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REGULATORY GUIDE

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MEASURING, EVALUATING, AND REPORTING RADIOACTIVE MATERIAL IN LIQUID AND GASEOUS EFFLUENTS AND SOLID WASTE

A. INTRODUCTION

This guide describes methods the staff of the U.S. Nuclear Regulatory Commission (NRC) considers acceptable for use: (1) in measuring, evaluating, and reporting plant-related radioactivity (excluding background radiation) in effluents and solid radioactive waste shipments from NRC licensed facilities, (2) in assessing and reporting the public dose from facility operations, and (3) on complying with 40 CFR 190 in accordance with the requirements of 10 CFR 20.1301(e).

This guide incorporates the risk-informed principles of the Reactor Oversight Process. A risk-informed, performance-based approach to regulatory decision-making combines the "risk-informed" and "performance-based" elements discussed in the staff requirements memorandum on SECY-98-144, "White Paper on Risk-Informed and Performance-Based Regulation," dated March 1, 1999 (Ref. 1).

The following regulations and design criteria establish the regulatory basis for the radiological effluent control program:

1. Title 10 of the *Code of Federal Regulations* (10 CFR) Section 20.1501, "Surveys" (Ref. 2),

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The NRC issues regulatory guides to describe and make available to the public methods that the NRC staff considers acceptable for use in implementing specific parts of the agency's regulations, techniques that the staff uses in evaluating specific problems or postulated accidents, and data that the staff needs in reviewing applications for permits and licenses. Regulatory guides are not substitutes for regulations, and compliance with them is not required. Methods and solutions that differ from those set forth in regulatory guides will be deemed acceptable if they provide a basis for the findings required for the issuance or continuance of a permit or license by the Commission.

This guide was issued after consideration of comments received from the public.

Regulatory guides are issued in 10 broad divisions: 1, Power Reactors; 2, Research and Test Reactors; 3, Fuels and Materials Facilities; 4, Environmental and Siting; 5, Materials and Plant Protection; 6, Products; 7, Transportation; 8, Occupational Health; 9, Antitrust and Financial Review; and 10, General.

Electronic copies of this guide and other recently issued guides are available through the NRC's public Web site under the Regulatory Guides document collection of the NRC's Electronic Reading Room at http://www.nrc.gov/reading-rm/doc-collections/reg-guides/ and through the NRC's Agencywide Documents Access and Management System (ADAMS) at http://www.nrc.gov/reading-rm/adams.html, under Accession No. ML091170109

2. 10 CFR 50.36a, "Technical Specifications on Effluents from Nuclear Power Reactors" (Ref. 3),

3. 10 CFR 20.1302, "Compliance with Dose Limits for Individual Members of the Public,"

4. 10 CFR 72.44(d), "License Conditions" (Ref. 4),

5. Section IV.B of Appendix I, "Numerical Guides for Design Objectives and Limiting Conditions for Operation to Meet the Criterion 'As Low As Is Reasonably Achievable' for Radioactive Material in Light-Water-Cooled Nuclear Power Reactor Effluents," to 10 CFR Part 50, "Domestic Licensing of Production and Utilization Facilities."

6. General Design Criterion 60, "Control of releases of radioactive materials to the environment," of Appendix A, "General Design Criteria for Nuclear Power Plants," to Title 10, Part 50, of the Code of Federal Regulations (10 CFR Part 50), "Domestic Licensing of Production and Utilization Facilities."

7. General Design Criterion 64, "Monitoring radioactivity releases," of Appendix A, "General Design Criteria for Nuclear Power Plants," to Title 10, Part 50, of the Code of Federal Regulations (10 CFR Part 50), "Domestic Licensing of Production and Utilization Facilities."

10 CFR 20.1501 requires surveys that may be necessary and are reasonable to evaluate the magnitude and extent of potential radiological hazards. In 10 CFR Part 20, "Standards for Protection against Radiation," "survey" is defined as an evaluation of the radiological conditions and potential hazards related to radioactive material or other sources of radiation, including (1) a physical survey of the location of radioactive material and (2) measurements or calculations of levels of radiation or concentrations or quantities of radioactive material present. The design objectives set out in 10 CFR Part 50, Appendix I, provide numerical guidance on limiting conditions for operation for light-water cooled nuclear power reactors to meet the requirement that radioactive materials in effluents discharged to unrestricted areas be kept as low as is reasonably achievable (ALARA).

10 CFR 50.36a requires establishing technical specifications with procedures and controls over effluents, including reporting (1) the quantity of each of the principal radionuclides discharged to unrestricted areas in liquid and gaseous effluents and (2) other information used to estimate the maximum potential annual radiation doses to the public from radioactive effluents.

In 10 CFR 20.1302, the NRC establishes requirements for surveys in the unrestricted and controlled areas and for radioactive materials in effluents discharged to unrestricted and controlled areas. The purpose of these surveys is to demonstrate compliance with the dose limits of 10 CFR 20.1301, "Dose Limits for Individual Members of the Public." Although 10 CFR 20.1302(b)(2) provides a second method of demonstrating compliance with dose limits for individual members of the public, nuclear power plant technical specifications essentially require use of 10 CFR 20.1302(b)(1) to determine the total effective dose equivalent to the individual likely to receive the highest dose. This requirement is based on actual, realistic exposure pathways to a real individual. (See also Regulatory Guide 1.109, "Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Demonstrating Compliance with 10 CFR Part 50, Appendix I" (Ref. 5) and Attachment 6 to SECY-03-0069, "Results of the License Termination Rule Analysis," dated May 2, 2003 (Ref. 6)).

In 10 CFR 72.44(d), the NRC establishes environmental monitoring requirements for each facility holding a specific license under Part 72 authorizing receipt, handling, and storage of spent fuel, high-level radioactive waste, and/or reactor-related greater than class "C" waste. This regulatory guide describes a method for reporting these results.

The general design criteria, Criterion 60, specifies nuclear power units shall control liquid and gaseous effluents and handle solid waste for both normal and anticipated operational occurrences.

The general design criteria, Criterion 64, specifies that a means shall be provided for monitoring effluent discharge paths and the plant environs for radioactivity that may be released during both normal and anticipated operational occurrences.

The reports required under (1) Subpart M, "Reports," of 10 CFR Part 20 (related to reports of exposures, radiation levels, and concentrations or radioactive material), (2) 10 CFR 50.72, "Immediate Notification Requirements for Operating Power Reactors," and (3) 10 CFR 50.73, "Licensee Event Report System," or other licensee requirements must be made in accordance with these applicable regulations. In addition, effluent discharges and radioactive material losses reported under those regulatory provisions should also be reported in the Annual Radioactive Effluent Release Report (ARERR) described in this regulatory guide.

This regulatory guide contains information collection requirements covered by 10 CFR Part 50 that the Office of Management and Budget (OMB) approved under OMB control number 3150-0011. The NRC may neither conduct nor sponsor, and a person is not required to respond to, an information collection request or requirement unless the requesting document displays a currently valid OMB control number.

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B. DISCUSSION

1. Regulatory Guidance

Six basic documents contain the regulatory guidance for implementing the 10 CFR Part 20 and 10 CFR Part 50 regulatory requirements and plant technical specifications related to monitoring and reporting of radioactive material in effluents and environmental media, solid radioactive waste disposal, and the public dose that results from licensed operation of a nuclear power plant:

1. Regulatory Guide 1.21, "Measuring, Evaluating, and Reporting Radioactive Material in Liquid and Gaseous Effluents and Solid Waste,"

2. Regulatory Guide 4.1, "Programs for Monitoring Radioactivity in the Environs of Nuclear Power Plants" (Ref. 7),

3. Regulatory Guide 4.15, "Quality Assurance for Radiological Monitoring Programs (Inception Through Normal Operations to License Termination)—Effluent Streams and the Environment" (Ref. 8),

4. NUREG-1301, "Offsite Dose Calculation Manual Guidance: Standard Radiological Effluent Controls for Pressurized Water Reactors" (Ref. 9),

5. NUREG-1302, "Offsite Dose Calculation Manual Guidance: Standard Radiological Effluent Controls for Boiling Water Reactors" (Ref. 10), and

6. Regulatory Guide 1.109, "Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Demonstrating Compliance with 10 CFR Part 50, Appendix I."

These six documents, when used in an integrated manner, provide the basic guidance and implementation details for developing and maintaining effluent and environmental monitoring programs at nuclear power plants. The four regulatory guides specify the guidance for radiological monitoring and the assessment of dose, and the two NUREGs provide the specific implementation details for effluent and environmental monitoring programs.

Regulatory Guide 1.21 addresses the measuring, evaluating, and reporting of effluent releases, solid radioactive waste, and public dose from nuclear power plants. The guide describes the important concepts in planning and implementing an effluent and solid radioactive waste program. Concepts covered include meteorology, release points, monitoring methods, identification of principal radionuclides, unrestricted area boundaries, continuous and batch release methods, representative sampling, composite sampling, radioactivity measurements, decay corrections, quality assurance (QA), solid radioactive waste shipments, and public dose assessments.

Regulatory Guide 4.1 addresses the environmental monitoring program. The guide discusses principles and concepts important to environmental monitoring at nuclear power plants. The regulatory guide addresses the need for preoperational and background characterization of radioactivity. It also addresses environmental monitoring (both on-site and offsite), including the exposure pathways. The guide defines the exposure pathways, the program scope of sampling media and sampling frequency, and

the methods of comparing environmental measurements to effluent releases in the Annual Radiological Environmental Operating Report.

Regulatory Guide 4.15 provides the basic principles of QA in all types of radiological monitoring programs for effluent streams and the environment. The guide addresses all types of licenses including nuclear power plants. The guide provides the principles for structuring organizational lines of communication and responsibility, using qualified personnel, implementing standard operating procedures, defining data quality objectives (DQOs), performing quality control (QC) checking for sampling and analysis, auditing the process, and taking corrective actions.

NUREG-1301 and NUREG-1302 provide the detailed implementation guidance by describing effluent and environmental monitoring programs. The NUREGs specify effluent monitoring and environmental sampling requirements, surveillance requirements for effluent monitors, types of monitors and samplers, sampling and analysis frequencies, types of analysis and radionuclides analyzed, lower limits of detection (LLDs), specific environmental media to be sampled, and reporting and program evaluation and revision.

Regulatory Guide 1.109 provides the detailed implementation guidance for demonstrating that radioactive effluents conform to the "As Low as is Reasonably Achievable" (ALARA) design objectives of 10 CFR 50, Appendix I. The regulatory guide describes calculational models and parameters for estimating dose from effluent releases, including the dispersion of the effluent in the atmosphere and different water bodies.

Note: The dose to occupational workers, including contributions from activities associated with effluent programs (such as low-level waste processing, storage and shipping, as well as dose from handling resins and filters for gaseous and liquid radioactive waste) is occupational dose associated with the licensed operation and is not included in RG 1.21.

The NRC issues regulatory guides to describe to the public methods that the staff considers acceptable for use in implementing specific parts of the agency's regulations, to explain techniques that the staff uses in evaluating specific problems or postulated accidents, and to provide guidance to applicants. Regulatory guides are not substitutes for regulations, and compliance with them is not required. The methods and practices outlined in regulatory guides are one acceptable method for implementing the regulations. Nuclear power reactor licensees may continue to use Revision 1 of Regulatory Guide 1.21, "Measuring, Evaluating, and Reporting Radioactivity in Solid Waste and Releases of Radioactive Materials in Liquid and Gaseous Effluents from Light-water Cooled Nuclear Power Plants," issued June 1974, or may adopt other procedures or practices that provide for the measuring, evaluating, and reporting of radioactive material in liquid and gaseous effluents and solid waste.

2. Objectives of the Radiological Effluent Control Program

The requirements for the radiological effluent control program appear in 10 CFR Part 20 and the technical specifications which are part of a license, including limitations on dose conforming to 10 CFR Part 50, Appendix I. In addition, a facility's technical specifications describe specific requirements. These regulatory requirements, in conjunction with the regulatory positions provided in this guide, can be used as a basis for establishing the radiological effluent control program. The radiological effluent control program for a nuclear power plant has the following six basic objectives:

1. ensure that effluent instrumentation has the functional capability to measure and analyze

effluent discharges,

2. ensure that effluent treatment systems are used to reduce effluent discharges to ALARA levels,

3. establish instantaneous release rate limitations on the concentrations of radioactive material,

4. limit the annual and quarterly doses or dose commitment to members of the public in liquid and gaseous effluents to unrestricted areas,

5. measure, evaluate, and report the quantities of radioactivity in gaseous effluents, liquid effluents, and solid radioactive waste, and

6. evaluate the dose to members of the public.

The Annual Radioactive Effluent Release Report (ARERR), submitted before May 1 (unless a licensing basis exists for a different submittal date), and the Annual Radiological Environmental Operating Report (AREOR) submitted annually by May 15 (unless a licensing basis exists for a different submittal date), are used to demonstrate compliance with the facility's technical specifications for the radioactive effluent control program. The reports demonstrate the following:

1. effectiveness of effluent controls and measurement of the environmental impact of radioactive materials,

2. compliance with the design objectives and limiting conditions for operation required to meet the ALARA criteria in Appendix I to 10 CFR Part 50,

3. relationship between quantities of radioactive material discharged in effluents and resultant radiation dose to individuals,

4. compliance with the radiation dose limits to members of the public established by the NRC and the U.S. Environmental Protection Agency (EPA), and

5. compliance with the effluent reporting requirements of 10 CFR 50.36a.

Licensees may also, if they choose to do so, use the format specified in this regulatory guide for 10 CFR 72.44(d) ISFSI effluent reports. However, the ISFSI effluent reporting requirement of 10 CFR 72.44(d) is not normally satisfied by inclusion as part of the Annual Radioactive Effluent Release Report (ARERR) since the reporting dates may conflict. If the dates are coincident, or can be met with a single report, licensees may use the ARERR to fulfill the 10 CFR 72.44(d) reporting requirements provided a copy is submitted as specified in 10 CFR 72.44(d)(3).

C. REGULATORY POSITION

1. Effluent Monitoring

1.1 Guidance for Effluent Monitoring

Monitoring programs should be established to identify and quantify principal radionuclides in effluents. NUREG-1301 (for pressurized-water reactors (PWRs)) and NUREG-1302 (for boiling-water reactors (BWRs)) specify the generic controls and surveillance requirements, including the frequency, duration, and methods of measurement. These NUREGs provide specifications for LLDs, requirements for batch releases and continuous releases, sampling frequencies, analysis frequencies and timelines, and composite sample requirements. Site-specific radiological effluent control programs may differ from the generic NUREG-1301 and NUREG-1302 guidance provided there is either a documented evaluation or justification for such deviations as part of an offsite dose calculation manual (ODCM) authorized change, or if submitted as part of the original ODCM in accordance with Generic Letter 89-01, "Implementation of Programmatic and Procedural Controls for Radiological Effluent Technical Specifications," (Ref. 11) dated January 31, 1989, and approved by the NRC.

1.2 Release Points for Effluent Monitoring

The ODCM should identify the facility's significant release points (see glossary) used to quantify liquid and gaseous effluents discharged to the unrestricted area. For those release points containing contributions from two or more inputs (or systems), it is preferable to monitor each major input (or system) individually to avoid dilution effects, which may impede or prevent radionuclide identification. NUREG-1301 and NUREG-1302 contain detailed guidance for the content and format of a licensee's ODCM. For purposes of effluent and direct radiation monitoring, the ODCM should list and/or describe the following:

1. Significant release points include stacks, vents, and liquid radioactive waste discharge points, among others.

2. Other release points should be listed in the ODCM if they are not normally classified as one of the significant release points but could become a significant release point based on expected operational occurrences (e.g., primary to secondary leakage for PWRs or failed fuel). This list does not need to be exhaustive or all-inclusive but instead should demonstrate that the licensee has reasonably anticipated expected operational occurrences and their effects on radioactive discharges. Examples may include main steam line safety valves, steam-driven feedwater pumps, turbine building sumps, containment ice condensers, leachate seepage from unlined ponds, or evaporative releases from ponds in the restricted or controlled areas.

3. The site environs map should show the following:

    a. significant release points,
    b. boundaries of the restricted area and the controlled area (per 10 CFR Part 20 definitions),
    c. boundary of the unrestricted area for liquid effluents (e.g., at the end of the pipe or entrance to a public waterway), and
    d. boundary of the unrestricted area for gaseous effluents (e.g., the site boundary).

4. Dose calculation methodologies should be described for exposure pathways and routes of exposure that are identified in Regulatory Guide 1.109, if applicable.

