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☐ New ☐ Total Rewrite ☒ Revision ☐ Page Change

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PUBLICATION RECORD

EFFECTIVE DATE	REVISION NUMBER	DESCRIPTION
03/30/2004	00	New Technical Basis Document for the Mound Site – Site Description. First approved issue. Initiated by Jeff Vollmer.
07/07/2006	00 PC-1	Page change revision initiated for biennial review. Incorporates NIOSH formal review comments. Changes were made to the required language on pages 5 and 6 in Section 2.0. No sections were deleted. Approved issue of Rev 00 PC-1. This revision results in no change to the assigned dose and no PER is required. Training required: As determined by the Task Manager. Initiated by Paul J. Demopoulos. Approval: Signature on File 06/06/2006 Stanley J. Waligora, TBD Team Leader Signature on File 06/06/2006 John M. Byrne, Task 3 Manager Signature on File 06/07/2006 Edward F. Maher, Task 5 Manager Signature on File 06/06/2006 Kate Kimpan, Project Director Signature on File 07/07/2006 James W. Neton, Associate Director for Science
03/13/2009	00 PC-2	Approved page change initiated to remove information pertaining to Monsanto Chemical Company, the subject of a class of employees added to the Special Exposure Cohort. These changes occurred on pages 6 - 13, 15, 16, 18, and 20 in Sections 2.0, 2.2, and 2.3, respectively. NIOSH required language was revised on page 5 in Section 2.0. Updated references on pages 29 - 30 in Reference Section. In this revision, Figure 2-1 was formerly Figure 2-3. Figures 2-1 and 2-2 from the previous revision were deleted. Incorporates formal internal and NIOSH review comments. No Sections were deleted. Training required: As determined by the Task Manager. Initiated by Donald N. Stewart. Approval: Signature on File 03/02/2009 Donald N. Stewart, Document Owner Signature on File 03/03/2009 John M. Byrne, Task 3 Manager Signature on File 03/02/2009 Edward F. Maher, Task 5 Manager Signature on File 03/11/2009 Kate Kimpan, Project Director Signature on File 03/13/2009 James W. Neton, Associate Director for Science

04/01/2013	01	Revision initiated to incorporate SEC-00090, SEC-00171, and SEC-00207. Updated Table 2-1 with information for 2003 and 2010. Added Special Exposure Cohort information pertaining to the SW Building in Section 2.1.3. Incorporates formal internal and NIOSH review comments. Training required: As determined by the Objective Manager. Initiated by Donald N. Stewart.

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ACRONYMS AND ABBREVIATIONS

CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
Ci	curie
CWPF	Consolidated Waste Processing Facility
D	deuterium
D&D	decontamination and demolition
DOE	U.S. Department of Energy
DOL	U.S. Department of Labor
EDTA	ethylene diamine tetraacetic acid
EEOICPA	Energy Employees Occupational Illness Compensation Program Act of 2000
ft	foot
g	gram
gal	gallon
HTO	tritium oxide (water or water vapor)
kg	kilogram
lb	pound
LLW	low-level waste
LSA	low specific activity
mg	milligram
NIOSH	National Institute for Occupational Safety and Health
ORAU	Oak Ridge Associated Universities
pCi	picocurie
POC	probability of causation
ppm	parts per million
PUREX	plutonium-uranium extraction
R&D	research and development
RTG	radioisotopic thermoelectric generator
SEC	Special Exposure Cohort
sOBT	physiologically soluble organically bound tritium
SRDB Ref ID	Site Research Database Reference Identification (number)
SRS	Savannah River Site
t	ton
T	tritium
TBD	technical basis document
TRU	transuranic
U.S.C.	United States Code
yd	yard

§ section or sections

2.1 INTRODUCTION

Technical basis documents and site profile documents are not official determinations made by the National Institute for Occupational Safety and Health (NIOSH) but are rather general working documents that provide historical background information and guidance to assist in the preparation of dose reconstructions at particular sites or categories of sites. They will be revised in the event additional relevant information is obtained about the affected site(s). These documents may be used to assist NIOSH staff in the completion of the individual work required for each dose reconstruction.

In this document the word "facility" is used as a general term for an area, building, or group of buildings that served a specific purpose at a site. It does not necessarily connote an "atomic weapons employer facility" or a "Department of Energy [DOE] facility" as defined in the Energy Employees Occupational Illness Compensation Program Act [EEOICPA; 42 U.S.C. § 7384l(5) and (12)]. EEOICPA defines a DOE facility as "any building, structure, or premise, including the grounds upon which such building, structure, or premise is located … in which operations are, or have been, conducted by, or on behalf of, the Department of Energy (except for buildings, structures, premises, grounds, or operations … pertaining to the Naval Nuclear Propulsion Program)" [42 U.S.C. § 7384l(12)]. Accordingly, except for the exclusion for the Naval Nuclear Propulsion Program noted above, any facility that performs or performed DOE operations of any nature whatsoever is a DOE facility encompassed by EEOICPA.

For employees of DOE or its contractors with cancer, the DOE facility definition only determines eligibility for a dose reconstruction, which is a prerequisite to a compensation decision (except for members of the Special Exposure Cohort). The compensation decision for cancer claimants is based on a section of the statute entitled "Exposure in the Performance of Duty." That provision [42 U.S.C. § 7384n(b)] says that an individual with cancer "shall be determined to have sustained that cancer in the performance of duty for purposes of the compensation program if, and only if, the cancer … was at least as likely as not related to employment at the facility [where the employee worked], as determined in accordance with the POC [probability of causation[1]] guidelines established under subsection (c) …" [42 U.S.C. § 7384n(b)]. Neither the statute nor the probability of causation guidelines (nor the dose reconstruction regulation, 42 C.F.R. Pt. 82) restrict the "performance of duty" referred to in 42 U.S.C. § 7384n(b) to nuclear weapons work (NIOSH 2010).

