CHAPTER 1

Introduction

1-1. Purpose. This engineer manual (EM) contains planning and management guidelines to be used for United States Army Corps of Engineers (USACE) work with radioactive waste, either alone or combined with hazardous or toxic components. This manual primarily describes regulatory and management responsibilities, provides guidance on accomplishing those responsibilities, and explains their relation to the Project Management Business Process (PMBP) and Technical Project Planning (TPP) applied to USACE activities at radioactive waste sites. Additionally, this manual will promote USACE policies to ensure Corps-wide application across all programs. This manual is not intended to provide detailed technical recommendations or sophisticated scientific procedures. The manual will necessarily incorporate some technical information to provide background for the regulatory and management responsibilities. In addition to the Department of Defense (DOD) branches, these responsibilities are defined and enforced by other Federal agencies, including the Nuclear Regulatory Commission (NRC), the Department of Energy (DOE), the Environmental Protection Agency (EPA), the Department of Transportation (DOT), and the Occupational Safety and Health Administration (OSHA).

1-2. Applicability. The guidelines within this manual are applicable to all USACE elements and major subordinate commands (MSC) having responsibility through governmental interagency agreement or by assignment by HQUSACE for the remediation of sites contaminated with radioactive materials. These guidelines are applicable to both the Military and Civil Works missions of the USACE. Strictly chemical or biological aspects of sites are not addressed except in passing reference to their component part of mixed waste. While most of the guidance included will be applicable to work performed outside the United States, other regulatory agencies, dose limits, and radioactive handling and disposal regulations may be applicable.

1-3. Distribution Statement. Approved for public release; distribution is unlimited.

1-4. References. References are at Appendix A. Referenced documents throughout the text are hyperlinked to internet available copies when possible.

1-5. Scope.

a. Intended Audience. This document is intended to assist Project Managers in the development of Project Management Plans and supporting documents that will lead to the successful restoration of sites contaminated with radioactive material. Guidance is included to ensure that each Project Delivery Team (PDT) is established with the necessary disciplines and perspectives. Individuals asked to work on radioactively contaminated sites may find the

document useful in understanding and fulfilling their role as members of the PDT. Various terms, regulations, and processes used in the restoration of radioactively contaminated sites are described to facilitate effective communication between the PDT members and stakeholders.

b. Contents.

- Chapter 1 explains the purpose, scope and intended audience of this guidance document. It lists some important units, quantities and conversions that are necessary to fully understand and work on remediation of radioactively contaminated sites.
- Chapter 2 explains how the presence of radioactive waste affects the necessary actions and associated management of a project.
- Chapter 3 explains the TPP approach to managing remediation at sites contaminated with radioactive materials.
- Chapter 4 discusses health and safety concerns relative to a radioactive site.
- Chapter 5 describes the conceptual site model and risk assessment.
- Chapter 6 describes sampling of radioactive materials.
- Chapter 7 describes characterization of sites.
- Chapter 8 describes characterizing radioactive waste.
- Chapter 9 addresses the primary regulatory processes involved at radioactive remediation sites.
- Chapter 10 addresses remedies and innovative technologies that may be used at radioactive remediation sites.
- Chapter 11 explains the procedures and issues involved in transportation of radioactive materials.
- Chapter 12 discusses options and methods of disposal of radioactive materials.
- Chapter 13 discusses the Multi-Agency Radiation Site Survey and Investigation Manual (MARSSIM) Final Status Survey (FSS).
- Appendix A provides references and bibliography of regulatory documents, regulations and laws.
- Appendix B provides contact information for Federal and state radiation control agencies.
- Appendix C includes technical information on radioactive materials, decay, measuring techniques, and instrumentation.
- Appendix D lists some typical remediation site characteristics.

1-6. Units, Definitions, and Conversions. Several systems of units are applicable to USACE radioactive materials sites. The following is a brief description of the units, what they measure, and how they will be used on USACE sites. Conversions between different systems of units are included where appropriate. A more complete explanation may be found in EM 385-1-80.

a. Radioactivity or Activity. Radioactivity is unstable atomic nuclei becoming more stable by emitting energy. The types and amounts of energy emitted are characteristic of the radioactive material. The radioactivity or activity of a material is the rate of decay per unit time. There are two systems that are used to measure activity: the US system and the System International (SI). In this manual, when reporting activity, the US system units will be listed first, followed by the SI unit in parentheses.

(1) US System. Activity is measured using the curie (Ci). 1 Ci is 3.7×10^{10} decays per second (1 gram of pure radium has 1 Ci of activity).

(2) SI. Activity is measured using the becquerel (Bq). 1 Bq is 1 disintegration per second.

$1 \text{ Ci} = 3.7 \times 10^{10} \text{ Bq}$

$1 \text{ Bq} = 2.7 \times 10^{-11} \text{ Ci}$

(3) Specific Activity (activity per unit mass). This is reported as Ci/g (Bq/kg). Note that DOT requires SI units to be entered on shipping papers and labels. US customary units may accompany the SI units in parentheses.