5. Dose calculation methodologies for direct radiation should be described if necessary (e.g., when assessing direct radiation from the facility). The methodology should include background subtraction, or if appropriate, extrapolation of radiation measurements to points of interest (e.g., to the individual members of the public likely to receive the highest dose).

The unrestricted area may be defined separately for each of the following: (1) liquid effluents, (2) gaseous effluents, and (3) if appropriate, for other radiological controls such as direct radiation.

1.3 Monitoring a Significant Release Point

A significant release point is any location, from which radioactive material is released, that contributes greater than 1 percent of the activity discharged from all the release points for a particular type of effluent considered. Regulatory Guide 1.109 lists the three types of effluent as (1) liquid effluents, (2) noble gases discharged to the atmosphere, and (3) all other radionuclides discharged to the atmosphere.

The ODCM should list significant release points. Significant release points should be monitored in accordance with the ODCM. If a new significant release point is identified and is not listed in the ODCM, licensees should (1) establish an appropriate sampling interval (e.g., in site-specific procedures) and (2) update the ODCM within a reasonable timeframe (e.g., yearly). Releases from a significant release point should be assessed based on an appropriate combination of actual sample analysis results, radiation monitor responses, flow rate indications, tank level indications, and system pressure indications as necessary to ensure that the amount of radioactive material released, and the corresponding doses, are not substantially underestimated (see 10 CFR Part 50, Appendix I, Section III, "Implementation"). If activity is detected when monitoring a significant release point, the radionuclides detected should be reported in the effluent totals (including those with half-lives less than 8 days) in the ARERR (i.e., in Table A-1 or Table A-2), provided that the amount discharged is significant to the three-digit exponential format required for the ARERR.

1.4 Monitoring a Less-Significant Release Point

NUREG-1301/1302 provides tables designating sampling and analysis frequencies for release points. Historically these tables together with the guidance from Revision 1 of RG 1.21 provided the sampling and analysis frequencies. Licensees may continue to use this guidance from NUREG-1301 and NUREG-1302 and Revision 1 of RG 1.21. This method of assigning sample frequencies is simple to implement, but in certain cases, it may entail an inappropriately large number of samples for less-significant release points which have no – or extremely low – impact on the parameters reported in the ARERR. As a result, for less-significant release points, licensees may evaluate and assign more appropriate sample frequencies. If a licensee wishes to deviate from the sample frequencies listed in NUREG-1301 and NUREG-1302, the licensee's evaluation, showing that the effectiveness of the radioactive effluent control program is not reduced, should be maintained in site documentation. Regardless of the surveillance frequencies, if activity is detected when monitoring a less-significant release point, the licensee must (per 10 CFR Part 50.36a and 10 CFR Part 50, Appendix I, Section III.A.1) report the cumulative activity in the effluent totals (i.e., in Table A-1 or Table A-2) in the ARERR (provided that the amount discharged is significant to the three-digit exponential format required for the ARERR).

Site documentation should identify less-significant release points, to the extent reasonable, but it is not necessary to list all possible release points in site documentation. Releases from a less-significant release point may be assessed (see section 5.1, "Bounding Assessments") to the extent reasonable using assumptions and bounding calculations (in lieu of, or in addition to, sampling and analysis). When plant conditions change, and such changes may reasonably affect the status of a less-significant release point (e.g., significant change in primary-to-secondary leakage in PWRs or substantial cross-contamination between systems), sampling and analysis of the affected less-significant release points should be conducted. These sample results should be evaluated to (1) confirm the continued validity of the bounding calculations (if used) regarding effluent accountability and (2) determine the impact (if any) on effluent accountability. The guidance in this regulatory guide regarding monitoring less-significant release points for purposes of accountability (via the ARERR) does not replace, supersede, or otherwise modify any responsibility for monitoring systems normally not contaminated, as outlined in NRC Inspection and Enforcement (IE) Bulletin 80-10, "Contamination of Nonradioactive System and Resulting Potential for Unmonitored, Uncontrolled Release of Radioactivity to Environment," dated May 6, 1980 (Ref. 12).

1.5 Monitoring Leaks and Spills

An area where an unplanned release occurred into the on-site environs (e.g., a leak or spill) should be identified as an "impacted area" for decommissioning purposes in accordance with NUREG-1757, "Consolidated Decommissioning Guidance," issued September 2006 (Ref. 13). A leak or spill should be assessed to obtain the necessary information for the ARERR as specified in Regulatory Position 8.5.1, "Abnormal Releases or Abnormal Discharges" (see glossary). Leaks or spills to the ground will be diluted on contact with soil and water in the environment. Samples of the undiluted liquid (from the source of the leak or spill) and samples of the affected soil (or surface water or ground water) should be analyzed as soon as practical. In some instances, sampling, particularly soil sampling, may not be practical if the leak occurred in inaccessible areas, or if there are extenuating considerations. In this respect, ground water monitoring may be used as a surrogate for soil sampling. If sampling is not practical, the 10 CFR 50.75(g) records should describe why sampling was not conducted (e.g., the area was inaccessible or there were safety considerations). The location and estimated volume of the leak or spill should be recorded to identify the extent of the impacted area and predicted size or extent of the contaminant plume. If a spill is promptly remediated (e.g., within 48 hours) and if subsequent surveys of the remediated area indicate no detectable residual radioactivity remaining in the soil or ground water (see paragraph below), then, for purposes of reporting discharges in the ARERR, there was no liquid discharge to the unrestricted area, and the spill need not be reported in the ARERR. However, the decommissioning file should be updated to include a description of the event as specified by 10 CFR 50.75(g). Licensees should review the decommissioning files before generating the ARERR to ensure that the ARERR includes the necessary information regarding leaks and spills.

When evaluating areas that have been remediated, the licensee should survey for residual radioactivity. There may be times when the licensee wants to verify that an area contains no residual radioactivity. There is existing regulatory guidance and information on analytical detection capabilities. Licensees should ensure that surveys are appropriate and reasonable (as defined in 10 CFR 20.1501). Licensees should generally ensure that surveys are conducted using the appropriate sensitivity levels (e.g., refer to the environmental LLDs in NUREG-1301 and NUREG-1302, Table 4.12-1, "Detection Capabilities for Environmental Sample Analysis," or LLDs determined by using the methodology outlined in NUREG-1576, "Multi-Agency Radiological Laboratory Analytical Protocols Manual," (MARLAP) issued July 2004 (Ref. 14)). Additionally, licensees should apply plant-process-system knowledge when evaluating leaks and spills. For example, consider a hypothetical case of a leak in a condensate storage

tank. Assume that the tank's contents were analyzed 30 days before the leak and determined to contain $1.2x10^{-6}$ microcuries per milliliter (uCi/mL) of tritium (1,200 picocuries/liter (pCi/L)). Additionally, assume that historical records indicate that the tank contained detectable levels of tritium about 50 percent of the time, and that tritium concentrations never exceeded 2,000 pCi/L of tritium. In this example, the licensee discovers a leak in the tank and is able to fix the leak after 400 gallons (1,500 liters) of water leaked to the ground surface. The licensee confirms the presence of tritium by sampling the tank contents and/or the wetted soil. Based on those results, the licensee chooses to remediate the affected soil and excavates the affected soil and places the removed soil into suitable containers. The licensee then samples undisturbed soil from several locations within the excavated area and analyzes the soil for tritium. The licensee adjusts the analytical method and the analytical sensitivity to allow detection of (the equivalent of) 1,000 pCi/L of tritium in the water fraction. The licensee analyzes the soil (for gamma activity) and the water fraction of soil (for tritium activity) from the excavated area and detects no radionuclides. The licensee also confirms radioactive material did not reach the water table by verifying the excavated area is above the water table. The NRC would find this to be an acceptable method for the licensee to use in concluding that there is no detectable residual radioactivity from the spill listed in this example.

This regulatory guide provides guidance regarding information the licensees should provide in the ARERR. In that context, when leaks and spills of radioactive material are identified, prompt response and timely actions should be taken to the extent reasonable to (1) evaluate radiological conditions and (2) ensure proper reporting of materials discharged off site. To realize these two goals, it may be necessary to isolate the leak or spill at the source, prevent the spread of the leak or spill, and remediate the affected area (if the licensee deems remediation to be reasonable and necessary). For leaks and spills involving the discharge of radioactive material to the unrestricted area, the dose to members of the public from the leak or spill should be evaluated using realistic or bounding exposure scenarios. (See Attachment 6 to SECY-03-0069 for more information on use of realistic scenarios.) However, for leaks or spills that occur on site, a realistic dose assessment to an offsite member of the public may become complicated especially if (1) no radioactive material has entered the unrestricted area and (2) there are no members of the public on site. For leaks and spills, licensees should perform surveys that are reasonable to evaluate the potential radiological hazard (as described in 10 CFR 20.1501). As a result, for leaks and spills, licensees may choose to use bounding assessments to estimate the potential hazard. For example, if a leak occurs on site and radioactive material is released at or below the ground surface, the licensee may choose to assess the potential hazard by assuming that a conservatively large (e.g., bounding) volume of water is part of an assumed exposure pathway (e.g., drinking water). Such assumptions would allow the licensee to assess the potential hazard to a hypothetical individual member of the public. A hazard assessment of this sort would be appropriate for inclusion in the supplemental information section of the ARERR. In such cases where there is no real exposure pathway to a member of the public, the licensee should indicate that the hazard assessment is a bounding estimate of the dose to a hypothetical individual member of the public and no actual exposure was received by a real individual member of the public.

If licensees choose to notify local authorities of spills or leaks (e.g., because of local ordinances or local and State government agreements), the licensee should review the reporting requirements of 10 CFR 50.72(b)(xi) and information in NUREG-1022, "Event Reporting Guidelines 10 CFR 50.72 and 50.73," (Ref. 15), for applicability. In such situations, licensees should ensure effective communication using the guidance provided in NUREG/BR-0308, "Effective Risk Communication," (Ref. 16), especially with respect to ensuring that the risk is described in the appropriate context. In general, licensees should notify the NRC when significant public concern is raised, in accordance with 10 CFR 50.72(b)(xi).

Although the licensee may choose to use its problem identification and resolution program (corrective action program) to document the evaluation of the spill or leak, appropriate documentation should be placed in, or cross-referenced to, the decommissioning files as required by 10 CFR 50.75(g).

Remediation should be evaluated and implemented as appropriate based on licensee evaluations and decision-making. Evaluation factors should include (1) the location and accessibility, (2) the concentrations of radionuclides and extent of the residual radioactivity, (3) the efficacy of monitored natural attenuation, (4) the volume of the release, (5) the mobility of the radionuclides, (6) the depth of the water table and (7) whether "significant residual radioactivity" (see glossary) is expected at the time of decommissioning. Since the contaminants, concentrations, and extent of contamination are expected to vary over time or plant life (either increase based on anticipated future leaks and spills or decrease based on remediation or monitored natural attenuation), no one set of numerical values defines significant residual radioactivity. However, licensees may make remediation decisions based on their expectations of being able to meet the decommissioning criteria of 10 CFR 20.1402, "Radiological Criteria for Unrestricted Use," at the anticipated time of decommissioning.

Information that may be useful in this decision-making includes (1) NUREG-1757, Volume 1, Appendix H, "Memorandum of Understanding between the Environmental Protection Agency and the Nuclear Regulatory Commission," (2) NUREG-1757, Volume 2, "Derived Concentration Guideline Levels in Table H.1," and (3) the derived concentration guideline levels that have been authorized for decommissioned nuclear power plants. For a more detailed analysis, licensees may use the RESRAD computer codes available from Argonne National Laboratory (Refs. 17, 18, and 19) or equivalent.

1.6 Monitoring Continuous Releases

For continuous releases, gross radioactivity measurements are often the only practical means of continuous monitoring. These gross radioactivity measurements are typically used to actuate alarms and terminate (trip) effluent releases, but by themselves, are generally not acceptable for demonstrating compliance with effluent discharge limits.

The use of continuously indicating radiation monitoring system results may be combined with sample analyses to more fully characterize and quantify a discharge. This technique may have particular applicability when (1) a short-term, rapid upscale indication of a process radiation monitor occurs during a release or (2) when there is a desire to verify whether a preliminary grab sample is representative. In these instances the radiation monitor responses (i.e., the radiation monitor efficiencies) for various radionuclides should be well characterized.

Grab samples should be collected at scheduled frequencies (see NUREG-1301 and NUREG-1302 or as approved in Generic Letter 89-01 submittals) to quantify specific radionuclide concentrations and release rates. The frequency of sample collection and radionuclide analyses should be based on the degree of variance in (1) the magnitude of the discharge and (2) the relative radionuclide composition from an established norm. Where the magnitude of the discharge and the relative nuclide composition of a continuous release vary significantly over the course of the discharge period, a combination of grab samples and continuous monitor readings can assist in accurately estimating the discharge. Continuous monitoring data (e.g., chart recorder data), as well as grab sample data, should be reviewed periodically and used to identify this variance from the established norm. Periodic evaluations should be made between gross radioactivity measurements and grab sample analyses of specific radionuclides. These evaluations should be used to verify (or modify) the conversion factors that correlate radiation monitor readings and concentrations of radionuclides in effluents.

1.7 Monitoring Batch Releases

For batch releases, measurements should be performed to identify principal radionuclides before a release. In those cases in which an analysis of specific "hard-to-detect" radionuclides (such as strontium-89/90 and iron-55 in liquid releases) cannot be done before release (see NUREG-1301 and NUREG-1302), representative samples should be collected for the purpose of subsequent composite analysis. The composite samples should be analyzed at the scheduled frequencies specified in NUREG-1301 and NUREG-1302 or, for less-significant release points, at the frequencies specified by the licensee. (See Regulatory Position 1.4.)

The use of continuously indicating radiation monitoring system results may be combined with sample analyses to more fully characterize and quantify a discharge. This technique may have particular applicability when (1) a short-term, rapid upscale indication of a process radiation monitor occurs during a discharge or (2) when there is a desire to verify whether a preliminary grab sample is representative. In these instances the radiation monitor responses (i.e., the radiation monitor efficiencies) for various radionuclides should be well characterized.

1.8 Principal Radionuclides for Effluent Monitoring

During analysis of samples, licensees should apply the appropriate analytical sensitivities to ensure adequate surveys are conducted. NUREG-1301/1302 provides a list of "principal gamma emitters" for which an LLD control applies. Historically, this list together with the guidance from Revision 1 of RG 1.21 provided the appropriate sensitivity levels for an analysis. Licensees may continue to use this guidance, which essentially classifies all radionuclides as principal radionuclides, and apply the analytical sensitivity levels (e.g., LLDs) directly from NUREG-1301 and NUREG-1302 and Revision 1 of RG 1.21. This method is simple to implement, but in certain cases, it may entail inappropriately long count times or it may involve alternate (or unnecessary) methods of analysis for low-activity radionuclides with no - or extremely low - dose significance.

Although the LLD list from NUREG-1301 and NUREG-1302 may be used for determination of principal radionuclides, in reality, the principal radionuclides at a site will be dependent on site-specific factors such as (1) the amount of failed fuel, (2) the extent of system leakage, (3) the sophistication of radioactive waste processing equipment, and (4) the level of expertise in operating radioactive waste processing system. Since the principal radionuclides will vary from site to site, licensees who wish to deviate from the historical method of determining principal radionuclides (as described above) may adopt a risk-informed approach to identify principal radionuclides (and the associated sensitivity levels) at a site.

This regulatory guide introduces the term "principal radionuclide" in a risk-informed context. A licensee may evaluate the list of principal radionuclides for use at a particular site. The principal radionuclides may be determined based on their relative contribution to (1) the public dose compared to the 10 CFR 50 Appendix design objectives or (2) the amount of activity discharged compared to other site radionuclides. Under this concept, radionuclides that have either a significant activity or a significant dose contribution should be monitored in accordance with a predetermined and appropriate analytical sensitivity level (LLD) outlined in a licensee's ODCM. This implementation of "primary radionuclides" ensures both (1) radionuclides that are present in relatively large amounts but that contribute very little to dose, and (2) radionuclides that are present in very small amounts but that have a relatively high contribution to dose are appropriately included in the ARERR.

NOTE: With respect to principal radionuclides, "dose" is the measure of risk whereas "activity" is not. For example, a relatively large amount of tritium released into a large body of water has little dose significance.

If adopting a risk-informed perspective, a radionuclide is considered a principal radionuclide if it contributes either (1) greater than 1 percent of the 10 CFR Part 50, Appendix I, design objective dose for all radionuclides in the type of effluent being considered, or (2) greater than 1 percent of the activity of all radionuclides in the type of effluent being considered. Regulatory Guide 1.109 lists the three types of effluent as (1) liquid effluents, (2) noble gases released to the atmosphere, and (3) all other radionuclides released to the atmosphere. In this context, the term "principal radionuclide" has special significance with respect to the required sensitivity levels (e.g., LLDs) for an analysis. The LLDs specified in NUREG-1301/1302 may be used, or LLDs may be determined based on the other methodologies (e.g., as outlined in MARLAP). Once principal radionuclides are identified, they should be monitored in accordance with the sensitivity levels (e.g., LLDs) listed in the ODCM.