The statute also includes a definition of a DOE facility that excludes "buildings, structures, premises, grounds, or operations covered by Executive Order No. 12344, dated February 1, 1982 (42 U.S.C. 7158 note), pertaining to the Naval Nuclear Propulsion Program" [42 U.S.C. § 7384l(12)]. While this definition excludes Naval Nuclear Propulsion Facilities from being covered under the Act, the section of EEOICPA that deals with the compensation decision for covered employees with cancer [i.e., 42 U.S.C. § 7384n(b), entitled "Exposure in the Performance of Duty"] does not contain such an exclusion. Therefore, the statute requires NIOSH to include all occupationally-derived radiation exposures at covered facilities in its dose reconstructions for employees at DOE facilities, including radiation exposures related to the Naval Nuclear Propulsion Program. As a result, all internal and external occupational radiation exposures are considered valid for inclusion in a dose reconstruction. No efforts are made to determine the eligibility of any fraction of total measured exposure for inclusion in dose reconstruction. NIOSH, however, does not consider the following exposures to be occupationally derived (NIOSH 2010):

- Background radiation, including radiation from naturally occurring radon present in conventional structures
- Radiation from X-rays received in the diagnosis of injuries or illnesses or for therapeutic reasons

[1] The U.S. Department of Labor (DOL) is ultimately responsible under the EEOICPA for determining the POC.

2.1.1 Purpose

The purpose of this technical basis document (TBD) is to provide a site description for the Mound Laboratory that contains technical basis information for use by the Oak Ridge Associated Universities (ORAU) Team to evaluate the total occupational dose for EEOICPA claimants.

2.1.2 Scope

The Mound Laboratory played an important role in the U.S. nuclear weapons program. Mound Laboratory activities were originally established in Dayton, Ohio, in the summer of 1943. The Monsanto Chemical Company operated the Dayton Laboratory at Units I, II, III, and IV. Of these, Units III and IV were created to produce large quantities of polonium. Operational experience at Units III and IV demonstrated the need for a specialized facility for polonium production and associated activities. This need led to the design and construction of the Mound Laboratory, initially known as Unit V of the Dayton Laboratory. The Mound Laboratory was initially occupied in 1948, and various research programs were begun; polonium production work was transferred to the new facility in 1949. The site's role grew to include nuclear weapons component development and production, and such secondary missions as radioactive waste management and recovery, the use of radioactive materials for nonweapons purposes, and the purification of nonradioactive isotopes for scientific and commercial research. This TBD contains supporting documentation to assist in the evaluation of worker dose from these processes at the Mound Laboratory, using the methodology in NIOSH implementation guides (NIOSH 2002, 2007).

Consideration of potential exposures and dose reconstruction methods for Monsanto Chemical Company operations are outside the scope of the Mound Laboratory TBDs.

Methods and concepts of measuring radiation exposure to workers have evolved since the beginning of Mound operations. An objective of this TBD is to provide supporting technical data to evaluate, with favorable to claimant assumptions, the total Mound occupational dose that can be associated reasonably with worker radiation exposure covered under EEOICPA legislation. This dose includes occupational internal and external exposures, occupationally required diagnostic X-ray examinations, and onsite exposure to site environmental releases. This TBD addresses evaluation of unmonitored and monitored worker exposure and missed dose. Consistent with NIOSH (2002, 2007), this document identifies how to adjust the historic occupational dose to account for current scientific methods and protection factors.

In addition, this TBD presents technical basis methods used to prepare the Mound worker dose records for input to the NIOSH Interactive RadioEpidemiological Program and the Integrated Modules for Bioassay Analysis computer programs used to evaluate worker dose. Because information on measurement uncertainties is an integral component of the NIOSH approach, this document describes the uncertainty evaluation for the Mound exposure and dose records.

Section 2.2 describes Mound facilities and processes as well as historical information related to worker internal and external exposures.

2.1.3 Special Exposure Cohort Petition Information for the Mound Plant

Classes Added to the SEC

Employees of the Department of Energy (DOE), its predecessor agencies, and DOE contractors or subcontractors who worked in any areas at the Mound Plant site from October 1, 1949, through February 28, 1959, for a number of work days aggregating at least 250 work days or in combination with work days within the parameters

established for one or more other classes of employees in the SEC (SEC-0090; Leavitt 2008).

All employees of the Department of Energy (DOE), its predecessor agencies, and its contractors and subcontractors who had at least one tritium bioassay sample and worked at the Mound Plant in Miamisburg, Ohio from March 1, 1959 through March 5, 1980, for a number of work days aggregating at least 250 work days, occurring either solely under this employment, or in combination with work days within the parameters established for one or more other classes of employees in the Special Exposure Cohort (SEC-00171; Sebelius 2010).

All employees of the Department of Energy (DOE), its predecessor agencies, and their contractors and subcontractors who worked at the Mound Plant in Miamisburg, Ohio, from September 1, 1972 through December 31, 1972, or from January 1, 1975 through December 31, 1976, for a number of work days aggregating at least 250 work days, occurring either solely under this employment or in combination with work days within the parameters established for one or more other classes of employees included in the Special Exposure Cohort (SEC-00207; Sebelius 2012).

Dose reconstruction guidance in this document for periods before March 6, 1980, is presented to provide a technical basis for partial dose reconstructions for claims not covered in the SEC class through March 5, 1980. Although NIOSH found that it is not possible to completely reconstruct radiation doses for the SEC classes above, NIOSH intends to use any internal and external monitoring data that may become available for an individual claim (and that can be interpreted using existing NIOSH dose reconstruction processes or procedures). Therefore, dose reconstructions for employees who worked in any areas of the Mound Plant during the periods from October 1, 1949 through February 28, 1959, or September 1, 1972 through December 31, 1972, or January 1, 1975 through December 31, 1976; or who worked in R or SW Buildings (as indicated by tritium bioassay) during the period from March 1, 1959 through March 5, 1980, but who do not qualify for inclusion in the SEC, may be performed using these data as appropriate.

