This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.

Designation: E1819 – 15 (Reapproved 2021)

# Standard Guide for Environmental Monitoring Plans for Decommissioning of Nuclear Facilities[1]

This standard is issued under the fixed designation E1819; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

## 1. Scope

1.1 This guide covers the development or assessment of environmental monitoring plans for decommissioning nuclear facilities. This guide addresses: (*1*) development of an environmental baseline prior to commencement of decommissioning activities; (*2*) determination of release paths from site activities and their associated exposure pathways in the environment; and (*3*) selection of appropriate sampling locations and media to ensure that all exposure pathways in the environment are monitored appropriately. This guide also addresses the interfaces between the environmental monitoring plan and other planning documents for site decommissioning, such as radiation protection, site characterization, and waste management plans, and federal, state, and local environmental protection laws and guidance. This guide is applicable up to the point of completing D&D activities and the reuse of the facility or area for other purposes.

1.2 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

## 2. Referenced Documents

2.1 *ASTM Standards:*[2]

E666 Practice for Calculating Absorbed Dose From Gamma or X Radiation

E668 Practice for Application of Thermoluminescence-Dosimetry (TLD) Systems for Determining Absorbed Dose in Radiation-Hardness Testing of Electronic Devices

E1167 Guide for Radiation Protection Program for Decommissioning Operations

E1281 Guide for Nuclear Facility Decommissioning Plans

E1892 Guide for Preparing Characterization Plans for Decommissioning Nuclear Facilities

ISO/ASTM 51707 Guide for Estimating Uncertainties in Dosimetry for Radiation Processing

2.2 *ANSI Standards:*[3]

ANSI N 545 Environmental Application of Thermoluminescent Dosimetry

ANSI N 13.1 Guide to Sampling Airborne Radioactive Materials in Nuclear Facilities

ANSI N323AB Standard for Radiation Protection Instrumentation Test and Calibration, Portable Survey Instruments

2.3 *Nuclear Regulatory Commission Documents:*[4]

NUREG CR-2082 Monitoring for Compliance with Decommissioning Termination Survey Criteria

NUREG-1575 Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM), Revision 1, August 2000

NUREG-1576 Multi-Agency Radiological Laboratory Analytical Protocols (MARLAP)

2.4 *U.S. Government Documents:*

29 CFR Part 1910.120[4]

2.5 *U.S. EPA Documents:*

OSWER-9950.1 RCRA Ground-Water Monitoring Technical Enforcement Guidance Document[5]

SW-846 Test Methods for Evaluating Solid Waste, Physical/Chemical Methods

40 CFR 302 Designation, Reportable Quantities, and Notifications

40 CFR 61 National Emission Standards for Hazardous Air Pollutants

40 CFR 58 Ambient Air Quality Surveillances

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[1] This guide is under the jurisdiction of ASTM Committee E10 on Nuclear Technology and Applicationsand is the direct responsibility of Subcommittee E10.03 on Radiological Protection for Decontamination and Decommissioning of Nuclear Facilities and Components.

Current edition approved Feb. 1, 2021. Published February 2021. Originally approved in 1996. Last previous edition approved in 2015 as E1819-15. DOI: 10.1520/E1819-15R21.

[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] Available from American National Standards Institute, 11 W. 42nd St., 13th Floor, New York, NY 10036.

[4] Available from Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402.

[5] Available from U.S. Environmental Protection Agency, 401 M St. SW, Washington, DC 20460.

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2.6 *American Public Health Association Document:*
Standard Methods for Examination of Water and Wastewater[6]

## 3. Terminology

3.1 *Definitions:*

3.1.1 *active phase, n*—time during which physical decontamination/dismantling operations are performed.

3.1.2 *characterization, n*—a systematic identification of the types, quantities, forms, and locations of contamination on the site.

3.1.3 *Data Quality Objectives (DQOs), n*—quantitative and qualitative statements that specify the quality of data needed from a particular data collection activity.

3.1.4 *decommission, vt*—to remove safely from service and reduce residual radioactivity to a level that permits release of the property for unrestricted use and termination of any applicable licenses.

3.1.5 *decontamination, n*—activities employed to reduce the levels of (radioactive or hazardous chemical) contamination in or on structures, equipment, materials, and personnel. Typical forms of decontamination may include: (*1*) decontamination to support decommissioning objectives; (*2*) decontamination to reduce radiation levels in support of as low as reasonably achievable (ALARA) objectives; (*3*) decontamination to limit the spread of radiological contamination; (*4*) decontamination to support the unrestricted release of material and equipment; and (*5*) decontamination of personnel.

3.1.6 *monitoring, vt*—observing or taking measurements systematically over time to determine the status of and to detect significant changes in conditions or performance of a system, facility, or area.