(a) Activities and specific activities may use metric prefix abbreviations as follows:

Prefix	Abbreviation	Quantity
Tera	T	1×10^{12}
Giga	G	1×10^{9}
Mega	M	1×10^{6}
Kilo	k	1×10^{3}
Milli	m	1×10^{-3}
Micro	µ	1×10^{-6}
Nano	n	1×10^{-9}
Pico	p	1×10^{-12}

(b) Several related units may be encountered on USACE sites. Their acceptability should be determined by the USACE health physicist assigned to the site.

b. dpm. Disintegrations (decays) per minute is often used in referring to surface contamination, most often as disintegrations per minute per one hundred square centimeters

(dpm/100 cm^2); dpm can be converted to Bq or Ci. Some survey instruments purport to present data in dpm. This can only be done correctly under very specific circumstances. These circumstances and the accuracy of the readings must be verified by a health physicist.

c. cpm. Counts per minute (radiation interactions with the detector) is often reported for hand held instrument surveys. Under certain very specific circumstances, cpm can be converted to dpm. A health physicist must be consulted to ensure that an accurate conversion is performed.

d. (Ionizing) Radiation (as used here). This is the energy emitted from radioactive material traveling from one point to another in the form of photons or particles. Depending upon how and where it is measured, there are a number of units used to quantify radiation. The standard units used at USACE sites are the roentgen (coulomb per kilogram), rad (gray), and rem (sievert).

e. Exposure. This is the amount of ionization in air produced by x- or gamma radiation with energies less than 3 MeV (mega electron volt). Exposure is the most commonly measured parameter of radiation. It is measured in roentgen (R). One R is equal to 2.58×10^{-4} coulomb of electrical charge produced in one kilogram (C/kg) of air.

f. Exposure Rate. This is the readout used by many field survey instruments. It commonly uses a fraction of roentgen per hour (R/hr), usually milliroentgen per hour (mR/hr), or micro roentgen per hour (µR/hr).

g. Absorbed dose. This is the energy deposited in matter by radiation. It is measured in rad or gray (Gy).

1 rad = 100 erg/g = 0.01 Gy

1 gray = 1 J/kg = 100 rad

1 R in air is about equal to 1 rad in soft tissue.

h. Dose Equivalent. This is the absorbed dose in soft tissue multiplied by a quality factor. The quality factor normalizes the harm done by different types of radiation. The dose equivalent is a measure of the biological damage expected from absorption of radiation.

(1) Typical quality factors are:

- Beta/gamma radiation.....1
- Alpha radiation.....20
- Neutron radiation.....10

(2) Dose equivalent is measured in rem (sievert [Sv]).

100 rem = 1 Sv

1 Sv = 100 rem

(3) For x-ray/gamma radiation.

1 R = 1 rad = 1 rem (1 Sv = 1 Gy)

(4) For alpha radiation.

1 rad = 20 rem (1 Gy = 20 Sv)

i. Radioactive Waste. A generic term for wastes containing radioactive materials. Regulatory agencies have different definitions for different types of radioactive wastes. The NRC only regulates source, byproduct, and special nuclear materials. The EPA regulates the hazardous component of mixed wastes. States may regulate other radioactive materials and radioactive wastes.

j. High-Level Radioactive Waste (HLW). The NRC defines High-Level Radioactive Waste as 1) irradiated reactor fuel, 2) liquid wastes resulting from operation of the first cycle solvent extraction system, or the equivalent, and the concentrated wastes from subsequent extraction cycles or equivalent in a facility for reprocessing irradiated reactor fuel, and 3) solids into which such liquid wastes have been converted (10 CFR 60). In layman's terms, HLW is spent fuel, or spent fuel reprocessing wastes. USACE does no work with HLW at present.

k. Low-Level Radioactive Waste (LLRW). LLRW is source, byproduct, or special nuclear material waste not classified as HLW, transuranic waste, spent nuclear fuel, or byproduct material as defined in section 11e.(2) of the Atomic Energy Act. In layman's terms, LLRW is NRC regulated waste that is not HLW, transuranic waste, or uranium or thorium mill tailings.

l. Transuranic Waste (TRU). TRU is waste materials contaminated with alpha-emitting nuclides with an atomic number greater than 92, half-lives greater than 20 years, and in concentration greater than 100 nCi/g of waste at the time of assay (40 CFR 191).

m. Uranium Mill Tailings Radiation Control Act (UMTRCA). Enacted to ensure investigation and remediation of past uranium and thorium mine and mill tailings and regulation of tailings at currently licensed sites.

n. Uranium or Thorium Tailings (11e.(2) materials). The tailings or wastes produced by the extraction or concentration of uranium or thorium from any ore processed primarily for its source material content (Atomic Energy Act). This designation only applies to tailings generated during or after 1978. This designation is sometimes incorrectly applied to tailings from the extraction of rare earth elements, which are often co-located in the same ores as uranium and thorium, or to the tailings from the extraction of radium. For legal reasons, those tailings generated prior to 1978 are referred to as "residuals from uranium or thorium ore processing prior to 1978."

o. Mixed Waste. An NRC regulated radioactive waste containing source, byproduct, or special nuclear material (LLRW, 11e.(2) or HLW) mixed with an RCRA (Resource Recovery and Conservation Act) listed or characteristic hazardous material.

p. Combined or Commingled Waste. Any radioactive waste mixed with any hazardous substance. Mixed waste is a subset of combined or co-mingled waste.

q. DOT Radioactive Material. A material with a total activity concentration exceeding 70 Bq/g (2000 pCi/g) (49 CFR 173.403). Note, this definition shall change under DOT and NRC harmonization rulemaking on 1 October 2004 to agree with the international definition of radioactive material. The international definition of radioactive material shall mean any material containing radionuclides where both the activity concentration and the total activity in the consignment exceed the values specified in the table in 49 CFR 173.436 or values derived according to the instructions in §173.433.