk. The majority of PFAS (14 chemicals analyzed in the 14 samples) were not detected (88 percent) in biological samples and nearly half of the samples did not contain any detectable concentrations of PFAS. Perfluorooctanesulfonic acid was the most commonly detected PFAS among animals; bird species had the greatest frequency of detections compared with snakes or ungulates (Tables S7-32 through S7-34). Three of the six snakes (two from onsite and one from background) contained only perfluorooctanesulfonic acid. Onsite snakes contained 1.65 to 1.97 nanograms per gram and the background snake contained 0.60 nanograms per gram. In ungulates, two deer from onsite and the elk from background did not contain any detectable levels of PFAS. One deer collected at LANL contained 0.40 nanograms per gram of perfluorohexanoic acid.

The bird species contained the greatest frequency of detects ranging from three to eight PFAS per individual. All birds contained perfluorooctanesulfonic acid at levels that ranged from 1.97 to 6.34 nanograms per gram. The American kestrel and one of the common ravens also contained detectable concentrations of perfluorooctanoic acid (0.37 and 0.93 nanograms per gram, respectively) and perfluorohexanesulfonic acid (0.55 and 3.35 nanograms per gram, respectively). At this time, there is no data available on PFAS levels in birds from background locations.

The highest concentrations and the greatest frequency of detects were observed in the common raven (n = 8) and could be explained by diet. Common ravens are omnivores and consume garbage, which could contain fast food wrappers manufactured with PFAS. The great horned owl (n = 5) also contained a higher number of detections of PFAS when compared with other species. This observation may also be explained by diet. Some PFAS are known to bioaccumulate and biomagnify in the food chain; therefore, a top predator, such as the great horned owl, could have greater concentrations when compared with species lower on the food chain.

Some detections of PFAS in biological samples may be explained by false positives, which is when the test results indicate PFAS are present in a sample when they actually are not. As PFAS have such low concentrations for their detection limits and due to their prevalence in common consumer products, false positive detection can occur during investigations. The bird and snake samples, for example, were collected and submitted as whole-body samples and therefore could have had external PFAS contamination from the road or from the vehicle that struck it. Muscle tissue was collected from deer and elk samples and overall had fewer detections than bird and snake samples. Collecting internal tissues from all animals may reduce or eliminate potential false positives from external sources and provide data that are more comparable.

Our observations are within the ranges of PFAS concentrations observed in animal tissues from published studies, including studies that occurred away from point source pollution and in the Antarctic where global fallout is the primary source of PFAS in the environment (Aas et al. 2014, Bossi et al. 2015). As PFAS are recently emerging chemicals of concern, little is known about wildlife tissue concentrations and their relation to adverse effects. Long-term monitoring around the site could help determine whether Laboratory operations are affecting PFAS chemicals in biological tissues, as well as monitoring at background locations to allow for comparisons.

BIOLOGICAL RESOURCES MANAGEMENT PROGRAM

We monitor migratory bird species and federally listed threatened or endangered species, and provide guidelines and requirements for Laboratory operations to protect these species and comply with laws and regulations.

Breeding Season Bird Capture and Banding at the Sandia Wetlands

We have been operating a bird banding station in the Sandia Canyon wetlands since 2014. This wetlands contains primarily broadleaf cattail (*Typha latifolia*), lanceleaf cottonwood (*Populus acuminata*), narrowleaf willow (*Salix exigua*), and Russian olive (*Elaeagnus angustifolia*) (N3B 2019). The purpose of the study is to monitor the species, age, breeding status, and return rates of songbirds using the area around the wetlands.

Beginning in May each year, we operate the bird banding station following a protocol called Monitoring Avian Productivity and Survivorship (DeSante 1992) administered by the Institute for Bird Populations. Use of the Monitoring Avian Productivity and Survivorship protocol is a continent-wide collaborative effort among public agencies, nongovernmental groups, and individuals. Following a standard protocol where methods are the same at every site provides data that can be compared among sites.

During banding sessions, we deploy 12 mist nets that are 12-meters long with 30-millimeter mesh webbing in and around the wetlands. A standard U.S. Fish and Wildlife Service numbered band is put on each captured bird. All birds are identified, aged, sexed, weighed, measured, fat scored, and checked for signs of molt. We use the aging and sexing criteria provided in Pyle (1997).

A total of 1,311 birds representing 72 species were captured during the breeding seasons of 2014 through 2019. In 2019 alone, we captured 217 birds representing 34 species. The most commonly captured bird at this site is the song sparrow (*Melospiza melodia*). The second most commonly captured species in 2019 was the spotted towhee (*Pipilo maculatus*). The Sandia wetlands support numerous species of breeding birds, including species of conservation concern.

Data from 2014–2019 were analyzed for population and community changes (Stanek et al. 2020). The overall numbers of birds and species captured were variable among years. We did not see any decreases in bird species diversity, abundance, or the percentage of birds breeding during the study period. We also did not see a declining population trend for the top 10 most-captured species or for any of the species of conservation concern over time. Our recapture rates for adults in successive years at the Sandia wetlands are low when compared with estimated adult survival in migratory passerines from peer-reviewed literature (Stanek et al. 2020). We need more years of data to make robust conclusions about population trends through time.

Fall Bird Migration Capture and Banding at Pajarito Wetlands

Biologists at the Laboratory also document fall migration patterns of birds on Laboratory property. During the fall of 2019, we completed the tenth year of monitoring fall migration songbirds. Songbirds were captured at a mist-netting station located in a wetland and riparian complex in Technical Area 36 on the north side of Pajarito Road.

The fall banding station used 14 mist nets that were 12-meters long with 30-millimeter mesh. After a bird was extracted from the mist net, a standard U.S. Fish and Wildlife Service numbered band was put on each bird. All birds were identified, aged, sexed, weighed, measured, fat scored, and checked for signs of molt. The aging and sexing criteria were based on Pyle (1997).

In 2019, 1,375 birds representing 51 species were banded. The number of nets and banding days in 2019 did not change from previous years, yet the number of birds banded was almost three times the previous highest total, which was 474 in 2010. The number of birds banded was unprecedented and the reasons for the increase are unclear. There were 482 chipping sparrows (*Spizella passerina*) captured in 2019, which alone is higher than the previous best year with all species combined. Other seed eaters were also unusually high in number such as the lesser goldfinch (*Spinus psaltria*), Brewer's sparrow (*Spizella breweri*), Lincoln's sparrow (*Melospiza lincolnii*), and house finch (*Haemorhous mexicanus*). Aerial insectivores such as the ruby-crowned kinglet (*Regulus calendula*), orange-crowned warbler (*Leiothlypis celata*), and Virginia's warbler (*Leiothlypis virginiae*) were also captured in increased numbers. Capture rates at another local bird banding station at Bandelier National Monument were not elevated as observed at the LANL station (unpublished data). More years of data are required to determine if this was an unusual eruptive bird year or if numbers are starting to climb overall.

Threatened and Endangered Species Surveys

In 2019, surveys were completed for three species protected under the Endangered Species Act—the Mexican spotted owl (*Strix occidentalis lucida*), southwestern willow flycatcher (*Empidonax trailii extimus*), and Jemez Mountains salamander (*Plethodon neomexicanus*).

Mexican spotted owl

The Mexican spotted owl generally inhabits mixed conifer, ponderosa pine (*Pinus ponderosa*), and gambel oak (*Quercus gambelii*) forests in mountains and canyons (U.S. Fish and Wildlife Service 2012). Mexican spotted owls in the Jemez Mountains of northern New Mexico prefer cliff faces in canyons for their nest sites (Johnson and Johnson 1985).

Under the Laboratory's Threatened and Endangered Species Habitat Management Plan, Mexican spotted owl habitat has been identified based on a combination of cliff habitat and forest characteristics (LANL 2017b). Mexican spotted owl habitats are called areas of environmental interest at LANL. Currently, there are five Mexican spotted owl areas of environmental interest at the Laboratory that span seven canyons.

Surveys for breeding Mexican spotted owls are conducted every year in all areas of environmental interest. In 2019, we detected Mexican spotted owls in the Mortandad-Sandia and Threemile Canyon areas of environmental interest. These two sites have had Mexican spotted owls in previous years (Thompson et al. 2019).

Southwestern willow flycatcher

The Southwestern willow flycatcher is found in close association with dense stands of willows, arrowweed (*Pluchea* sp.), buttonbush (*Cephalanthus occidentalis*), tamarisk (*Tamarix*), Russian olive, and other riparian vegetation, often with a scattered overstory of cottonwood (U.S. Fish and Wildlife Service 2002).

Under the Laboratory's Threatened and Endangered Species Habitat Management Plan, southwestern willow flycatcher habitat has been identified based on the presence of riparian habitat with suitable wetland vegetation (LANL 2017b). There is only one area of environmental interest for the southwestern willow flycatcher at the Laboratory, located in the bottom of Pajarito Canyon. The survey results in 2019 were all negative for the southwestern willow flycatcher (Thompson et al. 2019).

Jemez Mountains salamander

The Jemez Mountains salamander occurs predominantly at elevations between 7,000 and 11,000 feet in mixed-conifer and spruce-fir forests, consisting primarily of Douglas fir (*Pseudotsuga menziesii*), blue spruce (*Picea pungens*), Engelmann spruce (*Picea Engelmannii*), white fir (*Abies concolor*), limber pine (*Pinus flexilis*), ponderosa pine, Rocky Mountain maple (*Acer glabrum*), and aspen (*Populus tremuloides*) (Degenhardt et al. 1996).

Under the Laboratory's Threatened and Endangered Species Habitat Management Plan, Jemez Mountains salamander habitat has been identified based on a geographical information systems analysis and a field-validated inspection of suitable habitat components (LANL 2017b). Currently, there are five Jemez Mountains salamander areas of environmental interest at the Laboratory that span four canyons. Surveys are conducted when suitable environmental conditions are met. Surveys were only conducted in one of the Los Alamos Canyon areas of environmental interest in 2019 due to suitable environmental conditions existing for a short window of time. Surveys were negative for the Jemez Mountains salamander (Thompson et al. 2019).

Bird Monitoring at Open Detonation and Open Burning Firing Sites

An annual bird population monitoring program was started in 2013 as part of a Resource Conservation and Recovery Act permitting process for two open detonation firing sites and one open burning site. Open detonation sites are locations at the Laboratory where explosives are set off. The open burning site is a facility where materials are ignited for self-sustained combustion (for example, to remove residues of high explosives). The two open detonation sites included in the permitting process are Technical Area 36 (Minie) and Technical Area 39 Point 6; the open burning site is the Technical Area 16 Burning Ground. Together these are referred to as the treatment sites (Hathcock and Fair 2013; Hathcock 2014; 2015; Hathcock et al. 2017; 2018, 2019). The ongoing objective of the population monitoring is to determine whether Laboratory operations at these sites impact bird species richness (the number of different species present), species diversity (a combination of the number of species present and their relative abundance), or composition (the presence or absence of each individual species).

Biologists at the Laboratory use point count methodology to record the birds present along transects at the three treatment sites and compare the results to surveys conducted in similar habitat types in less developed areas (control sites). Summer surveys provide information about which birds are breeding at each site. The habitat type at Technical Area 36 (Minie) and Technical Area 39 is a two-needle piñon pine (*Pinus edulis*) and one-seed juniper woodland habitat referred to as piñon-juniper. The habitat type at Technical Area 16 is a ponderosa pine forested habitat referred to as ponderosa pine.

A total of 853 birds representing 53 species were recorded at the three treatment sites combined in 2019 (Hathcock et al. 2020). The species richness and diversity at the treatment sites were not statistically different from their associated controls. Rarefaction and extrapolation plots for 2013 through 2018 suggest that over time the species diversity was statistically different between treatments and controls, although the diversity was higher at the treatment sites than the control sites. Avian abundance showed more variability, but treatment and controls have the same trends year to year.

During the 2019 nesting season, 15 nest boxes at each treatment site were actively monitored. The overall avian nest box network, excluding the three treatment sites, contained 378 nest boxes in 2019. Of those, 167 contained active nests and 85 of those nests fledged young successfully. This was an overall occupancy rate of 44 percent with a 51 percent success rate. In 2019, there were four successful nests that fledged young at Technical Area 36 (Minie), zero at Technical Area 39, and seven at Technical Area 16. Both occupancy and success rates at Technical Area 39 were low in comparison with the other treatment sites and the overall network. Technical Area 39 is the lowest elevation treatment site and occupancy has been decreasing over time at both this site and other areas of the avian nest box network at a similar elevation. Wysner et al. (2019) found that western bluebirds, one of the target species of the network, have increased the elevation they select for nesting over time in the study area, which may be affecting use of the lower-elevation sites. Occupancy and success rates at the other two treatment sites seem to be fluctuating in the same manner as the overall network and have not displayed a decreasing trend over time.

The results from 2019 continue to indicate that operations at the three treatment sites are not negatively affecting bird populations.

BIOTA RADIATION DOSE ASSESSMENT

Introduction

The purpose of the biota radiation dose assessment is to ensure that plant and animal populations are protected from the effects of Laboratory absorbed radioactive materials as required by DOE Order 458.1. This assessment follows the guidance of the DOE standard, "A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota" (DOE 2019), and uses the DOE dose calculation program, RESRAD-BIOTA version 1.8.

Previous biota dose assessments were reported in the Annual Site Environmental Reports and concluded that biota doses for populations at the Laboratory are well below the DOE limits of 1 rad/day for terrestrial plants and aquatic animals and 0.1 rad/day for terrestrial animals (DOE 2019).

Plants receive doses from external radiation and receive internal doses from radionuclides taken up through their roots, which in some cases penetrate material buried in material disposal areas. Animals also receive external dose, and in addition, receive internal dose when they eat the plants. When a predator eats its prey, there is a possibility for bioaccumulation as the ingested material passes up the food chain. Bioaccumulation is accounted for by introducing "bioaccumulation factors" or "concentration ratios," which are the ratios of the radionuclides in living tissue to the concentrations in the underlying soil or water.

The well-established concentration ratios provide the option of calculating estimates of the levels in living tissue from the measured levels in soil. Alternatively, the concentration ratios can be used to calculate estimates of the levels in soil from measured levels in biota tissue. The comparison of these two methods shows that in most cases, results calculated using the concentration ratios are conservative overestimates of dose.

The biota doses reported below are calculated using site-representative values as described in Appendix F of DOE-STD-1153-2019 (DOE 2019). Whenever the data allow alternative calculations of the dose from either soil or tissue data, the largest dose is reported.

The material potentially contributing to the biota doses at the Laboratory is legacy waste material. Ongoing remediation and radioactive decay result in decreasing concentrations, so a generally decreasing trend in biota doses is expected. However, ongoing operations and movement of soil or sediment may cause an accumulation of radioactive material, so key locations are re-assessed annually.

What is a rad?

"Rad" is an acronym for <u>r</u>adiation <u>a</u>bsorbed <u>d</u>ose. A dose of 1 rad means that 1 gram of material absorbed 100 erg of energy as a result of exposure to ionizing radiation. One rad is the same as 0.01 gray. Different materials that receive the same exposure may not absorb the same amount of radiation.

Mesa-Top Facilities

Area G

This chapter reports new measurements of soil and vegetation around Material Disposal Area G, known as "Area G." The results are generally comparable with previous years, although there is some year-to-year variation depending on the exact locations sampled. This year-to-year variation can be seen in the trend graphs of this chapter. As recommended by DOE-STD-1153-2019 (DOE 2019), this assessment uses the highest measured concentrations, and the resulting doses are reported in Tables 7-1 and 7-2.

Table 7-1. Dose to Terrestrial Animals at Area G for 2019
DOE Limit: 0.1 rad/day for Terrestrial Animals

Nuclide	External		Internal		Nuclide Total (rad/day)
	Water (rad/day)	**Soil (rad/day)**	**Water (rad/day)**	**Soil (rad/day)**	
Am-241	5.7E-10	5.7E-06	1.9E-07	4.4E-05	5.0E-05
Cs-137	3.0E-08	3.0E-05	2.2E-07	1.9E-06	3.2E-05
H-3	1.1E-04	2.2E-04	2.2E-04	2.2E-04	7.7E-04
Pu-238	2.0E-10	8.0E-07	4.2E-07	2.9E-05	3.0E-05
Pu-239	8.7E-11	3.5E-07	3.1E-07	2.0E-05	2.0E-05
Sr-90	1.4E-07	8.5E-06	8.9E-06	3.4E-05	5.2E-05
U-234	7.3E-09	7.3E-07	5.5E-06	2.1E-05	2.7E-05
U-235	1.8E-08	1.8E-06	4.5E-07	1.7E-06	3.9E-06
U-238	5.6E-07	5.6E-05	5.3E-06	2.0E-05	8.1E-05
Medium Total	1.1E-04	3.2E-04	2.4E-04	3.9E-04	**Overall Dose** **1.1E-03**

Table 7-2. Dose to Terrestrial Plants at Area G for 2019
DOE Limit 1.0 rad/day for Terrestrial Plants

Nuclide	External		Internal	Nuclide Total (rad/day)
	Water (rad/day)	**Soil (rad/day)**	**Soil (rad/day)**	
Am-241	5.7E-10	5.7E-06	8.4E-05	9.0E-05
Cs-137	3.0E-08	3.0E-05	1.9E-06	3.2E-05
H-3	1.1E-04	2.2E-04	2.3E-04	5.6E-04
Pu-238	2.0E-10	8.0E-07	9.0E-05	9.1E-05
Pu-239	8.7E-11	3.5E-07	9.7E-05	9.7E-05
Sr-90	1.4E-07	8.5E-06	3.4E-05	4.3E-05
U-234	7.3E-09	7.3E-07	2.1E-05	2.2E-05
U-235	1.8E-08	1.8E-06	1.7E-06	3.5E-06
U-238	5.6E-07	5.6E-05	2.0E-05	7.6E-05
Medium Total	1.1E-04	3.2E-04	5.8E-04	Overall Dose 1.0E-03

At Area G, the largest dose contribution is from tritium, which is mostly concentrated near the southern edge of Area G, at locations 29-03 and 30-1 (Figure 7-1). The results in Table 7-1 show that the biota doses at Area G are well below the DOE limits of 0.1 rad/day for animals, and Table 7-2 shows the doses are also below the limit of 1 rad/day for plants. Overall, there are no measurable impacts to biota health.

Dual-Axis Radiographic Hydrodynamic Test Facility

The Dual-Axis Radiographic Hydrodynamic Test Facility biota dose assessment uses the same methods described in the previous section. The largest doses were calculated from the soil data, indicating that the tissue-to-soil concentration ratios are overestimates, as discussed above. The largest soil activities were entered into RESRAD-BIOTA, and the results are reported in Tables 7-3 and 7-4.

Table 7-3. Dose to Terrestrial Animals at Dual-Axis Radiographic Hydrodynamic Test Facility for 2019
DOE Limit: 0.1 rad/day for Terrestrial Animals

Nuclide	External		Internal		Nuclide Total (rad/day)
	Water (rad/day)	**Soil (rad/day)**	**Water (rad/day)**	**Soil (rad/day)**	
Am-241	1.1E-12	1.8E-08	3.6E-10	1.4E-07	1.6E-07
Cs-137	9.0E-09	1.1E-05	6.5E-08	6.7E-07	1.1E-05
H-3	1.1E-07	2.1E-07	2.1E-07	2.1E-07	7.4E-07
Pu-238	1.2E-12	2.3E-09	2.5E-09	8.3E-08	8.8E-08
Pu-239	6.8E-13	5.5E-09	2.4E-09	3.1E-07	3.2E-07
Sr-90	6.0E-08	1.5E-05	3.7E-06	6.0E-05	7.9E-05
U-234	2.2E-08	2.4E-06	1.6E-05	6.9E-05	8.7E-05
U-235	6.2E-08	3.8E-06	1.6E-06	3.5E-06	8.9E-06
U-238	9.9E-06	4.4E-04	9.5E-05	1.6E-04	7.0E-04
Medium Total	1.0E-05	4.7E-04	1.2E-04	2.9E-04	**Overall Dose** **8.9E-04**

Table 7-4. Dose to Terrestrial Plants at Dual-Axis Radiographic Hydrodynamic Test Facility for 2019
DOE Limit: 1.0 rad/day for Terrestrial Plants

Nuclide	External		Internal	Nuclide Total (rad/day)
	Water (rad/day)	**Soil (rad/day)**	**Soil (rad/day)**	
Am-241	1.1E-12	1.8E-08	2.6E-07	2.8E-07
Cs-137	9.0E-09	1.1E-05	6.7E-07	1.1E-05
H-3	1.1E-07	2.1E-07	2.2E-07	5.4E-07
Pu-238	1.2E-12	2.3E-09	2.6E-07	2.6E-07
Pu-239	6.8E-13	5.5E-09	1.5E-06	1.5E-06
Sr-90	6.0E-08	1.5E-05	6.0E-05	7.5E-05
U-234	2.2E-08	2.4E-06	6.8E-05	7.1E-05
U-235	6.2E-08	3.8E-06	3.6E-06	7.4E-06
U-238	9.9E-06	4.4E-04	1.6E-04	6.1E-04
Medium Total	1.0E-05	4.7E-04	2.9E-04	**Overall Dose** **7.8E-04**

The largest dose contribution is from uranium, most of which is the result of Laboratory operations. The activities of the other radionuclides are consistent with natural background and global fallout.

Tables 7-3 and 7-4 show that the biota doses are well below the DOE limits of 0.1 rad/day for animals and 1 rad/day for plants. There are no measurable impacts to biota health.

Sediment Retention Sites in Canyons

Los Alamos Canyon Weir

The Los Alamos Canyon weir receives drainage from legacy materials at Technical Areas 01, 02, and 21. The soil and sediment trapped by the weir include slightly elevated activities of fission products (Cs-137 and Sr-90) and transuranics (americium and plutonium). The largest doses were from natural uranium.

As shown in Tables 7-5 and 7-6, the doses are all less than 0.1 percent of the DOE limits.

Table 7-5. Dose to Terrestrial Animals in Los Alamos Canyon Weir for 2019
DOE Limit: 0.1 rad/day for Terrestrial Animals

Nuclide	External		Internal		Nuclide Total (rad/day)
	Water (rad/day)	**Soil (rad/day)**	**Water (rad/day)**	**Soil (rad/day)**	
Am-241	2.6E-11	2.6E-07	8.6E-09	2.0E-06	2.3E-06
Cs-137	1.6E-08	1.6E-05	1.2E-07	1.0E-06	1.7E-05
H-3	7.8E-08	1.6E-07	1.5E-07	1.5E-07	5.4E-07
Pu-238	2.0E-12	8.0E-09	4.2E-09	2.9E-07	3.0E-07
Pu-239	2.4E-11	9.7E-08	8.5E-08	5.5E-06	5.7E-06
Sr-90	4.7E-08	2.8E-06	3.0E-06	1.1E-05	1.7E-05
U-234	3.4E-09	3.4E-07	2.5E-06	9.5E-06	1.2E-05
U-235	7.3E-09	7.3E-07	1.8E-07	6.8E-07	1.6E-06
U-238	2.0E-07	2.0E-05	1.9E-06	7.1E-06	2.9E-05
Medium Total	3.5E-07	4.1E-05	7.9E-06	3.8E-05	**Overall Dose** **8.7E-05**

Table 7-6. Dose to Terrestrial Plants in Los Alamos Canyon Weir for 2019
DOE Limit: 1 rad/day for Terrestrial Plants

Nuclide	External		Internal	Nuclide Total (rad/day)
	Water (rad/day)	**Soil (rad/day)**	**Soil (rad/day)**	
Am-241	2.6E-11	2.6E-07	3.8E-06	4.1E-06
Cs-137	1.6E-08	1.6E-05	1.0E-06	1.7E-05
H-3	7.8E-08	1.6E-07	1.7E-07	4.0E-07
Pu-238	2.0E-12	8.0E-09	9.0E-07	9.1E-07
Pu-239	2.4E-11	9.7E-08	2.7E-05	2.7E-05
Sr-90	4.7E-08	2.8E-06	1.1E-05	1.4E-05
U-234	3.4E-09	3.4E-07	9.5E-06	9.8E-06
U-235	7.3E-09	7.3E-07	7.0E-07	1.4E-06
U-238	2.0E-07	2.0E-05	7.2E-06	2.7E-05
Medium Total	3.5E-07	4.1E-05	6.1E-05	**Overall Dose** **1.0E-04**

Pajarito Canyon Flood-Retention Structure

The Pajarito Canyon flood-retention structure does not receive significant quantities of LANL radionuclides. During 2019, any contribution from DOE operations was indistinguishable from background. The total biota dose in Pajarito Canyon is much less than 1 percent of the DOE limits and has no measurable impact on biota health.

Animals at Other Locations

At other locations, roadkilled animals provide information about the presence of radioactive material within their home ranges.