For radionuclides that are not identified as principal radionuclides, licensee discretion may be applied to the sensitivity of analysis provided that there is no reduction in the effectiveness of the radioactive effluent control program. If analytical sensitivities are chosen that are different from those in NUREG-1301 and NUREG-1302, the basis for the deviations should be documented. For example, data quality objectives (DQOs) and other concepts from Regulatory Guide 4.15, "Quality Assurance for Radiological Monitoring Programs (Inception through Normal Operations to License Terminations)—Effluent Streams and the Environment," Revision 2, issued July 2007 (Ref. 20), may be useful for determining risk-informed sensitivity levels for an analytical method.

If a risk-informed approach is used, principal radionuclides should be determined based on an evaluation over a time period that includes a refueling outage (e.g., one fuel cycle). A periodic reevaluation should be performed to determine whether the radionuclide mix has changed and/or to identify new principal radionuclides. If a risk-informed approach is applied to the determination of principal radionuclides, the ODCM becomes the controlling document and specifies the list of principal radionuclides. If adopting this method, the ODCM should be updated with the list of principal radionuclides within 1 year of their identification. Licensees are allowed to revise the ODCM in accordance with the ODCM change process as described in the plant's technical specifications (which includes documented evaluations of such changes).

The concept of "principal radionuclides" does not reduce the requirement for reporting radionuclides detected in effluents. In addition to principal radionuclides, other radionuclides detected during routine monitoring of release points should be reported in the radioactive effluent release report and included in dose assessments to members of the public.

1.9 Carbon-14

Carbon-14 (C-14) is a naturally occurring isotope of carbon. Nuclear weapons testing in the 1950s and 1960s significantly increased the amount of C-14 in the atmosphere. C-14 is also produced in commercial nuclear reactors, but the amounts produced are much less than those produced naturally or from weapons testing. Since the NRC published Regulatory Guide 1.21, Revision 1, in 1974, the analytical methods for determining C-14 have improved. Coincidentally the radioactive effluents from commercial nuclear power plants over the same period have decreased to the point that C-14 is likely to be a principal radionuclide (as defined in this document) in gaseous effluents.

C-14 releases in PWRs occur primarily as a mix of organic carbon and carbon dioxide released from the waste gas system. In BWRs, C-14 releases occur mainly as carbon dioxide in gaseous waste (Ref. 21). Because the dose contribution of C-14 from liquid radioactive waste is much less than that contributed by gaseous radioactive waste, evaluation of C-14 in liquid radioactive waste is not required. Many documents provide information about the magnitude of C-14 in typical effluents from commercial nuclear power plants (e.g., Refs. 21, 22). Those documents suggest nominal annual releases of C-14 in gaseous effluents are approximately 5 to 7.3 curies from PWRs and between 8 to 9.5 curies from BWRs. Licensees should evaluate whether C-14 is a principal radionuclide for gaseous releases from their facility.

10 CFR 50.36a requires that operating procedures be developed for the control of effluents and that quantities of principal radionuclides be reported. The quantity of C-14 discharged can be estimated by sample measurements or by use of a normalized C-14 source term and scaling factors based on power generation (see National Council on Radiation Protection and Measurements Report No. 81, "Carbon-14 in the Environment," issued January 1985 (Ref. 23)) or estimated by use of the GALE code from NUREG-0017, "Calculation of Releases of Radioactive Materials in Gaseous and Liquid Effluents from Pressurized Water Reactors PWR-GALE Code," April 1985 (Ref. 22). Because the production of C-14 is expected to be relatively constant at a particular site, if sampling is performed for C-14 (instead of estimating C-14 discharges based on calculations from a normalized source term), the sampling frequency may be adjusted to that interval that allows adequate measurement and reporting of effluents. If estimating C-14 based on scaling factors and fission rates, a precise and detailed evaluation of C-14 is not necessary. It is not necessary to calculate uncertainties for C-14 or to include C-14 uncertainty in any subsequent calculation of overall uncertainty.

1.10 Abnormal Releases and Abnormal Discharges

In the previous revision of the Regulatory Guide 1.21, the terms "release" and "discharge" were synonymous. This regulatory guide uses the term "release" to describe an effluent from the plant (regardless of where the effluent is deposited), whereas the term "discharge" is used only to describe an effluent that enters the unrestricted area. Although the term "release" includes effluents to either (1) the on-site environs or (2) the unrestricted area, for purposes of this regulatory guide, the use of the term "release" will generally be reserved for those instances when an effluent is released from the power plant into the on-site environs. The on-site environs in this context encompass locations outside of nuclear power plant systems, structures, and components as described in the final safety analysis report or ODCM. This is a change in terminology with respect to the definition of "abnormal release" in Regulatory Guide 1.21, Revision 1, which defined abnormal releases to be "from the site boundary."

An "abnormal release" (see glossary) is an unplanned or uncontrolled release of licensed radioactive material from the plant. Abnormal releases may be categorized as either batch or continuous depending on the circumstances. By contrast, an "abnormal discharge" (see glossary) is an unplanned or uncontrolled release of licensed radioactive material to the unrestricted area. Abnormal discharges may also be categorized as either batch or continuous depending on the circumstances. The distinction between the terms "abnormal release" and "abnormal discharge" is important for describing the staff position for measuring, evaluating, and reporting releases and discharges, especially where leaks and spills are involved.

That portion of an abnormal release that is discharged to the unrestricted area is reported as a abnormal discharge in the year in which the discharge occurred. The portion of an abnormal release that remains on site is considered residual radioactivity (see 10 CFR 20) and is documented in accordance with 10 CFR 50.75(g).

Low-level radioactive system leakage resulting from minor equipment failures and component aging (wear and tear) may be expected to occur as an anticipated part of the plant operation. If such leakage is captured by, or directed to, a system designed to accept and handle radioactive material including the subsequent planned and controlled discharge of the radioactive material (e.g., as described in the FSAR or ODCM), that evolution is not considered an abnormal release. Normal system leakage captured by effluent ventilation control systems or sumps is not an abnormal release (provided that, before discharge of the radioactive material, the discharge is planned and controlled). (See also the definitions of "unplanned release" and "uncontrolled release" in the glossary.)

In certain circumstances, some subjectivity may be associated with the definitions of "unplanned release" and "uncontrolled release." In these situations, additional circumstances should be considered to determine if an abnormal release occurred. A well-designed and documented evaluation of a release point can include an evaluation of the potential for an unplanned or uncontrolled release. The evaluation can establish bounding criteria that establish a threshold for an abnormal release based on planning and control. Generally, releases that may reasonably be categorized as both unplanned and uncontrolled should be considered abnormal releases.

For example, consider an underground pipe that carries radioactive liquid to an outside storage tank. If this pipe develops a leak, and licensed radioactive material escapes into the surrounding soil, it is considered an abnormal release if some portion or all of the radioactive material remains on site. This type of leak should be reported as an abnormal release in the next ARERR. If the licensee predicts (e.g., based on site conceptual model and subsequent ground water monitoring results) that the radioactive material will enter the unrestricted area in 2 years, the resulting radioactive discharge (that would occur 2 years hence) will be considered an abnormal discharge. Therefore, the resulting radioactive discharge should be reported along with other data for the affected calendar year in a future ARERR (i.e., in this example, 3 years later). Both releases and discharges (either routine or abnormal) should be reported on a calendar-year basis for the year in which the release or discharge occurred.

Consider another example involving a volume of radioactive gas from the containment atmosphere that escapes the equipment hatch during a refueling outage (especially during the time interval when the containment purge exhaust fans are off). This would generally not be considered an abnormal discharge if (1) the duration was preplanned (e.g., for a "short" duration such as 12 hours), (2) the containment activity (gas, particulate, tritium, and iodine) was preplanned, known, and very low (e.g., such that a bounding estimate of the radioactive material discharged indicated there would be no measurable impact relative to typical discharges), (3) the containment activity was monitored (e.g., by sampling or radiation monitoring equipment), and (4) an evaluation was completed to identify a preplanned limiting (or "trigger") level of activity that would initiate remedial or mitigating action (e.g., close the equipment hatch to control gases escaping containment). In this example, the actions taken (i.e., preplanning and monitoring) before and during the evolution are sufficient to establish control of this discharge. As a result, this type of evolution should not be categorized as an abnormal discharge.

2. Effluent Sampling

2.1 Representative Sampling

A typical schedule for radioactive effluent sample collection and analyses appears in NUREG-1301 and NUREG-1302. Some licensees may have modified these sampling schedules (typically contained in the ODCM) as part of implementing Generic Letter 89-01 as approved by the NRC.

Additional samples should be obtained as needed to characterize abnormal releases, abnormal discharges, or other significant operational evolutions. Samples should be representative of the overall effluent in the bulk stream, collection tank, or container. Representative samples should be obtained from well-mixed streams or volumes of effluent at sampling points by using proper equipment and sampling procedures.

2.2 Sampling Liquid Radioactive Waste

Before sampling, large volumes of liquid waste should be mixed to ensure that sediments or particulate solids are distributed uniformly in the waste mixture. For example, a large tank may be mixed using a sparger system or recirculated three or more volumes to ensure that a representative sample can be obtained, as recommended by American Society for Testing and Materials (ASTM) D 3370-07, "Standard Practices for Sampling Water from Closed Conduits" (Ref. 24). If tank-mixing practices deviate from industry standards (i.e., those for recirculation or other), a technical evaluation or other justification should be provided. Sample points should be located where there is a minimum of disturbance of flow caused by fittings and other physical characteristics of the equipment and components. Sample nozzles should be inserted into the flow or liquid volume to ensure sampling of the bulk volume of pipes and tanks. Sample lines should be flushed for a sufficient period of time before sample extraction to remove sediment deposits and air and gas pockets. Generally, three line volumes should be purged (see ASTM D 3370-07) before withdrawing a sample, unless a technical evaluation or other justification is provided. Periodically, a series of samples should be taken during the interval of discharge to determine whether any differences exist as a function of time and to ensure that individual samples are indeed representative of the effluent mixture. In some instances, this may be accomplished by collecting one or more samples (either by "grab" or composite sampler) during the discharge and comparing with one or more samples taken before the discharge. If a series of samples are collected, these samples can be used to assess the amount of measurement uncertainty in obtaining representative samples.

2.3 Sampling Gaseous Radioactive Waste

Although all licensees may not be committed to Regulatory Guide 4.15, American National Standards Institute (ANSI) N42.18-2004, "Specification and Performance of On-Site Instrumentation for Continuously Monitoring Radioactivity in Effluents" (Ref. 25), and ANSI/Health Physics Society (HPS) N13.1-1999, "Sampling and Monitoring Releases of Airborne Radioactive Substances from the Stacks and Ducts of Nuclear Facilities" (Ref. 26), the documents contain the general principles for designing and conducting monitoring programs for airborne effluents. The cited references also contain recommendations for obtaining valid samples of airborne radioactive material in effluents and the guidelines for sampling from ducts and stacks. Licensees should use the appropriate licensing documents to evaluate the validity of representative samples (e.g., evaluate the potential for inaccurate sampling of gaseous effluents that may bypass a particulate filter and collect on an iodine collection cartridge) and to identify any inaccurate sample analyses configurations or counting geometries.

2.4 Sampling Bias

Sampling and storage techniques that could bias quantitative results for effluent measurements should be evaluated and corrections applied as necessary. These biases include inaccurate measurement of sample volumes resulting from pressure drops in long sample lines and loss of particulates or iodine in sample lines resulting from deposition or plate-out. Samplers for gaseous waste should be evaluated for particulate deposition using ANSI N13.1-1999 (Ref. 26) or equivalent.

2.5 Composite Sampling

Composite samples should be representative of the average quantities and concentrations of radioactive materials discharged in liquid and gaseous effluents. Composite samples should be collected in proportion to the effluent flow rate or in proportion to the volume of each batch of effluent discharges.

2.6 Sample Preparation and Preservation

Methods of sample preparation and/or sample storage should minimize the potential for loss of radioactive material (i.e., deposition of analyte on walls of the sample container or volatilization of analyte). Composite sample storage time should be as short as practical to preclude deposition on the storage container, or sample stabilization should be considered. Before quantitative radionuclide analyses for liquid effluent composites, samples should be mixed thoroughly so that the sample is representative of the material discharged.

Procedures should be instituted for handling, packaging, and storing samples to ensure that losses of radioactive materials or other factors causing sample deterioration do not invalidate the analysis. For example, filters should be stored carefully so as to prevent loss of radioactive material from the filter paper.

2.7 Short-Lived Radionuclides and Decay Corrections

In the analysis of short-lived radionuclides (e.g., short-lived noble gases), measurements should generally be made as soon as practical after collection to minimize loss by radioactive decay. In other cases, when needed to improve the detection of the longer-lived radionuclides, time should be allowed for the decay of short-lived, interfering radionuclides.

Some special considerations may be applicable in those instances where short-lived radionuclides are being measured. In general, sample collection (or analysis frequencies) should take into account the half-lives of the radionuclides being measured. This may have special applicability for continuous samples or composite samples. It is generally best to select a compositing interval (and analysis frequency) appropriate for the effluent (radionuclide) being analyzed. In cases where the compositing interval is selected appropriately, analytical bias is minimized. One way to avoid analytical bias is to decrease the composite sampling interval (and analysis frequency).

To minimize bias in measurements, it may be necessary to decay correct analysis results for short-lived radionuclides. Licensees should be cognizant of those situations in which analytical bias may be introduced when analyzing short-lived radionuclides and should select appropriate methods to minimize such bias.

3 Effluent Dispersion (Meteorology and Hydrology)

3.1 Meteorological Data

Gaseous effluents discharged into the atmosphere are transported and diluted as a function of (1) the atmospheric conditions in the local environment, (2) the topography of the region, and (3) the characteristics of the effluents. Licensees should consider the guidance in Regulatory Guide 1.23, "Meteorological Monitoring Programs for Nuclear Power Plants" (Ref. 27), in the development and implementation of site programs designed to collect site-specific meteorological data. The meteorological data do not need to be reported in the ARERR, but the data should be summarized and maintained as

documentation (records). An annual meteorological summary report that provides the joint frequency distributions of wind direction and wind speed by atmospheric stability class (see Regulatory Guide 1.23) should be prepared and maintained on site for the life of the plant. In addition, hourly meteorological data should be recorded and available if needed for assessing abnormal gaseous releases.

3.2 Atmospheric Transport and Diffusion

Site-specific meteorological data collected should be analyzed and used to generate gaseous effluent dispersion factors (χ/Q) and deposition factors (D/Q) in accordance with Regulatory Guide 1.111, "Methods for Estimating Atmospheric Transport and Dispersion of Gaseous Effluents in Routine Releases from Light-Water-Cooled Reactors" (Ref. 28). The use of annual average meteorological conditions to determine χ/Q and D/Q is appropriate for continuous releases and for establishing instantaneous release set points (see NUREG-0133, "Preparation of Radiological Effluent Technical Specifications for Nuclear Power Plants," issued October 1978 (Ref. 29)). This practice may also be acceptable for calculating doses from intermittent releases if the releases occur randomly and with sufficient frequency to justify the use of annual average meteorological conditions (see Regulatory Guide 1.111). When calculating long-term, annual average frequency distributions, 5 (or more) years of data should be used. If long-term, annual average χ/Q and D/Q values are used in determining dose to individual members of the public, the values should be revalidated or updated periodically (e.g., every 3 to 5 years). If the evaluation indicates the long-term, annual average χ/Q and D/Q are nonconservative by 10 percent or more, either revise the affected values or document the reason why such changes are not deemed necessary.

3.3 Release Height

The release height affects the transport and dispersion of radioactive materials especially with respect to "downwash" and building wake effects. For facilities with both ground-level and elevated releases, an evaluation should be made to determine the proper location of the maximum exposed individual member of the public. From a dispersion perspective, when determining the maximum exposure location (submersion and/or deposition), the evaluation should consider the magnitude of release originating as an elevated release and the magnitude of release originating as a ground-level release. For example, a close-in, downwind location in one sector may have a higher χ/Q (i.e., less dispersion) for a ground-level release; however, the majority of the source term may be originating as an elevated release, causing a higher concentration (χ) at a more distant location, possibly in a different sector. See Regulatory Guide 1.111 for a more complete discussion of release height.