2.2 SITE ACTIVITIES AND PROCESSES

2.2.1 Mound Laboratory

The Mound Laboratory facility was established on a hill 878 feet above sea level and about 200 ft above the Miami River in Miamisburg, Ohio. Mound Laboratory became the first permanent U.S. Atomic Energy Commission facility in May 1948. At the Mound Laboratory there were originally 14 buildings with 360,000 ft^2 of space. Polonium processing began in February 1949 (Gilbert 1969).

During the early years of operation at the Mound Laboratory in Miamisburg, a number of small research activities were carried out involving ^{226}Ra, ^{227}Ac, ^{228}Th, ^{232}Th, ^{230}Th, ^{231}Pa, and ^{233}U (Meyer 1992). From the early 1950s to the early 1980s Mound conducted various programs that involved extraction and purification of ^{226}Ra, ^{227}Ac, ^{230}Th, and ^{231}Pa. Ores were typically depleted of uranium before processing.

The narrowly focused polonium production work expanded to the development and production of weapons components. Production of ^{238}Pu and ^{239}Pu grew from the early work with polonium (Gilbert 1969). Mound's main focus was to support DOE weapons and nonweapons programs, especially in the areas of chemical explosives and nuclear technology. Its principal mission was to research, develop, and manufacture nonnuclear explosive components for nuclear weapons that were assembled at other sites.

Early programs investigated chemical and metallurgical properties of ^{210}Po and its applications. Research and development (R&D) included the fabrication of neutron and alpha sources for weapons and nonweapons use. Starting in the early 1950s, Mound developed radioisotopic thermoelectric generators (RTGs), which have been used on a variety of missions to provide heat and power for spacecraft. Production of ^{210}Po declined in the 1960s until it phased out in 1971 (Meyer 1992).

Developing, producing, and providing surveillance of detonators for military applications began in 1957. Explosive timers were developed in 1959, and manufacture of the timers began in 1963 (MEMP 2000). Ferroelectric transducers and firing set component development and manufacture began in 1962 (MEMP 2000).

Tritium handling technologies began in the mid-1950s. Mound tritium programs supported weapons and nonweapons programs (MEMP 2000). Beds and vessels containing uranium and/or other metals were used to trap and store tritium in the form of a metal tritide. In addition, research was conducted on metal tritides and tritium targets might also have been processed.

Other major operations included:

- Manufacture of enriched stable isotopes for medical, industrial, and general research;
- Development and manufacture of chemical heat sources;
- Recovery and purification of tritium from waste from Mound and other DOE sites;
- Development of radioisotopic heat sources for the National Aeronautics and Space Administration and other programs;
- R&D of chemical explosives and pyrotechnics, adhesives, plastics, and elastomers for the nuclear weapons program;
- R&D of thermonuclear energy fuel systems;
- R&D of the joining of exotic metals;
- Development of instrumentation for the nuclear safeguard program;
- R&D of separation of gases and energy conversion systems; and
- R&D of technologies for radioactive waste management.

Table 2-1 summarizes Mound operations.

Table 2-1. Chronology of significant Mound Laboratory programs and events.[a]

Year	Activity
1946	Mound Laboratory planning started.
1948	Mound Laboratory occupied (May).
1949	Polonium operations moved from Dayton Units to Mound Laboratory beginning in February. First program separated Ra-226 from barium-rich uranium ore, pitchblende residue called K-65, which consisted of the following: **Constituent** **Percent by weight** Water 30% Lead oxide 19%

Year	Activity
	Barium sulfate 7% (375 mg of radium in the barium) Silicon dioxide 35% Metals 9% trace metals similar to Cotter Concentrate Experimental extraction of Ra-226 from the K-65 was conducted in the R Building. In October Mound received 200 lb of K-65 in a single drum. Study of processes for decontamination of radioactive waste from plutonium, production reactors at Hanford. From 1948 to 1952 three different types of processing wastes were studied to concentrate constituents such as Cs-137, Ru-106, SR-90, Zr-93, Co-60, Nb-94, Sb-125, Te-123, Ni-63, rare-earth elements, and Pu-239. Bench scale testing began in R Building.
1950	Separation of Po-208 and Po-209 from proton (accelerator) irradiation of bismuth. Separation of Ac-227 from irradiated Ra-226. Uranyl sulfate – heavy water fuel system research. Civilian power reactor research involving uranium, Pa-231, and Pu-239; mission ended in 1963.
1951	Small amount of research with Ra-226 in preparation of cave operation in SW Building. Involved irradiated Ra-226 and recovery of Ac-227 and Th-228 from Ra-226.
1952	Pilot plant installed in SW Building for processing reactor waste. Reactor waste processing areas also included Warehouses 9 and 13 and WD, SD, SW, R, and M Buildings.
1953	SW Building for tritium handling constructed with a dirt floor.
1954	Invention of the Po-210-fueled RTG. Initiation of several programs requiring tritium-handling technologies. Construction of thorium refinery for breeder reactor program (never operated).
1955	Repackaging of 6,000 55-gal drums containing thorium ore and sludge occurred through 1965 at three different times to help prevent the possibility of further contamination. August: Small research program in R Building involving recovery and subsequent purification of Pa-231 from natural sources. June: Radium Cave operation shut down (Ra-226, Ac-227, Th-228, Ra-223, Ra-224 progeny)
1956	Completed separation of 1.3 g of Pa-231 in HH (Hydrolysis House) Building. Weighable quantities of Th-230 (ionium) separated. Pu-239-Be neutron sources manufactured. Nuclear weapon detonator development, production, and surveillance; mission ended in 1989.
1959	Pu-239 reactor fuels laboratory operational. Tritium waste recovery and purification facility operational. U-233 research involving about 10 research personnel.
1960	Pu-238 used in large quantities in production operations. Process areas included the R, SM (Special Metallurgical), and PP (Plutonium Processing) Buildings.
1961	Development of Pu-238 heat sources for thermoelectric generators.
1963	Several Po and gadolinium polinide heat sources containing 100–1,000 Ci of Po-210 were encapsulated in refractory metal.
1964	190 mg of Ac-227 was processed in the New Cave area.
1965	Gaseous effluent control system operational in SW Building.
1966	Thorium ore and sludge moved to bulk storage in Building 21.
1967	54,000 Ci of high-purity Po-210 were processed for Mound experimental work and commercial use. 14.5 kg of Pu-238 were recovered from waste material.
1968	PP Building 38 operational for processing Pu-238.
1969	Waste line break and subsequent contamination of the abandoned Miami-Erie Canal bed with Pu-238. Began tritium recycling from retired weapon parts. 3,701 Ci of Po-210 were produced for both internal and external customers. Six Systems for Nuclear Auxiliary Power (SNAP)-27 sources were produced. Each source contained 3,735 Ci of Pu-238.
10/1970–06/1971	Plutonium inventory was reduced to a minimum level. 22.5 kg of Pu-238 scrap was shipped to the Savannah River Site (SRS) for burial.
1972	Tritium effluent control project began. Nonweapons polonium work terminated.