Measurements of radioactive materials in large animals are reported in Tables S7-20 (deer), S7-21 (elk), S7-22 (snakes), and S7-23 (birds and badger). The concentration of tritium in a snake near Area G was above background but below the concentrations used for the assessment of Table 7-1. The doses are much less than 1 percent of the DOE limits, and there is no measurable impact to the health of these animals from radioactive material.

Conclusion

Previous biota dose assessments have shown that biota doses at LANL are far below the DOE limits. This 2019 assessment confirms the previous assessments and shows that there are no harmful effects to the health of biota populations at LANL.

QUALITY ASSURANCE

The Soil, Foodstuffs, and Biota Program collects samples according to written, standard quality assurance and quality control procedures and protocols. These procedures and protocols are identified in the Laboratory's *Implementation of the Soil, Foodstuffs, and Biota Program, Quality Assurance Project Plan* (EPC-ES-QAPP-001) and in the following Laboratory procedures:

- *Soil and Vegetation Sampling for the Environmental Surveillance Program* (EPC-ES-TP-003)
- *Soil and Vegetation Sampling at Facility Sites* (EPC-ES-TP-006)
- *Soil Sampling for Land Transfer and Conveyance and Other Special Projects* (EPC-ES-TP-017)
- *Produce Sampling* (EPC-ES-TP-004)
- *Road Kill Sampling* (EPC-ES-TP-007)
- *Crayfish Sampling* (EPC-ES-TP-008)
- *Benthic Macroinvertebrate Sampling* (EPC-ES-TP-013)
- *Fish Sampling* (EPC-ES-TP-005)
- *Managing and Sampling Honey Bee Hives* (EPC-ES-TP-219)
- *Live Trapping of Small Mammals* (EPC-ES-TP-201)
- *Sediment Sampling in Reservoirs and Rivers* (EPC-ES-TP-035)
- *General PFAS Sampling Guidance for the Soil, Foodstuffs, and Biota Program* (EPC-ES-GUIDE-015)

The Soil, Foodstuffs, and Biota Program collects biological samples under approved New Mexico Game and Fish Scientific Collection Permits as well as approved Institutional Animal Care and Use Committee protocols.

In addition, procedures and protocols for biota dose assessment can be found in the *Technical Project Plan for Biota Dose Assessment* (EPC-ES-TPP-002).

These procedures ensure that the collection, processing, and chemical analysis of samples; the validation and verification of data; and the tabulation of analytical results are conducted in a consistent manner from year to year. Locations and samples have unique identifiers to provide chain-of-custody control from the time of collection through analysis and reporting.

The Biological Resources Program collects field data according to written quality control procedures.

- *Institutional Animal Care and Use Committee Operations* (EPC-ES-AP-014)
- *Threatened and Endangered Species Surveys* (EPC-ES-TP-203)
- *Avian Monitoring* (EPC-ES-TP-205)

In addition to these procedures, some parts of our work require federal and state permits. These permits are individual permits and not institutional. Personnel working as wildlife biologists at LANL must have the training and background to be able to obtain such permits.

- Federal bird banding permits issued by the U.S. Geological Survey's bird banding laboratory
- Federal recovery permits to survey or handle federally listed species issued by the U.S. Fish and Wildlife Service
- State permits for scientific research issued by the New Mexico Department of Game and Fish
- Surveys for federally listed species follow specific protocols set forth by the U.S. Fish and Wildlife Service and training to these protocols is a prerequisite to obtaining a permit.

The Health Physics program calculates dose to nonhuman biota according to a written quality control procedure.

- *Calculating Dose to Nonhuman Biota* (EPC-ES-TP-001)

Field Sampling Quality Assurance

Overall quality of field sampling is maintained through the rigorous use of carefully documented procedures, listed above, which govern all aspects of the sample collection program.

Samples are collected under full chain-of-custody procedures to minimize the chances of data transcription errors. Once collected, samples are hand-delivered to the Laboratory's Sample Management Office, which ships the samples via express mail directly to an external analytical laboratory under full chain-of-custody control. Sample Management Office personnel track all samples. Upon receipt of data from the analytical laboratory (electronically and in hard copy), the completeness of the field sample process and other variables is assessed. A quality assessment document is created, attached to the data packet, and provided in the data package. Field data completeness for sample collection in 2019 was 100 percent.

Analytical Laboratory Quality Assessment

In 2019, ALS in Fort Collins, Colorado, inadvertently ashed an American badger muscle sample for radionuclide analyses before it underwent inorganic element analyses. As inorganic element concentrations reported on an ash weight do not allow for comparisons with current monitoring data, we did not request the lab to proceed with inorganic analyses. In total, we lost inorganic results from one sample in 2019 due to laboratory error.

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U.S. Department of Energy regulations limit the total annual radiological dose to the public from Los Alamos National Laboratory (LANL, or the Laboratory) operations to 100 millirem. Furthermore, doses must be as low as reasonably achievable and must not exceed 25 millirem from any one exposure pathway. The annual dose received by the public from airborne emissions of radionuclides is limited by Clean Air Act regulations to 10 millirem.

The objective of this chapter is to use environmental sampling data collected from air, water, soil, and foodstuffs to answer the question, "What are the potential doses and risks to the public from the Laboratory's operations?" All known radionuclides released in significant quantities from LANL are reported and used in dose calculations. The assessments show that during 2019 all doses to the public were far below all regulatory limits and guidance and that the public is well protected. Radiological doses to the public from Laboratory operations are less than 1 millirem per year, and health risks are indistinguishable from zero.

INTRODUCTION

In this chapter, dose and risk from radiological and chemical sources are assessed to ensure the public is protected and to demonstrate compliance with federal regulations and U.S. Department of Energy (DOE) orders. Using standard methods to calculate the potential effects of radiological dose and risk, the data reported here and in the previous chapters are considered in the context of public exposure. These methods do not include tribal-specific exposure scenarios. The results are compared with regulatory limits and international standards.

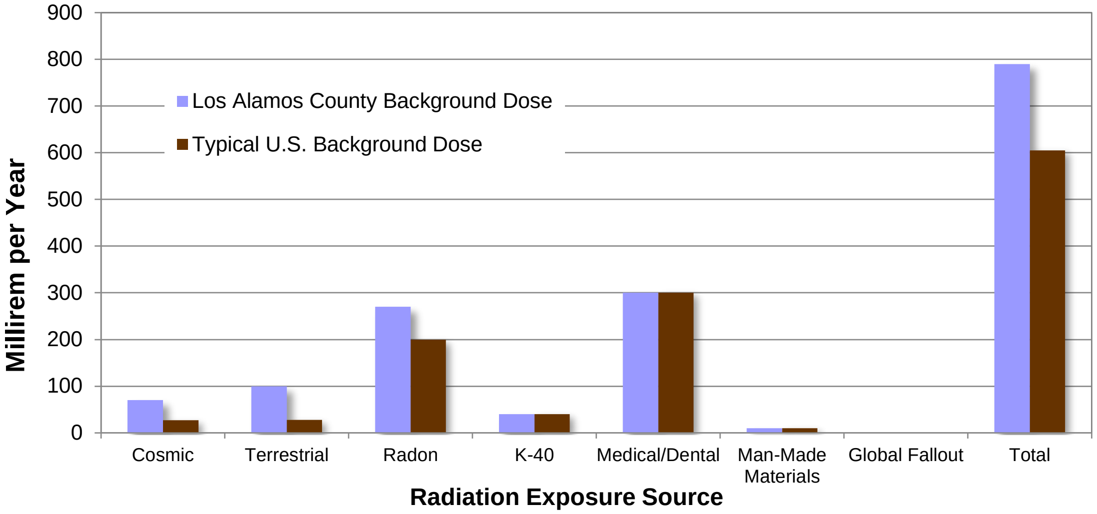
RADIOLOGICAL DOSE ASSESSMENT FOR THE PUBLIC

Overview of Radiological Dose

Radiological dose is the primary measure of harm from radiation. We calculate doses using the standard methods specified in guidance documents (DOE 1988a, 1988b, 2011a, 2011b; U.S. Environmental Protection Agency 1988, 1993, 1997, 1999; International Commission on Radiological Protection 1996; Nuclear Regulatory Commission 1977). In this section, we assess doses to the public. Doses to plants and animals are assessed in Chapter 7.

DOE regulations limit the total annual dose to the public from Los Alamos National Laboratory operations to 100 millirem. Furthermore, doses must be as low as reasonably achievable and must not exceed 25 millirem from any one exposure pathway, such as from eating food or from the storage of waste (DOE 1999, 2011a; LANL 2008). The annual dose received by the public from airborne emissions of radionuclides is limited to 10 millirem by the *National Emission Standards for Hazardous Air Pollutants Other Than Radon From Department of Energy Facilities*, Title 40, Part 61, Subpart H of the Code of Federal Regulations. The annual dose from community drinking water supplies is limited under the Safe Drinking Water Act to 4 millirem (*National Primary Drinking Water Regulations*, Title 40, Part 141 of the Code of Federal Regulations).

To place these limits in context, the dose from natural background and from medical and dental procedures is about 800 millirem per year (Figure 8-1). The origins and reasons for the Los Alamos background dose are discussed briefly below and in detail in the paper by Gillis et al. (2014). In contrast, doses from Laboratory operations are typically less than 1 millirem per year.



Note: K-40 = Potassium-40

Figure 8-1. The average Los Alamos County radiation background dose compared with average U.S. radiation background dose (Gillis et al. 2014)

Exposure Pathways

Potential doses to the public from radionuclides associated with Laboratory operations are calculated by evaluating all potential exposure pathways. Total dose is the sum of three principal exposure pathways: (1) direct-penetrating (photon or neutron) radiation, (2) inhalation of airborne radioactive particles, and (3) ingestion of radionuclides in water or food.

Direct Radiation

We monitor direct-penetrating radiation from photons and neutrons at 80 locations in and around the Laboratory (see Chapter 4). Direct-penetrating radiation from Laboratory sources contributes to a measurable dose only within about 1 kilometer of the source. At distances more than 1 kilometer, dispersion, scattering, and absorption of the photons and neutrons attenuate the dose to much less than 0.1 millirem per year, which cannot be distinguished from natural background radiation. The only measurable above-background doses from direct-penetrating radiation originate from Technical Area 53 and Technical Area 54, as reported in Chapter 4.

Inhalation

At distances of more than 1 kilometer from Laboratory sources, any dose related to Laboratory operations is almost entirely from airborne radioactive emissions. Whenever possible, we use the airborne radioactivity levels directly measured by the air sampling network reported in Chapter 4 (the Ambient Air Sampling for Radionuclides section) to calculate doses. Where local levels of airborne radioactivity are too small to measure or cannot be measured by the environmental air-monitoring station methods, doses are calculated using a model called CAP88 (Clean Air Act Assessment Package-1988, PC Version 4) (U.S. Environmental Protection Agency 2013). CAP88 is an atmospheric-dispersion and dose-calculation computer code that combines stack emissions with meteorological data to estimate dose.

Some of the radionuclide emissions from Technical Area 53 are short-lived and cannot be measured by the environmental air stations. These emissions are measured at the stacks (Chapter 4, the Exhaust Stack Sampling for Radionuclides section), and the resulting estimated doses are calculated with CAP88.

The air-pathway dose assessment is described in detail in an annual air emissions report (Lattin and Fuehne 2020) and in Chapter 4.

Ingestion

Ingestion includes drinking liquids and eating food. We report measurements from water in Chapters 5 and 6 and measurements from soil, plants, and animals here and in Chapter 7.

Local drinking water contains no measurable radioactivity from current or historical Laboratory operations. For further information regarding Los Alamos County drinking water quality, refer to the Los Alamos Department of Public Utilities “2019 Annual Drinking Water Quality Report” (Los Alamos County 2020).

Foodstuffs Monitoring

Monitoring Network

The Soil, Foodstuffs, and Biota Program monitors constituents in a wide variety of foodstuffs to determine whether Laboratory operations are affecting human health via the food chain. Foodstuffs samples are collected once every 3 years. In general, we collect foodstuffs from sites on the Laboratory, from communities surrounding the Laboratory (i.e., perimeter locations), from areas downstream of the Laboratory that are irrigated with Rio Grande water, and from background locations that are more than 9 miles from the Laboratory and represent worldwide fallout or natural levels. In 2019, wild foods, fruits, and vegetables (hereafter referred to as crops) were collected from the Laboratory, from gardens and farms located in Los Alamos townsite, White Rock/Pajarito Acres, Pueblo de San Ildefonso (perimeter locations), Pueblo de Cochiti (downstream of LANL), and from regional background locations (Figure 8-2). Eggs, milk, and tea were also collected from select locations. Additionally, deer and elk samples are collected on an annual basis, primarily as roadkill or hunter donations; detailed results regarding deer and elk samples can be found in Chapter 7.

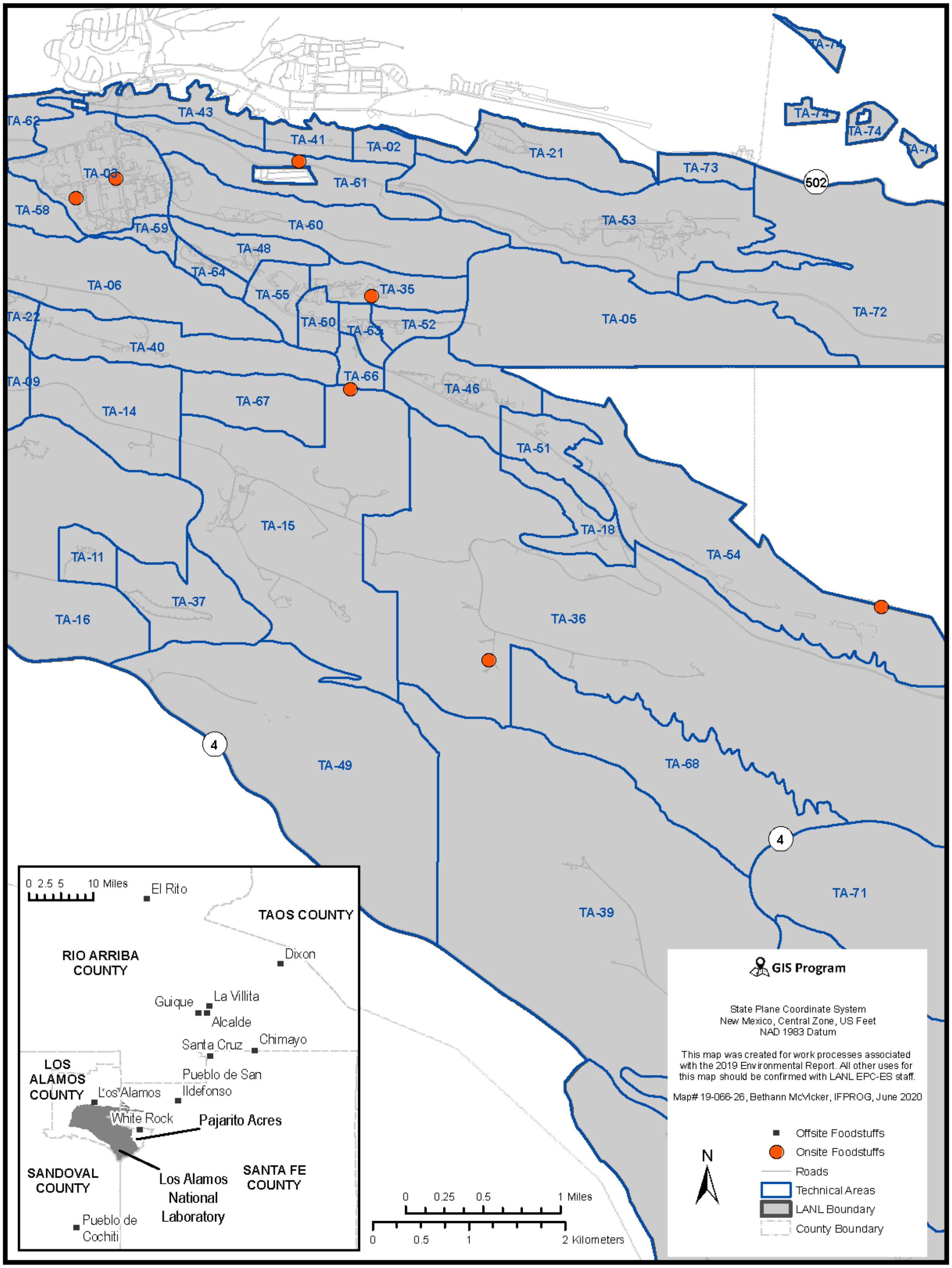


Figure 8-2. Locations of foodstuffs samples collected around Los Alamos National Laboratory, from surroundings communities, and from background locations in 2019

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Methods and Analyses

Approximately 2 to 3 pounds of crops were collected per sample and rinsed thoroughly with municipal tap water before analyses. Crop samples were placed into a zippered plastic bag; egg and milk samples were placed in amber-colored glass jars and polyethylene sample bottles. All samples were then labeled, sealed with chain-of-custody tape, placed on ice, and submitted to the Laboratory's Sample Management Office. All samples were shipped under full chain of custody to ALS Laboratory, Fort Collins, Colorado, or GEL Laboratories, Charleston, South Carolina, for analyses. All samples were analyzed for radionuclides (americium-241, cesium-137, plutonium-238, plutonium-239/240, strontium-90, tritium, uranium-234, uranium-235/236, and uranium-238) and inorganic elements (aluminum, antimony, arsenic, barium, beryllium, cadmium, calcium, chromium, cobalt, copper, iron, lead, magnesium, manganese, mercury, nickel, potassium, selenium, silver, sodium, thallium, vanadium, and zinc). Milk and eggs were also analyzed for polychlorinated biphenyl (PCB) congeners.

All detected results of radionuclides, inorganic elements, and PCBs in foodstuffs were compared with their regional statistical reference levels. The regional statistical reference level for a chemical or radionuclide is the level below which 99 percent of the results from samples taken at regional background locations over the past 10 years fall. It is calculated from the mean value plus 3 standard deviations of the regional background results for the chemical or radionuclide. Total PCB concentrations in milk and eggs were also compared with U.S. Food and Drug Administration's *Tolerances for Polychlorinated Biphenyls (PCBs*), Title 21, Part 190, Section 30 of the Code of Federal Regulations. Radionuclide and inorganic element levels in foodstuffs were analyzed for differences between locations (onsite, perimeter, and downstream locations compared with background) with an analysis of variance (ANOVA) test or a Kruskall-Wallis test; the appropriate test was selected after testing for normality with a Shapiro-Wilk test. Outliers were identified and removed before analyses with an iterative Grubbs test. Exceptions to these statistical methods occurred when a particular data set contained ≥ 80% nondetects (Helsel 2012) or when the sample size was too small for testing ($n \leq 3$).

Radionuclide Monitoring in Foodstuffs

Most radionuclide activities in crops were either below the minimum detectable activity—the majority of the results—or below the regional statistical reference levels (Table S8-1). Strontium-90 was detected above the regional statistical reference level of 0.648 picocuries per gram in three samples collected at the Laboratory, ranging from 0.930 to 2.39 picocuries per gram. Strontium-90 was also detected above the regional statistical reference level in prickly pear collected from Pueblo de San Ildefonso at 1.68 picocuries per gram (Table S8-1). Uranium-238 was detected above the regional statistical reference level of 0.2052 picocuries per gram in peaches collected from Pueblo de San Ildefonso (Table S8-1).

Radionuclide activities in crops from the Laboratory, perimeter, and downstream locations did not differ from radionuclide activities in crops collected from background locations in 2019 (ANOVA or Kruskall-Wallis; $p > 0.05$). The Kruskall-Wallis test was significant ($p < 0.05$) when comparing uranium-238 activities in crops among locations. Therefore, a Dunn's multiple comparisons test was conducted to examine pairwise comparisons (i.e., each site directly compared with another), which revealed no significant differences of uranium-238 activities among locations, including background.

The majority of radionuclides in goat milk, chicken eggs, and goose eggs were not detected or were below the regional statistical reference levels (Table S8-2). In 2019, chicken and goose eggs collected from White Rock were analyzed on a wet weight basis and could not be compared with the regional statistical reference level, which is on an ash weight basis. However, chicken eggs collected from background in 2019 were also analyzed on a wet weight basis; for radionuclides with detectable activities, levels were similar between the White Rock and background location (Table S8-2).

Cota tea from Pueblo de San Ildefonso was analyzed for radionuclides and inorganic elements. The majority of radionuclides in tea from Pueblo de San Ildefonso were not detected; however, uranium-234, uranium-235/236, and uranium-238 were detected (Table S8-3). As tea has not been collected from background locations, we cannot make comparisons with background levels. However, cota was collected in 2012 from several perimeter locations, including Pueblo de San Ildefonso (Table S8-3). Activities of uranium isotopes were higher in tea collected in 2019 than in tea brewed from cota in 2012; however, these data could not be statistically analyzed due to small sample size. The water that was used to brew the tea could explain the differences in uranium isotopes' activities between 2012 and 2019. In 2012, tea samples were brewed at the analytical laboratory using distilled water. In 2019, tea was brewed with water from the Pueblo de San Ildefonso. Uranium activities observed in the tea are within the ranges of uranium activities observed in water samples from the Black Mesa monitoring well between 2011 and 2019. The source of the uranium in the groundwater at the Black Mesa well is from underground uranium deposits in the Espanola basin (McLemore et al. 2011) and not from Laboratory operations. Statistical comparisons among locations could not be made due to small sample sizes.

Inorganic Element Monitoring in Foodstuffs

Several inorganic elements were detected in crops (Table S8-4). The majority (98%) of inorganic element results were below the regional statistical reference levels. Inorganic elements that exceeded the regional statistical reference levels include antimony, copper, lead, manganese, mercury, and nickel. For these elements, levels exceeded regional statistical reference levels at onsite, perimeter, and downstream locations (Table S8-4). Levels of inorganic elements in crops from the Laboratory, perimeter, and downstream locations did not differ when compared with levels from background locations in 2019 (Kruskall-Wallis; $p > 0.05$).

Detection patterns and levels of detectable inorganic elements were similar in goat milk, chicken eggs, and goose eggs collected from perimeter locations compared with background (Table S8-5). Chicken eggs from Pueblo de San Ildefonso were analyzed on a dry weight basis while background chicken eggs were analyzed on a wet weight basis, preventing direct comparisons. However, the detection patterns were similar between locations (Table S8-5).

Several inorganic elements were not detected in cota tea (Table S8-3). Arsenic, calcium, copper, magnesium, manganese, potassium, vanadium, and zinc were detected. No tea from background was collected for comparisons and tea collected in 2012 was only analyzed for radionuclides. The majority of detectable inorganic element concentrations were within the range of elements detected in water samples from the Black Mesa well, and both arsenic and copper levels were well below the drinking water standards in the *National Primary Drinking Water Regulations*, Title 40, Part 141 of the Code of Federal Regulations.

PCB Monitoring in Foodstuffs

PCBs were evaluated in animal foodstuffs samples, including goat milk from North Mesa Stables in Los Alamos and from Santa Cruz, a background sample. Goat milk from Santa Cruz did not contain any detectable concentrations of PCBs. Goat milk from Los Alamos contained 0.00922 parts per billion (Table S8-6). This is well below the PCB tolerance value in milk of 1500 parts per billion (from *Tolerances for Polychlorinated Biphenyls (PCBs)*, Title 21, Part 190, Section 30 of the Code of Federal Regulations).

PCBs were evaluated in chicken eggs collected from perimeter locations, including White Rock and Pueblo de San Ildefonso, and from a background location in El Rito; goose eggs from White Rock were also analyzed for PCBs. All egg samples contained PCBs ranging from 0.0000264 to 0.00228 parts per million and all concentrations were well below the PCB tolerance value in eggs of 0.3 parts per million.

Overall, PCB concentrations in milk and eggs are well below levels that are associated with adverse effects in humans. Statistical comparisons between locations could not be made due to small sample sizes.

Dose from Food

DOE Standard 1196 (DOE 2011b) was used to calculate the dose from ingestion of locally grown food. The following analyses are from radionuclides that are not associated with the Laboratory; strontium-90 is from global fallout and uranium is naturally occurring. However, they show that even in the worst cases, the dose from ingestion of foodstuffs is small.

The strontium-90 concentrations in foodstuffs from global fallout were especially variable because some types of plants take up more strontium than others (Burger 2019). The largest concentration, 1.68 picocuries per gram, was measured in prickly pear (Table S8-1). Eating a kilogram of this prickly pear would result in a dose of 0.004 millirem.

The uranium in the water used to brew the cota tea is naturally occurring (McLemore et al. 2011) and is similar to nearby locations (Kraig and Gladney 2001). The dose from drinking a liter of this tea would be 0.003 millirem.

The data demonstrate that the dose from eating local or regional foodstuffs, including crops, eggs, milk, tea, deer, and elk (deer and elk discussed in Chapter 7), is well below 0.1 millirem per year. Radionuclide concentrations in publicly available food is consistent with global fallout or naturally occurring material and any contributions from the Laboratory are too small to measure. Whatever the source, the dose from ingestion of foodstuffs is very small.