3.4 Aquatic Dispersion (Surface Waters)

Liquid radioactive effluents may be disposed in accordance with 10 CFR 20.2001, "General Requirements," into a variety of receiving surface water bodies, including non-tidal rivers, lakes, reservoirs, settling ponds, cooling ponds, estuaries, and open coastal waters. This effluent is dispersed by various mechanisms (i.e., turbulent mixing, stream flow in the water bodies, and internal circulation or flow-through in lakes, reservoirs, and cooling ponds). Parameters influencing the dispersion patterns and concentrations near a site include the direction and speed of flow of currents, both natural and plant-induced, in the receiving water; the intensity of turbulent mixing; the size, geometry, and bottom topography of the receiving water; the location of effluent discharge in relation to the receiving water surface and shoreline; the amount of recirculation of previously discharged effluent; the characteristics of suspended and bottom sediments; and sediment sorption properties. Regulatory Guide 1.113, "Estimating Aquatic Dispersion of Effluents from Accidental and Routine Releases for the Purpose of Implementing Appendix I" (Ref. 30), describes calculational models for estimating aquatic dispersion to surface water

bodies. However, the dispersion characteristics may be highly site dependent and local characteristics should be considered when performing dispersion modeling and dose assessments.

3.5 Spills and Leaks to the Ground Surface

Liquid releases onto the land surface are transported and diluted as a function of site-specific hydrologic features, events, and processes and properties of the effluent. The releases may temporarily accumulate, pool, or runoff to natural and/or engineered drainage systems. During this process, water may also be absorbed into the soil (addressed in the next paragraph). Regulatory Guide 1.113 discusses the use of simple models to estimate transport through surface water bodies and considers water usage effects. Spills or leaks of radioactive material to the ground surface should initiate characterization of the runoff. The characterization activities should, at a minimum, satisfy (1) the requirements of 10 CFR 50.75(g), as well as (2) the effluent reporting requirements of NUREG-1301 and NUREG-1302 typically associated with planned effluents (e.g., sampling before discharge to unrestricted areas). Refer to Regulatory Positions 8.5.1, 8.5.2, and 8.5.9 in this guide for recommendations on the general format for reporting abnormal releases to on-site areas and abnormal discharges to unrestricted areas.

3.6 Spills and Leaks to Ground Water

Liquid radioactive leaks and spills are sometimes released to on-site ground water or discharged to offsite ground water. Leaks and spills onto the ground surface can be absorbed into the soil. Once in the soil, some of the material in the leak or spill may, depending on the local soil properties and associated liquid flux of the release, eventually reach the local water table. The dispersion of this material depends on the local subsurface geology and hydrogeologic characteristics. Liquid releases into the subsurface will be transported as a function of ground water flow processes and conditions (e.g., hydraulic gradients, permeability, porosity, and geochemical processes) and will eventually be released to the unrestricted area.

A ground water site conceptual model should be developed to predict the subsurface water flow parameters to include direction and rate and to be used as the basis for estimating the dispersion of abnormal releases of liquid effluents into ground water (see Regulatory Guide 4.1). References that can be used in developing an adequate ground water site conceptual model include the following:

1. ANSI/American Nuclear Society (ANS) 2.17, “Evaluation of Subsurface Radionuclide Transport at Commercial Nuclear Power Production Facilities” (Ref. 31);

2. NUREG/CR-6948, “Integrated Ground-Water Monitoring Strategy for NRC-Licensed Facilities and Sites,” issued November 2007 (Ref. 32); and

3. Electric Power Research Institute (EPRI) Report No. 1011730, “Ground Water Monitoring Guidance for Nuclear Power Plants, issued September 2005 (Ref. 33).

4. NUREG/CR-6805, “A Comprehensive Strategy of Hydrogeology Modeling and Uncertainty Analysis for Nuclear Facilities and Sites,” July, 2003 (Ref 54).

5. EPRI Report No. 1015118, “Ground Water Protection Guidelines for Nuclear Power Plants,” Electric Power Research Institute, Palo Alto, CA, November 2007 (Ref 34).

Simple analytical models or more rigorous numerical codes (i.e., simulations) may be used to evaluate subsurface transport following a release. These models and codes will depend on the release rate,

depth of the release, depth to the local water table, ground water flow directions, ground water flow rates, geochemical conditions, and other geochemical processes (e.g., geochemical retardation). Additionally, water usage such as ground water pumping from wells may create local ground water depression(s) that can alter the natural ground water flow.

Sites should perform a basic site hydrogeological characterization, in advance of leaks or spills, to be prepared to evaluate potential leaks and spills. Sites with significant residual radioactivity that are likely to exceed the radiological criteria for unrestricted use at the time of decommissioning (e.g., as described in 10 CFR 20.1402) should perform more extensive evaluation. Initial assessments should be conducted with relatively simple site conceptual models using scoping surveys and/or bounding assumptions. The complexity of the models should increase as (1) more knowledge is obtained about the system under evaluation (e.g., source of leak, plume size, concentrations, radionuclides, site characteristics, presence of preferential flow pathways, etc) and as (2) the dose estimates rise above significant residual radioactivity levels (see definition in the glossary). Industry documents (Refs. 31, 33, and 34) that contain details of various industry practices can be used as part of a ground-water monitoring program. Sites with low-level spills or leaks generally do not require extensive site characterization and monitoring.

Some basic steps in monitoring ground water contamination are summarized below:

1. Use the site conceptual model (as necessary) to assist in monitoring, evaluating, and reporting radioactive releases and radioactive discharges.

2. Collect empirical data by one or more of the following (as necessary):
    a. sample and analyze ground water from existing monitoring wells, and
    b. conduct additional hydrogeologic testing using existing wells (or new wells) if required.

3. Test the site conceptual model and radionuclide transport predictions using groundwater sample results and data collected during hydrogeologic testing.

4. Modify site conceptual model and radionuclide transport parameters as necessary to predict discharges and assess doses to members of the public.

5. Return to step 1.

The ground water monitoring results should be used in the development and testing of a site conceptual model to predict radionuclide transport in ground water. A more thorough discussion is contained in the references listed in section C.3.6. The site conceptual model is generally considered adequate when it predicts the results of monitoring (sometimes called a calibrated model). Ground water monitoring results are used to evaluate the validity of the site conceptual model. Following a leak or spill of contaminated material, the site conceptual model may be used in conjunction with radionuclide transport modeling and ground water monitoring to comprise a basis for predicting future effluents from the site. Account should be taken of dispersion and dilution that occurs over time and in three dimensions.

The site conceptual model together with a strategic and carefully planned monitoring program can ensure that necessary and reasonable surveys are performed (i.e., limited scoping surveys or more extensive surveys). Limited scoping surveys should be performed to determine if significant residual radioactivity exists and to determine if there is adequate protection of public health and safety. If the limited scoping surveys identify significant residual radioactivity, then the extent of the contamination

should be further evaluated by more extensive surveys (e.g., monitoring wells or other evaluations as appropriate). These survey activities may be direct (i.e., occurring at, or very near, the source of the leak) or indirect (i.e., occurring at some distance from the source of the leak) depending on the accessibility of the source of the spill or leak and the mobility of the radionuclides. For spills or leaks occurring below the soil surface in inaccessible locations, direct scoping and characterization may not be feasible. In these cases, indirect monitoring techniques (e.g., ground water monitoring wells in a down gradient direction) should be used to satisfy existing regulatory requirements. These survey activities should, at a minimum, satisfy (1) the requirements of 10 CFR 50.75(g) and (2) the effluent reporting requirements of 10 CFR 50.36a for ground water discharges to the unrestricted area. In general, leaks and spills of radioactive material should be described (reported) in the ARERR for the calendar year the spill or leak occurred. Additionally, ground water monitoring data should be reported in the ARERR for the calendar year in which the data were collected. Refer to Regulatory Positions 8.5.1, 8.5.2, and 8.5.9 of this document for guidance on the general format for reporting abnormal releases to on-site areas and abnormal discharges to unrestricted areas.

Although licensees may conduct a ground water monitoring effort for different reasons, for purposes of this regulatory guide, the surveys, characterization activities, site conceptual models, and other components of any ground water monitoring effort should be sufficient to do the following:

1. appropriately report, for purposes of accountability, effluents discharged to unrestricted areas,

2. document information in a format consistent with Table A-6 and Regulatory Position 8.5,

3. provide advance indication of potential future discharges to unrestricted areas (to ensure releases are planned and monitored before discharge),

4. demonstrate that significant residual radioactivity has not migrated off site to an unrestricted area in the annual reporting interval, and

5. communicate pertinent information to the NRC.

4. Quality Assurance

4.1 Regulatory Guidance

A range of QC checks and tests should be applied to the analytical process. Regulatory Guide 4.15, Revisions 1 and 2, describe the QA program activities for ensuring that radioactive effluent monitoring systems and operational programs meet their intended purpose. Each licensee's licensing basis determines the applicability of Revision 1 or Revision 2. Licensees with programs in operation before the issuance of Regulatory Guide 4.15, Revision 2, may rely exclusively on Revision 1. Regulatory Guide 4.15, Revision 2, contains guidance on determining appropriate sensitivity levels for analytical instrumentation based on data quality objectives (DQOs). The use of DQOs may provide a better technical basis for determining sensitivity levels (LLDs) than the use of the default values supplied in NUREG-1301 and NUREG-1302. A combination approach (using both Revision 1 and Revision 2 of Regulatory Guide 4.15) can be used to determine appropriate sensitivity levels (LLDs) different (i.e., higher or numerically larger) than those listed in NUREG-1301 and NUREG-1302.

4.2 Quality Control Checks

QC checks of laboratory instrumentation should be conducted daily or before use, and background variations should be monitored at regular intervals to demonstrate that a given instrument is in working condition and functioning properly. QC records should include results of routine tests and checks, background data, calibrations, and all routine maintenance and service.

4.3 Functional Checks

Routine qualitative tests and checks (e.g., channel operational tests, channel checks, or source checks to demonstrate that a given instrument is in working condition and functioning properly) may be performed using radioactive sources that are not traceable by the National Institute of Standards and Technology (NIST). The schedule for source checks, channel checks, channel calibrations, and channel operational tests should be in accordance with NUREG-1301 and NUREG-1302.

4.4 Procedures

Individual written procedures should be used to establish specific methods of calibrating installed radiological monitoring systems and grab sampling equipment. Written procedures should document calibration practices used for ancillary equipment and systems (e.g., meteorological equipment, airflow measuring equipment, in-stack monitoring pitot tubes). Calibration procedures may be compilations of published standard practices or manufacturers' instructions that accompany purchased equipment, or they may be specially written in house to include special methods or items of equipment not covered elsewhere. Calibration procedures should identify the specific equipment or group of instruments to which the procedures apply.

Written procedures should be used for maintaining counting room instrument accuracy, including maintenance, storage, and use of radioactive reference standards; instrumentation calibration methods; and QC activities such as collection, reduction, evaluation, and reporting of QC data.

4.5 Calibration of Laboratory Equipment and Radiation Monitors

Calibrations (e.g., of laboratory equipment and continuous radiation monitoring systems used to quantify radioactive effluents) should be performed using reference standards certified by NIST or standards that have been calibrated against NIST-certified standards. Calibration standards should have the necessary accuracy, stability, and range required for their intended use. Continuous radioactivity monitoring systems should be calibrated against appropriate NIST standards. The relationship between concentrations and monitor readings should be determined over the full range of the readout device. Adequacy of the system should be judged on the basis of reproducibility, time stability, and sensitivity. Periodic inservice correlations that relate monitor readings to the concentrations and/or release rates of radioactive material in the monitored release path should be performed to validate the adequacy of the system. These correlations should be based on the results of analyses for specific radionuclides in grab samples from the release path.

The use of NIST-traceable sources combined with mathematical efficiency calibrations may be applied to instrumentation used for radiochemical analysis (e.g., gamma spectroscopy systems) if employing a method provided by the instrument manufacturer.

4.6 Calibration of Measuring and Test Equipment

Measuring and test equipment should be calibrated using reference standards certified by NIST or standards that have been calibrated against standards certified by NIST. The calibration standards should be representative of the sample types analyzed and have the necessary accuracy, stability, and range required for their intended use.

4.7 Calibration Frequency

Calibrations should generally be performed at regular intervals in accordance with the frequencies established in NUREG-1301 and NUREG-1302. A change in calibration frequency (an increase or decrease) should be based on the reproducibility and time stability characteristics of the system. For example, an instrument system that gives a relatively wide range of readings when calibrated against a given standard should be recalibrated at more frequent intervals than one that gives measurements within a more narrow range. Any monitoring system or individual measuring equipment should be recalibrated or replaced whenever it is suspected of being out of adjustment, excessively worn, or otherwise damaged and not operating properly.

4.8 Measurement Uncertainty

The measurement uncertainty (formerly called measurement error) associated with the measurement of radioactive materials in effluents should be estimated. Counting statistics can provide an estimate of the statistical counting uncertainty involved in radioactivity analyses. Because it may be difficult to assign error terms for each parameter affecting the final measurement, detailed statistical evaluations of error are not required. Normally, the statistical counting uncertainty decreases as the amount (concentration) of radioactivity increases. Thus, for the radioactive effluent release report, the statistical counting uncertainty is typically a small component of the total uncertainty. The sampling uncertainty is likely the largest component and includes uncertainties such as the uncertainty in volumetric and flow rate measurements and laboratory processing uncertainties.

The total or expanded measurement uncertainty associated with the effluent measurement should ideally include the cumulative uncertainties resulting from the total operation of sampling and measurement. Expanded uncertainty should be reported with measurement results. The objective should be to evaluate only the important contributors and obtain a reasonable measure of the uncertainty associated with reported results. Detailed statistical and experimental evaluations are not required. The overall objective should be to obtain an overall estimate of measurement uncertainty. The formula for calculating the total or expanded uncertainty classically includes the square root of the sum of squares of each important contributor to the measurement uncertainty. Licensees may obtain additional information from NUREG-1576 and ANSI/HPS N13.1-1999 if there is a need to improve the estimate of uncertainty.

5. Dose Assessments for Individual Members of the Public

The regulation in 10 CFR 20.1301 establishes dose limits for individual members of the public. The regulations referenced in Regulatory Positions 5.4 through 5.6 contain both dose limits and design objectives that the licensee demonstrates compliance with through calculations. Table 1 summarizes the fundamental parameters associated with the dose calculations. Regulatory Positions 5.7 and 5.8 present important concepts for these calculations. Because of differences between NRC and EPA regulations, only demonstrating compliance with radiological effluent technical specifications (based on Appendix I to

10 CFR Part 50) does not necessarily ensure compliance with EPA's 40 CFR Part 190, "Environmental Radiation Protection Standards for Nuclear Power Operations" (Ref. 35), particularly if there is a direct radiation component (e.g., from BWR shine, ISFSI, or radioactive materials storage).

Table 1. Parameters Associated with Dose Calculations

	10 CFR Part 50, Appendix I	**10 CFR 20.1301(e) (EPA 40 CFR Part 190)**
Dose	Whole Body, Max of Any Organ, Gamma Air, and Beta Air	Whole Body, Thyroid, and Max of Any Organ
Basis	ICRP-2	EPA 40 CFR Part 190
Where	Unrestricted Area	Unrestricted Area
Individual Receptor	Real Person/Exposure Pathway (nearest real residence, real garden, real dairy/meat animal)	Real Person/Exposure Pathway (nearest real residence, real garden, real dairy/meat animal)
Origin	Liquid and Gas Radioactive Waste	Liquid and Gas Radioactive Waste Direct Radiation (e.g., shine, nitrogen-16, ISFSI, radioactive materials storage, outside tanks) Accumulated Radioactive Material (e.g., tritium in lake water) Not Already Included in Dose Estimates
Radioactive Material	Licensed Only	Licensed and Unlicensed
When	Current year	Current and Prior Years' Operation

5.1 Bounding Assessments

Bounding assessments may be useful in those circumstances where compliance can be readily demonstrated using conservative assumptions. For purposes of this document, the term "bounding assessment" means that the reported value is unlikely to be substantially underestimated (see 10 CFR 50 Appendix I, Section III). Bounding assessments for the current year do not imply the absolute bounds for future conditions.

For example, licensees may use conservative bounding dose assessments in lieu of site-specific dose assessments of the maximum dose to individual members of the public. Instead of assessing dose from ground level effluent releases to a real individual member of the public located 2 miles from the site boundary, a conservative bounding dose assessment can be performed for a hypothetical individual located at the site boundary.

If bounding assumptions are made, the radioactive effluent release report should state such and should annotate the assumptions. Hypothetical exposure pathways and locations are sometimes used for bounding dose assessments (or hazard evaluations done in accordance with 10 CFR 20.1501). See the definition of "hypothetical exposure pathway" in the glossary.