3.1.7 *passive phase, n*—time of surveillance and maintenance from the time plant operations cease until decontamination/dismantling operations begin, and from the end of active decontamination/dismantling operations until the site is released for unrestricted use.

3.1.8 *radiological release criteria, n*—levels of residual radioactivity present at the completion of a decommissioning activity below which the site may be released to the general public for unrestricted use.

3.1.9 *hazardous material clean-up criteria, n*—the reduction of hazardous contaminants needed to reduce the risk identified in the baseline health-based risk assessment to a level consistent with Applicable and Relevant or Appropriate Requirement (ARAR) values.

3.1.10 *hazardous substance, n*—any material identified by the Environmental Protection Agency (EPA) in 40 CFR 262.

3.1.11 *restricted use, n*—organizational control is maintained over a property through physical barricades, signs and notices, or deed covenants that limit the full use of the property by an owner or prospective owner.

3.1.12 *unrestricted use, n*—control over the property is fully released for any use desired by the owner.

## 4. Summary of Guide

4.1 Nuclear facilities must have established plans for monitoring the environment surrounding the site as part of their license or technical specifications. These plans are designed to identify any release of radioactive or hazardous material and to assess the resulting impacts. Similar plans are required during surveillance and maintenance, decommissioning or site remediation to continue environmental monitoring, although the types of discharges and the affected pathways may be different from those monitored during facility operations.

4.2 In addition, limited environmental surveillance may have been performed since the facility operated. The existing environmental monitoring plans should be modified for decommissioning and reflect the current environment, potential release points, and affected pathways. If no environmental monitoring plan exists, one must be developed.

4.3 The decommissioning environmental monitoring plan must be consistent and complete to ensure the detection and mitigation of off-site impacts caused by radioactive or hazardous materials released from decommissioning activities at nuclear facilities.

## 5. Significance and Use

5.1 Use of this guide will ensure that the potential impact on the surrounding environment from planned decommissioning activities has been properly assessed.

5.2 Use of this guide will ensure that the adequacy of environmental sampling has been assessed for location, frequency, analytical techniques, and media type to monitor the environment and to detect site-related releases and their impact.

## 6. Organizational Interfaces

6.1 The environmental monitoring plan should coordinate with other decommissioning documents. Guide E1281 recommends that certain planning documents and implementation plans will be prepared prior to commencement of dismantlement actions. This guide ensures that the basic environmental monitoring planning elements and requirements are identified, examined, and addressed to accomplish the decommissioning activities. Other project plans and reports guide the operations and organization for the decommissioning project.

6.1.1 Planning and implementation documents define the activities around which the site environmental monitoring program will be developed. Documents that should be reviewed include the following:

6.1.1.1 Site Description and Operating History Reports,
6.1.1.2 Site Characterization Report,
6.1.1.3 Health Based Baseline Risk Assessment,
6.1.1.4 Planned Decommissioning Activities Document,
6.1.1.5 Licensing and Regulatory Issues Document,
6.1.1.6 Quality Assurance Document, and
6.1.1.7 Radiation Protection Document.

6.1.1.8 Appendix X1 contains brief overviews of these documents, as they contribute to the environmental plan.

[6] Available from American Public Health Association, 1015 15th St. NW, Washington, DC 20005.

## 7. Elements of an Environmental Monitoring Plan

7.1 Site environmental monitoring shall comply with a written plan. This plan must both direct the performance of monitoring and inform concerned individuals as to the intent and methodologies used in monitoring the environment. The plan must clearly define the scope of work activities, that is, describe the site, area, or room to be decommissioned. Guidance on the content and structure of the plan is outlined in 7.2 – 7.10.12. Additional guidance relative to the requirements for monitoring of environmental pollutants at facilities being decommissioned can be found in such references as , 40 CFR 61, and 40 CFR 58. These cover such topics as notification of the release of hazardous materials, emission standards for air pollutants, and air monitoring of these materials.

7.2 *Introduction and Objectives*—The introduction should address the history of actions leading to decommissioning, identify the organizations involved, describe the decommissioning process and required documentation, define the objective or purpose of the environmental monitoring program, and describe the intended use of the monitoring data.

7.2.1 *Monitoring Objectives*—Basic objectives should include the following, as a minimum:

7.2.1.1 Assess the actual or potential doses to man from contaminants released to the environment as a result of decontamination efforts,

7.2.1.2 Demonstrate compliance with applicable environmental regulations during decommissioning and with established release criteria. Chapter 4 of The Decommissioning Handbook[7] provides an excellent summary of the various environmental regulations that apply to decommissioning work,

7.2.1.3 Evaluate the adequacy and effectiveness of the containment and effluent control system during decontamination.

7.2.2 *Calibration and Measurement System Performance:*

7.2.2.1 Provisions must be made when planning environmental monitoring activities at decommissioning sites to ensure that all data are obtained using instruments and instrumentation systems capable of producing accurate and valid data. This requires the use of instruments and equipment having valid and current calibration certificates. ANSI N323AB describes the protocols for portable instrument calibration. It also means that careful consideration should be given to the appropriate use of spiked samples, blanks, and split samples as quality assurance principles are incorporated into the environmental monitoring program. The MARLAP manual provides guidance for this.