Year	Activity
1973	Pu-238 oxide was processed for 4 multihundred watt (4.2 kg each) and 2 Viking sources (1.2 kg each)
1974	Thorium ore and sludge completely removed from site. Po-210 decontamination of Technical (T) Building completed.
1975	Pu-238 recovery operations terminated.
1977	Californium Multiplier Neutron Radiography Facility installed.
1989	Removal of soil contaminated with uranium near Building 34.
1990	Pu-238 decontamination of inactive laboratories in R Building.
1991	Removal of Pu-238-contaminated waste line connecting HH Building with WD Building.
1993	DOE decision to transfer defense mission from Mound. Pu-238 decontamination of PP Building 38 and Acid Leach Field (Area D).
1994	Demolition of SM Building structure contaminated with Pu-238.
1995	All weapon components production terminated.
1996	Demolition of SD Building (sanitary waste treatment facility) and Building 21 (thorium ore and sludge bulk storage facility) including excavation of contaminated soil. Miami-Erie Canal removal action (Pu-238 contaminated sediments) fieldwork begins in October.
1997	Removal of soil contaminated with Ac-227 at Area 7.
1998	Miami-Erie Canal removal action fieldwork completed; approximately 30,000 yd^3 removed for offsite disposal.
2003	All operations ceased.
2010	Remediation activities completed (DOE 2011).

a. Adapted from DOE 1993, DOE 1999, DOE 2011 and EPA 2003.

2.2.2 Buildings with Radionuclide Activity

The information in this section is from EG&G (1995) unless otherwise noted.

Figure 2-1 shows the Mound Laboratory site. The buildings of concern at the Mound Laboratory include HH, PP (also called Building 38), R, SM, SW, T, and WD/WDA. Supporting buildings that were not directly involved in research or production operations that are considered in this TBD evaluation include:

- Warehouses 9, 13, and 15; and
- Buildings 15, 21, 34, 50, 59, 68, B, E, H, I, M, P, RR, and SD.

HH Building
HH Building or Hydrolysis House derived its name from its primary function: the hydrolysis of highly radioactive bismuth chloride and aluminum chloride solutions. In 1963, the HH Building was converted to stable gaseous isotope separation using thermal diffusion, liquid diffusion, and cryogenic processes. Table 2-2 is a summary of the rooms, dates, and radionuclides for the HH Building. All dates represent the duration of actual use of radioisotopes in the projects.

PP Building (38)
The Plutonium Processing (PP) Building (38) was completed in December 1967. SM Building processes, fabrication operations, and recovery processes were transferred to PP Building along with waste treatment facilities, R&D including material research, and analytical laboratory support activities. PP Building was used primarily for processing ^{238}Pu dioxide from the Savannah River Site (SRS).

Plutonium dioxide was received in a powder form with the following isotopic mixture and a purity of 99.9% according to (EG&G 1995).