5.2 Individual Members of the Public

Individual members of the public reside in the unrestricted area but at times may enter the controlled area of a commercial nuclear power plant. Each licensee is responsible for classifying individuals (by location) as either members of the public or as occupational workers. (See definition of "members of the public" in 10 CFR Part 20.) The annual dose limits for members of the public in the unrestricted area are 25 millirem (mrem) whole body and 75 mrem to the thyroid and 25 mrem to any other organ in accordance with the EPA regulations in 40 CFR Part 190; the limits are 100 mrem in accordance with 10 CFR 20.1301. In effect, annual dose limits to members of the public while in the unrestricted area are the EPA limits of 25 mrem whole body and 75 mrem to the thyroid and 25 mrem to any other organ; whereas the annual dose limit for a member of the public in the licensee's controlled area is the NRC's total effective dose equivalent limit of 100 mrem.

If bounding assessments are not used, licensees should perform evaluations to determine the dose to a real, maximum exposed member of the public, regardless of whether the individual is in an unrestricted area or a controlled area. If no member of the public is allowed in the controlled area, the evaluation need consider only members of the public in the unrestricted area. A member of the public is typically a real individual in a designated location where there is a real exposure pathway (e.g., a real garden, real cow, real goat, or actual drinking water supply) and is typically not a fictitious fencepost resident or an exposure pathway that includes a virtual goat or cow. Licensees are encouraged (but not required) to use real individual members of the public when performing dose assessments for radioactive discharges. Table 1 in Regulatory Guide 1.109 allows a dose evaluation to be performed at a location where an exposure pathway and dose receptor actually existed at the time of licensing.

5.3 Occupancy Factors

For members of the public in the unrestricted area, occupancy factors should be assumed to be 100 percent at locations identified in the land use census, unless site-specific information indicates otherwise. Occupancy factors may be applied inside the controlled area based on estimated hours spent in the controlled area.

5.4 10 CFR Part 50, Appendix I

Appendix I to 10 CFR Part 50 contains numerical guidance for design objectives and limiting conditions of operation for radioactive waste systems to ensure discharges of radioactive liquid and gaseous effluents to unrestricted areas are ALARA. This numerical guidance is listed in terms of annual air doses (gamma and beta), annual total body doses, and annual organ doses (see below). License technical specifications require that exposure to liquid and gaseous effluents conform to the numerical guidance in 10 CFR Part 50, Appendix I. Per 10 CFR 50.34a, "Design Objectives for Equipment to Control Releases of Radioactive Material in Effluents—Nuclear Power Reactors," these numerical guides for design objectives and limiting conditions of operation are not to be construed as radiation protection standards. For these dose calculations, the following terms are generally used:

1. air doses (gamma and beta), total body doses, and organ doses (based on International Commission on Radiation Protection (ICRP)-2, "Report of Committee II on Permissible Dose for Internal Radiation," issued 1959 (Ref. 36));

2. effluent discharges only (excludes direct radiation from the facility and ISFSIs);

3. current annual period (excludes accumulated radioactivity from prior-year effluents); and

4. unrestricted area (excludes individuals in the restricted areas and controlled areas).

When calculating air doses licensees should assure that for any location outside the site boundary doses do not exceed the 10 CFR 50 Appendix I design objectives. Calculation of air dose at the site boundary would assure the most conservative calculation of air doses for ground-level releases. This may not be true for elevated releases. Licensees should select a location that assures the most conservative calculation of air dose.

5.5 10 CFR 20.1301(a) through (c)

This regulation specifies dose limits for members of the public from licensed operation of the facility. These limits apply to doses resulting from licensed and unlicensed radioactive material and from radiation sources other than background radiation (see 10 CFR 20.1001, "Purpose"). Demonstration of compliance with the limits of 40 CFR Part 190 will be considered to also demonstrate compliance with the 0.1 rem total effective dose equivalent limit of 10 CFR 20.1301(a) (Ref. 37).

5.6 10 CFR 20.1301(e)

For those facilities subject to EPA's generally applicable environmental radiation standards promulgated in 40 CFR Part 190, licensees must assess the highest cumulative (whole body and organ) doses from the uranium fuel cycle to a real individual outside the site boundary. The limits include (1) contributions from current-year effluents, (2) current-year direct radiation from the facility, and (3) accumulated radioactivity from prior-year effluents that are not already included in items 1 and 2. These requirements include the following considerations:

1. "Whole body and organ doses" (ICRP-2 concepts).

2. "Any member of the public" means any individual except when that individual is receiving an occupational dose.

3. The "unrestricted area" means in the general environment outside the (boundaries of) locations under the control of persons possessing or using radioactive material. This is the area outside the site boundary, excluding the controlled area and the restricted area. (See the definition of "generally applicable environmental radiation standards" in 10 CFR 20.1003, "Definitions.")

4. "Current-year effluents" includes both normal and abnormal discharges to the unrestricted area.

5. "Current-year direct radiation" includes all direct radiation from the facility (e.g., radioactive waste storage and ISFSIs) but excludes doses from radioactive waste shipments.

6. "Cumulative" dose means the sum of (1) current-year effluent dose, (2) current-year direct radiation dose, and (3) dose from accumulated radioactivity if not already included in the first two categories.

7. "Accumulated radioactivity" includes radioactive material in the unrestricted area from prior-year discharges that remains in the environment (e.g., tritium in lake water or radionuclides).

8. The "uranium fuel cycle" excludes uranium mining, radioactive waste shipping (in the unrestricted area), operations at waste disposal sites, and reuse of non-uranium special nuclear materials (see definition of "uranium fuel cycle" in 40 CFR Part 190, also in Glossary of this document).

5.7 Dose Assessments for 10 CFR Part 50, Appendix I

Dose assessments to show compliance with technical specification requirements for meeting the numerical values of 10 CFR Part 50, Appendix I, design objectives should include quarterly and annual doses using the considerations of Regulatory Position 5.4. They should be reported in a format similar to that shown in Table A-4 in the appendix to this regulatory guide and include the items listed below:

1. doses from liquid effluents
   a. total body dose, quarterly and annual,
   b. organ dose, quarterly and annual (maximum, any organ), and
   c. percent of limits for each of the above.

2. doses from gaseous effluents
   a. beta and gamma air doses, quarterly and annual,
   b. organ dose commitment from iodine, tritium, and particulate releases with half-lives greater than 8 days, quarterly and annual, and
   c. percent of limit for each of the above.

An evaluation of the local exposure pathways to determine the maximum exposed member of the public should be performed. However, maximum doses from various exposure pathways are not additive from different locations. For example, dose from a downstream drinking water exposure pathway should not be added to the dose to an upstream resident whose exposure is from gaseous effluents and direct radiation unless that individual's drinking water is obtained from the down stream location.

"Maximum" doses to real individuals are assessed as described in Regulatory Guide 1.109. The locations and exposure pathways are those where real individuals are present and exposed. Maximum exposed individuals are characterized as "maximum" with regard to food consumption, occupancy, and other usage of the region in the vicinity of the plant site. For example, licensees should make "maximum" assumptions for food consumption and occupancy factors at actual locations when assessing dose to the maximum exposed individual, unless they have determined and applied site-specific (actual) data. In lieu of assessing dose to real individuals, bounding dose assessments may also be used for compliance with 10 CFR Part 50, Appendix I (see the section titled "Bounding Assessments").

The objective of Appendix I is to provide numerical guides for design objectives and limiting conditions for operation to ensure that radioactive effluent control equipment is effective in reducing emissions to ALARA levels. The numerical guidance pertains to quarterly and annual dose criteria at or beyond the unrestricted area from current-year effluent discharges. The Appendix I related calculations do not include dose from radioactivity in prior-year, accumulated, effluent discharges (e.g., last year's radioactivity remaining in lake water is excluded). Note: However, the dose calculations for

demonstrating compliance with the EPA limits do include accumulated radioactivity. (See Section 5.8 below.)

The exposure pathways and routes of exposure identified in Regulatory Guide 1.109 and other exposure pathways and routes of exposure that may arise because of unique conditions at a specific site should be considered if they are likely to contribute significantly to the total dose. Other exposure pathways are considered significant if a conservative evaluation yields an additional dose increment equal to or more than 10 percent of the total from all exposure pathways considered in RG 1.109 (see the regulatory position C in Regulatory Guide 1.109). An evaluation of other exposure pathways (not included in dose assessments) should be performed and maintained for purposes of demonstrating compliance with staff position C in Regulatory Guide 1.109. A thoroughly designed and documented evaluation of a less significant release point could also assist in the evaluation and characterization of abnormal releases and abnormal discharges.

Real exposure pathways are identified for routine discharges and direct radiation based on the results of the land use census. Dose calculations should typically be performed based on real exposure pathways. Conversely, dose assessments (i.e., surveillances and dose calculations) are not needed for exposure pathways that do not exist at a site. For example, if the land use census does not identify the existence of an ingestion exposure pathway involving a milk animal, the licensee is not required to assess that route of exposure for the ingestion exposure pathway. Similarly, if a licensee discharges liquid radioactive waste to a body of water (either surface water or ground water) and that body of water is not used as a source of drinking water (either private or public), a drinking water assessment is not required. For purposes of reporting information in the ARERR, there is a distinction between dose assessments for Appendix I to 10 CFR Part 50 and hazard assessments that may be conducted for on-site spills and leaks as outlined in 10 CFR 20.1501 (where bounding estimates may be necessary). (See "bounding dose estimates" in Section 5.1.)

5.8 Dose Assessments for 10 CFR 20.1301(e)

To show compliance with 10 CFR 20.1301(e), dose assessments should be reported according to the generally applicable environmental radiation standards promulgated by EPA at 40 CFR Part 190, with consideration of Regulatory Position 5.6 and in a format similar to that shown in Table A-5 of the appendix to this guide.

5.8.1 The following should be reported:

1. whole body dose to the maximum individual member of the public
2. thyroid dose to the maximum individual member of the public
3. dose to any other organ to the maximum individual member of the public
4. percent of the applicable limit

5.8.2 One means of demonstrating compliance with 40 CFR Part 190 is listed in the *Federal Register* (42 FR 2859), (Ref. 38), which states the following:

> "In the case of light water reactors, … demonstrating conformance with Appendix I of 10 CFR 50 are generally adequate for demonstrating compliance with [EPA 40 CFR Part 190]."

As a result, a licensee who (1) can demonstrate that external sources of direct radiation are indistinguishable from background and who (2) demonstrates compliance with the numerical dose

guidance of 10 CFR Part 50, Appendix I, may cite the above reference as the basis for demonstrating compliance with 40 CFR Part 190.

However, licensees who (1) have external sources of direct radiation that are above background and (2) demonstrate compliance with the numerical dose guidance of 10 CFR Part 50, Appendix I, must also include sources of direct radiation from uranium fuel cycle operations (e.g., including direct radiation from the licensed facility as well as co-located or nearby nuclear power facilities if appropriate).

5.8.3 The dose contributions from direct radiation may be estimated based on either (1) direct radiation measurements (e.g., thermoluminescent dosimeters, optically stimulated devices, or integrating portable ion chambers), (2) calculations, or (3) a combination of measurements and calculations. When direct radiation dose is determined by measurement, estimates of background levels of radiation may be subtracted based on selected control locations. The doses measured from control and indicator locations should be taken from the same time period. When choosing the appropriate control location(s), licensees should consider the historical variability in doses measured at the control and indicator locations. Several sources contain additional information regarding background subtraction for thermoluminescent dosimeters (Refs. 39, 40, 41, and 42). Methods of determining dose from direct radiation to the maximum exposed individual member of the public may also include extrapolation methods.

Licensees must demonstrate compliance with 10 CFR 20.1301(e) for the generally applicable environmental radiation standards promulgated in 40 CFR Part 190. These include the concept of a total dose (to the whole body and to any organ) from all sources related to the uranium fuel cycle.

Contributions to the total dose from radioactive effluents (liquid and gaseous) and direct radiation should be included, if applicable. Other sources (e.g., accumulated radioactive materials in offsite ponds or lakes from previous years' discharges) should also be included, if applicable, when estimating the total dose. However, if the contributions from direct radiation or accumulated radioactivity are generally minor (as evaluated and documented in a licensee technical evaluation as not contributing to the total dose), these contributions need not be included in the total dose evaluation, but the basis for exclusion should be documented.

5.9 Dose Calculations

Acceptable dose assessment models, such as those provided in Regulatory Guides 1.109, 1.111, 1.112, "Calculation of Releases of Radioactive Materials in Gaseous and Liquid Effluents from Light-Water-Cooled Power Reactors," (Ref. 43) and 1.113, should be used to make dose calculations. When calculating organ doses from airborne effluents, contributions from I-131, I-133, tritium, and radionuclides in particulate form with half-lives greater than 8 days should be included in the assessment.

6. Solid Radioactive Waste Shipped for Processing or Disposal

Solid radioactive waste shipments should be reported in a format similar to that of Table A-3 in Appendix A to this guide. The data should be divided by waste classification and by the waste stream categories listed in Table A-3. The waste streams are (1) resins, filters, and evaporator bottoms, (2) dry active waste, (3) irradiated components, and (4) other waste. The data reported should be for the low-level waste (LLW) volumes shipped from a plant site for waste processing or disposal (not the radioactive waste volumes that are ultimately buried).

Note: Data on LLW disposed in licensed LLW disposal facilities is available using the Manifest Information Management System (MIMS) operated by the Department of Energy. There are no requirements for reporting storage of LLW at nuclear power plants. However, LLW storage records are maintained at nuclear plants and are available for NRC inspection during routine effluent inspections.

Shipments that do not need to be reported include shipments of metal melt, contaminated equipment for transfer between licensees or equipment for refurbishment, contaminated laundry (either launderable or dissolvable), or radioactive samples for analysis. Potentially contaminated dry active waste sent for resurvey and segregation (sometimes referred to as "green is clean") does not need to be reported. Equipment shipped for decontamination and free release does not need to be reported. However, records of these types of shipments should be maintained on site.

The total curie quantity and major radionuclides in the solid waste shipped off site should be determined and reported in a format similar to that of Table A-3.

7. Reporting Errata in Effluent Release Reports

Errors in radioactive effluent release reports should be classified and reported as described below.

7.1 Examples of Small Errors

Small errors may be any of the following:

1. inaccurate reporting of dose that equates to ≤10 percent of the applicable 10 CFR 50 Appendix I design objective or ≤10 percent of the EPA public dose criterion,

2. inaccurate reporting of curies (or release rates, volumes, etc.) that equate to ≤10 percent of the affected curie total (or release rate, volume, etc.), after correction;

3. omissions that do not impede the NRC's ability to adequately assess the information supplied by the licensee, or

4. typographical errors or other errors that do not alter the intent of the report.

7.2 Reporting Small Errors

Small errors should be corrected within one year of discovery, and the correction may be submitted with the next (normally scheduled) submittal of the ARERR as follows. A brief narrative explanation of the errors should be included in Section 8, "Errata/Corrections to Previous ARERRs," of Table A-6, "Supplemental Information." The narrative should include a statement that the affected pages, in their entirety, are included as attachments to the ARERR. Additionally, the affected, corrected pages, in their entirety, should be submitted as an attachment (or addendum) to the ARERR. The corrected pages should reference the affected calendar year and should contain revision bars in the margins of the page to indicate the locations of the changes. If submitting corrections to multiple ARERRs, make a separate attachment (or addendum) for each of the affected years. Other methods of correcting previous ARERRs may be used provided the corrections are clearly and completely described.

7.3 Examples of Large Errors

Large errors may be any of the following:

1. inaccurate reporting of dose that equates to >10 percent of the Appendix I or EPA public dose criterion, after correction;

2. inaccurate reporting of curies (or release rate, volume, etc. that equate to >10 percent of the affected curie total (or release rate, volume, etc.), after correction; "

3. omissions that may impede the NRC's ability to adequately assess the information supplied by the licensee; and

4. typographical errors or other errors that do significantly alter the intent of the report.

7.4 Reporting Large Errors

Large errors should be corrected within 90 days of discovery. The correction may be made by special submittal or may be submitted with the next (normally scheduled) ARERR (if the next ARERR is to be submitted within 90 days of discovery of the error). If corrections are made by special submittal, include a brief narrative explaining the errors. The narrative should include a statement that the affected pages, in their entirety, are included as an attachment. Attach the affected, corrected pages, in their entirety. The corrected pages should reference the affected calendar year and should contain revision bars in the margins of the page to indicate the locations of the changes. If submitting corrections to multiple ARERRs, make a separate attachment (or addendum) for each of the affected years. If corrections are made coincident with the next (normally scheduled) submittal of the ARERR, use the correction process as specified in section 7.2 (for small errors) above. Other methods of correcting previous ARERRs may be used provided the corrections are clearly and completely described.