7.2.3 *Data Quality Objectives*—The DQOs impact statistical sampling design, sampling techniques, analytical procedures, and documentation procedures. The elements for a decommissioning monitoring plan will be prepared with concern for the DQO process. Technical monitoring objectives will be established to support the data quality objectives in the monitoring plan. The objectives will be specified in terms of precision, accuracy, representativeness, completeness, comparability, and detection limit. For further information on DQOs, see Ref (**1**).[8]

7.3 *Background Information:*

7.3.1 *Location*—The plan should specify the location and describe the site and surrounding area.

7.3.2 *Source of Contaminants and Transport Pathways*—The source term from the site characterization data should be complete enough to identify the types of radionuclides and hazardous materials on site, their quantities, and the physical conditions in which they are found. The plan should specify the chemical composition and condition of the material, extent of contamination, and whether the material is in soil or groundwater, or on buildings and equipment surfaces. Implementation of a site characterization plan, developed using guidance provided in Guide E1892, will provide this data.

7.3.3 *Information Sources*—Sources of information on the site should be identified, searched for pertinent information, and summarized, including previous sampling, facility waste plans, environmental characterizations, radiation surveys, and local sampling problems.

7.3.4 *Impact Data*—Available environmental impact data should be summarized.

7.3.5 *Background Evaluation Requirements:*

7.3.5.1 Requirements governing the decommissioning activities and release of the site may be based on levels above background; therefore, careful evaluation of background conditions at the decommissioning site should be considered when planning the environmental monitoring program.

7.4 *Evaluation of Existing Data:*

7.4.1 *Source Term Examination*—Once all contaminants present at the site are identified, those contaminants that potentially could be released to the environment during decommissioning should be identified specifically and included in the transport model, as discussed in 7.4.2.

7.4.2 *Pathways Modeling for Monitoring System Design*—The decommissioning activities specified in the decommissioning plan should be reviewed to identify activities that could release hazardous materials to the off-site environment. The environmental transport pathways will then be identified, including critical environmental components and receptors. Using the strength of the source and the model, the most significant pathways and receptors will be identified for each contaminant.

7.4.2.1 The pathways model (conceptual or mathematical) for transport of material to the environment should establish the critical population and the most probable locations for accumulation of radioactivity or hazardous material. Pathways with potentially high accumulation rates should be selected for sampling to provide a means of detecting releases at the earliest opportunity. Likewise, exposure pathways to humans defined in the site release criteria (that is, milk, fish, and groundwater consumption, and dust ingestion and inhalation) should be specifically considered for sampling. These pathways to humans provide a means of comparing site releases and resultant

[7] Taboas, A. L., Moghissi, A. A., and LaGuardia, T. S., Eds., The Decommissioning Handbook, Chapter 4, Environmental and Related Requirements, ASME, Three Park Ave., New York, NY, 2004.

[8] The boldface numbers in parentheses refer to a list of references at the end of this guide.

environmental levels with calculated doses to individuals. The model must consider the transport of each contaminant separately, since their sources and environmental fates may be different.

7.5 *Sampling and Analytical Design:*

7.5.1 *Statistical Design*—A variety of statistical monitoring designs are available to meet monitoring objectives, including stratified, systematic, and random with grab or composite sampling. The statistical design chosen must account for the source of statistical variability in the samples, such as space, time, sampling procedures, sample handling, sample processing including subsampling, sample extraction, and analytical measurements. The parameters include several sources of statistical error. The development of data quality objectives requires consideration of these sources of error, an estimate of their magnitude, and, if necessary, a review of methods to reduce the overall variability in a cost-effective manner. For further information on statistical sampling design and data interpretation, see Refs (**2**) and (**3**). In addition, the Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM) provides excellent guidance on sampling design for these projects. See NUREG CR-2082 for additional guidance.

7.5.2 *Initial Baseline Conditions*—The site description and operating history should be reviewed to identify any previous environmental sampling plans and the resultant data. All licensed sites and sites operated by the government should have a documented baseline prior to the initial start of operations. These data should be reviewed, and those sample points used to establish the previous background should be trended through subsequent environmental reports to update the background value of these locations before decommissioning operations begin. This documentation should be supported by new samples taken from the original baseline sampling locations and new locations for pathways resulting from decommissioning activities. The long-term sampling data should depict the status of the environment at the start of decommissioning operations.

