CHAPTER 7

Characterization

7-1. Introduction. Characterization refers to three separate tasks that are part of the CERCLA process: site characterization, contaminant characterization, and waste characterization.

7-2. Chemical and Radioactive Contaminants. Radioactive materials can pose two separate hazards to human health at a site. They may be hazardous chemicals, and they also decay and emit ionizing radiation. The chemical hazard posed by an element is the same regardless of whether a stable or radioactive isotope is involved. The chemical hazard depends on the molecular complex to which the atom is affixed. Regardless of the chemical form, if the isotope is radioactive, the molecular form will emit radiation, and, therefore, be hazardous. Besides its chemical toxicity, the molecular form will determine its transportability in the environment.

a. A contaminant's characteristics can change over time. Chemical degradation occurs in many contaminants over periods of months or years. Radioactive decay transmutes the radionuclide from one element to another, which in turn can alter the way it behaves on the molecular level and also how it is transported in the environment. For example, radium-226 is often found in water-soluble compounds that can be dissolved and percolate through the soil column to ground water. Radium-226 decays to radon-222, an inert gas that may rise through the soil column and disperse in the air, but is also highly water soluble. Radon-222 decays to a number of short-lived decay products, all of which are solids and will attach electro-statically to dust particles in the air, further allowing air migration, or they will be washed out of the air by precipitation, and reenter the soil. In summary, the contaminant can change atomic form, change the radiations emitted, change chemical form, change fate and transport methods, and change chemical and radio toxicity over time.

b. For these reasons, it may be necessary to characterize both the radioactive and the chemical/molecular form of the suspected contaminants and to determine how these characteristics change over time. When this characterization is too complex or too expensive to determine, it is necessary to make some assumptions about how the characteristics will change and how these changes will affect transportation and exposure pathways in the environment. It is important to ensure that, whenever any assumptions are made, they are fully documented in the characterization report, and that an estimate of their reliability be incorporated in the report.

c. Samples taken and analyzed during the site characterization may be useful during the waste characterization. If the actions generating the waste stream do not greatly alter the type or concentration of the contaminants, site characterization sample results may be used

for waste characterization. It is important to know the disposal site's waste acceptance criteria and the required sample analyses to ensure that site characterization sample analyses will be acceptable to the disposal site. This will aid in decreasing the number of samples being analyzed over the entire life of the project.

7-3. Site Characterization. This is the quantitative description of the site properties that influence the determination of risk to human health or the environment from a contaminant present at the site. The site characterization includes an investigation of the physical nature of the site and the contaminants at the site. It attempts to define the sources of the contamination, and determine the nature and extent of the contamination. It also seeks to identify exposure pathways and potential receptors for the risk assessors. As a corollary to this, it also is used to identify areas that are not contaminated. All sampling and characterization should be oriented toward provision of data necessary to complete the final status survey, and reach closure of the project.

a. The physical characteristics of the site may include geophysical and hydrogeological parameters, as well as the site use and accessibility in the past, present, and future. It also includes characterization of the volumetric distribution or dispersion of the contaminants or contaminant at the site.

b. The site characterization is attempting to answer the questions: What is the contaminant on-site? What are its radiological as well as its chemical characteristics? Where is the contamination? What is the pattern or distribution, if any, of the contaminants? What are the actual and potential modes of transport of the contaminant in the environment? Who are the potentially exposed populations? What are the routes of exposure?

c. Site characterization is described further in EPA CERCLA guidance. Important differences in site characterization on radioactive sites that may manifest themselves are the variations in radionuclide pathways from the standard chemical pathways. Especially the decay chain radionuclide series, where there is a change in physical form that accompanies the decay, such as solid radium-226 decaying to gaseous radon-222. There is also the change in chemical form and in chemical reactivity that will affect pathways. After most decays, the radionuclide is left in an ionized state, which is chemically highly reactive.

d. Contaminant characterization, a subtask of site characterization, describes the physical, chemical, and radiological parameters of the contaminants as they exist at the site.

7-4. Waste Characterization. Waste characterization defines the waste stream containing the contaminants as it will be delivered to the disposal facility. Waste characterization can be a multi-stage process. On many sites, large numbers of site characterization samples are taken of soils and debris. In most cases the act of removing and packaging the contaminated soil or debris does not significantly alter the radioactivity of the waste. In these cases we can use

the site characterization sample data to contribute to the waste characterization data. This will significantly lower the number of samples and analyses needed on the waste stream. If this is the case, it is important to ensure that the site characterization sample data are of the same caliber needed for waste characterization. Additionally, removal and packaging methodology that ensures that concentrations of radioactive contaminants in the soil and debris are not significantly altered needs to be included in the data package.

a. The concentration, activity, and chemical form of the contaminant may have altered because of some remedial, removal, or other actions taken at the site, or on the waste stream. When this is the case, a more stringent waste-characterization sampling program will be required to ensure adequate confidence in the level of activity in the waste and the homogeneity of the waste.

b. For disposal, waste streams may sometimes be combined to allow for more economical transportation and disposal. While radioactive waste streams may be combined and the average concentration of radionuclides in one waste stream may be lowered by the combination, waste may not be diluted to become unregulated. Both waste streams must meet the waste acceptance criteria of the proposed disposal site to be blended. If one waste stream does not, it should not be blended. Waste will not purposefully be mixed with uncontaminated soils to lower its radioactive concentration. In the process of remediation, some clean material is unavoidably collected along with the contaminated material; this is acceptable and is not considered blending.