8. Format and Content of the Annual Radioactive Effluent Release Report

In accordance with 10 CFR 50.4, "Written Communications," the annual report should be submitted electronically or in a written communication. The report should consist of a summary of the numerical data in a tabular format similar to Tables A-1 through A-5 in Appendix A to this guide. Effluent data reported in Tables A-1, A-1A through A-1F, A-2, A-2A, A-2B, and A-4 should be summarized on a quarterly and annual basis. Tables A-3 and A-5 should be summarized on an annual basis. In addition to numerical data, additional supplemental information should be included containing all the information in (but not necessarily in the format of) Table A-6. Additional detail for the information contained in each of these tables is listed below. For purposes of compliance with 10 CFR 50.36a, the ARERR must be submitted by May 1 (unless a licensing basis exists for a different submittal date) for effluents and solid waste from the previous calendar year.

Radionuclides that are not detected for the entire reporting period do not need to be listed in the tables (Tables A-1A through A-1F, A-2A, and A-2B). Activity that is detected should be reported in the appropriate tables (i.e., Tables A-1, A-2, A-1A through A-1F, A-2A, and A-2B) in the ARERR, provided that the amount discharged is numerically significant with respect to the three-digit exponential format recommended for the ARERR. This should not be confused with three significant figures. Licensees may

round numbers according to accepted practices (e.g., refer to ASTM E-29, "Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications" (Ref. 48)); however, after rounding has been completed, values should be reported in the ARERR in a three-digit exponential format. Measurements should be reported for positive values. Some radionuclides that are detected in a year may not be detected in all quarters. If results are determined to be below detectable levels for an entire quarter, the table entry should include a suitable designation (e.g., N/D and an accompanying footnote) to denote that measurements were performed but no activity was detected.

The format specified in Revision 2 of this regulatory guide differs slightly from that specified in Revision 1 of Regulatory Guide 1.21. The format and content as specified in Revision 2 are one acceptable method of reporting the data. Other formats may be used (e.g., some tables may be combined) as long as the specified content is satisfied (e.g., quarterly totals and annual totals by each release category). All plants are encouraged to use the format listed below to maximize consistency in data reporting. This format is designed to be consistent with some commonly used electronic-data-reporting software packages. Consistency aids review by members of the public and allows easier industry-wide comparisons of the data.

8.1 Gaseous Effluents

The quarterly and annual sums of all radionuclides discharged in gaseous effluents (i.e., routine and abnormal discharges, continuous, and batch) should be reported in a format similar to that of Tables A-1A through A-1F in Appendix A to this regulatory guide. The data should then be further summarized and reported in the format of Table A-1. Additional information on each of these tables is provided below.

Table A-1, "Gaseous Effluents - Summation of All Discharges," contains a summation of all gaseous effluent discharges from all release points and all modes of release. The data are subdivided by quarter and year for each radionuclide category: (a) fission and activation gases, (b) iodines/halogens, (c) particulates, (d) tritium, and (e) gross alpha.

Table A-1A, "Gaseous Effluents—Ground-Level Release—Batch Mode," contains a summation of gaseous effluent releases from ground-level release points in the batch mode of release for five radionuclide categories: fission and activation gases, iodines/halogens, particulates, tritium, and gross alpha. Licensees should report the following:

1. curies of each radionuclide discharged by quarter and year, and
2. total curies discharged in each radionuclide category (fission and activation gases, iodines/halogens, particulates, tritium, and gross alpha) by quarter and year.

Some licensees may have surveillance requirements allowing the non-noble gas radionuclides (e.g., iodines and tritium) for some types of batch releases (e.g., containment purge) to be reported with continuous release results. In these instances, the table entries for the affected radionuclides for batch releases should include an appropriate designation (e.g., "*") and an accompanying footnote describing this situation.

Table A-1B, "Gaseous Effluents - Ground-Level Release - Continuous Mode," contains a summation of gaseous effluent releases from ground-level release points in the continuous mode of release for five radionuclide categories: fission and activation gases, iodines/halogens, particulates, tritium, and gross alpha. Licensees should report the following:

1. curies of each radionuclide discharged by quarter and year, and
2. total curies discharged in each radionuclide category by quarter and year.

Table A-1C, "Gaseous Effluents.-.Elevated Release.-.Batch Mode," contains a summation of gaseous effluent releases from elevated release points in the batch mode of release for five radionuclide categories: fission and activation gases, iodines/halogens, particulates, tritium, and gross alpha. Licensees should report the following:

1. curies of each radionuclide released by quarter and year, and
2. total curies released in each radionuclide category by quarter and year.

Some licensees may have surveillance requirements allowing the non-noble gas radionuclides (e.g., iodines and tritium) for some types of batch releases (e.g., containment purge) to be reported with continuous release results. In these instances, the table entries for the affected radionuclides for batch releases should include an appropriate designation (e.g., "*") and an accompanying footnote describing this situation.

Table A-1D, "Gaseous Effluents—Elevated Release—Continuous Mode," contains a summation of gaseous effluent releases from elevated release points in the continuous mode of release for five radionuclide categories: fission and activation gases, iodines/halogens, particulates, tritium, and gross alpha. Licensees should report the following:

1. curies of each radionuclide released by quarter and year, and
2. total curies released in each radionuclide category by quarter and year.

Table A-1E, "Gaseous Effluents—Mixed Mode Release—Batch Mode," contains a summation of gaseous effluent releases from mixed-mode release points in the continuous mode of release for five radionuclide categories: fission and activation gases, iodines/halogens, particulates, tritium, and gross alpha. Licensees should report the following:

1. curies of each radionuclide released by quarter and year, and
2. total curies released in each radionuclide category by quarter and year.

Some licensees may have surveillance requirements allowing the non-noble gas radionuclides (e.g., iodines and tritium) for some types of batch releases (e.g., containment purge) to be reported with continuous release results. In these instances, the table entries for the affected radionuclides for batch releases should include an appropriate designation (e.g., "*") and an accompanying footnote describing this situation.

Table A-1F, "Gaseous Effluents - Mixed Mode Release - Continuous Mode," contains a summation of gaseous effluent releases from mixed-modes release points in the continuous mode of release for five radionuclide categories: fission and activation gases, iodines/halogens, particulates, tritium, and gross alpha. Licensees should report the following:

1. curies of each radionuclide released by quarter and year, and
2. total curies released in each radionuclide category by quarter and year.

8.2 Liquid Effluents

The quarterly and annual sums of all radionuclides released in liquid effluents (i.e., routine and abnormal discharges, continuous, and batch) should be reported in a format similar to that of the Tables A-2A and A-2B. The data should then be further summarized and reported in the format of Appendix A, Table A-2. The following provides additional information on each of these tables.

Table A-2, "Liquid Effluents - Summation of All Releases," contains a summation of all liquid radioactive discharges from all release points and all modes of release. The data are subdivided by quarter and year for each of the radionuclide categories: (a) fission and activation products, (b) tritium, (c) dissolved and entrained noble gases, and (d) gross alpha. The total volume of "primary coolant waste" (typically batch mode releases) before dilution is also included. In this context, "primary coolant waste" means the higher activity waste that generally is not discharged directly, but is instead typically processed through the liquid radioactive waste treatment system before discharge. Various methods exist for calculating the dilution water flow rate. Health Physics Position HPPOS-099, "Attention to Liquid Dilution Volumes in Semiannual Radioactive Effluent Release Reports," issued November 1984, indicates that licensees should use the total volume of dilution flow, not just that flow during periods of liquid effluent releases (Ref. 49). Licensees should include information describing how this value is calculated in either the ODCM or the ARERR. Because the primary coolant waste typically accounts for the vast majority of the radioactive liquid waste discharges, it is recommended the volume and dilution data be summarized separately from the low-activity waste described in the following paragraph.

Report the total measured volume or average flow rate of waste from secondary or balance-of-plant systems (e.g., steam generator blowdown, low activity waste sumps, and auxiliary boilers). In this context, secondary or balance-of-plant waste means the typically very low activity waste that is generally not processed with the liquid radioactive waste treatment system and that collectively represents a very large volume of waste. Various methods exist for calculating the dilution water flow rate. Health Physics Position HPPOS-099 indicates that licensees should use the total volume of dilution flow, not just that volume discharged during periods of liquid effluent releases. Licensees should include information describing how this value is calculated in either the ODCM or the ARERR. Because of the potentially high volume and extremely low activity of this type of waste, it is recommended the volume and dilution data be summarized separately from the higher activity waste described in the previous paragraph.

Licensees should report dilution flow rates during periods of release (before effluent is discharged to the receiving water body) as described above. If calculated differently than described above, the licensee should describe the method of calculation. Licensees may choose to report near-field dilution if dilution by the receiving water body is taken into account. Licensees may report the average, minimum, and/or peak river or stream flow rates if applicable.

Table A-2A, "Liquid Effluents—Batch Mode," contains a summation of liquid effluent discharges in the batch mode of release. The table is divided into four radionuclide categories: fission and activation products, tritium, dissolved and entrained gases, and gross alpha. Licensees should report the following:

1. curies of each radionuclide and gross alpha discharged by quarter and year, and
2. total curies in each radionuclide category by quarter and year.

Table A-2B, "Liquid Effluents—Continuous Mode," contains a summation of liquid effluent discharges in the continuous mode of release. The table is divided into four radionuclide categories: fission and activation products, tritium, dissolved and entrained gases, and gross alpha. Licensees should report the following:

1. curies of each radionuclide and gross alpha discharged by quarter and year, and
2. total curies in each radionuclide category by quarter and year.

8.3 Solid Waste Storage and Shipments

Appendix A, Table A-3, summarizes the solid radioactive waste (low-level waste) shipped from the site during the reporting period. It is the intent that licensees report the volumes shipped and that licensees are not required to report the volumes that are buried.

The volume and curies shipped in each Waste Classification A, B, and C should be reported for each of the following waste streams:

1. resins, filters, and evaporator bottoms,
2. dry active waste,
3. irradiated components,
4. other waste, and
5. sum of all waste.

Excluded from the reporting are those materials that are either being sent for laundry (either for washing or dissolving), metal melt, equipment for decontamination before disposal, and other very low-level waste such as material being surveyed for release in lieu of disposal. However, records of these types of shipments should be maintained on site.

8.4 Dose Assessments

The annual evaluations of dose to members of the public should be calculated using the regulatory guidance in Regulatory Position 5 and should be reported in the format of Tables A-4 and A-5. Dose assessments should be performed to demonstrate compliance with the following:

1. Licensees should demonstrate compliance with 10 CFR Part 50, Appendix I (Table A-4), by doing the following (note that the type of individual or dose receptor should be identified as a real individual or as a hypothetical individual if using bounding dose assessments; the individual/receptor is in the unrestricted area):

    a. Report the calculated dose from liquid effluents on a quarterly and annual basis to the total body and maximum organ and the percentage of the Appendix I design objectives for the maximum exposed individual. If a particular exposure pathway is not applicable (i.e., it does not exist at a site), no dose should be calculated for that exposure pathway.

    b. Report the highest air dose from gaseous effluents on a quarterly and annual basis at any location that could be occupied by individuals in the unrestricted area and the percentage of the Appendix I design objectives.

c. Report the organ dose from iodine, tritium, and particulates with a half-life greater than 8 days to the maximum exposed individual in an unrestricted area from all pathways of exposure (e.g., submersion and ingestion).

2. Licensees should demonstrate compliance with 10 CFR 20.1301(e) and 40 CFR Part 190 (Table A-5) by doing the following:

a. Report the whole body, thyroid, and highest dose to any other organ from licensed and unlicensed radioactive material in the uranium fuel cycle, excluding background, to the individual member of the public likely to receive the highest dose.

8.5 Supplemental Information

Table A-6 in the appendix can be used to provide supplemental information in a descriptive, narrative form. Relevant information and a description of circumstances should be provided as appropriate for each the following categories, adding categories as appropriate. Use the annotation N/A if not applicable.

8.5.1 Abnormal Releases or Abnormal Discharges

1. Specific information should be reported concerning abnormal (airborne and/or liquid) releases on site and abnormal discharges to the unrestricted area. The report should describe each event in a way that would enable the NRC to adequately understand how the material was released and if there was a discharge to the unrestricted area. The report should describe the potential impact on the ingestion exposure pathway involving surface water and ground water, as applicable. The report should also describe the impact (if any) on other affected exposure pathways (e.g., inhalation).

2. The following are the thresholds for reporting abnormal releases and abnormal discharges in the supplemental information section:

a. abnormal releases or abnormal discharges that are voluntarily reported to local authorities under NEI 07-07, "Industry Ground Water Protection Initiative—Final Guidance Document," (Ref.50);

b. abnormal releases or abnormal discharges estimated to exceed 100 gallons (380 liters) of radioactive liquid where the presence of licensed radioactive material is positively identified (in either the on-site environs or in the source of the leak or spill) as greater than the minimum detectable activity (the minimum detectable activity is a post-analysis calculation of sensitivity level based on the actual sample measurement) for the laboratory instrumentation;

c. abnormal releases to on-site areas that result in detectable residual radioactivity after remediation;

d. abnormal releases that result in a high effluent radiation alarm without an anticipated system trip occurring; and

e. abnormal discharges to an unrestricted area.

3. Information on abnormal releases or abnormal discharges should include the following, as applicable:

a. date and duration,
b. location,
c. volume,
d. estimated activity of each radionuclide,
e. effluent monitoring results (if any),
f. on-site monitoring results (if any),
g. depth to the local water table,
h. classification(s) of subsurface aquifer(s) (e.g., drinking water, unfit for drinking water, not used for drinking water),
i. size and extent of any ground water plume,
j. expected movement/mobility of any ground water plume,
k. land use characteristics (e.g., water used for irrigation),
l. remedial actions considered or taken and results obtained,
m. calculated member of the public dose attributable to the release
n. calculated member of the public dose attributable to the discharge,
o. actions taken to prevent recurrence, as applicable, and
p. whether the NRC was notified, the date(s), and the contact organization.

8.5.2 Non-routine Planned Discharges

Discharges resulting from remediation efforts that are not identified in the ODCM should be reported. For example, the remediation effort may include pumping of contaminated ground water in response to leaks and spills.

8.5.3 Radioactive Waste Treatment System Changes

Report any changes or modifications affecting any portion of the gaseous radioactive waste treatment system, the ventilation exhaust treatment system, or the liquid radioactive waste treatment.

8.5.4 Annual Land Use Census Changes

Report any changes or modifications affecting significant aspects of the environmental monitoring program such as receptors, receptor locations, sample media availability, new (or changed) routes of exposure, etc.

8.5.5 Effluent Monitoring System Inoperability

1. If an effluent radiation monitor is not operable for the consecutive time period listed in the licensee's ODCM or technical specifications (typically 30 days), then the ARERR should include the radiation monitor's equipment designation, the common name of the effluent radiation monitor, the time period of the inoperability, the reason why this inoperability was not corrected in a timely manner, and any other information required by the licensee's ODCM or technical specifications.

2. In accordance with NUREG-1301 and NUREG-1302, Sections 3.3.3.10.b and 3.3.3.11.b the information above is required only when the minimum channels operability requirement is not achieved for the consecutive time period listed in the ODCM (typically 30 days).

8.5.6 Offsite Dose Calculation Manual Changes

Report any changes or modifications affecting significant aspects of the ODCM.

8.5.7 Process Control Program Changes

Report any changes or modifications affecting significant aspects of the ODCM.

8.5.8 Corrections to Previous Reports

1. include a brief explanation of the error(s)

2. include a statement that the affected pages, in their entirety, are included as attachments to this ARERR

3. ensure a copy of the affected page(s), in their entirety, are included as attachments to this ARERR. The attached pages should reference the affected calendar year and contain revision bars.

8.5.9 Other (Narrative Descriptions of Other Information Related to Radioactive Effluents)

D. IMPLEMENTATION

The purpose of this section is to provide information to applicants and licensees regarding the NRC's plans for using this regulatory guide. The NRC does not intend or approve any imposition or backfit in connection with its issuance.

Except in those cases in which an applicant or licensee proposes or has previously established an acceptable alternative method for complying with the specified portions of the NRC's regulations, the NRC staff will use the methods described in this guide in evaluating compliance with the applicable regulations.

GLOSSARY

***a priori*—** Before the fact limit representing the capability of a measurement system and not as an after the fact (*a posteriori*) limit for a particular measurement.

abnormal discharge—The unplanned or uncontrolled emission of an effluent (i.e., containing plant-related, licensed radioactive material) into the unrestricted area.

abnormal release—The unplanned or uncontrolled emission of an effluent (i.e., containing plant-related, licensed radioactive material).

accumulated radioactivity—Radioactivity from prior-year effluent releases that may still be present in the media of concern.