7.5.2.1 If the existing documentation or current sampling indicates that contamination has been deposited off-site, the quantity and location of this material must be characterized. Contaminants existing in the environment before decommissioning may be transported as a plume or slug and could result in increasing environmental levels. Without adequate data, the increase could be attributed incorrectly to decommissioning activities.

7.5.2.2 Sites with no previous environmental monitoring program should establish a baseline. Many state environmental or radiation protection programs maintain environmental sampling locations that can provide baseline information for normal air activity, radon levels, external beta/gamma radiation values, or trace element levels in ambient air. The baseline sampling activity should account for fluctuations in data taken by other programs, such as radon emanation rates and air activity levels.

7.5.3 *Sampling Rationale*—Select the media to sample according to the results of pathways modeling (see 7.3.2). Those pathways deemed significant for their possible dose to the public or release to the environment (both accidental and planned) should be monitored. For decontamination activities, the most important pathways to the off-site environment are typically atmospheric and surface water transport of contaminants. The sources may be point (such as a stack or discharge pipe) or non-point (fugitive dust or erosion of soil by surface water). The releases may be planned, unplanned, continuous, or episodic.

7.5.3.1 The most common environmental media to monitor for decommissioning operations are air, water (surface, ground, and drinking), soil, sediments, and biota. Paragraphs 7.5.3.2 – 7.5.3.8 discuss basic considerations. Corley et al. (**2**) provides further guidance on monitoring system design, sample type, sampling locations, and frequency.

7.5.3.2 *Air*—Air is an important transport pathway to off-site areas and an exposure pathway to man from contaminants released to the atmosphere. Therefore, environmental air sampling should be conducted to determine whether contaminants are migrating off-site and to evaluate potential doses to environmental populations from inhaled or ingested contaminants or from external exposure.

*(1)* The sampling method depends upon the contaminants of interest, such as particulates, radioiodines, noble gases, tritium, or volatile organic compounds. Particulate sampling techniques include filtration, electrostatic precipitation, impingement (into or onto a collection medium), and impaction. For particulates, proper particle sizes and sampling equipment must be selected to comply with current clean air regulations.[9] Factors to consider in filter selection are pressure drop, flow reduction due to particle collection efficiency (filter loading), particle-size selectivity, retention of alpha-emitting particles on the filter surface, and the ease of radiochemical analysis. Gases may be sampled either actively or passively using sorbent traps of Tenax, activated charcoal, or silica gel for example. For additional information on TDLs, see Practices E666 and E668 and ISO/ASTM Guide ISO/ASTM 51707, as well as ANSI N 545.

*(2)* Deposition sampling is an alternative to active air sampling for particulate contaminants. Deposition collectors include pails, dustfall jars, coated surfaces, and precipitation collectors. These methods are inexpensive, provide time integrated samples, are easy to maintain, and do not require power. However, the resultant data cannot easily be incorporated into dose assessment models. In addition, vegetation and surface soil may be sampled to evaluate atmospheric deposition.

*(3)* Thermoluminescent dosimeters (TLDs) may be used to determine an integrated exposure at site boundaries and population centers. TLDs are a relatively inexpensive means of determining external doses of radionuclides. It should be noted, however, that the correct use of TLDs outside of a controlled laboratory environment requires a certain amount of care.

*(4)* When selecting air sampling locations, consider the characteristics of the potential source and local meteorology. To monitor continuous releases from stacks, use a mathematical model to predict the area of maximum impact. The model should account for hours of operation, exhaust gas temperature

[9] Consult current ICRP recommendations and EPA regulations.

and velocity, stack height, expected meteorological conditions, and form of the contaminant (particulate, gas). Then, select exposed population. To monitor episodic or accidental releases from stacks, use an isokinetic stack monitoring program coupled with reliable meteorological data to calculate off-site doses to the exposed population because the exact area of maximum impact cannot be predicted *a priori*. Monitoring at selected population centers may also be considered to evaluate exposure at specific locations in the event of an episodic release.

*(5)* For contaminants released at ground level, the maximum expected off-site concentration frequently is detected at or near the downwind site boundary. Position a series of air samplers along the boundary of the facility calculated to be downwind of the stack the greatest percentage of time, within the nearest exposed community, and upwind of the source for control samples.

*(6)* Recommended guides for air sampling include ANSI N13.1 and Ref (**4**).

7.5.3.3 *Surface Water*—Contamination of surface water during decommissioning may result from direct discharge or surface runoff. Both routes may be routinely monitored. In addition, the receiving water body or drinking water supply may be sampled as part of the D&D monitoring program. Exposure from the surface water pathway results primarily from ingesting drinking water, but may also result from ingesting fish, shellfish, and other foodstuffs from potentially contaminated surface water used for fishing, irrigation, or watering livestock.