The conclusion is that the ingestion dose from Los Alamos National Laboratory operations is much less than 0.1 millirem per year and consistent with zero.

Dose from Naturally Occurring Radiation

Near Los Alamos, naturally occurring sources of radioactivity include (1) cosmic rays, (2) direct-penetrating radiation from terrestrial sources, (3) radon gas, and (4) elements that occur naturally inside the human body, such as potassium-40 (Figure 8-1).

Annual doses from cosmic radiation range from 50 millirem at lower elevations near the Rio Grande to about 90 millirem in the higher elevations west of Los Alamos (Bouville and Lowder 1988, Gillis et al. 2014).

Annual background doses from external gamma radiation (from natural terrestrial sources such as uranium and thorium and their decay products) range from about 50 millirem to 150 millirem (DOE 2012).

The inhalation of naturally occurring radon and its decay products constitutes a large proportion of the annual dose for a member of the public. Nationwide, the average annual dose from radon is about 200 millirem to 300 millirem (National Council on Radiation Protection and Measurements 1987). In Los Alamos County, the average residential radon concentration results in an annual dose of about 300 millirem (Whicker 2009a, 2009b).

An additional 30 millirem per year results from naturally occurring radioactive materials in the body, such as potassium-40, which is present in all food and living cells.

Additional man-made sources of radiation, including medical and dental uses of radiation and building products such as stone walls, raise the total average annual background dose (Gillis et al. 2014). Members of the U.S. population receive an average annual dose of 300 millirem from medical and dental uses of radiation (National Council on Radiation Protection and Measurements 2009). Another 10 millirem per year comes from man-made products, such as stone or adobe walls.

In total, the average annual dose from sources other than Laboratory operations is about 800 millirem for a typical Los Alamos County resident. Figure 8-1 compares the average radiation background in Los Alamos County with the average background dose in the United States.

Generally, any additional dose of less than 0.1 millirem per year cannot be distinguished from the dose generated by background levels of radiation.

Results and Dose Calculations

The objective of this section is to calculate doses to the public from Laboratory operations.

As required by DOE Order 458.1 Chg 3, *Radiation Protection of the Public and the Environment*, we calculated doses from the Laboratory to the following members of the public:

- the total human population within 80 kilometers (50 miles) of the Laboratory, and
- the hypothetical "maximally exposed individual."

To identify the location of and the total dose to the hypothetical maximally exposed individual, the following are considered:

- the air-pathway dose,
- the onsite dose at publicly accessible locations,
- other locations with measurable dose, and
- the offsite dose.

Collective Dose to the Population within 80 Kilometers

The collective population dose from Laboratory operations is the sum of the doses for each member of the public within an 80-kilometer radius of the Laboratory (DOE 2011a). Outside of Los Alamos County, the doses are too small to measure directly, so the collective dose was calculated by modeling the transport of radioactive air emissions using CAP88. The doses from the pathways other than air are either negligible or nonexistent.

The 2019 collective population dose to persons living within 80 kilometers of the Laboratory is 0.07 person-rem (Lattin and Fuehne 2020). This dose is less than 0.001 millirem per person and is much less than the background doses shown in Figure 8-1.

Tritium contributed 46 percent of the dose from the Laboratory, and short-lived activation products, such as carbon-11 from the Los Alamos Neutron Science Center, contributed 54 percent. Collective population doses for recent years are shown in Figure 8-3. The trend line for the past 10 years shows a general decrease, which is the result of improved engineering controls at the Los Alamos Neutron Science Center and the tritium facilities.

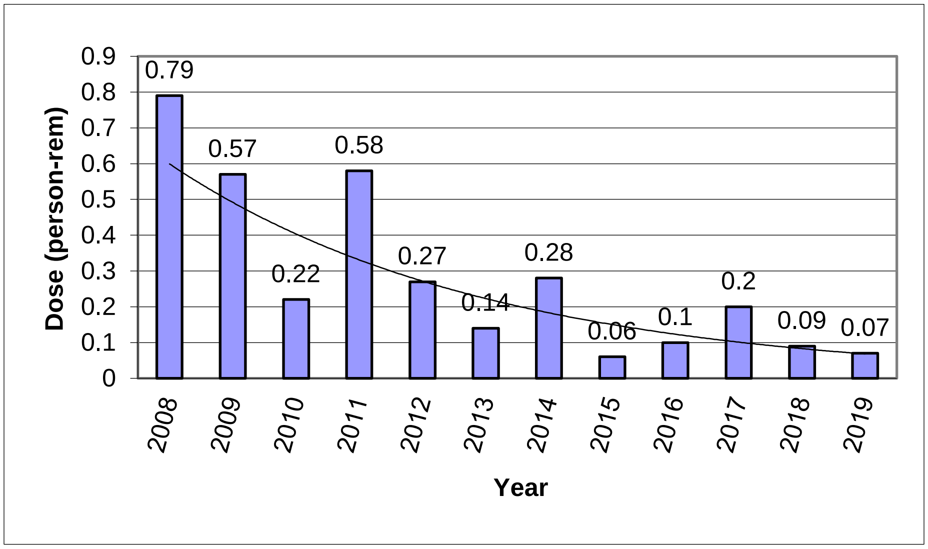


Figure 8-3. Annual collective dose (person-rem) to the population within 80 kilometers of the Laboratory

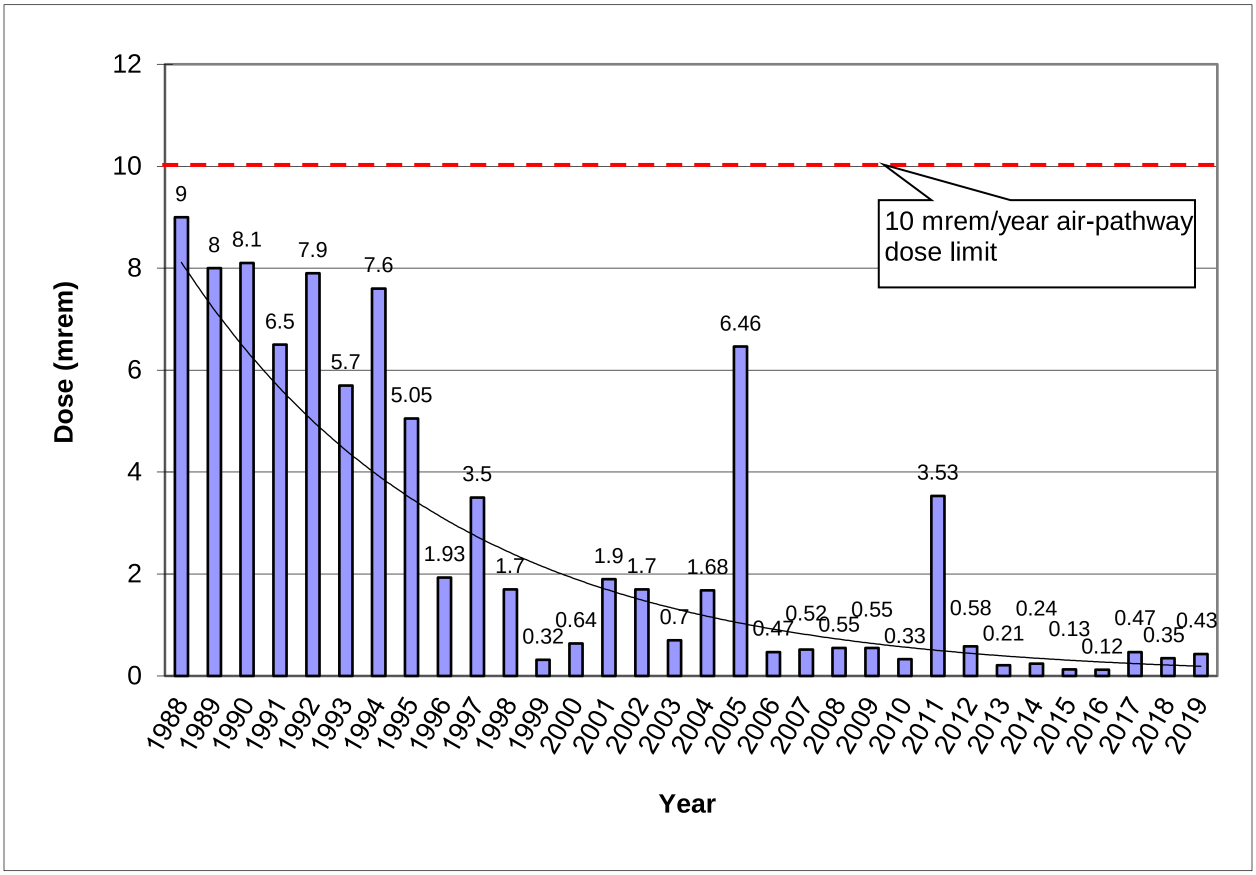
Dose to the Maximally Exposed Individual

The "maximally exposed individual" is a hypothetical member of the public who receives the greatest possible dose from Laboratory operations (DOE 2011a). To determine the location where a member of the public would be maximally exposed, we consider all exposure pathways that could cause a dose and all publicly accessible locations, both within the Laboratory boundary (onsite) and outside the boundary (offsite).

Maximally Exposed Individual Offsite Dose for 2019

The air-pathway dose calculations are described in an annual air emissions report (Lattin and Fuehne 2020). In 2019, the offsite location of the hypothetical maximally exposed individual was at 27 DP Road, close to environmental air-monitoring station #317 (Chapter 4, Figure 4-1). The total offsite dose for a maximally exposed individual during 2019 was 0.43 millirem (Figure 8-4; Lattin and Fuehne 2020).

Contributions to this annual dose were from short-lived activation products from the Los Alamos Neutron Science Center stacks (0.002 millirem), other stack emissions (0.001 millirem), environmental measurements at air-monitoring stations (0.184 millirem), and the potential dose contribution from unmonitored stacks (0.246 millirem). Doses from ingestion and direct radiation were less than 0.01 millirem.



Note: mrem = millirem

Figure 8-4. Annual maximally exposed individual offsite dose

Maximally Exposed Individual Onsite Dose for 2019

The onsite locations where a member of the public could receive a measurable dose are on or near publicly accessible roads (McNaughton et al. 2013). The only location with a measurable Laboratory-generated dose is at East Jemez Road near Technical Area 53. As reported in Chapter 4 (the Monitoring for Gamma and Neutron Direct-Penetrating Radiation section), at this location in 2019 the neutron dose was 0.7 millirem and the gamma dose was 0.1 millirem for a total of 0.8 millirem. The contribution from stack emissions was less than 0.01 millirem. These are the doses that would be received by a hypothetical individual at this location 24 hours per day and 365 days per year; however, members of the public, such as joggers, bus drivers, or cyclists, spend less than 1 percent of their time at this location (National Council on Radiation Protection and Measurements 2005). Therefore, the onsite dose for a maximally exposed individual is less than 1 percent of 0.8 millirem, which is much less than the offsite dose for a maximally exposed individual described in the previous section.

Other Locations with Measurable Dose

As reported in Chapter 4, neutron dose was measured in Cañada del Buey, north of Technical Area 54, Area G, and near the Pueblo de San Ildefonso boundary. Transuranic waste at Area G awaiting shipment to the Waste Isolation Pilot Plant in Carlsbad, New Mexico, emits neutrons. After subtracting background, the measured neutron dose in Cañada del Buey in 2019 was 2 millirem. After applying the standard factor of 1/20 for occasional occupancy (National Council on Radiation Protection and Measurements 2005), the individual neutron dose in 2019 was 2/20 ≈ 0.1 millirem. The contribution from Laboratory stack emissions was less than 0.001 millirem. Within the boundaries of Area G, the average air concentration of americium and plutonium was 2 attocuries per cubic meter (Chapter 4, Tables 4-3 and 4-4) and the average uranium-238 concentration was 7 attocuries per cubic meter (Chapter 4, Table 4-5). Using the dose conversion factors from DOE Standard 1196 (DOE 2011b) and assuming 1/20 occupancy, the annual dose both within and near Area G was much less than 0.001 millirem from air concentrations of transuranic materials.

Thus, in 2019, the total dose in Cañada del Buey was 0.1 millirem.

Maximally Exposed Individual Summary

At the offsite location for the maximally exposed individual, 278 DP Road, the direct-penetrating radiation and ingestion doses are essentially zero, so the largest all-pathway dose for 2019 was the same as the air-pathway dose of 0.43 millirem.

The calculated offsite doses for the maximally exposed individual each year for recent years are shown in Figure 8-4. The general downward trend is the result of improved engineering controls and ongoing remediation.

As described in previous annual site environmental reports, the 6.46-millirem dose in 2005 resulted from a leak at Technical Area 53, and the 3.53-millirem dose in 2011 was from the remediation of Material Disposal Area B. The 2011 maximally exposed individual location was the same as the 2019 location, near the middle of Material Disposal Area B.

The dose of 0.43 millirem in 2019 is far below the 10-millirem annual air-pathway limit in the *National Emission Standards for Hazardous Air Pollutants Other Than Radon From Department of Energy Facilities*, Title 40, Part 61, Subpart H of the Code of Federal Regulations, and the 100-millirem all-pathway DOE limit (DOE 2011a). The dose for the maximally exposed individual is less than 0.1 percent of the average U.S. background radiation dose shown in Figure 8-1.

Conclusion

The doses to the public from Laboratory operations are summarized in Table 8-1. Doses are far below all regulations and standards.

Table 8-1. LANL Radiological Doses for Calendar Year 2019

Pathway	Dose to Maximally Exposed Individual (millirems per year)	Percentage of DOE 100-millirem-per-year Limit	Estimated Population Dose (person-rem)	Number of People within 80 kilometers	Estimated Background Population Dose (person-rem)
Air	0.43	0.43%	0.07	n/a[1]	n/a
Water	<0.1	<0.1%	0	n/a	n/a
Other pathways (foodstuffs, soil, etc.)	<0.1	<0.1%	0	n/a	n/a
All pathways	0.43	0.43%	0.07	~343,000	~268,000[2]

[1] n/a = Not applicable. Background population dose is not calculated for individual exposure pathways.
[2] Based on 780 millirem per person as shown in Figure 8-1

NONRADIOLOGICAL MATERIALS

Introduction

This section summarizes the potential human health risk from nonradiological materials released from the Laboratory in 2019. Air emissions are reported in Chapters 2 and 4; groundwater is reported in Chapter 5; surface water and sediment are reported in Chapter 6; and soil, plants, and animals are reported in Chapter 7. Foodstuffs are reported in this chapter. The results are summarized below.

Results Summary

Air

The data reported in Chapters 2 and 4 show that the Los Alamos air quality is good and well below all applicable state and federal air quality standards. The Laboratory's emissions of regulated pollutants are below the amounts allowed in LANL's Title V Operating Permit. There are no measurable health effects to the public from Laboratory air emissions.

Groundwater

Groundwater data are reported in Chapter 5.

Los Alamos County monitors its water supply in compliance with the Safe Drinking Water Act, and we analyzed additional samples from Los Alamos County water supply wells in 2019. No water supply wells showed detections of Laboratory-related constituents above an applicable drinking water standard. The drinking water supply meets New Mexico Environment Department and U.S. Environmental Protection Agency drinking water standards (Los Alamos County 2020).

Additional supplemental water sampling was conducted in the City of Santa Fe's Buckman well field. No Laboratory-related constituents were present above state or federal drinking water quality standards in this drinking water supply.

Within Laboratory boundaries, hexavalent chromium from the Laboratory has been detected above the New Mexico groundwater standard (50 micrograms per liter) in the regional aquifer below Mortandad Canyon. As described in Chapter 5, the Laboratory has begun remediation to control migration of this chromium plume.

The Los Alamos County drinking water contains 5 micrograms per liter of naturally occurring chromium that is unrelated to the Laboratory (Los Alamos County 2020). More information on groundwater quality is available in Chapter 5.

Surface Water and Sediment

The concentrations of chemicals in surface water and sediment are reported in Chapter 6. The sediment data verify the conceptual model that movement and addition of sediment from repeated flood events result in lower concentrations of Laboratory-related constituents in newer sediment deposits compared with previous deposits. The data also show that the human health risk assessments in the canyons investigation reports (see Chapter 6) represent an upper bound of potential risks. Human exposure scenarios were discussed in the investigation reports. The conclusions in the investigation reports, that there were no human health risks, remain accurate because the constituent concentrations decrease with time.

In Chapter 6, we compared unfiltered storm water concentrations with drinking water standards as screening levels. However, storm water is not a drinking water source and therefore is not a significant pathway to human exposure. The plant and animal measurements reported in Chapters 7 and 8 confirm that there is not significant uptake into the food chain.

Chapter 6 presents data for PCBs in the surface water of the Pajarito Plateau. The foodstuffs that may use this water are primarily terrestrial animals, such as deer and elk. The data reported in Chapter 7 show that the concentrations of PCBs in deer and elk are far below the human health screening values and are unlikely to cause adverse human health effects.

The only aquatic animals eaten by people that may be influenced by surface water runoff from the Laboratory are in the Rio Grande. In the Rio Grande, PCB concentrations in aquatic animals are similar upstream and downstream of LANL influence (LANL 2017, Chapter 7). There is no detectable contribution from the Laboratory to PCB concentrations in aquatic animals in the Rio Grande.

We conclude there is no risk to the public from exposure to surface water and sediment resulting from either current or legacy Laboratory releases.

Soil, Plants, and Animals

Soil and biota sampling results are reported in Chapter 7. The results are similar to previous years. At offsite locations in 2019, chemical concentrations above human-health-based screening criteria were not detected.

Conclusion

The environmental data collected in 2019 show that at present there is no measurable risk to the public from materials released from the Laboratory. In all cases, the public doses and risks from Los Alamos National Laboratory operations are much smaller than the regulatory limits and the naturally occurring background levels.

QUALITY ASSURANCE

The Soil, Foodstuffs, and Biota Program collects samples according to written, standard quality assurance and quality control procedures and protocols. These procedures and protocols are identified in the Laboratory's *Implementation of the Soil, Foodstuffs, and Biota Program, Quality Assurance Project Plan* (EPC-ES-QAPP-001) and in the following Laboratory procedures pertaining to foodstuffs collections:

- *Produce Sampling* (EPC-ES-TP-004),
- *Road Kill Sampling* (EPC-ES-TP-007),
- *Crayfish Sampling* (EPC-ES-TP-008), and
- *Fish Sampling* (EPC-ES-TP-005).

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Appendix A
STANDARDS AND SCREENING LEVELS FOR RADIONUCLIDES AND OTHER CHEMICALS IN ENVIRONMENTAL SAMPLES

GENERAL FORMATION OF A STANDARD OR SCREENING LEVEL

An environmental standard is a value, generally defined by a regulator such as the U.S. Environmental Protection Agency, that specifies the maximum permissible concentration of a potentially hazardous chemical in an environmental sample, generally of air or water. A screening level is a value, which may be calculated by a regulator or by another party, that when exceeded in a sample result, indicates the sampled location may warrant further investigation or site cleanup. Standards and screening levels are crafted to protect a target group from chemical exposure when considering a given exposure pathway or scenario for a specific time frame. A target group may refer to, for example, the general public, animals, or a sensitive population like children. Pathways of exposure include inhalation of air and ingestion of water, soil, animals, or plants. Length of exposure is important because prolonged exposure to low levels of a potentially hazardous chemical may have adverse health effects, as may a short exposure to high levels. Scenarios describe the activities of a target group at the site, which influence both the length and likelihood of exposures. Examples of exposure scenarios include residential (living on a site) and construction worker (disturbing soil during construction activities at a site).

Throughout this report, levels of radioactive and chemical constituents in air and water samples are compared with pertinent standards and guidelines in regulations of federal and state agencies. For environmental samples that do not have standards or guidelines, levels are compared with screening levels.

RADIATION STANDARDS

The U.S. Department of Energy (DOE) limits the radiation dose that can be received by members of the public as a result of normal operations at Los Alamos National Laboratory (LANL, or the Laboratory).

DOE Order 458.1 Chg 3, *Radiation Protection of the Public and the Environment*, describes the current radiation protection standards for the public, referred to as public dose limits; limits are listed in Table A-1. DOE's public dose limits apply to the effective dose that a member of the public can receive from DOE operations. For all exposure pathways combined, the total limit is 100 millirem per year (mrem/yr).

Radionuclide activities in water are compared with DOE's derived concentration guides to evaluate potential impacts to members of the public. The derived concentration guides for water are those concentrations in water that if consumed at a rate of 730 liters per year, would give a dose of 100 mrem/yr.

Table A-1. DOE Dose Limits
for External and Internal Exposures

Exposure Pathway	Dose Equivalent at Point of Maximum Probable Exposure
Exposure of Any Member of the Public	
All pathways	100 mrem/yr
Air pathway only*	10 mrem/yr
Drinking water	4 mrem/yr

**This level is from the U.S. Environmental Protection Agency's regulations issued under the Clean Air Act (Code of Federal Regulations Title 40, Part 61, Subpart H).*

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Table A-2 shows the derived concentration guides. For comparison with drinking water systems, the derived concentration guides are multiplied by 0.04 to correspond with the U.S. Environmental Protection Agency limit of 4 millirem per year.

Table A-2. DOE's Derived Concentration Guides for Water[a]

Nuclide	Derived Concentration Guides for Water Ingestion in Uncontrolled Areas (pCi/L[b])	Derived Concentration Guides for Drinking Water Systems[c] (pCi/L)
Hydrogen-3	2,000,000	80,000
Beryllium-7	1,000,000	40,000
Strontium-89	20,000	800
Strontium-90	1000	40
Cesium-137	3000	120
Uranium-234	500	20
Uranium-235	600	24
Uranium-238	600	24
Plutonium-238	40	1.6
Plutonium-239	30	1.2
Plutonium-240	30	1.2
Americium-241	30	1.2

[a] *Derived concentration guides for uncontrolled areas are based on DOE's public dose limit for the general public. Derived concentration guides apply to concentrations in excess of those occurring naturally or from worldwide fallout.*

[b] *pCi/L = picocuries per liter*

[c] *Drinking water derived concentration guides are 4% of the derived concentration guides for nondrinking water.*

In addition to DOE standards, in 1985 and 1989, the U.S. Environmental Protection Agency established the "National Emission Standards for Emissions of Radionuclides Other than Radon from Department of Energy Facilities," in Title 40, Part 61, Subpart H of the Code of Federal Regulations. This regulation states that emissions of radionuclides to the ambient air from DOE facilities shall not exceed those amounts that would cause any member of the public to receive in any year an effective dose of 10 millirem per year. DOE has adopted this dose limit (Table A-1). In addition, the regulation requires monitoring of all release points that can produce a dose of 0.1 millirem to a member of the public.

NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM

The types of monitoring required under the National Pollutant Discharge Elimination System and the limits established for sanitary and industrial outfalls can be found at http://water.epa.gov/polwaste/npdes/.

DRINKING WATER STANDARDS

For chemical constituents in drinking water, regulations and standards are issued by the U.S. Environmental Protection Agency and adopted by the New Mexico Environment Department as part of the New Mexico Drinking Water Regulations. To view the New Mexico Drinking Water Regulations, go to https://www.env.nm.gov/drinking_water/laws-and-regs/.

Radioactivity in drinking water is regulated by U.S. Environmental Protection Agency regulations contained in Title 40, Part 141 of the Code of Federal Regulations and by the New Mexico Drinking Water Regulations, Sections 206 and 207. These regulations stipulate that combined radium-226 and radium-228 activity in drinking water may not exceed 5 picocuries per liter. Gross-alpha activity (including radium-226 but excluding radon and uranium) may not exceed 15 picocuries per liter. We use

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a screening level of 5 picocuries per liter for gross alpha to determine when further analysis for the radium isotopes is needed.

For man-made beta- and photon-emitting radionuclides, U.S. Environmental Protection Agency drinking water standards are limited to activities that would result in doses not exceeding 4 millirem per year. In addition, DOE Order 458.1 requires that persons consuming water from DOE-operated public water supplies do not receive a dose greater than 4 millirem per year. Derived concentration guides for drinking water systems based on this requirement are in Table A-2.

SURFACE WATER STANDARDS

Activities of radionuclides in surface water samples may be compared with either the DOE derived concentration guides (Table A-2) or the New Mexico Water Quality Control Commission stream standards, which reference the state's radiation protection regulations. The concentrations of nonradioactive constituents may be compared with the New Mexico Water Quality Control Commission stream standards, available at https://www.env.nm.gov/surface-water-quality/wqs/. The New Mexico Water Quality Control Commission groundwater standards can also be applied in cases where discharges may affect groundwater.