ALARA—As Low as Reasonably Achievable

ARERR—Annual Radioactive Effluent Release Report

AREOR—Annual Radiological Environmental Operating Report

background (radiation)—Means radiation from cosmic sources; naturally occurring radioactive material, including radon (except as a decay product of source or special nuclear material); and global fallout as it exists in the environment from the testing of nuclear explosive devices and from past nuclear accidents such as Chernobyl that contribute to background radiation and are not under the control of the licensee. Background radiation does not include radiation from source, byproduct, or special nuclear materials regulated by the Commission.

batch release—The release of liquid (radioactive) wastes of a discrete volume or the release of a tank or purge of radioactive gases into the site environs.

channel check—The qualitative assessment of channel behavior during operation by observation. This determination shall include, where possible, comparison of the channel indication and/or status with other indications and/or status derived from independent instrument channels measuring the same parameter.

channel operational test—A channel operational test shall be the injection of a simulated signal into the channel as close to the sensor as practicable to verify operability of alarm, interlock and/or trip functions. The channel operational test shall include adjustments, as necessary, of the alarm, interlock, and/or trip setpoints such that the setpoints are within the required range and accuracy.

continuous release—An essentially uninterrupted release of gaseous or liquid effluent for extended periods during normal operation of the facility where the volume of radioactive waste is non-discrete and there is input flow during the release.

controlled area (10 CFR 20)—Means an area, outside of a restricted area but inside the site boundary, access to which is limited by the licensee for any reason.

controlled area (10 CFR 72)—Means that area immediately surrounding an Independent Spent Fuel Storage Installation (ISFSI) or a Monitored Retrievable Storage facility (MRS) for which the licensee exercises authority over its use and within which ISFSI or MRS operations are performed.

controlled discharge—A radioactive discharge is considered to be "controlled" if (1) the discharge was conducted in accordance with methods, and without exceeding any of the limits, outlined in the ODCM, or (2) if one or more of the following three items are true:

1. The radioactive discharge had an associated, pre-planned method of radioactivity monitoring that assured the discharge was properly accounted and was within the limits set by 10 CFR 20 and 10 CFR 50.

2. The radioactive discharge had an associated, pre-planned method of termination (and associated termination criteria) that assured the discharge was properly accounted and was within the limits set by 10 CFR 20 and 10 CFR 50.

3. The radioactive discharge had an associated, pre-planned method of adjusting, modulating, or altering the flow rate (or the rate of release of radioactive material) that assured the discharge was properly accounted and was within the limits set by 10 CFR 20 and 10 CFR 50.

controlled release—A radioactive release is considered to be "controlled" if (1) the release was conducted in accordance with methods, and without exceeding any of the limits, outlined in the ODCM, or (2) if one or more of the following three items are true:

1. The radioactive release had an associated, pre-planned method of radioactivity monitoring that assured the release was properly accounted and was within the limits set by 10 CFR 20 and 10 CFR 50.

2. The radioactive release has an associated, pre-planned method of termination (and associated termination criteria) that assured the release was properly accounted and was within the limits set by 10 CFR 20 and 10 CFR 50.

3. The radioactive release had an associated, pre-planned method of adjusting, modulating, or altering the flow rate (or the rate of release of radioactive material) that assured the release was properly accounted and was within the limits set by10 CFR 20 and 10 CFR 50.

conversion factor—A factor (e.g., microcuries per cubic centimeter per counts per minute (μCi/cc/cpm)) used to estimate a radioactivity concentration in an effluent based on a gross radioactivity measurement (e.g., counts per minute).

D/Q—A dispersion parameter for estimating the dose to an individual at a specified (e.g., controlling) location. D/Q may be described as the downwind surface or ground concentration (D) (e.g., in units of microcuries per square meter ($\mu Ci/m^2$)) of radioactive material at a location, divided by the release activity (Q) (e.g., in units of microcuries, μCi). D/Q is thus a normalized downwind surface concentration per unit release and can be used to determine the surface or ground radioactivity concentration during a measured effluent release. The units of D/Q are reciprocal square meters.

determination—A quantitative evaluation of the release or presence of radioactive material under a specific set of conditions. A determination may be made by direct or indirect measurements (e.g., with the use of scaling factors).

dilution water (for liquid radioactive waste)—For purposes of this regulatory guide, any water, other than the undiluted radioactive waste, that is mixed with undiluted liquid radioactive waste before its ultimate discharge to the unrestricted area.

discharge point—A location at which radioactive material enters the unrestricted area. This would be the point beyond the vertical plane of the unrestricted area (surface or subsurface).

DQO—Data Quality Objectives

drinking water—Water that does not contain an objectionable pollutant, contamination, minerals, or infective agent and is considered satisfactory for domestic consumption. This is sometimes called potable water. Potable water is water that is safe and satisfactory for drinking and cooking. Although EPA regulations only apply to public drinking water sources supplying 25 or more people (refer to EPA for more information), for purposes of the effluent and environmental monitoring programs, the term drinking water includes water from single-use residential drinking water wells.

effluent—Liquid or gaseous waste containing plant-related, licensed radioactive material, emitted at the boundary of the facility (e.g., buildings, end-of-pipe, stack, or container) as described in the final safety analysis report (FSAR).

effluent discharge—The portion of an effluent release that reaches an unrestricted area.

effluent release—The emission of an effluent. (Same as radioactive release.)

elevated release—A gaseous effluent release made from a height that is more than twice the height of adjacent solid structures, or releases made from heights sufficiently above adjacent solid structures that building wake effects are minimal or absent.

exposure pathway—A mechanism by which radioactive material is transferred from the (local) environment to humans. There are three commonly recognized exposure pathways; inhalation, ingestion, and direct radiation. For example, ingestion is an exposure pathway, and it may include dose contributions from one or more routes of exposure. For example, one route of exposure that may contribute to the ingestion exposure pathway is often referred to as grass-cow-milk-infant-thyroid route of exposure.

ground-level release—A gaseous effluent release made from a height that is at—or less than—the height of adjacent solid structures, or where the degree of plume rise is unknown or is otherwise insufficient to avoid building wake effects.

ground water—All water in the surface soil, the subsurface soil, or any other subsurface water. Ground water is simply water in the ground regardless of its quality, including saline, brackish, or fresh water. Ground water can be moisture in the ground that is above the regional water table in the unsaturated (or vadose) zone, or ground water can be at and below the water table in the saturated zone.

hypothetical exposure pathway—An exposure pathway in which one or more of the components involved in the transfer of a radionuclide from the environment to the human does not actually exist at the specified location, or if a real human does not consume, inhale, or otherwise become exposed to the radioactive material. For example, the grass-cow-milk-infant-thyroid route of exposure (associated with the ingestion exposure pathway) would be considered a hypothetical exposure pathway if the grass, the cow, or the milk did not actually exist at a specified location or if an infant did not actually consume the milk.

impacted areas—Means the areas with some reasonable potential for residual radioactivity in excess of natural background or fallout levels. [Note: See 10 CFR 50.2, "Definitions", and NUREG-1757 for a discussion of impacted areas. For example, impacted areas include locations where radiological leaks or spills have occurred within the onsite environs (i.e., outside of the facility's systems, structures, and components). (See also the definition of "significant contamination.")]

ISFSI—Independent Spent Fuel Storage Installation

leachate—Water containing contaminants that is percolating downward from a pond or lake into the subsurface.

less-significant release point—Any location, from which radioactive material is released as a liquid or gaseous effluent, contributing less than or equal to 1 percent of the activity discharged from all the release points for a particular type of effluent considered. Regulatory Guide 1.109 lists the three types of effluent as (1) liquid effluents, (2) noble gases discharged to the atmosphere in gaseous radioactive waste, and (3) all other nuclides discharged to the atmosphere in gaseous radioactive waste.

Example: If 1000 Ci of tritium are released in all liquid effluents in a given period of time (e.g., a typical calendar year or fuel cycle) and 0.01 Ci of tritium are released in steam generator blow down, then the steam generator blow down would be a less-significant release point. Similarly, for gaseous releases of radionuclides other than noble gases (i.e., iodine, particulates, and tritium) if the total effluents are 10 Ci (iodine, particulates, and tritium) and the Refueling Water Storage Tank released 0.009 Ci of iodine, particulates, and tritium, then the Refueling Water Storage Tank would be a less-significant release point. In both of these examples the sample frequency can be adjusted to a frequency that is appropriate for that less significant release point. Samples collected from these systems for other programs (e.g., detection of primary to secondary leakage) must still be collected and analyzed at the frequencies specified by the other programs.

licensed material—Means source material, special nuclear material, or byproduct material received, possessed, used, transferred, or disposed of under a general or specific license issued by the Commission.

lower limit of detection (LLD)—The *a priori* smallest concentration of radioactive material in a sample that will yield a net count, above system background, that will be detected with 95% probability

with only a 5% probability of falsely concluding that a blank observation represents a real signal (see NUREG-1301, NUREG-1302, and NUREG/CR-4007, "Lower Limit of Detection: Definition and Elaboration of a Proposed Position for Radiological Effluent and Environmental Measurements," issued September 1984 (Ref.51).

maximum individual—Individuals characterized as maximum with regard to food consumption, occupancy, and other usage of the region in the vicinity of the plant site. As such, they represent individuals with habits that are considered to be maximum reasonable deviations from the average for the population in general. Additionally, in physiological or metabolic respects, the maximum exposed individuals are assumed to have those characteristics that represent the averages for their corresponding age group in the general population. (This term typically refers to members of the public). See Regulatory Guide 1.109 for additional information.)

member of the public (10 CFR 20)—Means any individual except when that individual is receiving an occupational dose.

member of the public (40 CFR 190)—Means any individual that can receive a radiation dose in the general environment, whether he may or may not also be exposed to radiation in an occupation associated with a nuclear fuel cycle. However, an individual is not considered a member of the public during any period in which the individual is engaged in carrying out any operation which is part of a nuclear fuel cycle.

minimum detectable concentration—The smallest activity concentration measurement that is practically achievable with a given instrument and type of measurement procedure. It depends on factors involved in the survey measurement process (surface type, geometry, backscatter, and self-absorption) and is typically calculated following an actual sample analysis (a posteriori). (See NUREG-1507, "Minimum Detectable Concentrations with Typical Radiation Survey Instruments for Various Contaminants and Field Conditions," issued June 1998 (Ref. 52)).

mixed mode release—A gaseous effluent release made from a height higher than a ground-level release but less than an elevated release where, because of a lack of plume rise (e.g., buoyancy, momentum, and wind speed), a proper estimate of radionuclide transport and dispersion requires mathematically splitting the plume into (1) an elevated component and (2) a ground-level component to properly account for building wake effects. (See Regulatory Guide 1.111 for further guidance.)

monitoring—Radiation monitoring, radiation protection monitoring means the measurement of radiation levels, concentrations, surface area concentrations or quantities of radioactive material and the use of results of these measurements to evaluate potential exposures and doses.

nonroutine, planned discharge—An effluent release from a release point that is not defined in the ODCM but that has been planned, monitored, and discharged in accordance with 10 CFR 20.2001 (e.g., the discharge of water recovered during a spill or leak from a temporary storage tank).

nuclear fuel cycle—The operations defined to be associated with the production of electrical power for public use by any fuel cycle through the use of nuclear energy (see 40 CFR 190.02).

ODCM—The Offsite Dose Calculation Manual.

on-site environs—Location within the site boundary but outside of the systems, structures, or components described in the final safety analysis report or the ODCM.

operability (operable)—The ability of a system, subsystem, train, component, or device to perform its specified safety function(s) and the ability of all necessary attendant instrumentation, controls, normal or emergency electrical power, cooling and seal water, lubrication, and other auxiliary equipment (required for the system, subsystem, train, component, or device to perform its specified safety function(s)) to perform their related support function(s).

principal radionuclide—A principal radionuclide is one of the principal gamma emitters listed in NUREG-1301 and NUREG-1302, Tables 4.11-1 and Table 4.11-2, or alternatively, from a risk-informed perspective, a radionuclide is considered a principal radionuclide if it contributes either (1) greater than 1 percent of the 10 CFR Part 50, Appendix I, design objective dose when all radionuclides in the type of effluent are considered, or (2) greater than 1 percent of the activity of all nuclides in the type of effluent being considered. Regulatory Guide 1.109 lists the three types of effluents as (1) liquid effluents, (2) noble gases discharged to the atmosphere, and (3) all other nuclides discharged to the atmosphere. In this document, the terms "principal radionuclide" and "principal nuclide" are synonymous since this document is only concerned with measuring, evaluating, and reporting radioactive materials in effluents.

QA—Quality Assurance

QC—Quality Control

radioactive discharge—The emission of an effluent (i.e., containing plant-related, licensed radioactive material) into the unrestricted area. (Same as effluent discharge.)

radioactive release—The emission of an effluent (i.e., containing plant-related, licensed radioactive material). (Same as effluent release.)

real exposure pathway—An exposure pathway in which plant-related radionuclides in the environment at (or from) a specified location cause exposure to an actual individual. For example, the grass-cow-milk-infant-thyroid exposure pathway would be considered a real exposure pathway if the grass, the cow, and the milk actually existed at a specified location and an infant actually consumed the milk. For purposes of compliance with 10CFR50 Appendix I, the individual must be a member of the public.

release source—A system, structure, or component (containing radioactive material under the licensee's control) where radioactive materials are contained prior to release.

release point—A location from which radioactive materials are released from a system, structure, or component (including evaporative releases and leaching from ponds and lakes in the controlled or restricted area before release under 10 CFR 20.2001). For release points monitored by plant process radiation monitoring systems, the release point is associated with the piping immediately downstream of the radiation monitor. (See also the definition for "significant release point.") Several release sources may contribute to a common release point.

residual radioactivity—Residual radioactivity means radioactivity in structures, materials, soils, ground water, and other media at a site resulting from activities under the licensee's control. This includes radioactivity from all licensed and unlicensed sources used by the licensee, but it excludes background radiation. It also includes radioactive materials remaining at the site as a result of routine or accidental releases of radioactive material at the site and previous burials at the site, even if those burials were made in accordance with the provisions of 10 CFR Part 20.

restricted area—Restricted area means an area, access to which is limited by the licensee for the purpose of protecting individuals against undue risks from exposure to radiation and radioactive materials. Restricted area does not include areas used as residential quarters, but separate rooms in a residential building may be set apart as a restricted area.

route of exposure—A specific path (or delivery mechanism) by which radioactive material, originally in the environment at a specified location, can eventually cause a radiation dose to an individual. The path typically includes a type of environmental medium (e.g., air, grass, meat, or water) as the starting point and a recipient's organ or body as the end point. For example, the grass-cow-milk-infant-thyroid route of exposure may contribute to the ingestion exposure pathway. Additionally, several routes of exposure may contribute to a single exposure pathway.

scaling factor—A factor used to estimate the unknown activity of a radionuclide based on its ratio to the activity of a readily measured radionuclide or other parameter (e.g., C-14 scaled to power generation).

significant contamination—As used for 10 CFR 50.75(g) recordkeeping, a quantity and/or concentration of residual radioactivity that would require remediation during decommissioning in order to terminate the license by meeting the unrestricted use criteria stated in 10 CFR 20.1402 (see NUREG-1757).

significant release point—Any location, from which radioactive material is released, that contributes greater than 1 percent of the activity discharged from all the release points for a particular type of effluent considered. Regulatory Guide 1.109 lists the three types of effluent as (1) liquid effluents, (2) noble gases discharged to the atmosphere in gaseous radioactive waste, and (3) all other radionuclides discharged to the atmosphere in gaseous radioactive waste.

significant residual radioactivity—Synonymous with the term "significant contamination."

site boundary—Site boundary means that line beyond which the land or property is not owned, leased, or otherwise controlled by the licensee.

site environs—Locations outside of the nuclear power plant systems, structures, or components as described in the final safety analysis report or the ODCM.

source check—A source check is a qualitative assessment of the channel response when the channel sensor is exposed to a source of increased radioactivity.

survey—Survey means an evaluation of the radiological conditions and potential hazards incident to the production, use, transfer, release, disposal, or presence of radioactive material or other sources of radiation. When appropriate, such an evaluation includes a physical survey of the location of

radioactive material and measurements or calculations of levels of radiation, or concentrations or quantities of radioactive material present.