(1 ppm) – 1E-4% Pu-236	3.0% Pu-240
80.2% Pu-238	0.6% Pu-241

15.9% Pu-239 0.1% Pu-242

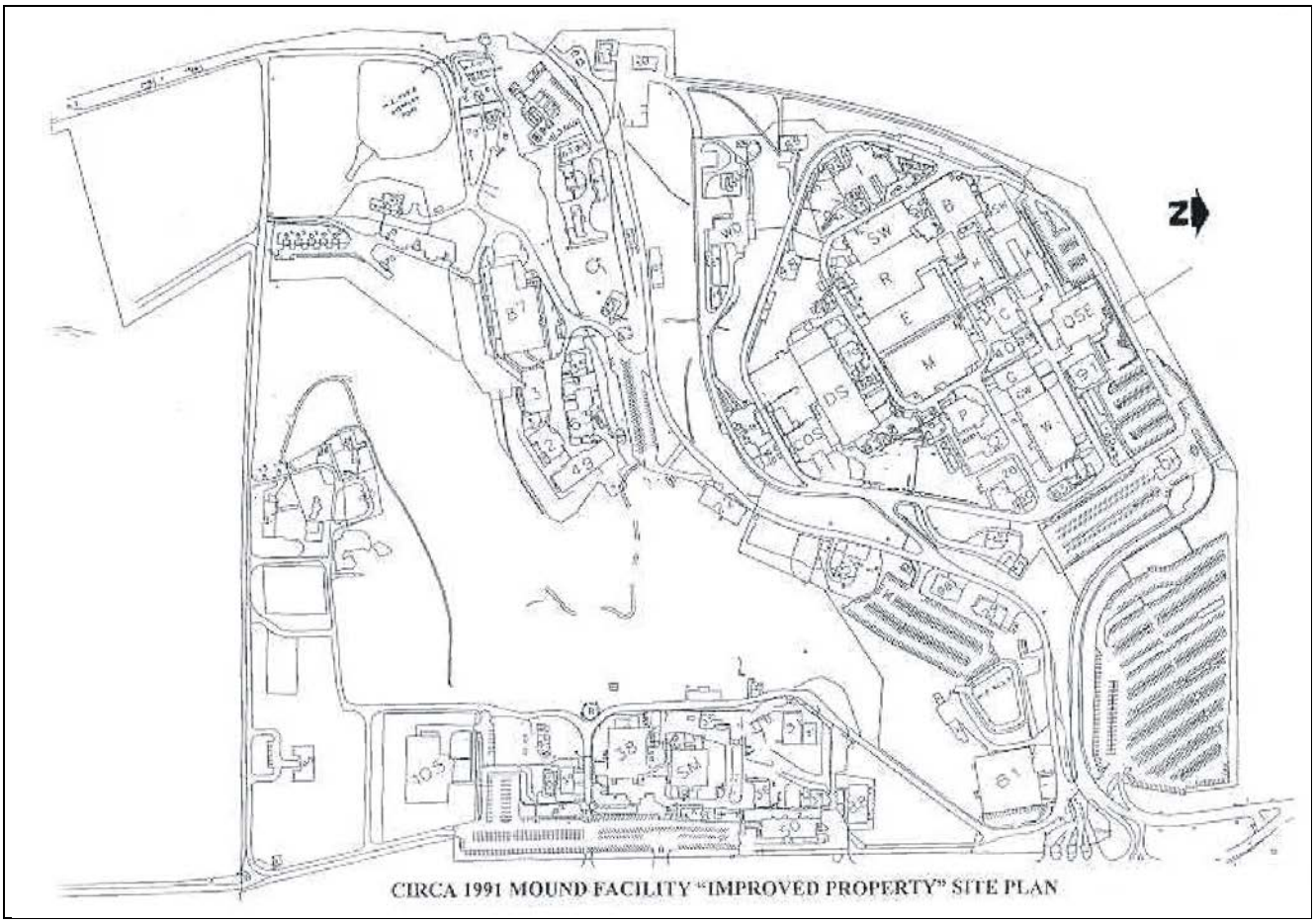

Figure 2-1. Mound (Unit V) site map.

Table 2-2. Radionuclides and related compounds for HH Building.

Rooms	Radionuclides and related compounds	Dates used
HH-3, 4	H-3	1960–1990
	Xe (all isotopes)	1964–1983
	Stable isotopes, Kr-85	1964–present
HH-5	Pa-231, Fe-59, Al-26, Ca-45, Co-60, Cu-65	1955–1956
	U-233, -234, -235, -238, Th-230, -232, Pa-231, Th-230, -232 progeny	1956
	H-3	1960–1990
	Xe (all isotopes)	1964–1983
	Stable isotopes, Kr-85	1964–present
HH-6	Pa-231, Fe-59, Al-26, Ca-45, Co-60, Cu-65	1955–1956
	U-233, -234, -235, -238, Th-230, -232, Th-230, -232 progeny	1956
HH-8	Ag-Po, Te-Po, $PoCl_2$, Po-208, -209, -210, Bi-209, -210, $Po(NO_3)_2$, Fe-55, -59, Si-31, Co-60, Pb-209, Sb-124, Sn-121, Zn-65, Cr-55, V-52, Te-121 to -134, Hg-203	1949–1958
	Kr-85, Xe (all radioisotopes)	1961–1963
HH-9	H-3	1965–1985
HH-10 to 12	Ag-Po, Te-Po, $PoCl_2$, Po-208, -209, -210, Bi-209, -210, $Po(NO_3)_2$, Fe-55, -59, Si-31, Co-60, Pb-209, Sb-124, Sn-121, Zn-65, Cr-55, V-52, Te-121 to 134, Hg-203	1949–1958
HH-119 to 122	H-3	1964–1980

Reference to ^{238}Pu in PP Building was a composite of the mixture identified above. This mixture included trace amounts of ^{241}Am, ^{237}Np, and ^{234}U. Dates represent the duration of radioisotope use in the projects.

Thorium-232 was often substituted for ^{238}Pu compounds for modeling purposes in R&D, because this isotope was less expensive and less hazardous, and had physical characteristics similar to ^{238}Pu. It is possible, therefore, to find ^{232}Th compounds identical to the ^{238}Pu compounds.

The term "high-fired," which is sometimes used, implies that the plutonium compound has been heated in a plasma torch process such that the lung solubility type is definitely S. The term "non-high-fired" implies an absence of such heating and, in extreme cases where indicated, a lung solubility type of M or even F might exist where there is high solubility.

Table 2-3 summarizes PP Building rooms, dates, and radioisotopes.

Table 2-3. Radionuclides and related compounds for Building PP (38).