SOILS AND SEDIMENTS

If chemical or radionuclide levels in soil exceed regional statistical reference levels (regional background levels), the levels are compared with screening levels. The human health screening level for soil from publically accessible locations is the level that would produce (1) a dose of 15 millirem or greater to an individual for radionuclides, (2) an estimated excess cancer risk of 1×10^{-5} for cancer-causing chemicals, or (3) a hazard quotient greater than 1 for hazardous chemicals that do not cause cancer. The screening levels are different for different exposure scenarios. Screening levels for radionuclides are found in a Laboratory document (LANL 2015); screening levels for nonradionuclides are found in a New Mexico Environment Department document (NMED 2015).

FOODSTUFFS

Federal standards exist for radionuclides and selected nonradionuclides (e.g., mercury and polychlorinated biphenyls [PCBs]) in foodstuffs. The Laboratory has established screening levels for radionuclides. If levels in foodstuffs exceed regional statistical reference levels, they are compared with screening levels and existing standards. The Laboratory has established a screening level of 1 millirem per year for activities of individual radionuclides in individual foodstuffs (e.g., fish, crops, etc.), assuming a residential scenario. The U.S. Environmental Protection Agency has established screening levels for mercury (EPA 2001) and PCBs (EPA 2000) in fish.

BIOTA

If radionuclide or chemical levels in biota exceed regional statistical reference levels, the levels are compared with screening levels. For radionuclides in biota, screening levels were set at 10% of the DOE standard (which is 1 rad per day for terrestrial plants and aquatic biota and 0.1 rad per day for terrestrial animals) by the Laboratory (DOE 2002). For chemicals, if a chemical in biota tissue exceeds the regional statistical reference level, (1) detected concentrations are compared with lowest observed adverse effect levels reported in published literature, if there is one available, and (2) chemical concentrations in the soil at the place of collection are compared with ecological screening levels (LANL 2017).

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UNITS OF MEASUREMENT

Throughout the Annual Site Environmental Report, the U.S. customary (English) system of measurement has generally been used. For units of radiation activity, exposure, and dose, U.S. customary units (that is, curie, roentgen, rad, and rem) are retained as the primary measurement because current standards are written in terms of these units. The equivalent units from the International System of Units are the becquerel, coulomb per kilogram, gray, and sievert, respectively. Table B-1 presents factors for converting U.S. customary units into units from the International System of Units.

Table B-1. Approximate Conversion Factors for Selected U.S. Customary Units

Multiply U.S. Customary Unit	by	to Obtain International System of Units (Metric) Unit
degrees Fahrenheit	5/9 (first subtract 32)	degrees Celsius
inches	2.54	centimeters
cubic feet	0.028	cubic meters
acres	0.4047	hectares
ounces	28.3	grams
pounds	0.453	kilograms
miles	1.61	kilometers
gallons	3.785	liters
feet	0.305	meters
parts per million	1	micrograms per gram
parts per million	1	milligrams per liter
square miles	2.59	square kilometers
picocuries	37	millibecquerel
rad	0.01	gray
millirem	0.01	millisievert

Table B-2 presents prefixes used in this report to define fractions or multiples of the base units of measurements. Scientific notation is used in this report to express very large or very small numbers. Translating from scientific notation to a more traditional number requires moving the decimal point either left or right from the number. If the value given is 2.0×10^{3}, the decimal point should be moved three numbers (insert zeros if no numbers are given) to the **right** of its present location. The number would then read 2000. If the value given is 2.0×10^{-5}, the decimal point should be moved five numbers to the **left** of its present location. The result would be 0.00002.

Table B-2. Prefixes Used with International System of Units (Metric) Units

Prefix	Factor	Symbol
mega	1,000,000 or 10^{6}	M
kilo	1000 or 10^{3}	k
centi	0.01 or 10^{-2}	c
milli	0.001 or 10^{-3}	m
micro	0.000001 or 10^{-6}	µ
nano	0.000000001 or 10^{-9}	n
pico	0.000000000001 or 10^{-12}	p
femto	0.000000000000001 or 10^{-15}	f
atto	0.000000000000000001 or 10^{-18}	a

DATA HANDLING OF RADIOCHEMICAL SAMPLES

Measurements of radioactivity in samples require that analytical or instrumental backgrounds be subtracted to obtain net values. Thus, net values are sometimes obtained that are lower than the minimum detection limit of the analytical technique, and results for individual measurements can be negative numbers. Although a negative value does not represent a physical reality, a valid long-term average of many measurements can be obtained only if the very small and negative values are included in the population calculations (Gilbert 1975).

For individual measurements, uncertainties are reported as one standard deviation. The standard deviation is estimated from the propagated sources of analytical error.

Standard deviations for the ambient air monitoring network station and group (offsite regional, offsite perimeter, and onsite) means are calculated using the standard equation:

$$s = (\Sigma\ (c_i - \bar{c})^2 / (N - 1))^{1/2}$$

where

c_i = sample i,

$\bar{c}$ = mean of samples from a given station or group, and

N = number of samples in the station or group.

This value is reported as one standard deviation for the station and group means.

REFERENCE

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Appendix C
DESCRIPTIONS OF TECHNICAL AREAS AND THEIR ASSOCIATED PROGRAMS

Locations of the technical areas operated by Los Alamos National Laboratory (the Laboratory) in Los Alamos County are shown in Figure 1-3 in Chapter 1. The main programs conducted at each of the areas are listed in this appendix.

Technical Area	Activities
00 (offsite facilities)	The Technical Area 00 designation is assigned to structures leased by the U.S. Department of Energy that are located outside the Laboratory's boundaries in the Los Alamos townsite and White Rock.
02 (Omega Site or Omega West Reactor)	Omega West Reactor, an 8-megawatt nuclear research reactor, was located at Technical Area 02. The reactor was decontaminated and decommissioned in 2002. It is now the location of the Omega West Monument and interpretive panels. The monument commemorates the historic reactors and other historical events that took place at Technical Area 02.
03 (Core Area or South Mesa Site)	Technical Area 03 is the Laboratory's core scientific and administrative area, with approximately half of the Laboratory's employees and total floor space. It is the location of a number of the Laboratory's key facilities, including the Chemistry and Metallurgy Research Building, the Sigma Complex, the Machine Shops, the Material Sciences Laboratory, and the Nicholas C. Metropolis Center for Modeling and Simulation.
05 (Beta Site)	Technical Area 05 is located between East Jemez Road and the Pueblo de San Ildefonso. It contains physical support facilities and an electrical substation. It is also the site of the Laboratory's interim measure to control chromium plume migration in the regional aquifer.
06 (Twomile Mesa Site)	Technical Area 06, located in the northwestern part of the Laboratory, is mostly undeveloped. It contains a meteorological tower, gas-cylinder-staging buildings, the Western Technical Area Substation, and buildings that are awaiting demolition.
08 (GT Site [Anchor Site West])	Technical Area 08, located along West Jemez Road, is a testing site where nondestructive dynamic testing techniques are used to ensure the quality of materials in items ranging from test weapons components to high-pressure dies and molds. Techniques used include radiography, radioisotope techniques, ultrasonic and penetrant testing, and electromagnetic test methods.
09 (Anchor Site East)	Technical Area 09 is located on the western edge of the Laboratory. Fabrication feasibility and the physical properties of explosives are explored at this technical area, and new organic compounds are investigated for possible use as explosives.
11 (K-Site)	Technical Area 11 is used for testing explosives components and systems, including vibration analysis and drop-testing materials and components under a variety of extreme physical environments. Facilities are arranged so that testing may be controlled and observed remotely, allowing devices that contain explosives, radioactive materials, and nonhazardous materials to be safely tested and observed.
14 (Q-Site)	Technical Area 14, located in the northwestern part of the Laboratory, is one of 14 firing areas. Most operations are remotely controlled and involve detonations, certain types of high-explosives machining, and permitted burning.
15 (R-Site)	Technical Area 15, located in the central portion of the Laboratory, is used for high-explosives research, development, and testing, mainly through hydrodynamic testing and dynamic experimentation. Technical Area 15 is the location of two firing sites: the Dual-Axis Radiographic Hydrodynamic Test Facility, which has an intense high-resolution, dual-machine radiographic capability; and building 306, a multipurpose facility where primary diagnostics are performed.

Technical Area	Activities
16 (S-Site)	Technical Area 16, in the western part of the Laboratory, is the location of the Weapons Engineering Tritium Facility, a state-of-the-art tritium processing facility. Technical Area 16 is also the location of high-explosives research, development, and testing; the High Explosives Wastewater Treatment Facility; the Tactical Training Facility; and the Indoor Firing Range.
18 (Pajarito Site)	Technical Area 18, located in Pajarito Canyon, was the location of the Los Alamos Critical Experiment Facility, a general purpose nuclear experiments facility. All operations at Technical Area 18 have ceased. The technical area, including the Pond Cabin and the Slotin Building, is now part of the Manhattan Project National Historical Park.
21 (DP Site)	Technical Area 21 is on the northern border of the Laboratory, next to the Los Alamos townsite. The former radioactive materials (including plutonium) processing facility was located in the western part of Technical Area 21. The Tritium Systems Test Assembly and the Tritium Science and Fabrication Facility were located in the eastern part. Operations from these facilities have been transferred and demolition was completed in 2010.
22 (TD Site)	Technical Area 22, located in the northwestern portion of the Laboratory, houses the Detonator Production Facility. Research, development, and fabrication of high-energy detonators and related devices are conducted at this facility.
28 (Magazine Area A)	Technical Area 28, located near the southern edge of the Laboratory, was an explosives storage area. Technical Area 28 contains five empty storage magazines that are being decontaminated and decommissioned.
33 (HP Site)	Technical Area 33 is a remotely located technical area at the southeastern boundary of the Laboratory. Technical Area 33 is used for experiments that require isolation but do not require daily oversight. The National Radioastronomy Observatory's Very Long Baseline Array telescope is located at this technical area.
35 (Ten Site)	Technical Area 35, located in the north-central portion of the Laboratory, is used for nuclear safeguards research and development, primarily in the areas of lasers, physics, fusion, materials development, and biochemistry and physical chemistry research and development. The Target Fabrication Facility, located at Technical Area 35, conducts precision machining and target fabrication, polymer synthesis, and chemical and physical vapor deposition. Additional activities at Technical Area 35 include research in reactor safety, optical science, and pulsed-power systems, as well as metallurgy, ceramic technology, and chemical plating. Additionally, there are some Biosafety Level 1 and 2 laboratories at Technical Area 35.
36 (Kappa Site)	Technical Area 36, a remotely located area in the eastern portion of the Laboratory, has four active firing sites that support explosives testing. The sites are used for a wide variety of nonnuclear ordnance tests.
37 (Magazine Area C)	Technical Area 37 is used as an explosives storage area. It is located along the eastern perimeter of Technical Area 16.
39 (Ancho Canyon Site)	Technical Area 39 is located at the bottom of Ancho Canyon. Technical Area 39 is used to study the behavior of nonnuclear weapons (primarily by photographic techniques) and various phenomenological aspects of explosives.
40 (DF Site)	Technical Area 40, centrally located within the Laboratory, is used for general testing of explosives or other materials and development of special detonators for initiating high-explosives systems.
41 (W-Site)	Technical Area 41, located in Los Alamos Canyon, is no longer actively used. Many buildings have been decontaminated and decommissioned; the remaining structures include historic properties.

Technical Area	Activities
43 (the Bioscience Facilities, formerly called the Health Research Laboratory)	Technical Area 43 is adjacent to the Los Alamos Medical Center at the northern border of the Laboratory and is the location of the Bioscience Facilities (formerly called the Health Research Laboratory). The Bioscience Facilities have Biosafety Level 1 and 2 laboratories and are the focal point of bioscience and biotechnology at the Laboratory. Research performed at the Bioscience Facilities includes structural, molecular, and cellular radiobiology; biophysics; radiobiology; biochemistry; and genetics.
46 (WA Site)	Technical Area 46, located between Pajarito Road and the Pueblo de San Ildefonso, is one of the Laboratory's basic research sites. Activities have focused on applied photochemistry operations and have included development of technologies for laser isotope separation and laser enhancement of chemical processes. The Sanitary Waste Water Systems Plant is also located within this technical area.
48 (Radiochemistry Site)	Technical Area 48, located in the north-central portion of the Laboratory, supports research and development in nuclear and radiochemistry, geochemistry, production of medical radioisotopes, and chemical synthesis. Hot cells are used to produce medical radioisotopes.
49 (Frijoles Mesa Site)	Technical Area 49, located near Bandelier National Monument, is used as a training area and for outdoor tests on materials and equipment components that involve generating and receiving short bursts of high-energy, broad-spectrum microwaves. The Interagency Wildfire Center and helipad located near the entrance to the technical area are operated by the National Park Service.
50 (Waste Management Site)	Technical Area 50, located near the center of the Laboratory, is the location of waste management facilities, including the Radioactive Liquid Waste Treatment Facility and the Waste Characterization, Reduction, and Repackaging Facility. The Actinide Research and Technology Instruction Center is also located in this technical area.
51 (Environmental Research Site)	Technical Area 51, located on Pajarito Road in the eastern portion of the Laboratory, is used for research and experimental studies on the long-term impacts of radioactive materials on the environment. Various types of waste storage and coverings are studied at this technical area.
52 (Reactor Development Site)	Technical Area 52 is located in the north-central portion of the Laboratory. A wide variety of theoretical and computational research and development activities related to nuclear reactor performance and safety, as well as to several environmental, safety, and health activities, are carried out at this technical area.
53 (Los Alamos Neutron Science Center)	Technical Area 53, located in the northern portion of the Laboratory, includes the Los Alamos Neutron Science Center. This facility houses one of the largest research linear accelerators in the world and supports both basic and applied research programs. Basic research includes studies of subatomic and particle physics, atomic physics, neutrinos, and the chemistry of subatomic interactions. Applied research includes materials science studies that use neutron spallation and contribute to defense programs. The facility also irradiates targets for medical isotope production.
54 (Waste Disposal Site)	Technical Area 54, located on the eastern border of the Laboratory, is one of the largest technical areas at the Laboratory. Its primary function is management of solid radioactive and hazardous chemical wastes, including storage.
55 (Plutonium Facility Complex Site)	Technical Area 55, located in the center of the Laboratory along Pajarito Road, is the location of the Plutonium Facility Complex. The Plutonium Facility provides chemical and metallurgical processes for recovering, purifying, and converting plutonium and other actinides into many compounds and forms. Radiological operations in the Radiological Laboratory/Utility/Office Building began in 2014.

Technical Area	Activities
57 (Fenton Hill Site)	Technical Area 57 is located about 20 miles (32 kilometers) west of the Laboratory on land administered by the U.S. Forest Service. The site has been used by the Laboratory since 1974, subject to an interagency agreement between the U.S. Department of Energy and the U.S. Forest Service. The site was originally developed for the Hot Dry Rock geothermal energy program, which was terminated in 1995, and subsequently used for astronomical studies. In 2012, the Laboratory demolished and removed several small structures, trailers, equipment pads, and equipment and implemented site stabilization. Some astronomy activities may continue.
58 (Twomile North Site)	Technical Area 58, located near the Laboratory's northwest border on Twomile Mesa North, is a forested area reserved for future use because of its proximity to Technical Area 03. The technical area houses the protective force running track, a few Laboratory-owned storage trailers, and a temporary storage area.
59 (Occupational Health Site)	Technical Area 59 is located on the south side of Pajarito Road adjacent to Technical Area 03. Technical Area 59 is the location of staff who provide support services in health physics, risk management, industrial hygiene and safety, policy and program analysis, air quality, water quality and hydrology, hazardous and solid waste analysis, and radiation protection. The medical facility at Technical Area 59 includes a clinical laboratory and provides bioassay sample analytical support.
60 (Sigma Mesa)	Technical Area 60 is located southeast of Technical Area 03. The technical area is primarily used for physical support and infrastructure activities. The Nevada Test Site Test Fabrication Facility and a test tower are also located at Technical Area 60. This facility is now being used as a waste storage area.
61 (East Jemez Site)	Technical Area 61, located in the northern portion of the Laboratory, contains physical support and infrastructure facilities, including a sanitary waste transfer station operated by Los Alamos County, a photovoltaic array, and sewer pump stations. This is the former site of the Los Alamos County landfill, which is now closed and capped.
62 (Northwest Site)	Technical Area 62, located next to Technical Area 03 and West Jemez Road in the northwest corner of the Laboratory, serves as a forested buffer zone. This technical area is reserved for future use.
63 (Pajarito Service Area)	Technical Area 63, located in the north-central portion of the Laboratory, contains physical support and infrastructure facilities and is the location of the new Transuranic Waste Facility.
64 (Central Guard Site)	Technical Area 64 is located in the north-central portion of the Laboratory and provides offices and storage space.
66 (Central Technical Support Site)	Technical Area 66 is located on the southeast side of Pajarito Road in the center of the Laboratory. The Advanced Technology Assessment Center, the only facility at this technical area, provides office and technical space for technology transfer and other industrial partnership activities.
67 (Pajarito Mesa Site)	Technical Area 67 is a forested buffer zone located in the north-central portion of the Laboratory. No operations or facilities are currently located at the technical area.
68 (Water Canyon Site)	Technical Area 68, located in the southern portion of the Laboratory, is a testing area for dynamic experiments. Twenty acres of land have been converted into a testing area for detecting materials of interest.
69 (Anchor North Site)	Technical Area 69, located in the northwestern corner of the Laboratory, serves as a forested buffer zone. The Emergency Operations Center is located here.
70 (Rio Grande Site)	Technical Area 70 is located on the southeastern boundary of the Laboratory. It is an undeveloped technical area that serves as a buffer zone. Part of the White Rock Canyon Reserve is located here.

Technical Area	Activities
71 (Southeast Site)	Technical Area 71 is located on the southeastern boundary of the Laboratory and is adjacent to White Rock to the northeast. It is an undeveloped technical area that serves as a buffer zone for the High Explosives Test Area. Part of the White Rock Canyon Reserve is located here.
72 (East Entry Site)	Technical Area 72, located along East Jemez Road on the northeastern boundary of the Laboratory, is used by protective force personnel for required firearms training and practice purposes.
73 (Airport Site)	Technical Area 73 is located along the northern boundary of the Laboratory, adjacent to NM 502. Los Alamos County manages, operates, and maintains the community airport under a leasing arrangement with the U.S. Department of Energy. Use of the airport by private individuals is permitted with special restrictions.
74 (Otowi Tract)	Technical Area 74 is a forested area in the northeastern corner of the Laboratory. A large portion of this technical area has been conveyed to Los Alamos County or transferred to the Department of the Interior in trust for the Pueblo de San Ildefonso and is no longer part of the Laboratory.

RELATED WEBSITES

For more information on environmental topics at Los Alamos National Laboratory (the Laboratory), access the following websites:

Current and past environmental reports and supplemental data tables	http://www.lanl.gov/environment/environmental-report.php
The Laboratory's website	http://www.lanl.gov/
U.S. Department of Energy/National Nuclear Security Administration Los Alamos Field Office	https://www.energy.gov/nnsa/locations
U.S. Department of Energy Environmental Management Los Alamos Field Office website	https://energy.gov/em-la/environmental-management-los-alamos-field-office
U.S. Department of Energy website	http://www.energy.gov/
The Laboratory's air quality pages	http://www.lanl.gov/environment/protection/monitoring/air-quality.php
The Laboratory's water quality pages	http://www.lanl.gov/environment/protection/monitoring/water-quality.php
The Laboratory's environmental stewardship pages	http://www.lanl.gov/environment/index.php
N3B – Los Alamos (Legacy Waste Cleanup Contractor)	https://n3b-la.com/
The Laboratory's Electronic Public Reading Room	https://eprr.lanl.gov/
Environmental Cleanup Electronic Public Reading Room	https://ext.em-la.doe.gov/EPRR/
The Laboratory's environmental database	https://www.intellusnm.com/

The following Los Alamos National Laboratory organizations perform environmental surveillance, ensure environmental compliance, and provide environmental data for this report:

Associate Directorate for Environment, Safety, Health, Quality, Safeguards, and Security
    Environmental Protection and Compliance Division
    Waste Programs Division
N3B Los Alamos
    Environmental Remediation Program

Previous reports in this series are LA-UR-19-28950, LA-UR-19-28565, LA-UR-17-27987, LA-UR-16-26788, LA-UR-15-27513, LA-UR-14-27564, LA-UR-13-27065, LA-14427-ENV, LA-13775-ENV, LA-13861-ENV, LA-13979-ENV, LA-14085-ENV, LA-14162-ENV, LA-14239-ENV, LA-14304-ENV, LA-14341-ENV, LA-14369-ENV, LA-14407-ENV, LA-14427-ENV, LA-14445-ENV, LA-14461-ENV.

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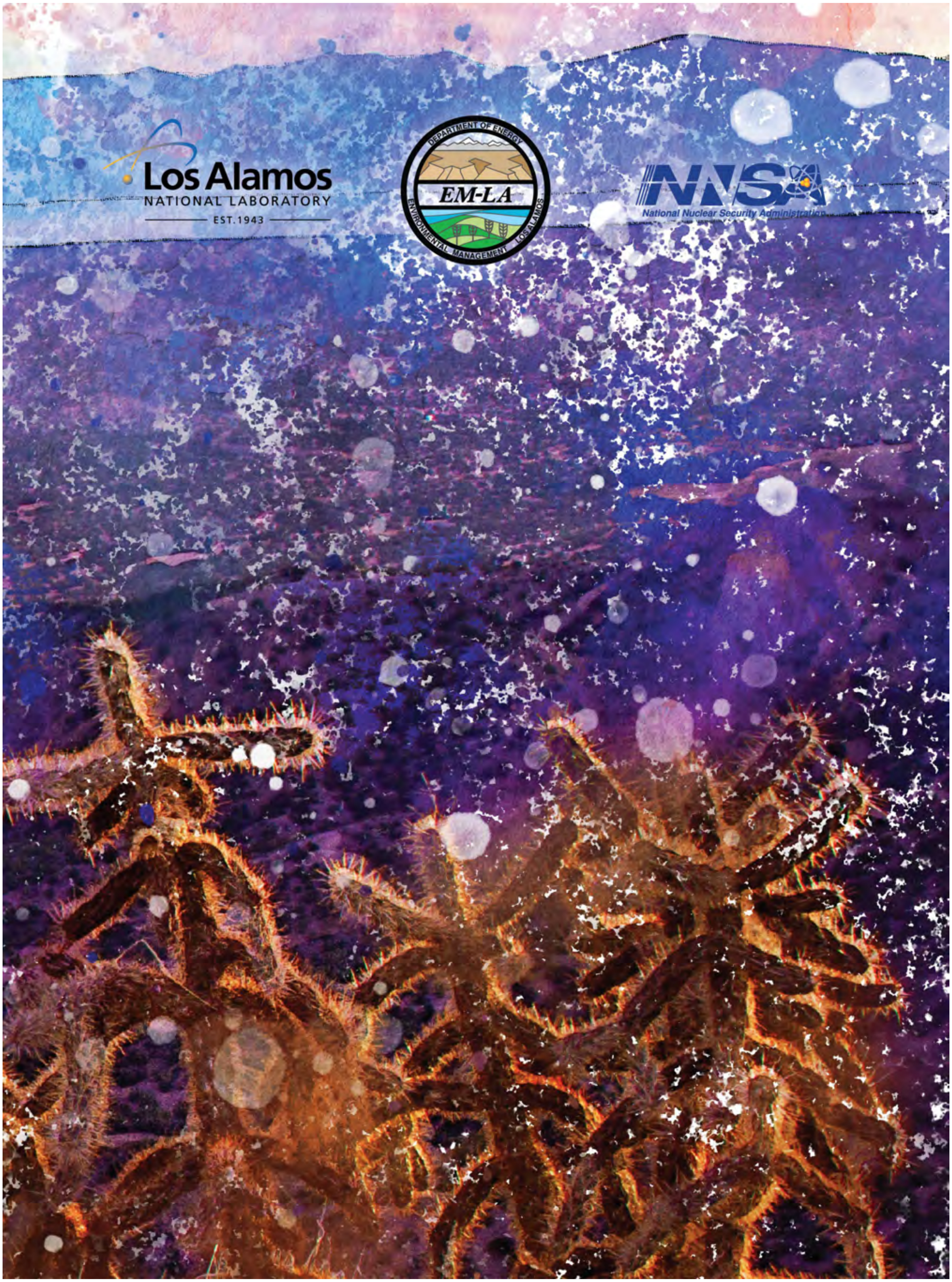
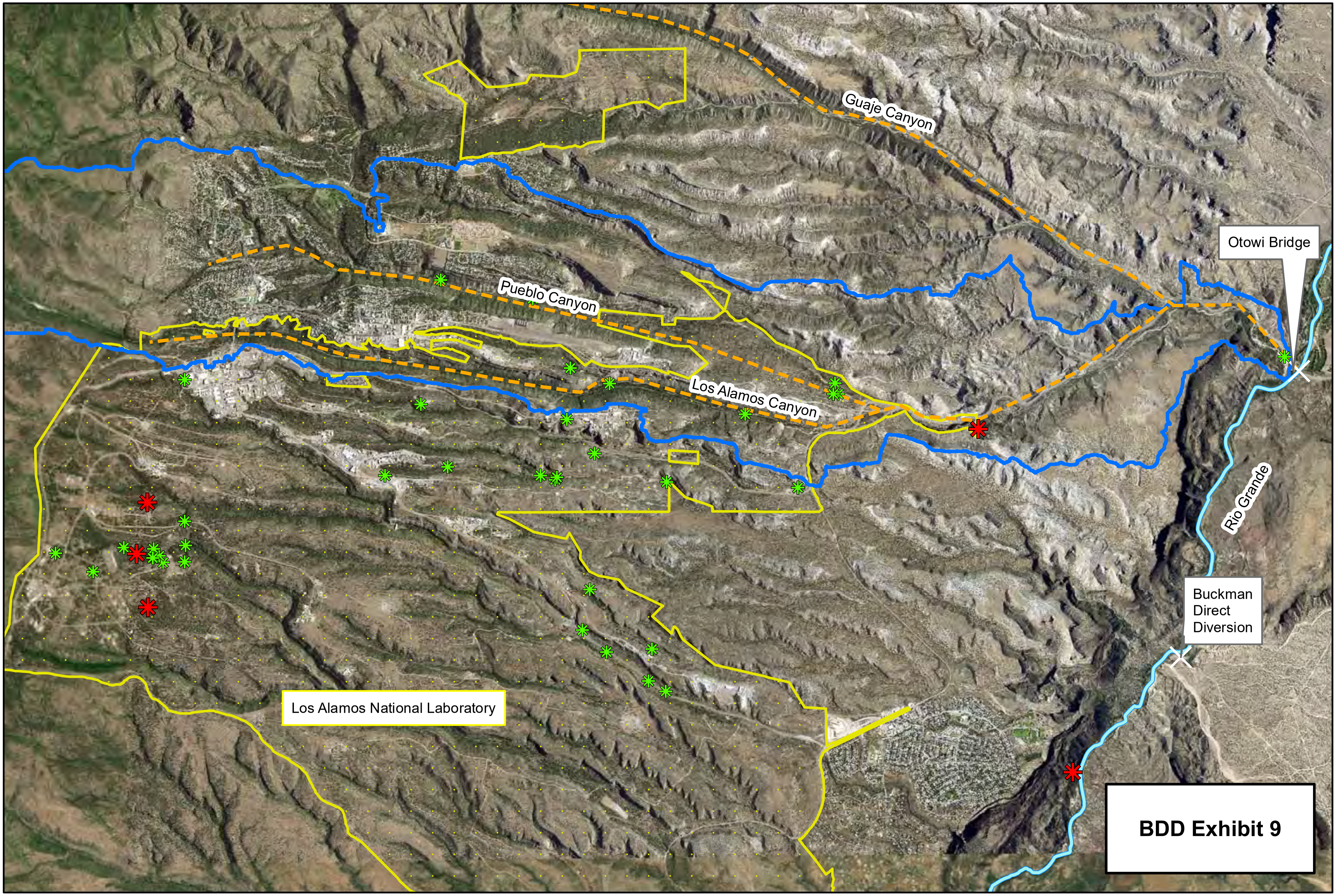