TEDE—Total Effective Dose Equivalent

type of effluent—A grouping of radioactive releases into one of the three categories listed in 10 CFR 50 Appendix I, paragraphs A through C. The three categories are classified in RG 1.109 as (1) liquid effluents, (2) noble gases discharged to the atmosphere in gaseous radioactive waste, and (3) all other nuclides discharged to the atmosphere in gaseous radioactive waste.

unlicensed material—Radioactive material including (1) previously licensed material discharged in effluents, (2) background radioactivity, or (3) global fallout. Licensed radioactive material becomes unlicensed radioactive material upon discharge in effluents in accordance with 10 CFR 20.2001.

uncontrolled discharge—An effluent discharge that does not meet the definition of a controlled discharge. See the definition of controlled discharge.

uncontrolled release—An effluent release that does not meet the definition of a controlled release. See the definition of controlled release.

unplanned discharge—The unintended or unexpected discharge of liquid or airborne radioactive material to the unrestricted area. Examples of an unplanned discharge would include:

1. the unintentional discharge of a wrong waste gas decay tank (or bulk liquid radioactive waste tank), or

2. the failure of a radiation monitor to divert liquid to the radioactive waste system in the case where radioactivity is present and the automatic alarm/trip function fails to divert material to liquid radioactive waste and that material (or a portion of that material) is instead discharged to the environment.

unplanned release—The unintended or unexpected release of liquid or airborne radioactive material to the on-site environment. An example of an unplanned release would include a plant occurrence that results in a leak or spill of radioactive material to on-site areas requiring a report under 10 CFR 50.72 or 10 CFR 50.73. (See NUREG/CR-5569, "Health Physics Positions Data Base," February, 1994, HPPOS-254, "Definition of Unplanned Release," (Ref. 53).)

For example, if a licensee has prepared documents describing an intended release (e.g., a preliminary radioactive waste release permit) in advance of the evolution, and the intended release occurs as planned, then the release is a planned release. If such documents (e.g., a preliminary release permit) are not prepared (or considered/evaluated) before the release, it is potentially an unplanned release (and additional information may be required to determine if it is an unplanned release).

unrestricted area—Unrestricted area means an area, access to which is neither limited nor controlled by the licensee.

uranium fuel cycle—The operations of milling of uranium ore, chemical conversion of uranium, isotopic enrichment of uranium, fabrication of uranium fuel, generation of electricity by a light-water-cooled nuclear power plant using uranium fuel, and reprocessing of spent uranium fuel, to the extent that these directly support the production of electrical power for public use utilizing nuclear energy, but excludes mining operations, operations at waste disposal sites, transportation of any radioactive material in support of these operations, and the reuse of recovered non-uranium special nuclear and byproduct materials from the cycle.

χ/Q—Referred to as "Xi over Q," χ/Q is the average atmospheric effluent concentration, χ, normalized by release rate, Q, at a distance (or location) in a given downwind direction. Expressed in another way, χ/Q is the concentration (χ) of airborne radioactive material (e.g., in units of $\mu Ci/m^3$) divided by the release rate (Q) (e.g., in units of μCi/s) at a specified distance and direction downwind of the release point.

REFERENCES[1]

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2. 10 CFR Part 20, "Standards for Protection against Radiation," U.S. Nuclear Regulatory Commission, Washington, DC.

3. 10 CFR Part 50, "Domestic Licensing of Production and Utilization Facilities," U.S. Nuclear Regulatory Commission, Washington, DC.

4. 10 CFR Part 72, "Licensing Requirements for the Independent Storage of Spent Nuclear Fuel, High Level Radioactive Waste, and Reactor-Related Greater Than Class C Waste," U.S. Nuclear Regulatory Commission, Washington, DC.

5. Regulatory Guide 1.109, "Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Demonstrating Compliance with 10 CFR Part 50, Appendix I," U.S. Nuclear Regulatory Commission, Washington, DC.

6. SECY-03-0069, "Results of the License Termination Rule Analysis," U.S. Nuclear Regulatory Commission, Washington, DC, May 2, 2003.

7. Regulatory Guide 4.1, "Programs for Monitoring Radioactivity in the Environs of Nuclear Power Plants," U.S. Nuclear Regulatory Commission, Washington, DC.

8. Regulatory Guide 4.15, "Quality Assurance for Radiological Monitoring Programs (Inception through Normal Operations to License Termination)—Effluent Streams and the Environment," U.S. Nuclear Regulatory Commission, Washington, DC.

9. NUREG-1301, "Offsite Dose Calculation Manual Guidance: Standard Radiological Effluent Controls for Pressurized Water Reactors," April 1991. (ADAMS Accession No. ML091050061)

10. NUREG-1302, "Offsite Dose Calculation Manual Guidance: Standard Radiological Effluent Controls for Boiling Water Reactors," April 1991. (ADAMS Accession No. ML091050059)

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APPENDIX A - TABLES

Table A-1. Gaseous Effluents—Summation of All Releases

Summation of All Releases	Units	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total	Uncertainty
Fission and Activation Gases	Ci						
Average Release Rate	µCi/s						
% of Limit	%						
Iodines (Halogens)	Ci						
Average Release Rate	µCi/s						
% of Limit	%						
Particulates	Ci						
Average Release Rate	µCi/s						
% of Limit	%						
Tritium	Ci						
Average Release Rate	µCi/s						
% of Limit	%						
Gross Alpha	Ci						

Table A-1A. Gaseous Effluents—Ground-Level Release—Batch Mode

Fission and Activation Gases	Units	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total
Ar-41	Ci					
Kr-85	Ci					
Kr-85m	Ci					
Kr-87	Ci					
Kr-88	Ci					
Xe-131m	Ci					
Xe-133	Ci					
Xe-133m	Ci					
Xe-135	Ci					
Xe-135m	Ci					
Xe-138	Ci					
(List Others)	Ci					
Total	Ci					

Iodines/Halogens	Units	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total
I-131	Ci					
I-132	Ci					
I-133	Ci					
I-134	Ci					
I-135	Ci					
Total	Ci					

Particulates	Units	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total
Co-58	Ci					
Co-60	Ci					
Sr-89	Ci					
Sr-90	Ci					
Cs-134	Ci					
(List Others)	Ci					
Total	Ci					

Tritium	Ci					

Gross Alpha	Ci					

Table A-1B. Gaseous Effluents—Ground-Level Release—Continuous Mode

Fission and Activation Gases	Units	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total
Ar-41	Ci					
Kr-85	Ci					
Kr-85m	Ci					
Kr-87	Ci					
Kr-88	Ci					
Xe-131m	Ci					
Xe-133	Ci					
Xe-133m	Ci					
Xe-135	Ci					
Xe-135m	Ci					
Xe-138	Ci					
(List Others)						
Total	Ci					

Iodines/Halogens	Units	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total
I-131	Ci					
I-132	Ci					
I-133	Ci					
I-134	Ci					
I-135	Ci					
Total	Ci					

Particulates	Units	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total
Co-58	Ci					
Co-60	Ci					
Sr-89	Ci					
Sr-90	Ci					
Cs-134	Ci					
(List Others)	Ci					
Total	Ci					

Tritium	Ci					

Gross Alpha	Ci					

Table A-1C. Gaseous Effluents—Elevated Release—Batch Mode

Fission and Activation Gases	Units	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total
Ar-41	Ci					
Kr-85	Ci					
Kr-85m	Ci					
Kr-87	Ci					
Kr-88	Ci					
Xe-131m	Ci					
Xe-133	Ci					
Xe-133m	Ci					
Xe-135	Ci					
Xe-135m	Ci					
Xe-138	Ci					
(List Others)	Ci					
Total	Ci					

Iodines/Halogens	Units	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total
I-131	Ci					
I-132	Ci					
I-133	Ci					
I-134	Ci					
I-135	Ci					
Total	Ci					

Particulates	Units	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total
Co-58	Ci					
Co-60	Ci					
Sr-89	Ci					
Sr-90	Ci					
Cs-134	Ci					
(List Others)	Ci					
Total	Ci					

Tritium	Ci					

Gross Alpha	Ci					

Table A-1D. Gaseous Effluents—Elevated Release—Continuous Mode

Fission and Activation Gases	Units	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total
Ar-41	Ci					
Kr-85	Ci					
Kr-85m	Ci					
Kr-87	Ci					
Kr-88	Ci					
Xe-131m	Ci					
Xe-133	Ci					
Xe-133m	Ci					
Xe-135	Ci					
Xe-135m	Ci					
Xe-138	Ci					
(List Others)	Ci					
Total	Ci					

Iodines/Halogens	Units	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total
I-131	Ci					
I-132	Ci					
I-133	Ci					
I-134	Ci					
I-135	Ci					
Total	Ci					

Particulates	Units	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total
Co-58	Ci					
Co-60	Ci					
Sr-89	Ci					
Sr-90	Ci					
Cs-134	Ci					
(List Others)	Ci					
Total	Ci					

Tritium	Ci					

Gross Alpha	Ci					

Table A-1E. Gaseous Effluents—Mixed Mode Release—Batch Mode

Fission and Activation Gases	Units	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total
Ar-41	Ci					
Kr-85	Ci					
Kr-85m	Ci					
Kr-87	Ci					
Kr-88	Ci					
Xe-131m	Ci					
Xe-133	Ci					
Xe-133m	Ci					
Xe-135	Ci					
Xe-135m	Ci					
Xe-138	Ci					
(List Others)	Ci					
Total	Ci					

Iodines/Halogens	Units	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total
I-131	Ci					
I-132	Ci					
I-133	Ci					
I-134	Ci					
I-135	Ci					
Total	Ci					

Particulates	Units	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total
Co-58	Ci					
Co-60	Ci					
Sr-89	Ci					
Sr-90	Ci					
Cs-134	Ci					
(List Others)	Ci					
Total	Ci					

Tritium	Ci					

Gross Alpha	Ci					

Table A-1F. Gaseous Effluents—Mixed Mode Release—Continuous Mode

Fission and Activation Gases	Units	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total
Ar-41	Ci					
Kr-85	Ci					
Kr-85m	Ci					
Kr-87	Ci					
Kr-88	Ci					
Xe-131m	Ci					
Xe-133	Ci					
Xe-133m	Ci					
Xe-135	Ci					
Xe-135m	Ci					
Xe-138	Ci					
(List Others)	Ci					
Total	Ci					

Iodines/Halogens	Units	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total
I-131	Ci					
I-132	Ci					
I-133	Ci					
I-134	Ci					
I-135	Ci					
Total	Ci					

Particulates	Units	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total
Co-58	Ci					
Co-60	Ci					
Sr-89	Ci					
Sr-90	Ci					
Cs-134	Ci					
(List Others)	Ci					
Total	Ci					

Tritium	Ci					

Gross Alpha	Ci					

Table A-2. Liquid Effluents—Summation of All Releases

Summation of All Liquid Releases	Units	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total	Uncertainty (%)
Fission and Activation Products (excluding tritium, gases, and gross alpha)	Ci						
Average Concentration	µCi/ml						
% of Limit	%						
Tritium	Ci						
Average Concentration	µCi/ml						
% of Limit	%						
Dissolved and Entrained Gases	Ci						
Average Concentration	µCi/ml						
% of Limit	%						
Gross Alpha	Ci						
Average Concentration	µCi/ml						
Volume of Primary System Liquid Effluent (Before Dilution)	Liters						
Dilution Water Used for Above	Liters						
Volume of Secondary or Balance-of-Plant Liquid Effluent (e.g., low-activity or unprocessed) (Before Dilution)	Liters						
Dilution Water Used for Above	Liters						
Average Stream Flow	m^3/s						

Table A-2A. Liquid Effluents—Batch Mode

Fission and Activation Products	Units	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total
Cr-51	Ci					
Mn-54	Ci					
Fe-55	Ci					
Fe-59	Ci					
Co-57	Ci					
Co-58	Ci					
Co-60	Ci					
Sr-89	Ci					
Sr-90	Ci					
Nb-95	Ci					
Ag-110m	Ci					
Sn-113	Ci					
Sb-124	Ci					
Sb-125	Ci					
I-131	Ci					
I-133	Ci					
I-135	Ci					
Cs-134	Ci					
Cs-137	Ci					
(List Others)	Ci					
Totals	Ci					

Table A-2A. Liquid Effluents—Batch Mode (continued)

Dissolved and Entrained Gases	Units	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total
Kr-85	Ci					
Kr-85m	Ci					
Kr-88	Ci					
Xe-131m	Ci					
Xe-133	Ci					
Xe-133m	Ci					
Xe-135	Ci					
Xe-135m	Ci					
(List Others)	Ci					
Totals	Ci					

Tritium	Ci					

Gross Alpha	Ci					

Table A-2B. Liquid Effluents—Continuous Mode

Fission and Activation Products	Units	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total
Cr-51	Ci					
Mn-54	Ci					
Fe-55	Ci					
Fe-59	Ci					
Co-57	Ci					
Co-58	Ci					
Co-60	Ci					
Sr-89	Ci					
Sr-90	Ci					
Nb-95	Ci					
Ag-110m	Ci					
Sn-113	Ci					
Sb-124	Ci					
Sb-125	Ci					
I-131	Ci					
I-133	Ci					
I-135	Ci					
Cs-134	Ci					
Cs-137	Ci					
(List Others)	Ci					
Totals	Ci					

Table A-2B. Liquid Effluents—Continuous Mode (continued)

Dissolved and Entrained Gases	Units	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total
Kr-85	Ci					
Kr-85m	Ci					
Kr-88	Ci					
Xe-131m	Ci					
Xe-133	Ci					
Xe-133m	Ci					
Xe-135	Ci					
Xe-135m	Ci					
(List Others)	Ci					
Totals	Ci					

Tritium	Ci					

Gross Alpha	Ci					

Table A-3. Low-Level Waste

Resins, Filters, and Evaporator Bottoms	**Volume**		**Curies Shipped**
Waste Class	**ft^3**	**m^3**	**Curies**
A			
B			
C			
ALL			

Major Nuclides for the Above Table:

Dry Active Waste	**Volume**		**Curies Shipped**
Waste Class	**ft^3**	**m^3**	
A			
B			
C			
ALL			

Major Nuclides for the Above Table:

Table A-3. Low-Level Waste (continued)

Irradiated Components	**Volume**		**Curies Shipped**
Waste Class	**ft^3**	**m^3**	
A			
B			
C			
ALL			

Major Nuclides for the Above Table:

Other Waste	**Volume**		**Curies Shipped**
WASTE CLASS	**ft^3**	**m^3**	
A			
B			
C			
ALL			

Major Nuclides for the Above Table:

Table A-3. Low-Level Waste (continued)

Sum of All Low-Level Waste Shipped from Site	**Volume**		**Curies Shipped**
Waste Class	**ft^3**	**m^3**	
A			
B			
C			
ALL			

Major Nuclides for the Above Table:

Table A-4. Dose Assessments, 10 CFR Part 50, Appendix I

	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Yearly
Liquid Effluent Dose Limit, Total Body	1.5 mrem	1.5 mrem	1.5 mrem	1.5 mrem	3 mrem
Total Body Dose					
% of Limit					
Liquid Effluent Dose Limit, Any Organ	5 mrem	5 mrem	5 mrem	5 mrem	10 mrem
Organ Dose					
% of Limit					
Gaseous Effluent Dose Limit, Gamma Air	5 mrad	5 mrad	5 mrad	5 mrad	10 mrad
Gamma Air Dose					
% of Limit					
Gaseous Effluent Dose Limit, Beta Air	10 mrad	10 mrad	10 mrad	10 mrad	20 mrad
Beta Air Dose					
% of Limit					
Gaseous Effluent Dose Limit, Any Organ (Iodine, Tritium, Particulates with >8-day half-life)	7.5 mrem	7.5 mrem	7.5 mrem	7.5 mrem	15 mrem
Gaseous Effluent Organ Dose (Iodine, Tritium, Particulates with > 8-Day half-life)					
% of Limit					

Table A-5. EPA 40 CFR Part 190 Individual in the Unrestricted Area

	Whole Body	Thyroid	Any other organ
Dose Limit	25 mrem	75 mrem	25 mrem
Dose			
% of Limit			

Table A-6. Supplemental Information

1. Abnormal Releases and Abnormal Discharges (e.g., leaks and spills)

2. Non routine, Planned Discharges (e.g., pumping of leaks and spills for remediation, results of ground water monitoring to quantify effluent releases to the offsite environment)

3. Radioactive Waste Treatment System Changes

4. Annual Land-Use Census Changes

5. Effluent Monitor Instrument Inoperability

6. Offsite Dose Calculation Manual Changes

7. Process Control Program Changes

8. Errata/Corrections to Previous ARERRs

9. Other (narrative description of other information that is provided to the U.S. Nuclear Regulatory Commission, e.g., the ARERR for ISFSIs)