*(1)* The selection of sampling locations depends on the type of water body (lake, stream, estuary), form of the contaminant (sorbed to particulate or soluble), monitoring objectives, and potential for collecting a representative sample. To determine actual doses to humans, use drinking water samples obtained from the water treatment plant or taps in the distribution system. To evaluate off-site transport, collect samples where the discharge has mixed with the receiving water. Complete mixing of the discharge and the water body may not occur for many miles and could require dye tracing studies or modeling. Similar problems exist in sampling lakes and estuaries where mixing may never be complete and collection of representative samples is difficult or impossible. To minimize these complications, sampling near the point of discharge is recommended. The effluent should also be sampled, but that may be an operational monitoring activity.

*(2)* Standardized sampling procedures and approaches are discussed in Ref (**5**).

7.5.3.4 *Soil*—Collection of soils in off-site areas to assess the impact of decommissioning operations is not recommended. The small amount of material deposited from atmospheric transport is greatly diluted when a soil sample is collected. Thus, soil is not a sensitive short-term indicator, but may be used for long-term monitoring. In addition, a statistically sound sampling scheme is difficult to design and expensive to implement because of spatial heterogeneity. Soils are a complicated medium, which presents a variety of problems to laboratory analysis that can adversely affect data quality. Special circumstances may require off-site monitoring of soils for a particular activity, but routine monitoring is not recommended. Air samplers, deposition collectors, and vegetation monitoring are much more sensitive techniques to assess atmospheric deposition of contaminants.

7.5.3.5 *Sediment*—Sediment is an excellent accumulator of certain contaminants and should be considered in pathways modeling. Sediment, like sessile aquatic biota, integrates exposure and can be used to determine whether contaminants with high partitioning or sorption coefficients have been released. Both upstream and downstream samples should be collected before decommissioning activities begin. Sediments should be collected in areas of low water velocity, such as the inside radius of stream bends, at the entrance to lakes and rivers, and above dams.

*(1)* Sediment may be sampled with dredges, hand or weighted corers, or by divers, depending on the depth and velocity of the water, type of sediment, and objectives. For further information on sediment sampling, see Refs (**5**), (**6**), and (**7**).

7.5.3.6 *Aquatic Biota*—Aquatic biota may indicate off-site contaminant transport and may represent a significant pathway of human exposure (via ingestion). Wastes released to a water body may partition to biota and result in relatively high concentrations of contaminants compared to the receiving water. The pathways model may have identified specific species or classes of organisms that could be ingested by man or could indicate off-site transport. For dose assessment, monitor the organisms directly ingested by man, although some surrogate organisms may be used in modeling. Fish, shellfish, and waterfowl may be collected through direct field sampling, or they may be acquired from sportsmen or commercial fishermen if the point of collection can be determined. While aquatic vegetation is not usually a direct pathway to man, rooted aquatic plants and algae are concentrators and, therefore, indicators of release for some radionuclides, metals, and organic compounds.

*(1)* Consider using exposed sessile organisms as integrators of exposure. These organisms should be sampled upstream and downstream of the discharge, as described under sediment. Locations for the collection of mobile species depend on the habits of the organism, while drift species should be collected from the potential plume areas. For more information, see Refs (**5**), (**6**), and (**7**).

7.5.3.7 *Terrestrial Biota and Food*—Terrestrial biota sampling may be used instead of, or along with, surface soil sampling, deposition samplers, and active air monitoring. Leaves, brush, litter, and new growth act as collectors for some contaminants and may be used to detect trends. The main attribute is simplicity and cost. Vegetative media should be selected for availability in the areas of interest, adequacy of analytical methods, and capacity of the media to collect the contaminant of interest.

*(1)* Food stuffs are monitored because they are a direct route of human exposure through ingestion. Milk, meat, and produce can become contaminated via atmospheric transport, irrigation using contaminated water, and direct ingestion of contaminated

water or feed. Pathways modeling identifies critical foods for particular contaminants. For further information, see Corley et al. (2).

7.5.3.8 *Groundwater*—Ingestion of contaminated groundwater is a significant human exposure pathway for some contaminants (usually soluble metals and volatile organics). Because groundwater moves slowly, it is unlikely that groundwater contamination from decommissioning activities would be detected during the project, or that it would be distinguishable from existing contamination. However, groundwater should be sampled as part of the environmental monitoring program in conjunction with a knowledgeable and independent organization (not the operational monitoring team).

*(1)* Volatile organic compounds pose the greatest threat to groundwater because of their mobility in vapor and liquid phases. Semivolatile organics, pesticides/PCBs, metals, and most radionuclides are less of a problem. One exception is tritium, which is highly mobile.