2020 TR BDD 0483

Exhibit 9

Map of PFAS Detections in Groundwater and Springs-Los Alamos National Laboratory

2020 TR BDD 0484



PFAS Detections in Groundwater and Springs Los Alamos National Laboratory

- ✳ PFAS Detection in Springs
- ✳ PFAS Detection in Groundwater
- ▭ Los Alamos Canyon Watershed
- - - - Canyons
- ▭ LANL Boundary

Note: Data from Intellusnm.com 6/21/2021

GLORIETA GEOSCIENCE, INC.

Exhibit 10

TREAT Raw Data v. 05312018

2020 TR BDD 0485 - 0502

TREAT RAW DATA		v. 05312018					
		Date of Sample	**3/22/2016 - 3/23/2016**				
		TREAT Sample Location	**RG**	**SS1**	**SS2**	**SS3**	**SS4**
		Sample Location Description	**Rio Grande**	**Raw Water**	**After Conventional Treatment**	**After Membrane Filter**	**After GAC**
		Primary Contract Laboratory	**Hall**	**Hall**	**Hall**	**Hall**	**Hall**
Analyte Group	**Analyte**	**units**					
Miscellaneous	TOC	mg/L	2.5	2.5	1.9	1.8	1.6
	Conductivity	µmhos/cm	230	220	240	240	240
	TDS	mg/L	162	164	160	154	153
	Chloride	mg/L	4.5	4.5	19	19	19
	Fluoride	mg/L	0.26	0.25	0.25	0.27	0.26
	Sulfate	mg/L	22	22	23	23	23
	Nitrate/Nitrite	mg/L	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Metals (total)	Aluminum	mg/L	0.56	0.50	0.040	< 0.020	< 0.020
	Antimony	mg/L	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
	Arsenic	mg/L	0.0016	0.0016	< 0.0010	< 0.0010	< 0.0010
	Barium	mg/L	0.049	0.046	0.031	0.030	0.033
	Beryllium	mg/L	< 0.0020	< 0.0020	< 0.0020	< 0.0020	< 0.0020
	Boron	mg/L	< 0.040	< 0.040	< 0.040	< 0.040	< 0.040
	Cadmium	mg/L	< 0.0020	< 0.0020	< 0.0020	< 0.0020	< 0.0020
	Calcium	mg/L	25	25	27	27	26
	Chromium	mg/L	< 0.0060	< 0.0060	< 0.0060	< 0.0060	< 0.0060
	Cobalt	mg/L	< 0.0060	< 0.0060	< 0.0060	< 0.0060	< 0.0060
	Copper	mg/L	0.0029	0.0029	0.0012	0.0014	< 0.0010
	Iron	mg/L	0.77	0.73	0.88	< 0.020	< 0.020
	Lead	mg/L	0.0026	0.0024	< 0.00050	< 0.00050	< 0.00050
	Magnesium	mg/L	5.0	5.0	5.1	5.0	5.0
	Manganese	mg/L	0.11	0.093	0.039	0.035	< 0.0020
	Mercury	mg/L	< 0.00020	< 0.00020	< 0.00020	< 0.00020	< 0.00020
	Nickel	mg/L	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
	Potassium	mg/L	2.4	2.3	2.5	2.5	2.5
	Selenium	mg/L	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
	Silver	mg/L	< 0.0050	< 0.0050	< 0.0050	< 0.0050	< 0.0050
	Sodium	mg/L	12	12	13	13	13
	Thallium	mg/L	< 0.00050	< 0.00050	< 0.00050	< 0.00050	< 0.00050
	Uranium	mg/L	0.0019	0.0018	0.0012	0.0011	< 0.0005
	Vanadium	mg/L	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050
	Zinc	mg/L	0.012	0.023	< 0.010	< 0.010	< 0.010
Metals (Dissolved)	Aluminum	mg/L					
	Antimony	mg/L					
	Arsenic	mg/L					
	Barium	mg/L					
	Beryllium	mg/L					
	Boron	mg/L					
	Cadmium	mg/L					
	Calcium	mg/L					
	Chromium	mg/L					
	Cobalt	mg/L					
	Copper	mg/L					
	Iron	mg/L					
	Lead	mg/L					
	Magnesium	mg/L					
	Manganese	mg/L					
	Mercury	mg/L					
	Nickel	mg/L					
	Potassium	mg/L					
	Selenium	mg/L					
	Silver	mg/L					
	Sodium	mg/L					
	Thallium	mg/L					
	Uranium	mg/L					

TREAT RAW DATA	v. 05312018						
	Date of Sample		**3/22/2016 - 3/23/2016**				
	TREAT Sample Location		**RG**	**SS1**	**SS2**	**SS3**	**SS4**
	Sample Location Description		**Rio Grande**	**Raw Water**	**After Conventional Treatment**	**After Membrane Filter**	**After GAC**
	Primary Contract Laboratory		**Hall**	**Hall**	**Hall**	**Hall**	**Hall**
	Vanadium	mg/L					
	Zinc	mg/L					
Suspended Sediment	SSC Coarse	mg/L	< 1.00	1.45	< 1.00	< 1.00	< 1.00
	SSC Fine	mg/L	28.3	45.8	2.68	< 1.00	< 1.00
	SSC Total	mg/L	28.3	47.3	2.68	< 1.00	< 1.00
PCBs	PCBs (total congeners)	pg/L	< 20.1	< 20.4	< 20.2	< 20.1	< 20.2
Dioxins and Furans	Total Tetracholodioxins	pg/L					
	Total Pentachorodioxins	pg/L					
	Total Hexacholrodioxins	pg/L					
	Total Heptacholrodioxins	pg/L					
	Octocholrodioxin	pg/L					
	Total Tetracholrofurans	pg/L					
	Total Pentachorofurans	pg/L					
	Total Hexacholrofurans	pg/L					
	Total Heptacholrofurans	pg/L					
	Octocholrofuran	pg/L					
	Total TEQ (2005 WHO TEFs)	pg/L					
Hormones-APOS	Ally Trenbolone	ng/L	< 0.813	< 0.811	< 0.813	< 0.809	< 0.830
	Androstenedione	ng/L	< 2.03	< 2.03	< 2.08	< 2.02	< 2.08
	Androsterone	ng/L	< 51.9	< 47.7	227	< 48.1	< 28.2
	Desogestrel 3	ng/L	< 185	< 291	< 93.9	< 98.9	< 71.3
	Estriol	ng/L	< 16.3	< 39.3	< 27.1	< 25.5	< 18.2
	Mestranol	ng/L	118*	150*	97.8*	120*	101*
	Norethindrone	ng/L	< 4.07	< 4.06	< 4.16	< 4.04	< 4.15
	Norgestrel	ng/L	< 4.07	< 4.06	< 4.16	< 4.04	< 4.15
	Progestrone	ng/L	< 0.813	< 0.811	< 0.831	< 0.809	< 0.83
	Testosterone	ng/L	< 0.813	< 0.811	< 0.831	< 0.809	< 0.83
Hormones-ANEG	17 alpha-Dihydroequilin	ng/L	< 4.07	< 4.06	< 4.16	< 4.04	< 5.04
	Equilenin	ng/L	< 0.813	< 1.96	< 0.831	< 0.809	< 0.830
	Equilin	ng/L	< 8.13	< 8.11	< 8.31	< 8.09	< 8.30
	17 beta-Estradiol	ng/L	< 5.64	< 5.96	< 5.91	< 7.65	< 5.07
	17 alpha-Estradiol	ng/L	< 4.07	< 4.06	< 4.16	< 4.04	< 4.15
	Estrone	ng/L	< 4.07	< 4.06	< 4.16	< 4.04	< 4.15
Hormones (other)	Diethylstilbestrol	ng/L					
	Ethinyl Estradiol	ng/L					
(AN3) Pharmaceutical & Personal Care Products	Bisphenol A	ng/L	< 508	< 507	< 519	< 506	< 519
	Furosemide	ng/L	< 40.7	< 40.6	< 41.6	< 40.4	< 41.5
	Gemfribozil	ng/L	< 1.53	< 1.52	< 1.56	< 1.52	< 1.56
	Glipizide	ng/L	< 6.10	< 6.09	< 6.23	< 6.07	< 6.23
	Glyburide	ng/L	< 3.05	< 3.04	< 3.12	< 3.03	< 3.11
	Hydrochorothiazide	ng/L	< 20.3	< 20.3	< 20.8	< 20.2	< 20.8
	2-Hydroxy-ibuprofen	ng/L	< 81.3	< 81.1	< 83.1	< 80.9	< 83.0
	Ibuprofen	ng/L	< 15.3	< 15.2	< 15.6	< 15.2	< 15.6
	Naproxen	ng/L	< 3.05	< 3.04	< 3.12	< 3.03	< 3.11
	Triclocarban	ng/L	< 3.05	< 3.04	< 3.12	< 3.03	< 3.11
	Triclosan	ng/L	< 61.0	< 60.9	< 62.3	< 60.7	< 62.3
	Warfarin	ng/L	< 1.53	< 1.52	< 1.56	< 1.52	< 1.56
(AP1) Pharmaceutical & Personal Care Products	Acetaminophen	ng/L	< 15.3	45.2	< 15.6	< 15.2	< 15.6
	Azithromycin	ng/L	< 1.53	< 1.52	< 1.56	< 1.52	< 1.56
	Caffeine	ng/L	< 15.3	17.7	< 15.6	< 15.2	< 15.6
	Carbadox	ng/L	< 1.53	< 1.52	< 1.56	< 1.52	< 1.56
	Carbamazepine	ng/L	< 1.53	< 1.52	< 1.56	< 1.52	< 1.56
	Cefotaxime	ng/L	< 21.1	< 16.4	< 22.4	< 13.0	< 13.8
	Ciprofloxacin	ng/L	< 221	< 149	< 37.3	< 9.25	< 6.23
	Clarithromycin	ng/L	< 1.53	< 1.52	< 1.56	< 1.52	< 1.56
	Clinafloxacin	ng/L			< 218	< 7.36	< 17.0

TREAT RAW DATA		v. 05312018					
	Date of Sample		3/22/2016 - 3/23/2016				
	TREAT Sample Location		RG	SS1	SS2	SS3	SS4
	Sample Location Description		Rio Grande	Raw Water	After Conventional Treatment	After Membrane Filter	After GAC
	Primary Contract Laboratory		Hall	Hall	Hall	Hall	Hall
	Cloxacillin	ng/L	< 3.05	< 3.04	< 3.12	< 3.03	< 3.11
	Dehydronifedipine	ng/L	< 0.610	< 0.609	< 0.623	< 0.607	< 0.623
	Diphenhydramine	ng/L	< 0.610	< 0.609	< 0.623	< 0.607	< 0.623
	Diltiazem	ng/L	< 0.305	< 0.304	< 0.312	< 0.303	< 0.311
	Digoxin	ng/L	< 6.10	< 6.09	< 6.23	< 6.07	< 6.23
	Digoxigenin	ng/L	< 6.10	< 6.09	< 6.23	< 6.07	< 6.23
	Enrofloxacin	ng/L			< 5.84	< 3.03	< 3.11
	Erythromycin-H2O	ng/L	< 2.34	< 2.33	< 2.39	< 2.33	< 2.39
	Flumequine	ng/L	< 1.53	< 1.52	< 1.56	< 1.52	< 1.56
	Fluoxetine	ng/L	< 1.53	< 1.52	< 1.56	< 1.52	< 1.56
	Lincomycin	ng/L	< 3.05	< 3.04	< 3.12	< 3.03	< 3.11
	Lomefloxacin	ng/L			< 3.12	< 3.03	< 3.11
	Miconazole	ng/L	< 1.53	< 1.52	< 1.56	< 1.52	< 1.56
	Norfloxacin	ng/L			< 100	< 15.2	< 15.6
	Norgestimate	ng/L	< 4.52	< 4.35	< 6.04	< 3.33	< 3.98
	Ofloxacin	ng/L			< 1.56	< 1.52	< 1.56
	Ormetoprim	ng/L	< 0.61	< 0.609	< 0.623	< 0.607	< 0.623
	Oxacillin	ng/L	< 3.05	< 3.04	< 3.12	< 3.03	< 3.11
	Oxolinic Acid	ng/L	< 1.11	< 0.643	< 1.05	< 1.04	< 0.841
	Penicillin G	ng/L	< 3.05	< 3.04	< 3.12	< 3.03	< 3.11
	Penicillin V	ng/L	< 3.05	< 3.04	< 3.12	< 3.03	< 3.11
	Roxithromycin	ng/L	< 0.305	< 0.304	< 0.312	< 0.303	< 0.311
	Sarafloxacin	ng/L			< 15.6	< 15.2	< 15.6
	Sulfachloropyridazine	ng/L	< 1.53	< 1.52	< 1.56	< 1.52	< 1.56
	Sulfadiazine	ng/L	< 1.53	< 1.52	< 1.56	< 1.52	< 1.56
	Sulfadimethoxine	ng/L	< 0.508	< 0.304	< 0.312	< 0.303	< 0.331
	Sulfamerazine	ng/L	< 0.610	< 0.609	< 0.623	< 0.607	< 0.623
	Sulfamethazine	ng/L	< 0.848	< 0.879	< 0.623	< 0.607	< 0.711
	Sulfamethizole	ng/L	< 0.610	< 0.609	< 0.623	< 0.607	< 0.623
	Sulfamethoxazole	ng/L	3.92	3.76	1.05	1.04	< 0.623
	Sulfanilamide	ng/L	< 15.3	< 15.2	< 15.6	< 15.2	< 15.6
	Sulfathiazole	ng/L	< 1.53	< 1.52	< 1.56	< 1.52	< 1.56
	Thiabendazole	ng/L	< 1.53	< 1.52	< 1.56	< 1.52	< 1.56
	Trimethoprim	ng/L	< 1.53	< 1.52	< 1.56	< 1.52	< 1.56
	Tylosin	ng/L	< 6.10	< 6.09	< 6.23	< 6.07	< 6.23
	Virginiamycin M1	ng/L	< 3.05	< 3.04	< 3.12	< 3.03	< 3.11
	1,7-Dimethylxanthine	ng/L	< 61.0	< 60.9	< 62.3	< 60.7	< 62.3
(AP5) Pharmaceutical & Personal Care Products	Alprazolam	ng/L	< 0.305	< 0.304	< 0.312	< 0.303	< 0.311
	Amitriptyline	ng/L	< 0.305	< 0.304	< 0.312	< 0.303	< 0.311
	Amlodipine	ng/L	< 1.53	< 1.52	< 1.56	< 1.52	< 1.56
	Benzoylecgonine	ng/L	< 0.305	0.407	< 0.565	< 0.303	< 0.311
	Benztropine	ng/L	0.601	< 0.507	< 0.519	< 0.506	< 0.519
	Betamethasone	ng/L	< 1.53	< 1.52	< 1.56	< 1.52	< 1.56
	Cocaine	ng/L	0.232	0.304	1.96	< 0.152	< 0.156
	DEET	ng/L	18.3	1.89	2.04	1.35	1.14
	Desmethyldiltiazem	ng/L	< 0.153	< 0.152	< 0.156	< 0.152	< 0.156
	Diazepam	ng/L	< 0.305	< 0.304	< 0.312	< 0.303	< 0.311
	Fluocinonide	ng/L	< 6.10	< 6.47	< 6.23	< 6.07	< 6.23
	Fluticasone propionate	ng/L	< 2.07	< 2.11	< 2.08	< 2.02	< 2.08
	Hydrocortisone	ng/L	< 61.0	< 60.9	< 62.3	< 60.7	< 62.3
	10-hydroxy-amitriptyline	ng/L	< 0.153	< 0.152	< 0.156	< 0.152	< 0.156
	Meprobamate	ng/L	< 4.07	< 4.06	< 4.16	< 4.04	< 4.15
	Methylprednisolone	ng/L	< 4.07	< 4.06	< 4.16	< 4.04	< 4.15
	Metoprolol	ng/L	< 2.82	< 2.61	< 3.52	< 2.96	< 2.35
	Norfluoxetine	ng/L	< 1.53	< 1.52	< 1.56	< 1.52	< 1.56
	Norverapamil	ng/L	< 0.153	< 0.152	< 0.156	< 0.152	< 0.156
	Paroxetine	ng/L	< 4.07	< 4.06	< 4.16	< 4.04	< 4.15

TREAT RAW DATA		v. 05312018					
		Date of Sample	**3/22/2016 - 3/23/2016**				
		TREAT Sample Location	**RG**	**SS1**	**SS2**	**SS3**	**SS4**
		Sample Location Description	**Rio Grande**	**Raw Water**	**After Conventional Treatment**	**After Membrane Filter**	**After GAC**
		Primary Contract Laboratory	**Hall**	**Hall**	**Hall**	**Hall**	**Hall**
	Prednisolone	ng/L	< 6.10	< 7.21	< 6.23	< 6.07	< 6.23
	Prednisone	ng/L	< 20.3	< 20.3	< 20.8	< 20.2	< 20.8
	Promethazine	ng/L	< 0.407	< 0.406	< 0.416	< 0.404	< 0.415
	Propoxyphene	ng/L	< 1.02	< 1.01	< 1.04	< 1.01	< 1.04
	Propranolol	ng/L	< 2.03	< 2.03	< 2.08	< 2.02	< 2.08
	Sertraline	ng/L	< 0.407	< 0.406	< 0.416	< 0.404	< 0.415
	Simvastatin	ng/L	< 20.3	< 20.3	< 20.8	< 20.2	< 20.8
	Theophylline	ng/L	< 61.0	< 60.9	< 62.3	< 60.7	< 62.3
	Trenbolone	ng/L	< 4.07	< 4.06	< 4.16	< 4.04	< 4.15
	Trenbolone acetate	ng/L	< 0.305	< 0.304	< 0.312	< 0.303	< 0.311
	Valsartan	ng/L	< 4.07	< 4.06	< 4.16	< 4.04	< 4.15
	Verapamil	ng/L	< 0.153	< 0.152	< 0.156	< 0.152	< 0.156
	Diclofenac	ng/L					
Pharmaceuticals (other)	Dilantin	ng/L					
	Hydrocodone	ng/L					
	Methadone	ng/L					
	Pentoxyfylline	ng/L					
Other Steroids and Endocrine Disrupting	Iopromide	ng/L					
	Oxybenzone	ng/L					
	Salicylic Acid	ng/L					
Herbicides	Atrazine	ng/L					
Radiologicals	Gross alpha	pCi/L	< 2.80	3.99	< 2.86	< 2.17	< 2.60
	Gross beta	pCi/L	5.58	7.17	2.45	< 2.95	< 2.89
	Ra-226	pCi/L	0.265	0.490	0.216	0.296	0.285
	Ra-228	pCi/L	< 0.467	< 0.459	< 0.475	< 0.471	< 0.481
	Am-241 (alpha spec)	pCi/L	< 0.040	< 0.0679	< 0.0722	< 0.0401	< 0.0376
	Pu-238	pCi/L	< 0.0797	< 0.0542	< 0.0179	< 0.0582	< 0.0162
	Pu-239/240	pCi/L	< 0.086	< 0.0723	< 0.0521	< 0.0456	< 0.0472
	Pu-244	pCi/L	< 0.0625	< 0.0723	< 0.0521	< 0.0286	< 0.0162
	U-234	pCi/L					
	U-235	pCi/L					
	U-233/234	pCi/L	1.06	0.967	0.620	0.617	0.331
	U-235/236 (alpha spec)	pCi/L	0.120	0.0405	0.0529	< 0.0601	0.0585
	U-238 (alpha spec)	pCi/L	0.702	0.629	0.326	0.373	0.215
	Ac-228	pCi/L	< 11.3	< 13.0	< 16.4	< 12.0	< 12.9
	Am-241 (gamma spec)	pCi/L	< 18.8	< 20.8	< 6.09	< 10.5	< 34.1
	Sb-124	pCi/L	< 9.35	< 7.89	< 9.50	< 8.41	< 8.07
	Sb-125	pCi/L	< 9.11	< 8.18	< 10.5	< 8.43	< 9.70
	Ba-133	pCi/L	< 4.23	< 4.01	< 4.19	< 4.46	< 4.16
	Ba-140	pCi/L	< 25.2	< 20.9	< 25.0	< 22.1	< 20.8
	Be-7	pCi/L	< 27.8	< 31.8	< 33.3	< 27.2	< 32.4
	Bi-212	pCi/L	< 43.5	< 44.1	< 48.1	< 42.6	< 50.4
	Bi-214	pCi/L	< 7.95	< 7.05	< 7.70	< 7.39	< 8.17
	Ce-139	pCi/L	< 3.06	< 3.30	< 3.35	< 2.45	< 3.34
	Ce-141	pCi/L	< 6.63	< 6.79	< 6.40	< 5.38	< 7.01
	Ce-144	pCi/L	< 21.6	< 21.6	< 20.7	< 18.3	< 23.4
	Cs-134	pCi/L	< 3.77	< 3.57	< 4.10	< 3.40	< 3.66
	Cs-136	pCi/L	< 8.37	< 9.47	< 8.12	< 7.30	< 8.67
	Cs-137	pCi/L	< 3.27	< 3.00	< 3.73	< 2.91	< 3.54
	Cr-51	pCi/L	< 40.9	< 37.6	< 37.1	< 31.2	< 38.8
	Co-56	pCi/L	< 3.13	< 3.70	< 4.40	< 3.41	< 3.25
	Co-57	pCi/L	< 2.86	< 3.07	< 2.63	< 2.58	< 3.25
	Co-58	pCi/L	< 3.34	< 3.34	< 3.76	< 2.90	< 3.44
	Co-60	pCi/L	< 4.16	< 3.59	< 4.44	< 3.29	< 3.00
	Eu-152	pCi/L	< 9.57	< 9.55	< 10.5	< 8.81	< 10.2
	Eu-154	pCi/L	< 9.49	< 8.72	< 11.4	< 9.12	< 9.87

