# Executive Summary

Radiological effluent monitoring and environmental surveillance have been performed for ~70 y to report on the impact of nuclear facilities and activities on humans and the environment. This Report is intended to support effective design and operation of these programs by describing the current state-of-the-art in radiological effluent monitoring and environmental surveillance with summaries and citations to guidance documents as well as publications with technical and methodological developments. This information can be applied by facility or activity managers, members of the public, and regulators to evaluate existing programs and to suggest improvements.

In this Report, *radiological effluent monitoring* refers to radionuclide and radiation measurements performed at points of radionuclide origin or release, while *environmental surveillance* refers to such measurements performed throughout the environment. A major theme in this Report is that the two activities are complementary and should be designed and operated as a single program at large facilities. At facilities that release only small amounts of radionuclides (either because the effluent is well controlled or because it is a small facility) detailed knowledge of radionuclide movement in the process and modeling of the released radionuclides may allow design of an innovative program that minimizes the surveillance component.

The major purposes of a radiological effluent monitoring and environmental surveillance program are to:

- collect information to guide the facility or activity operator in controlling potential contaminants;
- comply with required regulations or criteria;
- inform stakeholders, notably members of the public, the facility operator, and the regulator, concerning measured radionuclide releases, environmental radionuclide concentrations, environmental radiation levels, and radiation doses to individuals and biota in the environment;
- support environmental surveillance analysis (*e.g.*, contaminant plume and dispersion assessments); and
- establish a trustworthy historical record of such information.

These purposes are achieved in the design stage by:

- identifying the critical radionuclides, pathways, and exposed individuals;
- estimating the amount of radionuclides entering the environment; and
- relating released radionuclide concentrations to environmental concentrations and radiation exposure.

Subsequently, during operation, radiological effluent monitoring and environmental surveillance programs must reliably provide the measurements used to calculate actual, maximum and typical radiation exposure to humans and biota and to report this information for the uses cited above. After operation has ended, an appropriate program must ensure that releases produced during decontamination and decommissioning are acceptable and that the residual site meets criteria for either free or controlled access to members of the public.

The overall objective of the Report is to guide the user in planning effective radiological effluent monitoring and environmental surveillance programs. Each section contains the specific guidance and recommendations summarized here.

- Section 2 provides the background of objectives, program requirements, typical facilities and activities, and typical program applications that the planner must understand in developing a program for the facility and circumstance under consideration. The extensive experience with such programs is a major contributor to planning this program.
- Section 3 recommends the data quality objective (DQO) process for planning, maintaining and improving radiological effluent monitoring and environmental surveillance programs. The DQO process coordinates the many and complex aspects related to multiple sources, radionuclides, pathways, and exposed individuals or other biota. The sampling and measurement program must be designed with the spatial, temporal, and multi-radiation coverage needed to define the radiological environment at the sensitivity required by regulations and other criteria. It must focus on producing information that is sufficiently complete and transparent to fulfill the program objectives while satisfying the regulator and members of the public. The DQO process also is intended to continuously review the program and improve it.
- Section 4 recommends the framework of quality assurance (QA) and quality control (QC) to assure stakeholders that

radiological effluent monitoring and environmental surveillance results are trustworthy. A quality assurance project plan (QAPP) must be prepared that addresses every aspect of the program, from the reliability of sample collection through sample transport, storage, processing, measurement, to calculating results and formulating the report. The data life cycle (DLC) concept ensures that data pertaining to every step in the radiological effluent monitoring and environmental surveillance plan are recorded and evaluated for reliability.

- Section 5 describes the techniques to be used for gathering reliable information about the environment for calculating ambient radionuclide concentrations and radiation doses. This information provides the factors that quantitatively describe the transport of radionuclides through air and water; possible subsequent transport through vegetation, soil and animals; and exposure of humans or biota by inhalation, ingestion or external radiation. The information is developed from reports, expert advice, and studies of radionuclide transport under site-specific conditions.
- Section 6 makes available information on the computer models that are utilized for planning, operation and post-operation to determine environmental radionuclide concentrations and the resulting radiation doses based on radiological effluent measurements or estimation. These models provide the necessary computer simulation of radionuclide transport by environmental media to points of exposure, and consequent radiation dose to humans and biota. Models are available both for individual dispersion, transfer, and uptake calculations and for integrated calculations that relate monitoring data directly to environmental radiation doses. Reliability must be ensured by use of factors that apply to the site, validating each model for the intended purpose, and including an uncertainty estimate with the produced results.
- Section 7 presents systematic radiological effluent monitoring guidance for facilities large and small. The role of continuous and intermittent monitors for both air and water effluent is discussed in terms of source terms, variations in effluent levels, and response needs. Commercially-available instruments are identified, with applications consistent with specifications issued by standardization groups. Uncertainties and the potential for error must be evaluated to produce results that stand up under scrutiny.

- Section 8 provides guidance for applying the numerous methodologies and instruments available for radiological effluent monitoring and environmental surveillance. It indicates the detection capabilities and limitations for systems that have stood the test-of-time as well as for developments that can be more effective under specified conditions. Techniques for collection, preparation, radioanalytical chemistry, and radiation detection are recommended as appropriate to the various environmental media, radionuclides, and detection sensitivity requirements.
- Section 9 recommends the data processing and presentation suitable for the DQO and the DLC approach, controlled within QA/QC framework. The output of measurements must be validated and verified to ensure reliability in calculating and data transfer, and consistency with current and previous findings. The data must be safely stored and retrievable. Data reports must be in a format that is clear, specifies the uncertainty associated with each value, and presents the findings in understandable language. The links that connect sample to result must be sufficiently transparent and trustworthy to withstand legal challenges.

Literature surveys undertaken to prepare this Report suggest that both the concepts and objectives of radiological effluent monitoring and environmental surveillance and the methodologies related to radioanalytical chemistry, radiation detection, and computer simulation of transport and exposure have advanced during the past four decades. Even greater developments have occurred in formal guidance for planning and operating these programs to ensure that the sampling and analysis activities are indeed responsive to the program objectives with regard to coverage and sensitivity and to ensure by QA that the information is valid.