*(2)* The sampling technique and monitoring well design depend on the analytes of interest. Positive displacement submersible pumps and bailers are suitable for sampling volatiles, while pumps that draw a vacuum or create excessive turbulence are discouraged. In all cases, wells should be purged to obtain a representative sample of the aquifer. Generally, several well bore volumes must be removed until groundwater parameters stabilize, such as pH, temperature, and conductivity. However, purge water may have to be controlled as hazardous or mixed waste, depending on the contaminants.

*(3)* Wells must be constructed from stainless steel or Teflon wells to meet applicable EPA specifications[10] concerning polyvinylchloride (PVC) and carbon steel. The techniques for well drilling, grouting, and development are critical to obtain accurate and valid monitoring data.

*(4)* Recommended references for groundwater monitoring are U.S. EPA OSWER-9950.1 "RCRA Ground-Water Monitoring Technical Enforcement Guidance Document" and Ref (8).

7.5.4 *Analytes to be Determined*—The monitoring plan should specify the samples to be analyzed and the analytes, which should have been identified during site characterization and selected for analysis through the pathway analysis.

7.5.5 *Field Analytical Procedures*—The equipment and techniques should be described in the monitoring plan. When screen samples in the field are used to reduce the number of analyses required, the screening procedure must meet the DQOs and be clearly recorded in the plan, including quality control checks.

7.5.6 *Decontamination of Equipment and Supplies*—Environmental sampling may result in the contamination of personnel, sampling equipment, and supplies. Most decommissioning environments are relatively clean. However, any decontamination of personnel, if required, should be covered in a site safety or radiation protection plan, or both (Guide E1167). Contamination of sampling equipment and supplies should be avoided because decontamination is time consuming, costly, and generates waste that may require special disposal. Decontamination procedures for sampling equipment must be developed in conjunction with analytical personnel to ensure that no analytical interferences could be caused by any wash or rinse solutions.

7.5.6.1 Disposable sampling equipment should be used when applicable, available, and acceptable. Disposable equipment saves time and money and ensures that no cross contamination occurs.

7.5.6.2 Special consideration is required when both radioactive and chemical contaminants are present. At times, the presence of contamination (significantly above ambient) on equipment can be ascertained in the field using organic vapor analyzers for chemical contaminants and radiation monitoring equipment for radioactive contaminants. For many contaminants, no immediate methods are available to determine the effectiveness of decontamination. Collect decontamination or rinsate blanks to determine decontamination efficiency.

7.5.6.3 Prevent contamination of field measurement instrumentation by using them cautiously. If contamination does occur, it is difficult to clean most measurement instruments without damaging them. Any instruments that cannot be decontaminated easily should be protected while being used.

7.5.7 *Field Quality Control Samples*—Quality control samples that can be used, depending on the objectives of the program, include trip blanks, preserved water blanks, field duplicates, field replicates, spiked samples, known standards, and rinsate or decontamination samples.

7.6 *Sample, Document, and Data Management*—Sample and document management must be documented in the decommissioning monitoring plan. Document control procedures facilitate sample tracking and aid in the interpretation of sampling and analytical data. Recording the circumstances under which the samples were collected, handled, preserved, transported, and analyzed is important in interpreting and evaluating the data. Document control procedures provide standardized formats for data management systems that allow efficient retrieval and data manipulation.

7.6.1 Finally, document control establishes the authenticity of the data. Sampling and analysis results may be used as evidence in court proceedings and decision making. Decommissioning monitoring requires information to be gathered by procedures that are more restrictive on personnel, materials, and methods than procedures used for routine environmental surveys.

7.6.2 Decommissioning monitoring programs require rigorous record keeping for all field activities. A written record of all field data, samples, observations, and events fulfills the following requirements:

7.6.2.1 Ensures that all essential and required information is consistently acquired and preserved for current use and future reference,

7.6.2.2 Ensures timely, correct, and complete analysis for all parameters requested,

7.6.2.3 Satisfies quality assurance requirements,

7.6.2.4 Establishes a chain-of-custody record, and

[10] Consult the current specifications for well construction and groundwater sampling under the Resource Conservation and Recovery Act/Comprehensive Environmental Response, Compensation, and Liability Act.

7.6.2.5 Provides evidence in potential court proceedings.

7.6.3 Maintaining standardized records enhances the usability of data necessary to conduct and implement monitoring programs. Using standard forms also ensures that the same types of information are recorded consistently.

7.6.4 The decommissioning monitoring plan should specifically cover the following supplies, documentation, and procedures: sample tags and labels with sample coding; procedures for sample packaging, labeling, and shipping; procedures for sample preservation and holding times by sample type and analytes of interest; sample containers with required sample volume for each type of sample and analyte; log books, forms, and procedures for recording field information; and procedures for preserving records.