TREAT RAW DATA

v. 05312018

	Date of Sample		**3/22/2016 - 3/23/2016**				
	TREAT Sample Location		**RG**	**SS1**	**SS2**	**SS3**	**SS4**
	Sample Location Description		**Rio Grande**	**Raw Water**	**After Conventional Treatment**	**After Membrane Filter**	**After GAC**
	Primary Contract Laboratory		**Hall**	**Hall**	**Hall**	**Hall**	**Hall**
	Eu-155	pCi/L	< 12.1	< 11.0	< 10.2	< 9.85	< 14.2
	I-131	pCi/L	▨	▨	▨	▨	▨
	Ir-192	pCi/L	< 4.00	< 3.51	< 3.61	< 3.17	< 3.57
	Fe-59	pCi/L	< 7.57	< 7.47	< 8.21	< 7.06	< 6.48
	Pa-234m	pCi/L	▨	▨	▨	▨	▨
	Pb-210	pCi/L	< 467	< 572	< 51.9	< 208	< 1290
	Pb-212	pCi/L	< 7.27	< 7.03	< 6.87	< 6.06	< 7.21
	Pb-214	pCi/L	< 7.81	< 7.79	< 8.35	< 7.35	< 8.89
	Mn-54	pCi/L	< 3.09	< 2.94	< 3.52	< 2.79	< 3.04
	Hg-203	pCi/L	< 3.68	< 3.83	< 3.88	< 3.67	< 4.05
	Nd-147	pCi/L	< 47.7	< 51.9	< 48.6	< 45.1	< 44.4
	Np-239	pCi/L	< 29.2	< 29.9	< 28.6	< 26.1	< 33.7
	Nb-94	pCi/L	< 2.96	< 2.88	< 3.77	< 2.86	< 3.01
	Nb-95	pCi/L	< 3.85	< 3.71	< 4.04	< 3.54	< 3.64
	K-40	pCi/L	< 47.8	< 46.4	< 45.7	< 42.7	< 45.7
	Pm-144	pCi/L	< 3.25	< 3.20	< 3.88	< 3.11	< 3.38
	Pm-146	pCi/L	< 3.90	< 4.12	< 4.29	< 3.86	< 4.31
	Ra-228 (gamma spec)	pCi/L	< 11.3	< 13.0	< 16.4	< 12.0	< 12.9
	Ru-106	pCi/L	< 28.2	< 29.1	< 35.6	< 29.2	< 30.4
	Ag-110m	pCi/L	< 4.26	< 4.46	< 4.93	< 4.13	< 4.59
	Na-22	pCi/L	< 3.35	< 3.06	< 3.94	< 3.21	< 3.46
	Tl-208	pCi/L	< 3.30	< 3.55	< 4.05	< 3.06	< 4.11
	Th-234	pCi/L	< 178	< 193	< 85.3	< 94.6	< 295
	Sn-113	pCi/L	< 4.44	< 4.05	< 4.81	< 4.05	< 4.66
	U-235 (gamma spec)	pCi/L	< 21.8	< 22.1	< 21.5	< 18.0	< 24.5
	U-238 (gamma spec)	pCi/L	< 178	< 193	< 85.3	< 94.6	< 295
	Y-88	pCi/L	< 4.30	< 4.22	< 5.61	< 2.65	< 3.96
	Zn-65	pCi/L	< 7.78	< 6.73	< 7.86	< 6.33	< 8.60
	Zr-95	pCi/L	< 6.00	< 6.20	< 6.46	< 5.98	< 6.70
	Sr-90	pCi/L	< 0.483	< 0.372	< 0.310	< 0.471	< 0.477
	Tritium	pCi/L	12.5	10.2	9.39	14.8	12.8

Notes:

▨ = Not analyzed, not quantified, or not reported

*** = estimated value**

-- Data are not blank corrected, and should not be used for decision-level assessment

-- A "<" value is equivalent to a "non-detect" value; the number represents the detection limit

-- Detection limits for detected quantities are not noted; see laboratory reports for detection limits and data qualifiers

-- TREAT study described in Bowman, D. K. (2015). *Storm Water Quality Monitoring of Rio Grande at Buckman Direct Diversion* . NM: BDD.

-- Data herein were subject to quality control procedures described in a separate document, and therefore may deviate from data presented in previous published and unpublished reports not subject to the same procedures

TREAT RAW DATA		v. 05312018					
		Date of Sample	**5/9/2016 - 5/10/2016**				
		TREAT Sample Location	**RG**	**SS1**	**SS2**	**SS3**	**SS4**
		Sample Location Description	**Rio Grande**	**Raw Water**	**After Conventional Treatment**	**After Membrane Filter**	**After GAC**
		Primary Contract Laboratory	**Hall**	**Hall**	**Hall**	**Hall**	**Hall**
Analyte Group	**Analyte**	**units**					
Miscellaneous	TOC	mg/L	4.7	4.1	2.5	2.4	1.9
	Conductivity	µmhos/cm	260	260	280	290	280
	TDS	mg/L	206	196	194	194	192
	Chloride	mg/L	4.1	4.1	24	24	23
	Fluoride	mg/L	0.30	0.26	0.27	0.29	0.27
	Sulfate	mg/L	34	34	34	34	35
	Nitrate/Nitrite	mg/L	< 1.0	< 1.0	< 1.0	< 1.0	< 1.0
Metals (total)	Aluminum	mg/L	2.3	1.5	0.031	< 0.020	< 0.020
	Antimony	mg/L	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
	Arsenic	mg/L	0.0019	0.0017	< 0.0010	< 0.0010	< 0.0010
	Barium	mg/L	0.083	0.063	0.042	0.041	0.041
	Beryllium	mg/L	< 0.0020	< 0.0020	< 0.0020	< 0.0020	< 0.0020
	Boron	mg/L	< 0.040	< 0.040	< 0.040	< 0.040	< 0.040
	Cadmium	mg/L	< 0.0020	< 0.0020	< 0.0020	< 0.0020	< 0.0020
	Calcium	mg/L	32	30	30	30	30
	Chromium	mg/L	< 0.0060	< 0.0060	< 0.0060	< 0.0060	< 0.0060
	Cobalt	mg/L	< 0.0060	< 0.0060	< 0.0060	< 0.0060	< 0.0060
	Copper	mg/L	0.0063	0.0049	0.0019	0.0031	< 0.0010
	Iron	mg/L	2.3	1.5	0.92	< 0.020	< 0.020
	Lead	mg/L	0.0036	0.0024	< 0.00050	< 0.00050	< 0.00050
	Magnesium	mg/L	6.0	5.6	5.5	5.4	5.6
	Manganese	mg/L	0.15	0.1	0.062	0.057	< 0.002
	Mercury	mg/L	< 0.00020	< 0.00020	< 0.00020	< 0.00020	< 0.00020
	Nickel	mg/L	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
	Potassium	mg/L	2.8	2.5	2.4	2.3	2.4
	Selenium	mg/L	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
	Silver	mg/L	< 0.0050	< 0.0050	< 0.0050	< 0.0050	< 0.0050
	Sodium	mg/L	13	13	14	14	15
	Thallium	mg/L	< 0.00050	< 0.00050	< 0.00050	< 0.00050	< 0.00050
	Uranium	mg/L	0.0019	0.0018	0.00068	0.00052	< 0.00050
	Vanadium	mg/L	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050
	Zinc	mg/L	0.027	0.015	< 0.010	< 0.010	< 0.010
Metals (Dissolved)	Aluminum	mg/L	0.093	0.084	< 0.020	< 0.020	< 0.020
	Antimony	mg/L	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
	Arsenic	mg/L	0.0012	0.0013	< 0.0010	< 0.0010	< 0.0010
	Barium	mg/L	0.043	0.042	0.040	0.039	0.038
	Beryllium	mg/L	< 0.0020	< 0.0020	< 0.0020	< 0.0020	< 0.0020
	Boron	mg/L	< 0.040	< 0.040	< 0.040	< 0.040	< 0.040
	Cadmium	mg/L	< 0.0020	< 0.0020	< 0.0020	< 0.0020	< 0.0020
	Calcium	mg/L	28	28	28	28	28
	Chromium	mg/L	< 0.0060	< 0.0060	< 0.0060	< 0.0060	< 0.0060
	Cobalt	mg/L	< 0.0060	< 0.0060	< 0.0060	< 0.0060	< 0.0060
	Copper	mg/L	0.0020	0.0019	0.0015	0.0029	0.0011
	Iron	mg/L	0.070	0.071	< 0.020	< 0.020	< 0.020
	Lead	mg/L	< 0.00050	< 0.00050	< 0.00050	< 0.00050	< 0.00050
	Magnesium	mg/L	5.2	5.2	5.4	5.3	5.4
	Manganese	mg/L	0.0032	0.0036	0.059	0.056	< 0.0020
	Mercury	mg/L					
	Nickel	mg/L	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
	Potassium	mg/L	2.3	2.3	2.3	2.3	2.3
	Selenium	mg/L	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
	Silver	mg/L	< 0.0050	< 0.0050	< 0.0050	< 0.0050	< 0.0050
	Sodium	mg/L	14	14	15	15	15
	Thallium	mg/L	< 0.00050	< 0.00050	< 0.00050	< 0.00050	< 0.00050
	Uranium	mg/L	0.00160	0.00160	0.00055	0.00053	< 0.00050

TREAT RAW DATA		v. 05312018					
		Date of Sample	**5/9/2016 - 5/10/2016**				
		TREAT Sample Location	**RG**	**SS1**	**SS2**	**SS3**	**SS4**
		Sample Location Description	**Rio Grande**	**Raw Water**	**After Conventional Treatment**	**After Membrane Filter**	**After GAC**
		Primary Contract Laboratory	**Hall**	**Hall**	**Hall**	**Hall**	**Hall**
Analyte Group	**Analyte**	**units**					
	Vanadium	mg/L	< 0.050	< 0.050	< 0.050	< 0.050	< 0.050
	Zinc	mg/L	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Suspended Sediment	SSC Coarse	mg/L	< 1.00	3.33	< 1.00	< 1.00	< 1.00
	SSC Fine	mg/L	59.0	27.90	2.21	2.32	< 1.00
	SSC Total	mg/L	59.0	31.20	2.21	2.32	< 1.00
PCBs	PCBs (total congeners)	pg/L	< 20.4	< 20.2	< 20.9	< 20.7	< 21.0
Dioxins and Furans	Total Tetracholodioxins	pg/L					
	Total Pentachorodioxins	pg/L					
	Total Hexacholrodioxins	pg/L					
	Total Heptacholrodioxins	pg/L					
	Octocholrodioxin	pg/L					
	Total Tetracholrofurans	pg/L					
	Total Pentachorofurans	pg/L					
	Total Hexacholrofurans	pg/L					
	Total Heptacholrofurans	pg/L					
	Octocholrofuran	pg/L					
	Total TEQ (2005 WHO TEFs)	pg/L					
Hormones-APOS	Ally Trenbolone	ng/L	< 0.828	< 0.842	< 0.839	< 0.921	< 0.840
	Androstenedione	ng/L	< 2.07	< 2.10	< 2.10	2.38	< 2.10
	Androsterone	ng/L	< 25.4	< 31.4	< 21.5	< 23.8	< 21.0
	Desogestrel 3	ng/L	< 194	< 265	< 147	108	137
	Estriol	ng/L	< 29.6	< 32.4	< 20.5	< 20.9	< 16.8
	Mestranol	ng/L	156*	213*	155*	143*	115*
	Norethindrone	ng/L	< 4.14	< 4.21	< 4.19	< 4.6	< 4.2
	Norgestrel	ng/L	< 4.14	< 4.21	< 4.19	< 4.6	< 4.2
	Progestrone	ng/L	< 0.828	< 0.842	< 0.839	< 0.921	< 0.84
	Testosterone	ng/L	< 0.828	< 0.845	< 0.839	< 0.921	< 0.84
Hormones-ANEG	17 alpha-Dihydroequilin	ng/L	< 4.14	< 4.21	< 4.19	< 4.60	< 4.20
	Equilenin	ng/L	< 0.828	< 0.842	< 0.829	< 0.921	< 0.84
	Equilin	ng/L	< 8.28	< 8.42	< 8.39	< 9.21	< 8.40
	17 beta-Estradiol	ng/L	< 4.14	< 4.21	< 4.19	< 4.6	< 4.20
	17 alpha-Estradiol	ng/L	< 4.14	< 4.21	< 4.19	< 4.6	< 4.20
	Estrone	ng/L	< 4.14	< 4.21	< 4.19	< 4.6	< 4.20
Hormones (other)	Diethylstilbestrol	ng/L					
	Ethinyl Estradiol	ng/L					
(AN3) Pharmaceutical & Personal Care Products	Bisphenol A	ng/L	< 518	< 526	< 524	< 575	< 525
	Furosemide	ng/L	< 41.4	< 42.1	< 41.9	< 46.0	< 42.0
	Gemfribozil	ng/L	< 1.55	< 1.58	< 1.57	< 1.73	< 1.58
	Glipizide	ng/L	< 6.21	< 6.31	< 6.29	< 6.91	< 6.30
	Glyburide	ng/L	< 3.11	< 3.16	< 3.15	< 3.45	< 3.15
	Hydrochorothiazide	ng/L	< 12.4	< 12.6	< 12.6	< 13.8	< 12.6
	2-Hydroxy-ibuprofen	ng/L	< 82.8	< 84.2	< 83.9	< 92.1	< 84.0
	Ibuprofen	ng/L	< 15.5	< 15.8	< 15.7	< 17.3	< 15.8
	Naproxen	ng/L	< 3.11	< 3.16	< 3.15	< 3.45	< 3.15
	Triclocarban	ng/L	< 3.11	< 3.16	< 3.15	< 3.45	< 3.15
	Triclosan	ng/L	< 62.1	< 63.1	< 62.9	< 69.1	< 63.0
	Warfarin	ng/L	< 1.55	< 1.58	< 1.57	< 1.73	< 1.58
(AP1) Pharmaceutical & Personal Care Products	Acetaminophen	ng/L	< 15.5	< 15.8	< 15.7	< 17.3	< 15.8
	Azithromycin	ng/L	< 1.55	< 1.58	< 1.57	< 1.73	< 1.58
	Caffeine	ng/L	88.7	38.6	< 15.7	< 17.3	< 15.8
	Carbadox	ng/L	< 1.55	< 1.58	< 1.57	< 1.73	< 1.58
	Carbamazepine	ng/L	< 1.55	< 1.58	< 1.57	< 1.73	< 1.58
	Cefotaxime	ng/L	< 6.21	< 46.1	< 22.6	< 31.7	< 29.7
	Ciprofloxacin	ng/L	< 20.5	< 25.0	< 23.4	< 28.3	< 7.66

TREAT RAW DATA		v. 05312018					
		Date of Sample	5/9/2016 - 5/10/2016				
		TREAT Sample Location	RG	SS1	SS2	SS3	SS4
		Sample Location Description	Rio Grande	Raw Water	After Conventional Treatment	After Membrane Filter	After GAC
		Primary Contract Laboratory	Hall	Hall	Hall	Hall	Hall
Analyte Group	Analyte	units					
	Clarithromycin	ng/L	< 1.55	< 1.58	< 1.57	< 1.73	< 1.58
	Clinafloxacin	ng/L	< 59.4	< 21.9	< 33.5	< 36.1	< 13.3
	Cloxacillin	ng/L	< 3.11	< 3.16	< 3.15	< 3.45	< 3.15
	Dehydronifedipine	ng/L	< 0.779	< 0.694	< 0.629	< 0.691	< 0.630
	Diphenhydramine	ng/L	< 0.621	< 0.631	< 0.629	< 0.691	< 0.630
	Diltiazem	ng/L	< 0.311	< 0.316	< 0.315	< 0.345	< 0.315
	Digoxin	ng/L	< 6.21	< 6.31	< 6.29	< 6.91	< 6.30
	Digoxigenin	ng/L	< 54.2	< 492	< 34.6	< 33.3	< 31.2
	Enrofloxacin	ng/L	< 3.5	< 3.16	< 3.15	< 3.63	< 3.15
	Erythromycin-H2O	ng/L	< 2.38	< 2.42	< 2.41	< 2.65	< 2.42
	Flumequine	ng/L	< 1.55	< 1.89	< 1.65	< 1.79	< 1.58
	Fluoxetine	ng/L	< 1.55	< 1.58	< 1.57	< 1.79	< 1.58
	Lincomycin	ng/L	< 3.11	< 3.16	< 3.15	< 3.45	< 3.15
	Lomefloxacin	ng/L	< 6.57	< 5.36	< 4.46	< 6.98	< 3.15
	Miconazole	ng/L	< 1.55	< 1.58	< 1.57	< 1.73	< 1.58
	Norfloxacin	ng/L	< 53.2	< 61.2	< 30.5	< 61.3	< 30.3
	Norgestimate	ng/L	< 4.11	< 3.84	< 4.56	< 5.20	< 5.20
	Ofloxacin	ng/L	< 1.93	< 1.58	< 1.9	< 1.73	< 1.58
	Ormetoprim	ng/L	< 0.621	< 0.631	< 0.629	< 0.691	< 0.63
	Oxacillin	ng/L	< 3.11	< 3.16	< 3.15	< 3.45	< 3.15
	Oxolinic Acid	ng/L	< 1.58	< 1.54	< 1.19	< 1.80	< 0.686
	Penicillin G	ng/L	< 3.11	< 3.16	< 3.15	< 3.15	< 3.15
	Penicillin V	ng/L	< 3.11	< 3.16	< 3.15	< 3.45	< 3.15
	Roxithromycin	ng/L	< 0.311	< 0.316	< 0.315	< 0.345	< 0.315
	Sarafloxacin	ng/L	< 15.5	< 15.8	< 15.7	< 17.3	< 15.8
	Sulfachloropyridazine	ng/L	< 1.55	< 1.58	< 1.57	< 1.73	< 1.58
	Sulfadiazine	ng/L	< 1.55	< 1.58	< 1.57	< 1.73	< 1.58
	Sulfadimethoxine	ng/L	< 0.311	< 0.362	< 0.315	< 0.375	< 0.315
	Sulfamerazine	ng/L	< 0.621	< 0.631	< 0.629	< 0.691	< 0.630
	Sulfamethazine	ng/L	< 1.9	< 1.28	< 0.998	< 0.842	< 0.630
	Sulfamethizole	ng/L	< 0.791	< 0.631	< 0.629	< 0.691	< 0.630
	Sulfamethoxazole	ng/L	2.64	3.41	1.46	0.98	< 0.630
	Sulfanilamide	ng/L	< 15.5	< 15.8	< 15.7	< 17.3	< 15.8
	Sulfathiazole	ng/L	< 1.55	< 1.58	< 1.57	< 1.73	< 1.58
	Thiabendazole	ng/L	< 15.5	< 15.8	< 15.7	< 17.3	< 15.8
	Trimethoprim	ng/L	< 1.55	< 1.58	< 1.57	< 1.73	< 1.58
	Tylosin	ng/L	< 6.21	< 6.31	< 6.29	< 6.91	< 6.30
	Virginiamycin M1	ng/L	< 3.11	< 3.16	< 3.15	< 3.45	< 3.15
	1,7-Dimethylxanthine	ng/L	68.6	< 63.1	< 62.9	< 69.1	< 63.0
(AP5) Pharmaceutical & Personal Care Products	Alprazolam	ng/L	< 0.311	< 0.316	< 0.315	< 0.345	< 0.315
	Amitriptyline	ng/L	0.320	< 0.316	< 0.315	< 0.345	< 0.315
	Amlodipine	ng/L	< 1.55	< 1.58	< 1.57	< 1.73	< 1.58
	Benzoylecgonine	ng/L	0.414	< 0.316	< 0.315	< 0.345	< 0.315
	Benztropine	ng/L	< 0.518	< 0.526	< 0.524	< 0.575	< 0.525
	Betamethasone	ng/L	< 1.55	< 1.58	< 1.57	< 1.73	< 1.58
	Cocaine	ng/L	< 0.155	< 0.158	< 0.157	< 0.173	< 0.158
	DEET	ng/L	19.0	4.83	3.01	5.09	4.19
	Desmethyldiltiazem	ng/L	< 0.155	< 0.158	< 0.157	< 0.173	< 0.158
	Diazepam	ng/L	< 0.311	< 0.316	< 0.315	< 0.345	< 0.315
	Fluocinonide	ng/L	< 6.21	< 6.31	< 6.29	< 6.91	< 6.30
	Fluticasone propionate	ng/L	< 2.07	< 2.10	< 2.10	< 2.30	< 2.10
	Hydrocortisone	ng/L	< 62.1	< 63.1	< 62.9	< 69.1	< 63.0
	10-hydroxy-amitriptyline	ng/L	< 0.155	< 0.158	< 0.157	< 0.173	< 0.158
	Meprobamate	ng/L	< 4.14	< 4.21	< 4.19	< 4.60	< 4.20
	Methylprednisolone	ng/L	< 5.27	< 4.21	< 4.19	< 4.60	< 4.20

TREAT RAW DATA		v. 05312018					
		Date of Sample	5/9/2016 - 5/10/2016				
		TREAT Sample Location	RG	SS1	SS2	SS3	SS4
		Sample Location Description	Rio Grande	Raw Water	After Conventional Treatment	After Membrane Filter	After GAC
		Primary Contract Laboratory	Hall	Hall	Hall	Hall	Hall
Analyte Group	Analyte	units					
	Metoprolol	ng/L	< 1.55	< 1.58	< 4.97	< 4.11	< 1.58
	Norfluoxetine	ng/L	< 0.155	< 1.58	< 1.57	< 1.73	< 0.158
	Norverapamil	ng/L	< 0.155	< 0.158	< 0.157	< 0.173	< 0.158
	Paroxetine	ng/L	< 4.14	< 4.21	< 0.419	< 4.60	< 4.20
	Prednisolone	ng/L	< 10.0	< 6.31	< 6.29	< 8.52	< 6.30
	Prednisone	ng/L	< 20.7	< 21.0	< 21.0	< 23.0	< 21.0
	Promethazine	ng/L	< 0.414	< 0.421	< 0.419	< 0.460	< 0.420
	Propoxyphene	ng/L	< 1.04	< 1.05	< 1.05	< 1.15	< 1.05
	Propranolol	ng/L	< 2.07	< 2.3	< 2.1	< 2.3	< 2.1
	Sertraline	ng/L	< 0.414	< 0.421	< 0.419	< 0.46	< 0.42
	Simvastatin	ng/L	< 20.7	< 21.0	< 21.0	< 23.0	< 21.0
	Theophylline	ng/L	73.0	< 63.1	< 62.9	< 69.1	< 63.0
	Trenbolone	ng/L	< 4.14	< 4.21	< 4.19	< 4.60	< 4.20
	Trenbolone acetate	ng/L	< 0.311	< 0.316	< 0.315	< 0.345	< 0.315
	Valsartan	ng/L	< 4.14	< 4.21	< 4.19	< 4.60	< 4.20
	Verapamil	ng/L	< 0.155	< 0.158	< 0.157	< 0.173	< 0.158
Pharmaceuticals (other)	Diclofenac	ng/L					
	Dilantin	ng/L					
	Hydrocodone	ng/L					
	Methadone	ng/L					
	Pentoxyfylline	ng/L					
Other Steroids and Endocrine Disrupting	Iopromide	ng/L					
	Oxybenzone	ng/L					
	Salicylic Acid	ng/L					
Herbicides	Atrazine	ng/L					
Radiologicals	Gross alpha	pCi/L	5.86	3.23	< 2.79	< 2.80	< 2.95
	Gross beta	pCi/L	6.94	5.86	< 2.08	< 3.30	2.65
	Ra-226	pCi/L	0.274	0.401	0.427	< 0.249	< 0.234
	Ra-228	pCi/L	0.731	0.570	0.382	< 0.326	< 0.467
	Am-241 (alpha spec)	pCi/L	< 0.0816	< 0.0519	< 0.0675	< 0.0644	< 0.0847
	Pu-238	pCi/L	< 0.0843	< 0.127	< 0.0809	< 0.114	< 0.0578
	Pu-239/240	pCi/L	< 0.1360	< 0.1170	< 0.0721	< 0.125	< 0.107
	Pu-244	pCi/L	< 0.0973	< 0.0577	< 0.0524	< 0.114	< 0.0578
	U-234	pCi/L					
	U-235	pCi/L					
	U-233/234	pCi/L	1.12	0.564	0.435	0.439	0.157
	U-235/236 (alpha spec)	pCi/L	< 0.111	0.0709	< 0.124	< 0.127	< 0.0581
	U-238 (alpha spec)	pCi/L	0.432	0.613	0.286	0.228	0.137
	Ac-228	pCi/L	< 14.8	< 14.2	< 17.1	< 13.9	< 13.9
	Am-241 (gamma spec)	pCi/L	< 15.0	< 10.9	< 6.53	< 11.3	< 33.7
	Sb-124	pCi/L	< 10.3	< 9.29	< 11.9	< 10.6	< 11.7
	Sb-125	pCi/L	< 8.44	< 8.73	< 10.10	< 8.26	< 8.71
	Ba-133	pCi/L	< 4.11	< 4.20	< 4.94	< 4.34	< 4.32
	Ba-140	pCi/L	< 40.9	< 31.0	< 42.1	< 32.7	< 34.6
	Be-7	pCi/L	< 33.2	< 32.4	< 36.9	< 33.9	< 36.1
	Bi-212	pCi/L	< 44.8	< 43.9	< 56.9	< 48.2	< 42.8
	Bi-214	pCi/L	< 8.23	< 6.00	< 9.06	< 5.91	< 8.31
	Ce-139	pCi/L	< 3.23	< 2.80	< 3.81	< 2.98	< 3.65
	Ce-141	pCi/L	< 7.41	< 7.23	< 8.22	< 7.85	< 8.81
	Ce-144	pCi/L	< 21.0	< 19.5	< 23.3	< 21.1	< 24.2
	Cs-134	pCi/L	< 3.58	< 3.37	< 4.84	< 3.50	< 3.54
	Cs-136	pCi/L	< 13.2	< 11.7	< 16.4	< 11.9	< 12.8
	Cs-137	pCi/L	< 3.47	< 3.16	< 4.44	< 3.21	< 3.56
	Cr-51	pCi/L	< 48.7	< 40.8	< 52.8	< 43.2	< 45.9
	Co-56	pCi/L	< 3.80	< 3.88	< 5.44	< 3.71	< 3.67