c. The following is an example: A site contains a radioactive waste burial pit. The remediation method chosen was to remove the soils covering the pit, segregate these soils from the waste in the pit, excavate the waste in the pit, try to treat 10 cubic yards of the waste with a new technology that minimizes the waste volume, and ship all waste to disposal facilities. A characterization survey is conducted to determine the radionuclides present, their concentrations at various locations and depths, and their volumetric extent at the site. Assume the 85 characterization samples showed that the soil covering is uniformly contaminated with very low concentrations of radioactive waste and can be disposed of at an RCRA Subtitle C facility. In the process of excavating the contaminated soils, the buckets sometimes cut a few inches deeper into uncontaminated soils, incorporating some uncontaminated soil into the waste stream. This generated 2500 cubic yards of waste. This particular RCRA facility requires one confirmatory sample per 100 cubic yards of waste, so 25 confirmatory samples are required for this waste stream.

(1) The waste excavated from the pit is known from the characterization sampling to be uniformly contaminated but with a much higher activity. This 10,000 cubic yards of material must go to an NRC licensed radioactive waste disposal facility. The facility requires five confirmatory samples be taken from the entire waste stream. They also have additional testing when the waste reaches their site. If this testing reveal concentrations vastly different

from those presented by our sampling, the shipment will be returned to the originating site. To ensure we meet the waste acceptance criteria for the site, we use the information collected during the characterization of the site, applicable to this waste stream. These 200 subsurface soil samples show the radionuclide concentration to be a total of 3400 pCi/g ± 1200 pCi/g at a 95% confidence level. The five confirmatory samples varied between 2500 and 4200 pCi/g with a mean value of 3250 pCi/g. Site and process knowledge, combined with the confirmatory samples, provides excellent confidence that excavation and handling procedures did not significantly alter the radioactive contaminant concentration of this waste stream.

(2) The 10 cubic yards of the pit waste that are treated resulted in a volume reduction of 60%; 30 samples taken from the 6 cubic yards of 'cleaned' waste show that the radionuclide concentration is lower than the remediation goal for the site. With the concurrence of the site regulators, it may be disposed of on-site as fill. The remaining 4 cubic yards are sampled twice and both samples show the radionuclide concentration has been increased.

(3) This site has three radioactive waste streams: the 2500 cubic yards of slightly contaminated soil covering, the 10,000 cubic yards of pit contents, and the 4 cubic yards of treated waste. Total samples taken of each waste are as follows:

(a) For the 2500 cubic yard soil covering, 85 characterization samples and 25 confirmatory samples were taken.

(b) For the 9,994 cubic yard pit contents, 200 characterization survey samples and 5 confirmatory samples were taken.

(c) For the 4 cubic yards of treated pit contents, 2 samples were taken. The 4 cubic yards was then blended in with the 9,990 cubic yards of the original pit contents, and was calculated to not significantly change the content of the pit radionuclide concentrations.

d. In summary, the site characterization will have identified the radioisotopes, and provided a range of concentrations in each waste stream, and an estimated volume of each waste stream. To meet disposal facility requirements and USACE quality control, additional samples needed to be taken and analyzed to ensure that the waste, excavated and ready for transport to the disposal facility, has not been inadvertently altered through the remediation process. The information gathered from these samples is combined with the information from the characterization and any other surveys and is used to define the waste. By ensuring that all the surveys have similar data quality, we can combine the results and achieve a very reliable statistical estimate of our confidence in the data.

7-5. Site History and Waste Pedigree. A comprehensive site history can be very helpful in determining potential radioactive contaminants. If materials arrive as ores, and were smelted on the site, the residuals may contain both parent and progeny decay products. If material was already refined, parent or certain progeny may not be reasonably expected at the site. Potential areas of contamination can be determined if knowledge of the physical flow of materials in, around, and off the site is known. Soil and water extraction processes, wells, or surface water systems used at a site may have contributed to technically enhanced NORM (naturally occurring radioactive materials). All these processes and materials movement may help explain the presence and migration of contaminants on and off the site. Additionally, it is important to know the site history to characterize and classify the radioactive material.

7-6. Quantifying Contaminated Materials. A characterization study and interpretation of the data collected should yield the following information:

- The range and extent of contamination at the site.
- Each radionuclide present on-site.
- The range of concentrations of each radionuclide on-site.
- The volume and mass of soil expected to exceed site screening levels/PRGs.
- The total activity and concentration of the radioactivity in soil exceeding site screening levels/PRGs.
- The volume and mass of debris to exceed site screening levels/PRGs.
- The total activity and concentration of the radioactivity in or on debris exceeding site screening levels/PRGs.
- The activity, concentration, and volume of the highest 'hot-spot' in soils on the site.
- The concentration and total activity expected to remain in the soil on the site.
- The concentration and total activity expected to remain on or in buildings or debris left on the site.

All of the above data shall be quality controlled and of an accuracy and precision to be acceptable as MARSSIM final status survey compatible data. By conforming to MARSSIM Data quality objectives, these data can be combined meaningfully with all the other data obtained on the site and the waste to provide a better statistical accuracy to the data.

7-7. Other Media - Air, Water, Sediments. Depending on the site, air, surface water, or ground water may require characterization. The primary difference in characterization is that these measurements are normally provided in activity per unit volume, as opposed to activity per unit mass.