Room	Radionuclides and related compounds[a]	Dates used
PP-CORR-5A	PuO_2	1967–1974
PP-6	PuO_2, $Pu(NO_3)_4$, $Pu(C_2O_4)_4$, $Pu(OH)_4$	1967–1980
PP-6W	PuO_2, $Pu(NO_3)_4$, $Pu(C_2O_4)_4$, $Pu(OH)_4$	1967–present
PP-CORR-10	PuO_2	1967–present
PP-13, 14	PuO_2, $Pu(NO_3)_4$, $Pu(C_2O_4)_4$, $Pu(OH)_4$	1967–1980
PP-CORR-15 to 17	PuO_2, $Pu(NO_3)_4$, $Pu(C_2O_4)_4$, $Pu(OH)_4$	1967 –1974
PP-18	PuO_2, $Pu(NO_3)_4$	1967–present
PP-24	PuO_2, $Pu(NO_3)_4$, $Pu(C_2O_4)_4$, $Pu(OH)_4$	1967–present
PP-100	PuO_2	1967–present
PP-113	Pu-(238,239)O_2 Varied orphaned sources	1957–1989 1988–present
PP-CORR-115	Pu-(238,239)O_2	1967–present
PP-127	PuO_2, $Pu(NO_3)_4$, $Pu(C_2O_4)_4$, $Pu(OH)_4$	1967–present
PP-CORR-134 to 136	PuO_2	1967–present
PP-CORR-140 to 142	PuO_2, $Pu(NO_3)_4$, $Pu(C_2O_4)_4$, $Pu(OH)_4$, Th-232, ThO_2, $Th(NO_3)_4$, $Th(C_2O_4)_4$, $Th(OH)_4$	1967–present
PP-143(A1)	PuO_2, $Pu(NO_3)_4$, $Pu(C_2O_4)_4$, $Pu(OH)_4$, Th-232, ThO_2, $Th(NO_3)_4$, $Th(C_2O_4)_4$, $Th(OH)_4$	1967–1980
PP-142(A2)	PuO_2, $Pu(NO_3)_4$, $Pu(C_2O_4)_4$, $Pu(OH)_4$, PuF_4, PuC, Th-232, ThO_2, $Th(NO_3)_4$, $Th(C_2O_4)_4$, $Th(OH)_4$, ThF_4	1967–1980
PP-145(A3)	PuO_2	1967–1982
PP-146(B1)	PuO_2, $Pu(NO_3)_4$, $Pu(C_2O_4)_4$, $Pu(OH)_4$, PuF_4, PuC	1967–1980
PP-147(B2), PP-148(B3)	PuO_2, $Pu(NO_3)_4$, $Pu(C_2O_4)_4$, $Pu(OH)_4$, PuF_4, PuC, Th-232, ThO_2, $Th(NO_3)_4$, $Th(C_2O_4)_4$, $Th(OH)_4$, ThF_4	1967–1980
PP-149(B4)	PuO_2	1967–1982
PP-150 to 156 (C1 to C3, D1 to D3)	PuO_2, $Pu(NO_3)_4$, $Pu(C_2O_4)_4$, $Pu(OH)_4$, PuF_4, PuC	1967–1980
PP-157(E1), 158(E2), 162, 163	PuO_2	1967–1980
PP-159(E3)	PuO_2, $Pu(NO_3)_4$, $Pu(OH)_4$, PuF_4	1967–1980

a. Plutonium-238 was the designated radioisotope in every room unless otherwise specified. Other isotopes of the mixture identified in the introduction along with small amounts of ^{241}Am, ^{237}Np, and ^{234}U. Thorium-232 was sometimes used as a stand-in for plutonium.

R Building

R (for Research) Building, which was built in 1948, has handled a number of programs involving a number of radionuclides over the years. Some of the major programs are discussed below, as are elemental radionuclides and radioisotopic compounds from those processes.

Beginning in the fall of 1948, R&D for the ^{210}Po program began. This was pilot-scale work for processing in T Building. R&D work with polonium extended into the 1970s.

Plutonium-238 research began in R Building in1959 and continued through the 1960s. The plutonium isotope concentration was the same as referenced in EG&G (1995) for the material Mound received from SRS.

R&D was conducted with tritium in the R Building. Experimentation with metal tritides and deuterides such as uranium tritide and lithium tritide occurred, as did developmental studies with tritiated water.

Some tritides and tritiated compounds were so poorly metabolized that their biological half-lives were on the order of hours. This was not true for uranium tritides.

Table 2-4 summarizes rooms, dates, and radioisotopes in R Building.

Table 2-4. Radionuclides and related compounds for R Building.

Rooms	Radionuclides and related compounds[a]	Dates used
R-117, 120, 127 to 131, 133, 143, 144, 151, 152, 155, 159, 160 to 162, 167	$AlCl_3$, $BiCl_4$, Ag-Po, Te-Po, $PoCl_2$, Po-210, Bi-210, $Po(NO_3)_2$, Fe-55, -59, Si-31, Co-60, Pb-209, Sb-124, Sn-121, Zn-65, Cr-55, V-52, Ga-70, -72, Cs-137, Sr-90, Se-75, Ag-112, Te-121-134, Hg-203	1948–1951
R-105, 106	H-3, HTO	1958–1965
	H-3, Li(D,T), U-238(D,T)	1965–1978
R-108	Po-208, -210, H-3,	1948–1965
	H-3, Li(D,T), U-238(D,T), Ti(D,T), other tritides (Type F, S)	1975–present
R-110	Po-208, -210	1955–1972
	H-3	1972–present
R-111	Ac-227, AcO_2, $Ac(NO_3)_4$, $Ac(C_2O_4)_4$, Ra-223, -224, -226, Th-228, -229, -239, Ac and Ra progeny Po-208, -210, H-3	1951–1965
R-112	H-3, Li(D,T), U-238(D,T), other tritides (Type F, S)	1973–1993
R-113 to 115	Ac-227, AcO_2, $Ac(NO_3)_4$, $Ac(C_2O_4)_4$, Ra-223, -224, -226, Th-228, -229, -239, Ac and Ra progeny	1951–1955
	Po-210, Pu-238, -239, Po/Be, PoF_2, Po/B, Pu/Be, PuF_2, Pu/B	1956–1961
	H-3	1978–present
R-116	Po-210, Pu-238, -239, Po/Be, PoF_2, Po/B, Pu/Be, PuF_2, Pu/B	1956–1961
	Pu-238, -239, PuBe, Am-241	1956–1962
	H-3, Li(D,T), U-238(D,T)	1960–1965
R-117	Pu-238, -239, Pu/Be, PuO_2, Pu-238/Zr, Pa-231, Po-210/Be, Th-230	1948–1990
R-118	Ac-227, AcO_2, $Ac(NO_3)_4$, $Ac(C_2O_4)_4$, Ra-223, -224, -226, Th-228, -229, -230, (Ac and Ra progeny)	1955
	U-234, -235, -238, Pa-231, Th-230, -232, and Th-232 progeny	1956–1958
R-119 to 121,123	Po-210, Bi-210, $AlCl_3$, $BiCl_3$, $Po(NO_3)_2$, $PoCl_2$, Po/Ag, Po/Te	1948–1951
	Ac-227, AcO_2, $Ac(NO_3)_4$, $Ac(C_2O_4)_4$, Ra-226, Th-228, -229, -230, AcF_4, AcI_4, Ac-227 progeny,	1951–1953
	Pa-231, Th-230, -232, and Th-232 progeny, U-234, -235, -238	1956–1958
	Pu-239, Am-241	1956–1962
	Pu-238, oxide, neutrons	1959–1962
	Pu-238, $Pu(NO_3)_4$, $Pu(NO_3)_6$, PuO_2, Pu-Cu, $Pu(C_2O_4)_4$, $Pu(O_2).5H_2O$, Pu(OH), PuF_4, $PuCl_4$, Pu-Se, Pu-Zr, H-3, Pu rare earths, Po alloys and compounds	1959–1979
R-127	Po-210, Bi-210, $AlCl_3$, $BiCl_3$, $Po(NO_3)_2$, $PoCl_2$, Po/Ag, Po/Te	1948–1951
	Fe-55, -59	1952–1954
	H-3	1956–1961
	PuO_2, PuF_4, Pu-$MoCl_4$, Pu-MoF_4	1965–1978
	H-3, Pu-239	1987–present

