ENVIRONMENTAL SURVEILLANCE FOR LOW-LEVEL WASTE DISPOSAL SITES

Jacob Sedlet
Argonne National Laboratory
Argonne, Ilinois U.S.A.

INTRODUCTION

All nuclear facilities, including waste disposal sites, are expected to evaluate their effect on the environment. This paper describes a multidisciplinary approach to the design of environmental surveillance programs for near-surface disposal sites. Surveillance is broadly considered to include burial trench and other on-site measurements as well as offsite monitoring, and to include both radiological and non-radiological measurements.

The objectives of a surveillance program are: to determine the extent of any pollutant migration early enough for corrective action to be taken to minimize adverse impacts, to provide data to assess the impact of site operations on the environment and public, to predict long-term waste behavior, to satisfy regulatory agency requirements, and to obtain data on site and pollutant behavior for the design of future disposal sites and surveillance programs.

To meet these objectives, the surveillance program should include measurements of radioactive and chemically-toxic substances and of leachate indicators, measurements of direct penetrating radiation, determination of specific site and area properties, collection of specific information on the area, and interpretation of the results of the program in terms of health, environmental impact, standards, and expected performance.

These activities can be divided into three groups depending on their purpose: to measure the impact of the site on the public; to monitor site and burial trench performance; and measurements and data collections that support the first two activities. The first group of measurements should be made close to man; the second, close to the site and trenches. The third group includes observations and measurements needed for deciding on sampling locations and frequencies for the first two purposes, or are themselves indicators of site and trench performance.

DESIGN OF SURVEILLANCE PROGRAMS

An important starting point in program design is a pathway analysis that describes the routes of waste transport from burial site to man. Pathway analysis is a modeling exercise that analyzes compartmental transfer kinetics for a substance in the pathway. The major uncertainty in this process is that the compartmental transfer coefficients are highly site and substance specific and are not well known. However, even a qualitative analysis is very useful.

The waste composition and its chemical and physical properties are of particular importance, since it is the source term for the monitoring program and determines to a large degree the needed environmental measurements and the important pathways for pollutant transport. The number of radionuclides in the waste is limited by the definition of low-level waste and radioactive decay rates. The variety of chemical compounds is probably greater than the number of radionuclides. The pathways by which buried waste reach man are qualitatively the same whether the hazard of the migrating material is due to its radioactivity or chemical toxicity. Because of the variety of chemical and physical forms in which many radionuclides can exist, it is possible that the same radionuclide can migrate at different rates from the same trench. Also, the source term in a trench varies with time.

Information on a variety of properties and characteristics of the disposal site will be needed to design an adequate monitoring program and to evaluate the results of that program. Most of this information (e.g., meteorology, surface- and ground-water flow, geochemistry, land and water usage, and population distribution) will be obtained during the preoperational phase of a disposal site and when the site and surrounding area are being evaluated for suitability for waste disposal.

With the use of the information described above, a rationale for determining sampling and measurement locations and frequencies can be developed. The environmental media to be considered below are air, surface water, soil moisture in the unsaturated zone, water in trenches, ground water, surface soil, direct radiation, and plants and animals. Although the primary means of dispersal of buried waste are through air and water, biointrusion can be an important pathway in some locations.

For air and water, in which the direction and velocity of migrating waste can be estimated, the rationale is based on these basic principles: if the direction of a pollutant is from A toward B, a sampling station is placed along a line between A and B; the position of a station depends on the desired time for pollution detection and the speed of migration; and the time between sampling periods should be less than the travel time from A to the monitoring station. A different rationale is used for other cases, and statistical criteria for determining the number, as contrasted with the frequency, of samplings and measurements are also needed. Monitoring and sampling must also be conducted for comparison purposes at locations where the presence of migrating waste from the site is highly unlikely.

From measurements of wind velocity as a function of atmospheric stability, samplers can be placed where the average probability of detection is known. For a high total probability of detection, samplers are best placed in the buffer zone between the buried waste and site boundary. To detect releases before they leave the site boundary, an on-line device needs to be operated continuously downwind from an open trench. Such early detection is not possible for all contaminants. Sampling and measurement should be made for particulate contaminants, hydrogen-3, carbon-14, and radioiodines in several volatile chemical forms, and for some noble gases.