TREAT RAW DATA	v. 05312018						
		Date of Sample	**5/9/2016 - 5/10/2016**				
		TREAT Sample Location	**RG**	**SS1**	**SS2**	**SS3**	**SS4**
		Sample Location Description	**Rio Grande**	**Raw Water**	**After Conventional Treatment**	**After Membrane Filter**	**After GAC**
		Primary Contract Laboratory	**Hall**	**Hall**	**Hall**	**Hall**	**Hall**
Analyte Group	**Analyte**	**units**					
	Co-57	pCi/L	< 2.76	< 2.59	< 3.04	< 2.70	< 3.23
	Co-58	pCi/L	< 4.00	< 3.64	< 5.50	< 3.34	< 3.47
	Co-60	pCi/L	< 2.91	< 3.36	< 4.29	< 3.26	< 3.28
	Eu-152	pCi/L	< 9.19	< 8.84	< 11.3	< 9.73	< 10.4
	Eu-154	pCi/L	< 9.76	< 8.97	< 11.5	< 8.69	< 9.36
	Eu-155	pCi/L	< 11.4	< 10.6	< 10.9	< 11.3	< 13.9
	I-131	pCi/L	▨	▨	▨	▨	▨
	Ir-192	pCi/L	< 4.00	< 3.31	< 4.46	< 3.66	< 3.96
	Fe-59	pCi/L	< 7.85	< 8.02	< 9.85	< 8.82	< 8.70
	Pa-234m	pCi/L	▨	▨	▨	▨	▨
	Pb-210	pCi/L	< 372	< 207	< 60.8	< 214	< 1350
	Pb-212	pCi/L	< 7.24	< 6.34	< 7.17	< 6.70	< 7.33
	Pb-214	pCi/L	< 8.48	< 7.49	< 9.14	< 7.87	< 8.20
	Mn-54	pCi/L	< 3.15	< 2.98	< 4.02	< 3.31	< 3.34
	Hg-203	pCi/L	< 4.21	< 4.38	< 4.95	< 3.96	< 4.59
	Nd-147	pCi/L	< 77.2	< 71.2	< 101	< 75.1	< 82.1
	Np-239	pCi/L	< 27.1	< 27.3	< 28.3	< 28.2	< 36.1
	Nb-94	pCi/L	< 3.03	< 2.84	< 3.91	< 3.22	< 3.23
	Nb-95	pCi/L	< 4.04	< 3.56	< 4.80	< 3.90	< 3.77
	K-40	pCi/L	41.3	< 29.6	< 57.4	< 25.6	< 42.6
	Pm-144	pCi/L	< 2.75	< 3.27	< 4.09	< 3.18	< 3.39
	Pm-146	pCi/L	< 4.18	< 3.75	< 4.70	< 4.00	< 3.98
	Ra-228 (gamma spec)	pCi/L	< 14.8	< 14.2	< 17.1	< 13.9	< 13.9
	Ru-106	pCi/L	< 29.6	< 30.7	< 41.4	< 30.2	< 31.6
	Ag-110m	pCi/L	< 3.95	< 4.77	< 5.91	< 4.27	< 5.29
	Na-22	pCi/L	< 3.47	< 3.21	< 4.06	< 3.07	< 3.33
	Tl-208	pCi/L	< 4.22	< 3.34	< 4.52	< 3.96	< 3.71
	Th-234	pCi/L	< 128	< 100	< 86.8	< 126	< 254
	Sn-113	pCi/L	< 4.78	< 4.31	< 5.28	< 4.60	< 4.94
	U-235 (gamma spec)	pCi/L	< 21.1	< 20.1	< 23.3	< 21.8	< 25.2
	U-238 (gamma spec)	pCi/L	< 128	< 100	< 86.8	< 126	< 254
	Y-88	pCi/L	< 5.33	< 3.76	< 6.85	< 4.69	< 4.64
	Zn-65	pCi/L	< 6.61	< 6.67	< 9.12	< 7.13	< 6.55
	Zr-95	pCi/L	< 6.53	< 6.57	< 8.43	< 7.03	< 7.04
	Sr-90	pCi/L	< 0.484	< 0.474	< 0.490	< 0.488	< 0.475
	Tritium	pCi/L	13.1	17.3	16.6	15.7	16.6

Notes:

▨ = Not analyzed, not quantified, or not reported

*** = estimated value**

-- Data are not blank corrected, and should not be used for decision-level assessment

-- A "<" value is equivalent to a "non-detect" value; the number represents the detection limit

-- Detection limits for detected quantities are not noted; see laboratory reports for detection limits and data qualifiers

-- TREAT study described in Bowman, D. K. (2015). *Storm Water Quality Monitoring of Rio Grande at Buckman Direct Diversion* . NM: BDD.

-- Data herein were subject to quality control procedures described in a separate document, and therefore may deviate from data presented in previous published and unpublished reports not subject to the same procedures

TREAT RAW DATA		v. 05312018					
		Date of Sample	**9/14/2016 - 9/15/2016**				
		TREAT Sample Location	**RG**	**SS1**	**SS2**	**SS3**	**SS4**
		Sample Location Description	**Rio Grande**	**Raw Water**	**After Conventional Treatment**	**After Membrane Filter**	**After GAC**
		Primary Contract Laboratory	**ALS**	**ALS**	**ALS**	**ALS**	**ALS**
Analyte Group	**Analyte**	**units**					
Miscellaneous	TOC	mg/L	3.3	3.4	2.4	2.4	2
	Conductivity	µmhos/cm	320	322	332	333	330
	TDS	mg/L	190	200	200	200	200
	Chloride	mg/L	4.3	4.5	15	15	15
	Fluoride	mg/L	0.29	0.31	0.31	0.31	0.31
	Sulfate	mg/L	53	53	52	53	53
	Nitrate/Nitrite	mg/L	0.059	0.19	0.084	0.095	0.11
Metals (total)	Aluminum	mg/L	2.7	1.3	0.037	< 0.014	0.014
	Antimony	mg/L	0.00015	0.00015	< 0.00011	< 0.00011	< 0.00011
	Arsenic	mg/L	0.0028	0.0025	0.00035	0.0003	< 0.0002
	Barium	mg/L	0.12	0.11	0.076	0.075	0.051
	Beryllium	mg/L	0.00035	< 0.00027	< 0.00027	< 0.00027	< 0.00027
	Boron	mg/L	0.069	0.050	0.038	0.034	0.031
	Cadmium	mg/L	< 0.000088	< 0.000088	< 0.000088	< 0.000088	< 0.000088
	Calcium	mg/L	41	39	37	38	37
	Chromium	mg/L	0.0021	0.0011	< 0.00088	< 0.00088	< 0.00088
	Cobalt	mg/L	0.0011	0.00068	0.00011	< 0.000083	< 0.000083
	Copper	mg/L	0.0032	0.0044	0.0019	0.0015	< 0.0012
	Iron	mg/L	2.0	0.96	0.37	0.024	0.0084
	Lead	mg/L	0.0018	0.0012	< 0.00017	< 0.00017	< 0.00017
	Magnesium	mg/L	7.1	6.6	6.2	6.1	6.1
	Manganese	mg/L	0.096	0.079	0.023	0.023	0.00055
	Mercury	mg/L	< 0.00006	< 0.00006	< 0.00006	< 0.00006	< 0.00006
	Nickel	mg/L	< 0.004	0.0044	< 0.004	0.0081	0.006
	Potassium	mg/L	2.9	2.5	2.3	2.3	2.6
	Selenium	mg/L	< 0.00066	< 0.00066	< 0.00066	< 0.00066	< 0.00066
	Silver	mg/L	< 0.000041	< 0.000041	< 0.000041	< 0.000041	< 0.000041
	Sodium	mg/L	16	16	17	17	16
	Thallium	mg/L	0.00002	< 0.000018	< 0.000018	< 0.000018	< 0.000018
	Uranium	mg/L	0.0016	0.0015	0.0013	0.0013	0.0015
	Vanadium	mg/L	0.0073	0.0059	< 0.00071	< 0.00071	< 0.00071
	Zinc	mg/L	< 0.0098	0.018	< 0.0098	< 0.0098	< 0.0098
Metals (Dissolved)	Aluminum	mg/L	0.057	0.028	< 0.014	0.024	0.016
	Antimony	mg/L	0.00023	0.00019	0.00014	0.00013	0.00017
	Arsenic	mg/L	0.002	0.0022	0.00025	0.00026	0.00023
	Barium	mg/L	0.086	0.085	0.077	0.075	0.052
	Beryllium	mg/L	< 0.00027	< 0.00027	< 0.00027	< 0.00027	< 0.00027
	Boron	mg/L	0.072	0.046	0.035	0.033	0.031
	Cadmium	mg/L	< 0.000088	< 0.000088	< 0.000088	< 0.000088	< 0.000088
	Calcium	mg/L	39	37	37	38	37
	Chromium	mg/L	< 0.00088	< 0.00088	< 0.00088	< 0.00088	< 0.00088
	Cobalt	mg/L	0.0019	0.0018	0.00017	0.00023	0.00011
	Copper	mg/L	0.0021	0.0025	0.0019	0.0017	0.0014
	Iron	mg/L	0.230	0.070	0.038	0.060	0.048
	Lead	mg/L	< 0.00017	< 0.00017	< 0.00017	< 0.00017	< 0.00017
	Magnesium	mg/L	6.2	6.1	6.0	6.2	6.0
	Manganese	mg/L	0.0056	0.0033	0.020	0.023	0.00079
	Mercury	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
	Nickel	mg/L	< 0.004	< 0.004	< 0.004	< 0.004	0.0064
	Potassium	mg/L	2.4	2.2	2.3	2.3	2.3
	Selenium	mg/L	< 0.00066	< 0.00066	< 0.00066	< 0.00066	< 0.00066
	Silver	mg/L	< 0.000041	< 0.000041	< 0.000041	< 0.000041	0.00005
	Sodium	mg/L	16	16	16	17	17
	Thallium	mg/L	< 0.000018	< 0.000018	< 0.000018	< 0.000018	< 0.000018
	Uranium	mg/L	0.0014	0.0014	0.0013	0.0012	0.0015

TREAT RAW DATA		v. 05312018					
Date of Sample			9/14/2016 - 9/15/2016				
TREAT Sample Location			RG	SS1	SS2	SS3	SS4
Sample Location Description			Rio Grande	Raw Water	After Conventional Treatment	After Membrane Filter	After GAC
Primary Contract Laboratory			ALS	ALS	ALS	ALS	ALS
Analyte Group	Analyte	units					
	Vanadium	mg/L	0.0038	0.0037	< 0.00071	< 0.00071	< 0.00071
	Zinc	mg/L	0.037	< 0.0098	< 0.00980	< 0.0098	< 0.0098
Suspended Sediment	SSC Coarse	mg/L	33.8	5.0	2.9	< 1	< 1
	SSC Fine	mg/L	121.4	85.2	16.2	< 1	< 1
	SSC Total	mg/L	155.2	87.2	19.10	< 1	< 1
PCBs	PCBs (total congeners)	pg/L	327	297			179
Dioxins and Furans	Total Tetracholodioxins	pg/L					
	Total Pentachorodioxins	pg/L					
	Total Hexacholrodioxins	pg/L					
	Total Heptacholrodioxins	pg/L					
	Octocholrodioxin	pg/L					
	Total Tetracholrofurans	pg/L					
	Total Pentachorofurans	pg/L					
	Total Hexacholrofurans	pg/L					
	Total Heptacholrofurans	pg/L					
	Octocholrofuran	pg/L					
	Total TEQ (2005 WHO TEFs)	pg/L					
Hormones-APOS	Ally Trenbolone	ng/L					
	Androstenedione	ng/L	< 1.0	< 1.1			< 1.1
	Androsterone	ng/L					
	Desogestrel 3	ng/L					
	Estriol	ng/L	< 2.1	< 2.1			< 2.1
	Mestranol	ng/L					
	Norethindrone	ng/L					
	Norgestrel	ng/L					
	Progestrone	ng/L	< 2.1	< 2.1			< 2.1
	Testosterone	ng/L	< 2.1	< 2.1			< 2.1
Hormones-ANEG	17 alpha-Dihydroequilin	ng/L					
	Equilenin	ng/L					
	Equilin	ng/L					
	17 beta-Estradiol	ng/L	< 2.1	< 2.1			< 2.1
	17 alpha-Estradiol	ng/L	< 2.1	< 2.1			< 2.1
	Estrone	ng/L	< 5.2	< 5.3			< 5.3
Hormones (other)	Diethylstilbestrol	ng/L	< 2.1	< 2.2			< 2.2
	Ethinyl Estradiol	ng/L	< 2.1	< 2.1			< 2.1
(AN3) Pharmaceutical & Personal Care Products	Bisphenol A	ng/L	< 10	< 11			< 11
	Furosemide	ng/L					
	Gemfribozil	ng/L	< 1.0	< 1.1			< 1.1
	Glipizide	ng/L					
	Glyburide	ng/L					
	Hydrochorothiazide	ng/L					
	2-Hydroxy-ibuprofen	ng/L					
	Ibuprofen	ng/L	< 1.0	< 1.1			< 1.1
	Naproxen	ng/L	< 1.0	< 1.1			< 1.1
	Triclocarban	ng/L					
	Triclosan	ng/L	< 52	68			< 53
	Warfarin	ng/L					
(AP1) Pharmaceutical & Personal Care Products	Acetaminophen	ng/L	< 5.2	< 5.3			< 5.3
	Azithromycin	ng/L					
	Caffeine	ng/L	< 2.1	26			9.4
	Carbadox	ng/L					
	Carbamazepine	ng/L	< 1.0	< 1.1			< 1.1
	Cefotaxime	ng/L					
	Ciprofloxacin	ng/L					

TREAT RAW DATA			v. 05312018				
		Date of Sample	**9/14/2016 - 9/15/2016**				
		TREAT Sample Location	**RG**	**SS1**	**SS2**	**SS3**	**SS4**
		Sample Location Description	**Rio Grande**	**Raw Water**	**After Conventional Treatment**	**After Membrane Filter**	**After GAC**
		Primary Contract Laboratory	**ALS**	**ALS**	**ALS**	**ALS**	**ALS**
Analyte Group	**Analyte**	**units**					
	Clarithromycin	ng/L					
	Clinafloxacin	ng/L					
	Cloxacillin	ng/L					
	Dehydronifedipine	ng/L					
	Diphenhydramine	ng/L					
	Diltiazem	ng/L					
	Digoxin	ng/L					
	Digoxigenin	ng/L					
	Enrofloxacin	ng/L					
	Erythromycin-H2O	ng/L					
	Flumequine	ng/L					
	Fluoxetine	ng/L	< 1.0	< 1.1			< 1.1
	Lincomycin	ng/L					
	Lomefloxacin	ng/L					
	Miconazole	ng/L					
	Norfloxacin	ng/L					
	Norgestimate	ng/L					
	Ofloxacin	ng/L					
	Ormetoprim	ng/L					
	Oxacillin	ng/L					
	Oxolinic Acid	ng/L					
	Penicillin G	ng/L					
	Penicillin V	ng/L					
	Roxithromycin	ng/L					
	Sarafloxacin	ng/L					
	Sulfachloropyridazine	ng/L					
	Sulfadiazine	ng/L					
	Sulfadimethoxine	ng/L					
	Sulfamerazine	ng/L					
	Sulfamethazine	ng/L					
	Sulfamethizole	ng/L					
	Sulfamethoxazole	ng/L	6.9	7.6			< 1.1
	Sulfanilamide	ng/L					
	Sulfathiazole	ng/L					
	Thiabendazole	ng/L					
	Trimethoprim	ng/L	< 14.0	< 7.1			< 5.3
	Tylosin	ng/L					
	Virginiamycin M1	ng/L					
	1,7-Dimethylxanthine	ng/L					
(AP5) Pharmaceutical & Personal Care Products	Alprazolam	ng/L					
	Amitriptyline	ng/L					
	Amlodipine	ng/L					
	Benzoylecgonine	ng/L					
	Benztropine	ng/L					
	Betamethasone	ng/L					
	Cocaine	ng/L					
	DEET	ng/L	130	25			10
	Desmethyldiltiazem	ng/L					
	Diazepam	ng/L	< 1.0	< 1.1			< 1.1
	Fluocinonide	ng/L					
	Fluticasone propionate	ng/L					
	Hydrocortisone	ng/L					
	10-hydroxy-amitriptyline	ng/L					
	Meprobamate	ng/L	< 1.0	< 1.1			< 1.1
	Methylprednisolone	ng/L					

TREAT RAW DATA		v. 05312018					
		Date of Sample	**9/14/2016 - 9/15/2016**				
		TREAT Sample Location	**RG**	**SS1**	**SS2**	**SS3**	**SS4**
		Sample Location Description	**Rio Grande**	**Raw Water**	**After Conventional Treatment**	**After Membrane Filter**	**After GAC**
		Primary Contract Laboratory	**ALS**	**ALS**	**ALS**	**ALS**	**ALS**
Analyte Group	**Analyte**	**units**					
	Metoprolol	ng/L					
	Norfluoxetine	ng/L					
	Norverapamil	ng/L					
	Paroxetine	ng/L					
	Prednisolone	ng/L					
	Prednisone	ng/L					
	Promethazine	ng/L					
	Propoxyphene	ng/L					
	Propranolol	ng/L					
	Sertraline	ng/L					
	Simvastatin	ng/L					
	Theophylline	ng/L					
	Trenbolone	ng/L					
	Trenbolone acetate	ng/L					
	Valsartan	ng/L					
	Verapamil	ng/L					
Pharmaceuticals (other)	Diclofenac	ng/L	15	< 2.1			< 2.1
	Dilantin	ng/L	< 2.1	< 2.1			< 2.1
	Hydrocodone	ng/L	< 5.2	< 5.3			< 5.3
	Methadone	ng/L	< 5.2	< 5.3			< 5.3
	Pentoxyfylline	ng/L	< 5.2	< 5.3			< 5.3
Other Steroids and Endocrine Disrupting	Iopromide	ng/L	< 10.0	< 11			< 11
	Oxybenzone	ng/L	100	24			< 21
	Salicylic Acid	ng/L	< 21.0	< 21			< 21
Herbicides	Atrazine	ng/L	< 1.0	< 1.1			< 1.1
Radiologicals	Gross alpha	pCi/L	3.00	2.17	1.35	< 0.86	< 0.82
	Gross beta	pCi/L	6.34	4.29	2.75	2.85	3.05
	Ra-226	pCi/L	< 0.180	< 0.151	0.146	< 0.126	< 0.134
	Ra-228	pCi/L	< 0.66	< 0.92	< 0.65	< 0.82	< 0.78
	Am-241 (alpha spec)	pCi/L	< 0.0356	< 0.0347	< 0.0331	< 0.0347	< 0.0345
	Pu-238	pCi/L	< 0.0196	< 0.0219	0.0153	< 0.0249	< 0.0164
	Pu-239/240	pCi/L	< 0.0219	0.0164	< 0.0269	0.0231	0.0124
	Pu-244	pCi/L					
	U-234	pCi/L	0.998	0.823	0.802	0.828	0.931
	U-235	pCi/L	0.0284	0.0221	0.0314	0.0227	0.042
	U-233/234	pCi/L					
	U-235/236 (alpha spec)	pCi/L					
	U-238 (alpha spec)	pCi/L	0.608	0.517	0.5	0.454	0.578
	Ac-228	pCi/L	17.5	< 14.3	< 18.5	< 32	20
	Am-241 (gamma spec)	pCi/L					
	Sb-124	pCi/L					
	Sb-125	pCi/L					
	Ba-133	pCi/L					
	Ba-140	pCi/L					
	Be-7	pCi/L	< 40	< 34	< 40	< 35	< 41
	Bi-212	pCi/L	< 60	< 57	< 163	< 62	< 163
	Bi-214	pCi/L	< 21	< 23	< 21.3	< 20	< 25
	Ce-139	pCi/L					
	Ce-141	pCi/L					
	Ce-144	pCi/L					
	Cs-134	pCi/L	< 4.9	< 4.2	< 6.7	< 4.4	< 6.4
	Cs-136	pCi/L					
	Cs-137	pCi/L	< 4.2	< 4.3	< 4.9	< 4.5	< 4.9
	Cr-51	pCi/L					
	Co-56	pCi/L					

TREAT RAW DATA	v. 05312018						
		Date of Sample	**9/14/2016 - 9/15/2016**				
		TREAT Sample Location	**RG**	**SS1**	**SS2**	**SS3**	**SS4**
		Sample Location Description	**Rio Grande**	**Raw Water**	**After Conventional Treatment**	**After Membrane Filter**	**After GAC**
		Primary Contract Laboratory	**ALS**	**ALS**	**ALS**	**ALS**	**ALS**
Analyte Group	**Analyte**	**units**					
	Co-57	pCi/L					
	Co-58	pCi/L					
	Co-60	pCi/L	< 5.1	< 4.4	< 5.7	< 5.5	< 5.4
	Eu-152	pCi/L					
	Eu-154	pCi/L					
	Eu-155	pCi/L					
	I-131	pCi/L	< 24.0	< 16.1	< 14.8	< 12.6	< 15.7
	Ir-192	pCi/L					
	Fe-59	pCi/L					
	Pa-234m	pCi/L	< 690	< 720	< 780	< 800	< 780
	Pb-210	pCi/L					
	Pb-212	pCi/L	< 15.8	< 13.3	< 12.8	< 11.7	< 12.9
	Pb-214	pCi/L	< 19	< 8.5	< 20	< 17	< 20
	Mn-54	pCi/L					
	Hg-203	pCi/L					
	Nd-147	pCi/L					
	Np-239	pCi/L					
	Nb-94	pCi/L					
	Nb-95	pCi/L					
	K-40	pCi/L	< 127	< 134	< 138	< 133	< 138
	Pm-144	pCi/L					
	Pm-146	pCi/L					
	Ra-228 (gamma spec)	pCi/L					
	Ru-106	pCi/L					
	Ag-110m	pCi/L					
	Na-22	pCi/L	< 5	< 4.3	< 5.1	< 5.3	< 5.1
	Tl-208	pCi/L	< 10.4	< 8.3	< 9.2	< 7.3	4.9
	Th-234	pCi/L	< 190	< 260	< 135	< 126	< 135
	Sn-113	pCi/L					
	U-235 (gamma spec)	pCi/L					
	U-238 (gamma spec)	pCi/L					
	Y-88	pCi/L					
	Zn-65	pCi/L					
	Zr-95	pCi/L					
	Sr-90	pCi/L	< 0.171	< 0.158	< 0.148	< 0.159	< 0.142
	Tritium	pCi/L	< 300	< 300	< 300	< 300	< 300

Notes:

▨ = Not analyzed, not quantified, or not reported

*** = estimated value**

-- Data are not blank corrected, and should not be used for decision-level assessment

-- A "<" value is equivalent to a "non-detect" value; the number represents the detection limit

-- Detection limits for detected quantities are not noted; see laboratory reports for detection limits and data qualifiers

-- TREAT study described in Bowman, D. K. (2015). *Storm Water Quality Monitoring of Rio Grande at Buckman Direct Diversion* . NM: BDD.