Rooms	Radionuclides and related compounds[a]	Dates used
R-128	Po-210, Bi-210, $Po(NO_3)_4$, $PoCl_2$, Po/Ag, Po/Te	1948–1954
	PuO_2, PuF_4, Pu-$MoCl_4$, Pu-MoF_4	1965–1978
	H-3, U(D,T)	1987–present
R-129,130	Po-210, Bi-210, $P(NO_3)_2$, $PoCl_2$, Po/Ag, Po/Te	1948–1951
	Ac-227, AcO_2, $Ac(NO_3)_4$, $Ac(C_2O_4)_4$, Ra-223, -224, -226, Th-228, -229, -230	1951–1953
	Pu-238, PuO_2, PuF_4, Pu-$MoCl_4$, Pu-MoF_4, $PuCl_4$ (Th-232 compounds replacing Pu-238 compounds for analytical studies)	1965–1978
	H-3, Pu rare earths, Po alloys and compounds	1990–present
R-131	Po-210, Bi-210, $Po(NO_3)_2$, $PoCl_2$, Po/Ag, Po/Te	1948–1951
	Pu-238, PuO_2, PuF_4, Pu-$MoCl_4$, Pu-MoF_4, $PuCl_4$, Cm-244	1965–1978
R-133	Po-210, Bi-210, $Po(NO_3)_2$, $PoCl_2$, Po/Ag, Po/Te	1948–1954
	Ac-227, AcO_2, $Ac(NO_3)_4$, $Ac(C_2O_4)_4$, Ra-226, Th-228, -229, -230, AcF_4, AcI_4, Ac-227 progeny	1951–1953
	Pa-231, U-234, -235, -238, Th-230, -232; also Th-230, -232 progeny	1956–1958
	Pu-238, PuO_2, PuF_4, Pu-$MoCl_4$, Pu-MoF_4, $PuCl_4$, Cm-244	1965–1978
R-134	H-2, U-238, U-238(D,T)	1986–present
R-137	Ac-227, AcO_2, $Ac(NO_3)_4$, $Ac(C_2O_4)_4$, Ra-226, Th-228, -229, -230, AcF_4, AcI_4, Ac-227 progeny	1951–1953
R-140	Th-228, -230, -232, U-234, -235, -238, Pu-238, -239, Po-208, -209, -210, Cs-137, Pa-231, Ac-227, Ra-223, -224, -226, Sr-90	1950–1969
	Pu-238, -239, -240, -241 (alloys, compounds, and mixtures), $Pu(NO_3)_2$, Ac-227, Am-241	1969–present
R-142	Ra-226, $Ra(CO_3)$, $Ra(NO_3)_2$, $RaBr_2$, Ac-227, $Ac(C_2O_4)_4$, AcF_2, K-40, $Ba(NO_3)_2$, Th-228, -229, -230, radon and progeny, Po-208, -209, -210	1949–1953
	Pu-238,239, U-234,235,238, Th-230, Pa-231, Th-230 progeny	1956–1969
	PuO_2, (for Pu-238,239)	1966–1979
R-143,144	Po-210, Bi-210, $AlCl_3$, $BiCl_3$, $Po(NO_3)_2$, $PoCl_2$, Po/Ag, Po/Te	1948–1951
	PuO_2, (for Pu-238, -239)	1972–1976
R-145,147	Ra-226, $Ra(CO_3)$, $Ba(CO_3)$, $Ac(NO_3)_2$, Ra/Ba, Ac-227, $Ac(C_2O_4)_4$, AcO_2, Th-228, -229, -230	1949–1954
	Fe-59, Al-26, Ca-45, Co-60, Pa-231, Cu-65	1955–1956
	Pu-239, Am-241	1956–1959
	Pu-238 oxide, neutrons	1960–1962
	Pu-238, -239, PuO_2, U-234, -235, -238	1968–1975
R-148,149	Ra-226, Ra(CO3), Ba(CO3), Ac(NO3)2, Ra/Ba, Ac-227, $Ac(C2O_4)_4$, AcO_2, Th-228, -229, -230, Po-208, Pa-231	1949–1954
	Fe-59, Al-26, Ca-45, Co-60, Pa-231, Cu-65, Pu-238	1954–1958
	Pu-238, $Pu(C_2O_4)4$, $Pu(NO_3)_4$, Th-230,	1960–1968
	PuO_2, Pm-146 to -149, $U(234)(NO_3)_4$, $U(234)O_2$, Pu/Zr	1970–1980
R-151	Po-210, Bi-210, $Po(NO_3)_2$, $PoCl_2$, Po/Ag, Po/Te	1948–1951
	Pu-238, -239, $Pu(NO_3)_4$, $Pu(NO_3)_6$, PuO_2, Pu(OH), $Pu(C_2O_4)_4$, $Pu(O_2).5H_2O$, $PuCl_4$, PuF_4, $Pu(SO_4)_2$, Np-237, and EDTA, citrates, and other substances acting like chelating agents were present	1958–1983
R-152	Po-210, Bi-210, $AlCl_3$, $BiCl_3$, $Po(NO_3)_2$, $PoCl_2$, Po/Ag, Po/Te	1948–1954
	Ac-227, AcO_2, $Ac(NO_3)_4$, $Ac(C_2O_4)_4$, Ra-226, Th-228,229,230, AcF_4, AcI_4	1951–1953
R-155	Po-210, Bi-210, $AlCl_3$, $BiCl_3$, $Po(NO_3)_2$, $PoCl_2$, Po/Ag, Po/Te	1948–1951
	U-235, -238, Pu-239, Np-237, Cm-244, Am-241, (the following were tried in combination with those listed: Ni-63, Co-60, Si-31, Z-65, Bi-210, Pb-210, Zr-95, Al-26 are rare-earth elements)	1956–1969
R-159	Po-210, Bi-210, $AlCl_3$, $BiCl_+$, $Po(NO_3)_2$, $PoCl_2$, Po/Ag, Po/Te	1948–1951