Surface streams and lakes may receive waste from runoff of surface water that has been in contact with a trench and from discharge of contaminated ground water. Visual observation and topographic maps will indicate the appropriate locations for sampling. It is necessary to sample streams during dry seasons when the base flow is not being diluted by direct precipitation and runoff.

If the unsaturated zone is large, 15 meters or greater, it is useful to measure changes in soil moisture content beneath or between trenches and to sample soil moisture with pressure-vacuum lysimeters. Flow rate and solute transport in the unsaturated zone should be estimated by a combination of field measurements and mathematical modeling. Water monitoring inside a burial trench is a special case of unsaturated zone monitoring, and the same principles apply. Sumps should be installed in each trench, and from the concentration of a pollutant in sump water, the rate at which it leaves the trench can be estimated and used as the source term. The ground-water system beneath and in the vicinity of a disposal site must be evaluated by the methods described for the unsaturated zone - measurements and modeling. From this, monitoring lines from a group of trenches in the directions of flow can be established and monitoring wells placed along them.

Surface soil collected on and near the site, with locations concentrated in downwind directions, is needed to detect any pollutants deposited from airborne contamination, accidental spillage, evaporation of waterborne contamination, and resuspension and subsequent deposition. Two types of vegetation should be sampled: plants growing on completed trenches and plants used as food for man and grazing animals in areas that could become contaminated. Sampling of two types of animals should be conducted: animals that can burrow into a trench; and those that graze on land or consume water that can become contaminated or live in rivers and lakes that can become contaminated.

Direct radiation from buried waste should be measured near trenches, at the site perimeter, and at offsite locations for a complete evaluation of this source of radiation exposure.

STATISTICAL CONSIDERATIONS

Statistical criteria should be used to assist in deciding on the numbers of samples and measurements, and in deciding when small, but real, changes from background or previous levels have been detected. The application of statistics should begin in the preoperational phase. Sufficient sample collections and measurements should be made for all important media and pre-existing potential contaminants to obtain an observed mean and standard deviation of sufficient reliability to allow the use of established statistical tests. From the central limit theorem, this number is about 30. Subsequently, the number can be reduced, based on experience. Since releases from a burial site can be directional, individual results should be compared with preoperational and offsite means to judge the statistical significance of small changes.

MONITORING PROGRAMS

Programs for the three phases (preoperational, operational, post-closure) of the life cycle of a waste disposal facility can be developed from the above discussions. Suitable sampling and analysis programs will be given in the poster session; space does not allow giving such details here. Reliance should be placed on high-sensitivity gamma-ray spectrometry with large germanium detectors for gamma-ray emitting radionuclides. However, some of the most mobile long-lived radionuclides are pure low-energy beta emitters, for which radiochemical analyses are needed, and if the limits of transuranic elements in low-level waste are increased, their measurement should be included. The most important radionuclides that cannot readily be detected at low concentrations by gamma-ray spectrometry are hydrogen-3 (as water vapor and simple organic compounds), carbon-14 (as carbonate and simple organic compounds), nickel-63, krypton-85, strontium-90, technetium-99, iodine-129, radon-222, radium-226, uranium, and transuranic nuclides.

Of equal importance to radionuclide analyses, particularly in ground-water monitoring, are measurements of chemical indicators of waste migration to identify leachate movement. These measurements include pH, electrical conductivity, chloride and nitrate ions, chemical oxygen demand, organic carbon, and complexing agents for metallic ions. Chemically-toxic compounds and pathogens that may be associated with the buried waste should also be measured. Sample collection, preservation, and measurement procedures have not been addressed due to lack of space, but adequate consideration of these aspects are essential to the success of a monitoring program.

The details of postoperational monitoring will be determined principally by the operational monitoring results. The important migration and exposure pathways should be well known, and the number of radionuclides and chemical pollutants of concern should be fewer because of radioactive decay and non-detection during operational monitoring.

SUMMARY AND CONCLUSIONS

It should be recognized that shallow-land burial techniques will not retain the waste completely in place over time. Some migration is expected, but it must be acceptable in amount and rate. Surveillance programs will provide the information to determine if this is the case. Proper application of monitoring techniques and principles will result in a program that will meet its objectives and supply the data needed by operators and regulators to maintain a properly operating site.

REFERENCE

Environmental Monitoring for Low-Level Waste-Disposal Sites, Low-Level Radioactive Waste Management Handbook Series, Report DOE/LLW-13Tg, U. S. Department of Energy, EG&G Idaho (January, 1983).