7.7 *Logistics:*

7.7.1 *Schedules*—Logistics management is critical to an effectively run monitoring program. Advance work is required to plan and schedule field sampling, coordinate with analytical laboratories, arrange for site support (if needed), plan for disposal of waste materials generated during sampling, arrange for site access, and plan for the security of field equipment. For relatively short-term monitoring projects, the monitoring plan should contain all information. For long-term projects, a separate annual plan would be needed.

7.7.2 *Costs*—Cost estimates must be prepared for field sampling and analysis, analytical data management, and reporting. These estimates may be included in the monitoring plan.

7.7.3 *Equipment List*—The monitoring plan should include a checklist that covers all equipment and materials necessary to complete a particular field effort.

7.7.4 *Personnel*—Qualified personnel should be identified and their responsibilities defined in the plan or in a supporting document.

7.7.5 *Training*—All personnel must be adequately trained for the task they are to perform. The training requirements for each task should be documented in the plan.

7.8 *Analytical Procedures*—Specific methods should be identified for extraction, concentration, and analysis, as appropriate. Screening procedures may reduce the need for more expensive analyses if the limitations of the technique are known and if the data meet the DQOs.

7.8.1 In selecting analytical methods, the program DQOs must be kept in mind. The required precision and accuracy levels and the detection limit must be determined for the anticipated use of the data as well as for the analysis of field sampling errors. If field sampling errors are high, precise analytical methods would be useless because the levels of concern are orders of magnitude above the detection limits.

7.8.2 Specific analytical procedures are described in SW-846 "Test Methods for Evaluating Solid Waste" and "Standard Methods for Examination of Water and Wastewater."

7.9 *Data Management and Reporting*—Planning the data management and reporting process in the monitoring plan ensures that the required data are collected to meet the DQOs and that the final product meets the needs of the customers. Early coordination with data management personnel ensure sample tracking, data retrieval, and proper statistical analysis of the data. The statistical procedures to be used in evaluating and reporting the data should be identified before monitoring begins.

7.9.1 The monitoring plan and reports should be prepared for public distribution. The reports should include the objectives of the monitoring effort, a detailed discussion of the sampling design, a description or reference to exact sampling and analytical procedures, field and analytical data including quality control results, an evaluation of data quality including whether the data are adequate for the intended use, and an interpretation of results.

7.10 *Site Safety Plan*—A monitoring safety plan should be prepared as part of the monitoring plan, although the level of detail depends greatly on the hazards involved. For most decommissioning monitoring, little significant hazard exists from contaminants. However, if samples from high hazard areas are collected, the site health and safety plan, as a minimum, should address the following items, as stated in 29 CFR Part 1910.120:

7.10.1 The names of key personnel and alternates responsible for site safety and health and appointment of a site safety and health officer,

7.10.2 A safety and health risk analysis for each site task and operation,

7.10.3 Employee training assignments,

7.10.4 Personal protective equipment to be used by employees for each of the site tasks and operations being conducted,

7.10.5 Medical surveillance requirements,

7.10.6 Frequency and types of air monitoring, personnel monitoring, and environmental sampling techniques and instrumentation to be used,

7.10.7 Methods of maintenance and calibration of sampling equipment to be used,

7.10.8 Site control measures,

7.10.9 Decontamination procedures,

7.10.10 Standard operating procedures for the site,

7.10.11 A contingency plan that meets the requirements of 29 CFR 1910.120(1) (1) and (1) (2) for safe and effective response to emergencies including the necessary personal protective and other equipment, and

7.10.12 Entry procedures for confined spaces.

7.11 Additional information on site safety is available in Ref (**9**).

## 8. Passive Phase Requirements

8.1 *Sampling Plan Modifications*—Some environmental monitoring plans may cover the time from completion of decontamination activities until free-release of the site (potentially up to 100 years). In many decommissioning projects the site dismantlement actions are the final step prior to site release. However, some facilities require a period of organizational control following facility dismantlement and site remediation to achieve the required release criteria. As decommissioning is not accomplished until the site is free-released, this period of control is considered an ongoing part of decommissioning. Environmental monitoring will continue, albeit at a much reduced level.

8.1.1 The decommissioning environmental monitoring plan modified to passive phase monitoring should reflect the changes in release potential and pathways. Sampling locations should reflect exposure pathways and should be performed regularly, but less frequently. Annual sampling of several pathways should be sufficient to identify the longer term, slow release rates characteristic of a stabilized site following decommissioning activities. However, documentation, quality assurance, reporting, and an archive should be maintained with the same rigor as used for operational environmental sampling to ensure that the sampling program maintains continuity and credibility.