-- Data herein were subject to quality control procedures described in a separate document, and therefore may deviate from data presented in previo

TREAT RAW DATA	v. 05312018													
Date of Sample			4/25/2017 - 4/26/2017											
TREAT Sample Location			RG	RG	SS1	SS1	SS2	SS2	SS3	SS3	SS3A	SS3A	SS4	SS4
Sample Location Description			Rio Grande	Rio Grande	Raw Water	Raw Water	After Conventional Treatment	After Conventional Treatment	After Membrane Filter	After Membrane Filter	After Ozonation	After Ozonation	After GAC	After Gac
Primary Contract Laboratory			ALS	Hall	ALS	Hall	ALS	Hall	ALS	Hall	ALS	Hall	ALS	Hall
Analyte Group	Analyte	units												
Miscellaneous	TOC	mg/L	5		5.1		2.8		2.6		2.6		2.3	
	Conductivity	µmhos/cm	209		212		233		231		231		228	
	TDS	mg/L	160		160		150		160		160		150	
	Chloride	mg/L	2.9		3		24		24		25		25	
	Fluoride	mg/L	0.15		0.15		0.16		0.16		0.17		0.16	
	Sulfate	mg/L	31		31		31		30		31		32	
	Nitrate/Nitrite	mg/L	0.08		0.076		0.072		0.12		0.11		0.14	
Metals (total)	Aluminum	mg/L	2.1	3.9	2.1	5.1	0.17	0.12	< 0.015	0.0038	0.018	0.0034	< 0.015	0.0046
	Antimony	mg/L	< 0.00009	< 0.014	< 0.00009	< 0.014	< 0.00009	< 0.014	0.00042	< 0.014	< 0.00009	< 0.014	< 0.00009	< 0.014
	Arsenic	mg/L	0.0015	< 0.012	0.0015	< 0.012	< 0.0006	< 0.012	< 0.0006	< 0.012	< 0.0006	< 0.012	< 0.0006	< 0.012
	Barium	mg/L	0.073	0.09	0.081	0.09	0.043	0.043	0.04	0.043	0.044	0.042	0.045	0.042
	Beryllium	mg/L	0.00016	< 0.00044	0.00015	< 0.00044	< 0.00015	< 0.00044	< 0.00015	< 0.00044	< 0.00015	< 0.00044	< 0.00015	< 0.00044
	Boron	mg/L	0.03	0.02	0.031	0.02	0.028	0.018	0.027	0.017	0.028	0.018	0.027	0.019
	Cadmium	mg/L	0.00016	< 0.00040	< 0.00009	< 0.00040	< 0.00009	< 0.00040	< 0.00009	< 0.00040	0.029	< 0.0004	0.00099	< 0.00040
	Calcium	mg/L	26	31	27	30	24	28	24	27	26	27	25	27
	Chromium	mg/L	< 0.003	< 0.0022	< 0.003	0.0035	< 0.003	< 0.0022	< 0.003	< 0.0022	< 0.003	< 0.0022	< 0.003	< 0.0022
	Cobalt	mg/L	0.001	0.0013	0.00096	0.0016	< 0.0003	< 0.00081	< 0.0003	< 0.00081	0.00035	< 0.00081	< 0.0003	< 0.00081
	Copper	mg/L	0.0031	0.0096	< 0.003	0.0078	< 0.003	0.019	< 0.003	0.0071	0.0034	0.0044	< 0.003	< 0.0035
	Iron	mg/L	1.9	2.7	1.9	3.2	0.77	0.88	< 0.044	0.018	< 0.044	0.028	< 0.044	0.013
	Lead	mg/L	0.0022	< 0.0028	0.0023	< 0.0028	< 0.00016	< 0.0028	< 0.00016	< 0.0028	0.00083	< 0.0028	< 0.00016	< 0.0028
	Magnesium	mg/L	4.7	6.0	4.8	6.1	4.1	5.1	4.1	4.9	4.5	5.0	4.3	4.9
	Manganese	mg/L	0.1	0.12	0.099	0.11	0.059	0.067	0.058	0.06	0.067	0.076	0.0019	0.0023
	Mercury	mg/L	< 0.00006		< 0.00006		< 0.00006		< 0.00006		< 0.00006		< 0.00006	
	Nickel	mg/L	0.0025	0.0026	0.0049	0.0031	0.006	0.0022	< 0.0019	0.0023	0.0034	0.0029	0.0055	< 0.00093
	Potassium	mg/L	2.3	3.0	2.4	3.1	1.9	2.1	1.9	2.1	2.3	2.1	2	2.0
	Selenium	mg/L	0.0003	< 0.015	0.00042	< 0.015	< 0.0003	< 0.015	< 0.0003	< 0.015	< 0.0003	< 0.015	< 0.0003	< 0.015
	Silver	mg/L	< 0.00003	< 0.00077	< 0.00003	< 0.00077	< 0.00003	< 0.00077	< 0.00003	< 0.00077	< 0.00003	< 0.00077	< 0.00003	< 0.00077
	Sodium	mg/L	10	11	9.9	11	9.8	11	9.7	11	11	11	10	11
	Thallium	mg/L	< 0.00015	< 0.015	< 0.00015	< 0.015	< 0.00015	< 0.015	< 0.00015	< 0.015	< 0.00015	< 0.015	< 0.00015	< 0.015
	Uranium	mg/L	0.0011	< 0.11	0.0011	< 0.1	0.00021	< 0.11	0.00009	< 0.1	0.00012	< 0.1	< 0.000038	< 0.1
	Vanadium	mg/L	0.0056	0.0083	0.0055	0.0095	< 0.0003	< 0.002	< 0.0003	< 0.002	< 0.0003	< 0.002	< 0.0003	< 0.002
	Zinc	mg/L	0.017	0.014	0.015	0.015	0.007	0.0033	0.0089	0.0019	0.046	0.0019	0.056	0.0014
Metals (Dissolved)	Aluminum	mg/L	0.24	0.14	0.14	0.14	< 0.015	< 0.0024	0.016	< 0.0024	0.016	< 0.0024	0.022	< 0.0024
	Antimony	mg/L	0.00043	< 0.019	0.00019	< 0.019	0.00073	< 0.019	0.00087	< 0.019	< 0.00009	< 0.019	< 0.00009	< 0.019
	Arsenic	mg/L	0.0011	< 0.0095	0.00094	< 0.0095	< 0.0006	< 0.0095	< 0.0006	< 0.0095	< 0.0006	< 0.0095	< 0.0006	< 0.0095
	Barium	mg/L	0.046	0.041	0.047	0.040	0.041	0.040	0.043	0.041	0.044	0.039	0.041	0.041
	Beryllium	mg/L	< 0.00015	< 0.00024	< 0.00015	< 0.00024	< 0.00015	< 0.00024	< 0.00015	< 0.00024	< 0.00015	< 0.00024	< 0.00015	< 0.00024
	Boron	mg/L	0.025	0.017	0.027	0.017	0.025	0.017	0.026	0.017	0.025	0.017	0.034	0.018
	Cadmium	mg/L	0.19	< 0.00071	0.014	< 0.00071	0.00014	< 0.00071	< 0.00009	< 0.00071	0.00016	< 0.00071	< 0.00009	< 0.00071
	Calcium	mg/L	27	26	25	26	24	26	24	27	24	26	24	26
	Chromium	mg/L	< 0.003	< 0.0019	< 0.003	< 0.0019	< 0.003	< 0.0019	< 0.003	< 0.0019	< 0.003	< 0.0019	< 0.003	< 0.0019
	Cobalt	mg/L	0.00075	< 0.0010	< 0.0003	< 0.0010	0.00035	< 0.0010	0.00034	< 0.0010	< 0.0003	< 0.0010	< 0.0003	< 0.0010
	Copper	mg/L	0.04	0.0058	0.0041	0.0029	< 0.003	< 0.00097	< 0.003	0.010	< 0.003	0.0020	< 0.003	0.0012
	Iron	mg/L	0.22	0.24	0.13	0.093	0.066	0.0055	< 0.044	< 0.0042	< 0.044	0.0050	< 0.044	< 0.0042
	Lead	mg/L	0.006	< 0.0039	0.00078	< 0.0039	< 0.00016	< 0.0039	< 0.00016	< 0.0039	< 0.00016	< 0.0039	< 0.00016	< 0.0039
	Magnesium	mg/L	4.5	4.7	4.1	4.7	4.1	4.7	4.2	4.7	4.1	4.5	4	4.6
	Manganese	mg/L	0.016	0.0051	0.0044	0.0021	0.061	0.043	0.057	0.036	0.059	0.064	0.0015	0.0029
	Mercury	mg/L	< 0.00006		< 0.00006		< 0.00006		< 0.00006		< 0.00006		< 0.00006	
	Nickel	mg/L	0.012	< 0.00096	0.0039	< 0.00096	0.0066	< 0.00096	< 0.0019	0.0016	0.0037	0.0012	0.0062	< 0.00096
	Potassium	mg/L	4.3	2.0	2.4	2.0	1.9	2.0	1.8	2.1	1.8	2.0	1.9	2
	Selenium	mg/L	< 0.0003	< 0.029	< 0.0003	< 0.029	< 0.0003	< 0.029	< 0.0003	< 0.029	< 0.0003	< 0.029	< 0.0003	< 0.029
	Silver	mg/L	0.0001	< 0.00088	< 0.00003	< 0.0019	< 0.00003	< 0.00088	< 0.00003	< 0.00088	< 0.00003	< 0.00088	< 0.00003	< 0.00088
	Sodium	mg/L	13	10	10	10	9.8	11	9.7	11	9.6	10	9.8	11
	Thallium	mg/L	< 0.00015	< 0.0099	< 0.00015	< 0.0099	< 0.00015	< 0.050	< 0.00015	< 0.0099	< 0.00015	< 0.0099	< 0.00015	< 0.050
	Uranium	mg/L	0.001	< 0.060	0.00096	< 0.060	0.00015	< 0.060	0.00011	< 0.012	0.00009	< 0.060	< 0.000038	< 0.060
	Vanadium	mg/L	0.0022	0.0032	0.0021	0.003	< 0.0003	< 0.0020	< 0.0003	< 0.0020	< 0.0003	< 0.0020	< 0.0003	< 0.0020
	Zinc	mg/L	0.26	< 0.0040	0.031	< 0.0040	0.012	< 0.0040	0.0073	< 0.0040	0.0087	< 0.0040	0.049	< 0.0040
Suspended Sediment	SSC Coarse	mg/L	27.7		6.9		8.4		7.0		3.5		4.6	
	SSC Fine	mg/L	76.5		63.6		< 1.0		10.1		23.4		8.0	
	SSC Total	mg/L	104.2		70.5		8.4		17.1		26.9		12.6	
PCBs	PCBs (total congeners)	pg/L	799		1010								46.5	
Dioxins and Furans	Total Tetracholodioxins	pg/L	< 5.31										< 8.48	
	Total Pentachorodioxins	pg/L	< 2.21										< 3.09	
	Total Hexacholrodioxins	pg/L	11.6										23.8	
	Total Heptacholrodioxins	pg/L	< 1.25										14.2	
	Octocholrodioxin	pg/L	26.7										40.5	
	Total Tetracholrofurans	pg/L	13.4										< 5.85	
	Total Pentachorofurans	pg/L	< 2.06										< 2.37	
	Total Hexacholrofurans	pg/L	14.6										20.2	
	Total Heptacholrofurans	pg/L	11.7										14.7	
	Octocholrofuran	pg/L	14.2										18.7	
	Total TEQ (2005 WHO TEFs)	pg/L	5.54										9.57	
Hormones-APOS	Ally Trenbolone	ng/L												
	Androstenedione	ng/L	< 0.93		< 0.93				< 0.93		< 0.93		< 0.93	
	Androsterone	ng/L												
	Desogestrel 3	ng/L												
	Estriol	ng/L	< 1.9		< 1.9				< 1.9		< 1.9		< 1.9	
	Mestranol	ng/L												
	Norethindrone	ng/L												
	Norgestrel	ng/L												
	Progestrone	ng/L	< 1.9		< 1.9				< 1.9		< 1.9		< 1.9	
	Testosterone	ng/L	< 1.9		< 1.9				< 1.9		< 1.9		< 1.9	
Hormones-ANEG	17 alpha-Dihydroequilin	ng/L												
	Equilenin	ng/L												
	Equilin	ng/L												
	17 beta-Estradiol	ng/L	< 1.9		< 1.9				< 1.9		< 1.9		< 1.9	
	17 alpha-Estradiol	ng/L	< 1.9		< 1.9				< 1.9		< 1.9		< 1.9	
	Estrone	ng/L	< 4.7		< 4.7				< 4.7		< 4.7		< 4.7	
Hormones (other)	Diethylstilbestrol	ng/L	< 2		< 2				< 2		< 2		< 2	
	Ethinyl Estradiol	ng/L	< 1.9		< 1.9				< 1.9		< 1.9		< 1.9	
(AN3) Pharmaceutical & Personal Care Products	Bisphenol A	ng/L	< 9.3		< 9.3				< 9.3		< 9.3		< 9.3	
	Furosemide	ng/L												
	Gemfribozil	ng/L	< 0.93		< 0.93				< 0.93		< 0.93		< 0.93	
	Glipizide	ng/L												
	Glyburide	ng/L												
	Hydrochorothiazide	ng/L												
	2-Hydroxy-ibuprofen	ng/L												
	Ibuprofen	ng/L	< 0.93		< 0.93				< 0.93		< 0.93		< 0.93	
	Naproxen	ng/L	< 0.93		< 0.93				< 0.93		< 0.93		< 0.93	
	Triclocarban	ng/L												
	Triclosan	ng/L	80		< 47				< 47		< 47		< 47	
	Warfarin	ng/L												
(AP1) Pharmaceutical & Personal Care Products	Acetaminophen	ng/L	< 4.7		< 4.7				< 4.7		< 4.7		< 4.7	
	Azithromycin	ng/L												
	Caffeine	ng/L	90		93				6.8		11		16	

TREAT RAW DATA		v. 05312018												
		Date of Sample	**4/25/2017 - 4/26/2017**											
		TREAT Sample Location	**RG**	**RG**	**SS1**	**SS1**	**SS2**	**SS2**	**SS3**	**SS3**	**SS3A**	**SS3A**	**SS4**	**SS4**
		Sample Location Description	**Rio Grande**	**Rio Grande**	**Raw Water**	**Raw Water**	**After Conventional Treatment**	**After Conventional Treatment**	**After Membrane Filter**	**After Membrane Filter**	**After Ozonation**	**After Ozonation**	**After GAC**	**After Gac**
		Primary Contract Laboratory	**ALS**	**Hall**	**ALS**	**Hall**	**ALS**	**Hall**	**ALS**	**Hall**	**ALS**	**Hall**	**ALS**	**Hall**
Analyte Group	**Analyte**	**units**												
	Carbadox	ng/L												
	Carbamazepine	ng/L	< 0.93		< 0.93				< 0.93		< 0.93		< 0.93	
	Cefotaxime	ng/L												
	Ciprofloxacin	ng/L												
	Clarithromycin	ng/L												
	Clinafloxacin	ng/L												
	Cloxacillin	ng/L												
	Dehydronifedipine	ng/L												
	Diphenhydramine	ng/L												
	Diltiazem	ng/L												
	Digoxin	ng/L												
	Digoxigenin	ng/L												
	Enrofloxacin	ng/L												
	Erythromycin-H2O	ng/L												
	Flumequine	ng/L												
	Fluoxetine	ng/L	< 0.93		< 0.93				< 0.93		< 0.93		< 0.93	
	Lincomycin	ng/L												
	Lomefloxacin	ng/L												
	Miconazole	ng/L												
	Norfloxacin	ng/L												
	Norgestimate	ng/L												
	Ofloxacin	ng/L												
	Ormetoprim	ng/L												
	Oxacillin	ng/L												
	Oxolinic Acid	ng/L												
	Penicillin G	ng/L												
	Penicillin V	ng/L												
	Roxithromycin	ng/L												
	Sarafloxacin	ng/L												
	Sulfachloropyridazine	ng/L												
	Sulfadiazine	ng/L												
	Sulfadimethoxine	ng/L												
	Sulfamerazine	ng/L												
	Sulfamethazine	ng/L												
	Sulfamethizole	ng/L												
	Sulfamethoxazole	ng/L	< 0.93		< 0.93				< 0.93		< 0.93		< 0.93	
	Sulfanilamide	ng/L												
	Sulfathiazole	ng/L												
	Thiabendazole	ng/L												
	Trimethoprim	ng/L	< 4.7		< 4.7				< 4.7		< 4.7		< 4.7	
	Tylosin	ng/L												
	Virginiamycin M1	ng/L												
	1,7-Dimethylxanthine	ng/L												
(AP5) Pharmaceutical & Personal Care Products	Alprazolam	ng/L												
	Amitriptyline	ng/L												
	Amlodipine	ng/L												
	Benzoylecgonine	ng/L												
	Benztropine	ng/L												
	Betamethasone	ng/L												
	Cocaine	ng/L												
	DEET	ng/L	13		9.0				9.4		7.8		5.2	
	Desmethyldiltiazem	ng/L												
	Diazepam	ng/L	< 0.9		< 0.93				< 0.9		< 0.9		< 0.9	
	Fluocinonide	ng/L												
	Fluticasone propionate	ng/L												
	Hydrocortisone	ng/L												
	10-hydroxy-amitriptyline	ng/L												
	Meprobamate	ng/L	< 0.93		< 0.93				< 0.9		< 0.9		< 0.9	
	Methylprednisolone	ng/L												
	Metoprolol	ng/L												
	Norfluoxetine	ng/L												
	Norverapamil	ng/L												
	Paroxetine	ng/L												
	Prednisolone	ng/L												
	Prednisone	ng/L												
	Promethazine	ng/L												
	Propoxyphene	ng/L												
	Propranolol	ng/L												
	Sertraline	ng/L												
	Simvastatin	ng/L												
	Theophylline	ng/L												
	Trenbolone	ng/L												
	Trenbolone acetate	ng/L												
	Valsartan	ng/L												
	Verapamil	ng/L												
Pharmaceuticals (other)	Diclofenac	ng/L	< 1.9		< 1.9				< 1.9		< 1.9		< 1.9	
	Dilantin	ng/L	< 1.9		< 1.9				< 1.9		< 1.9		< 1.9	
	Hydrocodone	ng/L	< 4.7		< 4.7				< 4.7		< 4.7		< 4.7	
	Methadone	ng/L	< 4.7		< 4.7				< 4.7		< 4.7		< 4.7	
	Pentoxyfylline	ng/L	< 4.7		< 4.7				< 4.7		< 4.7		< 4.7	
Other Steroids and Endocrine Disrupting	Iopromide	ng/L	< 9.3		< 9.3				< 9.3		< 9.3		< 9.3	
	Oxybenzone	ng/L	25		< 19				< 19		< 19		< 19	
	Salicylic Acid	ng/L	25		23				43		30		< 19	
Herbicides	Atrazine	ng/L	< 0.93		< 0.93				< 0.93		< 0.93		< 0.93	
Radiologicals	Gross alpha	pCi/L	2.35		2.81		< 0.66		< 0.67		1.08		< 0.6	
	Gross beta	pCi/L	3.56		4.15		1.39		2.38		2.61		1.07	
	Ra-226	pCi/L	< 0.178		0.129		< 0.162		< 0.155		< 0.126		< 0.165	
	Ra-228	pCi/L	< 0.78		< 0.84		< 0.62		< 0.6		< 0.62		< 0.65	
	Am-241 (alpha spec)	pCi/L	< 0.0331		< 0.033		< 0.0328		< 0.0321		< 0.0312		< 0.0341	
	Pu-238	pCi/L	< 0.0152		< 0.0229		< 0.0177		< 0.0138		< 0.0136		< 0.0154	
	Pu-239/240	pCi/L	< 0.0152		< 0.0177		0.0115		< 0.0202		0.0166		0.0083	
	Pu-244	pCi/L												
	U-234	pCi/L	0.585		0.635		0.142		0.112		0.083		0.0352	
	U-235	pCi/L	0.0285		0.0233		< 0.0221		< 0.0177		< 0.0174		< 0.0214	
	U-233/234	pCi/L												
	U-235/236 (alpha spec)	pCi/L												
	U-238 (alpha spec)	pCi/L	0.378		0.342		0.081		0.053		0.0221		< 0.0257	
	Ac-228	pCi/L	< 17		< 15.7		< 18				< 30		< 18.3	
	Am-241 (gamma spec)	pCi/L												
	Sb-124	pCi/L												
	Sb-125	pCi/L												
	Ba-133	pCi/L												
	Ba-140	pCi/L												
	Be-7	pCi/L	< 37		< 27		< 35		< 37		< 35		< 36	
	Bi-212	pCi/L	< 64		< 56		< 60		< 66		< 59		< 69	
	Bi-214	pCi/L			< 19		< 22		< 9.3		< 21		< 19	

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		Date of Sample	**4/25/2017 - 4/26/2017**											
		TREAT Sample Location	**RG**	**RG**	**SS1**	**SS1**	**SS2**	**SS2**	**SS3**	**SS3**	**SS3A**	**SS3A**	**SS4**	**SS4**
		Sample Location Description	**Rio Grande**	**Rio Grande**	**Raw Water**	**Raw Water**	**After Conventional Treatment**	**After Conventional Treatment**	**After Membrane Filter**	**After Membrane Filter**	**After Ozonation**	**After Ozonation**	**After GAC**	**After Gac**
		Primary Contract Laboratory	**ALS**	**Hall**	**ALS**	**Hall**	**ALS**	**Hall**	**ALS**	**Hall**	**ALS**	**Hall**	**ALS**	**Hall**
Analyte Group	**Analyte**	**units**												
	Ce-139	pCi/L												
	Ce-141	pCi/L												
	Ce-144	pCi/L												
	Cs-134	pCi/L	< 4.8		< 3.7		< 4.7		< 4.7		< 4.7		< 5.1	
	Cs-136	pCi/L												
	Cs-137	pCi/L	< 4.4		< 3.9		< 4.8		< 4.7		< 4.1		< 4.5	
	Cr-51	pCi/L												
	Co-56	pCi/L												
	Co-57	pCi/L												
	Co-58	pCi/L												
	Co-60	pCi/L	< 5.5		< 4.3		< 5.0		< 5.6		< 4.8		< 5.3	
	Eu-152	pCi/L												
	Eu-154	pCi/L												
	Eu-155	pCi/L												
	I-131	pCi/L	< 8.3		< 6.9		< 6.9		< 9.4		< 8.4		< 8.0	
	Ir-192	pCi/L												
	Fe-59	pCi/L												
	Pa-234m	pCi/L	< 760		< 670		< 770		< 830		< 550		< 860	
	Pb-210	pCi/L												
	Pb-212	pCi/L	< 12.7		< 10.4		< 11.5		< 11.9		< 14.0		< 12.2	
	Pb-214	pCi/L	< 14.3		< 15.0		< 17		< 9.0		< 8.3		< 8.1	
	Mn-54	pCi/L												
	Hg-203	pCi/L												
	Nd-147	pCi/L												
	Np-239	pCi/L												
	Nb-94	pCi/L												
	Nb-95	pCi/L												
	K-40	pCi/L	< 130		< 110		< 122		< 164		< 127		< 138	
	Pm-144	pCi/L												
	Pm-146	pCi/L												
	Ra-228 (gamma spec)	pCi/L												
	Ru-106	pCi/L												
	Ag-110m	pCi/L												
	Na-22	pCi/L	< 5.1		< 4.1		< 4.6		< 4.9		< 4.7		< 5.5	
	Tl-208	pCi/L	< 9.1		< 6.8		< 8.6		< 7.7		< 11.4		< 10.9	
	Th-234	pCi/L	< 128		< 67		< 77		< 141		< 210		< 127	
	Sn-113	pCi/L												
	U-235 (gamma spec)	pCi/L												
	U-238 (gamma spec)	pCi/L												
	Y-88	pCi/L												
	Zn-65	pCi/L												
	Zr-95	pCi/L												
	Sr-90	pCi/L	< 0.13		< 0.14		< 0.141		< 0.134		0.154		< 0.135	
	Tritium	pCi/L	< 240		< 240		< 220		< 240		< 230		< 230	

Notes:

▨ = Not analyzed, not quantified, or not reported

*** = estimated value**

-- Data are not blank corrected, and should not be used for decision-level assessment

-- A "<" value is equivalent to a "non-detect" value; the number represents the detection limit

-- Detection limits for detected quantities are not noted; see laboratory reports for detection limits and data qualifiers

-- TREAT study described in Bowman, D. K. (2015). *Storm Water Quality Monitoring of Rio Grande at Buckman Direct Diversion* . NM: BDD.

-- Data herein were subject to quality control procedures described in a separate document, and therefore may deviate from data presented in previous published and unpublished reports not subject to the same procedures