8.2 *Verification/Certification Surveys and Dockets*—During and immediately following remediation and decommissioning operations at the site, an independent contractor will perform site sampling to verify the final site contamination levels and to determine whether release criteria have been met. This sampling shall be performed to a written protocol clearly identifying the DQOs, sampling plan, and analysis and quality assurance plan employed to ensure that DQOs are met. Document management and sample archiving are critical requirements of the verification protocol.

8.2.1 The environmental monitoring plan should address the actions needed to support the verification contractor, such as analysis of split samples. Additionally, if the final release of the site is delayed following decontamination activities, the modified environmental monitoring plan should refer to the verification/certification docket and any subsequent monitoring of pathways required to support the verification survey results.

8.3 *Environmental Inputs to Certification Docket*—The site verification/certification protocol should define all inputs to be included in the final free release certification docket for the site. Inputs required from the environmental monitoring plan should include annual/periodic monitoring reports, baseline documentation, and any passive-phase monitoring results. The document management section of the environmental monitoring plan should ensure that the independent verification contractor receives the required data and documents in a timely fashion.

8.4 *Archiving of Samples and Reports*—Formal archiving of samples and reports is the responsibility of the independent verification contractor in preparation of the certification docket. However, delayed free release or specific operational considerations may require continuation of environmental monitoring following verification survey activities. Archiving of environmental monitoring plan quality assurance documentation and monitoring reports provides independent evidence to support the certification docket in the event of post-closure litigation.

## 9. Keywords

9.1 decommissioning; decontamination; environmental monitoring plan

# APPENDIX

**(Nonmandatory Information)**

## X1. ENVIRONMENTAL MONITORING PLAN SUPPORTING REPORTS AND PLANS

X1.1 This appendix provides an overview of reports and plans that may be required or that may supply source information for the development and implementation of the environmental monitoring plan.

X1.1.1 *Site Description and Operating History Document*—The site description provides data on area climate, rainfall, hydrology, geology, demographic considerations (for example, farming patterns, local population distribution), and environmental considerations (for example, flora, fauna). The site operating history lists the types and quantities of radionuclides and hazardous materials used at the site and the normal discharge pathways to the environment, as well as any inadvertent releases that occurred.

X1.1.2 *Site Characterization Document*—The site characterization identifies the type, quantity, and location of radionuclides and hazardous materials on the site. This information provides the source term of potential materials that may be released to the environment and, along with the site description (X1.1.1), the most probable environmental transport mechanisms.

X1.1.3 *Health-Based Baseline Risk Assessment Document*—The health-based baseline risk assessment characterizes the chemical hazardous contaminants and their potential impacts on the health of local populations, if left as is. Information on types of contaminants as well as probable pathways for the release of non-radiological hazards should be taken from this document.

X1.1.4 *Planned Decommissioning Activities Document*—The decommissioning activities document details the actions that constitute site decommissioning, such as contaminated water treatment, demolition methods, site excavation and earth work, decontamination processes, and facility ventilation. This information identifies how and where radioactive and hazardous materials may be released during the decommissioning operations.

X1.1.5 *Licensing and Regulatory Issues Document*—The licensing and regulatory issues document specifies any required changes in Nuclear Regulatory Commission licensing, state licensing, or facility technical specifications, and specifies environmental monitoring activities that must be implemented to support these changes. This document identifies the federal,

state, and local pollution emission permits that are currently in place or required. Some permits require effluent monitoring, including water treatment discharges (National Pollution Discharge Elimination System (NPDES)) and air emissions from either ventilation systems or fugitive emission sources, such as dust from demolition activities (National Emission Standards for Hazardous Pollutants (NESHAP)).

X1.1.5.1 This document also provides a description of the pathway methodology and the resulting guidelines for residual radioactivity used as the release criteria for each media and contaminant of concern. This information identifies: (*1*) specific environmental sampling previously required; (*2*) environmental sampling needed to substantiate that permitted effluents are not impacting the environment; and (*3*) any environmental sampling needed to monitor the main exposure and transport pathways identified in the site release criteria.

X1.1.6 *Quality Assurance Document*—The site quality assurance document provides documentable and auditable quality requirements for the environmental monitoring program. The quality assurance document includes requirements for records, reporting, appraisals, and analytical data quality.

X1.1.7 *Radiation Protection Document*—The radiation protection document defines the organization, personnel, and equipment required to provide operational control of radiological exposure or releases to the environment during the decommissioning activities. Surveys performed as part of the radiation protection plan (that is, on-site air sampling, equipment release surveys, and liquid sampling of on-site sources) provide the types and levels of radioactive material releases and their potential pathways to the environment.

X1.1.8 The documents in X1.1.8.1 – X1.1.8.3 also may require update for decommissioning activities.

X1.1.8.1 Safety Analysis Report.

X1.1.8.2 NEPA Documentation.

X1.1.8.3 Other CERCLA documentation and reports, including, but not limited to, RI/FS.

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