Rooms	Radionuclides and related compounds[a]	Dates used
	U-235, -238, Pu-239, Np-237, Cm-244, Am-241, (the following were tried in combination with those listed: Ni-63, Co-60, Si-31, Z-65, Bi-210, Pb-210, Zr-95, Al-26 are rare-earth elements)	1956–1969
R-160,161	Po-210, Bi-210, $AlCl_3$, $BiCl_3$, $Po(NO_3)_2$, $PoCl_2$, Po/Ag, Po/Te	1948–1951
	Ac-227, AcO_2, $Ac(NO_3)_4$, $Ac(C_2O_4)_4$, Ra-226, Th-228, -229, -230	1951–1953
R-162	Ru-106, Cs-137, Sb-125, Te-121,127, Zr-93,95, Nb-94, Sr-90, Pu-238, -239, Y-88, -90, -91, Ce-144 and other rare earths	1948–1951
	Pu-238, -239	1950
	U-233, -235, -238	1958–1959
R-166	Po-210	1961–1968
R-167	Ru-106, Cs-137, Sb-125, Te-121 to -134, Zr-93, -95, Nb-94, Sr-90, Pu-238, -239, Y-88, -90, -91, Ce-144 and other rare earths	1948–1951
	Pu-239, U-234, -235, -238, I-131, Cs-137, Ce-144, Sr-90, Tc-99, Xe-133, Y-88, -90, -91	1949–1952
	Fe-55, -59, Al-26, Ca-45, Co-60, Pa-231, Cu-65	1954–1955
	Pu-239, Ac-227, neutrons	1955–1957
	U-233, Th-229, -230, -232	1958
	Sr-90, Y-88, -90, -91, Pa-231	1960–1962
	Pa-231, -233, Ce-141, -144, Am-241, Cm-244, U-233, Th-230, -232, Ra-226, Ti-208	1956–1987
R-168	U-238, UF_4, UO_2	1958
R-169	Th-230, -232, U-234, -235, -238, Pu-238, -239, Po-208, -209, -210, Cs-137, Pa-231, Ac-227, Ra-223, -224, -226	1960–1980
	U-235, -238, Pm-147, Ca-45	1980–present
R-170	U-238, Ca-45	1960–1964
R-171,172	Ra-223, -224, -226, $Ac(NO_3)_2$, Ac-227, $Ac(C_2O_4)_4$, AcO_2, Th-228, -229, -230, Ac and Ra progeny	1949–1954
	U-235, -238	1961–1963
	Pu-238, -239, -240, -241 (compounds, alloys and mixtures), Am-241, Ac-227, Ra-226	1965–1991
R-175,176	H-3	1970–present
R-197A	Pu-238, -239, PuO_2, Cm-244	1970–present
R-198	Pu-238, -239, $Pu(NO_3)_4$, PuO_2, PuF_4, Np-237, Ac-227, Cm-244, H-3, Po-210, PoF_4, Li(D,T), U-234, -235, -238, U(D,T), Am-241, Pr-146 to -149	1956–1982
R Building crawl space	Pu-238, -239, Ra-226, Ac-227, Po-210, Th-228, -229, -230	1948–present
R-CORR-5	Ac-227	1948–1984

a. D = deuterium; EDTA = ethylene diamine tetraacetic acid; HTO = tritium oxide (water or water vapor); T = tritium.

SM Building

The Special Metallurgical (SM) Building was built in 1960 and became operational in 1961. It was designed for the reception of a liquid plutonium nitrate mixture from SRS that was used in a variety of programs, mainly heat source projects. In addition, SM Building housed recovery processing, waste treatment facilities, R&D, and analytical support activities. Table 2-5 summarizes SM Building rooms, dates, and radioisotopes.

Table 2-5. Radionuclides and related compounds for SM Building.

Room	Radionuclides and related compounds	Dates used
SM-1	$Pu(NO_3)_4$, PuO_2, $Pu(C_2O_4)_4$, $Pu(OH)_4$, PuF_4	1961–1962
	$Pu(NO_3)_4.5H_2O$, $Pu(NO_3)_6$, $PuO_2.XH_2O$, PuO_2, $Pu(C_2O_4)_4$, $PuO_2.5H_2O$, Pu(OH), $Th(NO_3)_4$, ThO_2, $Th(OH)_4$, $ThO_2.XH_2O$	1962–1967
SM-2	PuO_2	1961–1967
SM-3,10	$Pu(NO_3)_4$, PuO_2, $Pu(C_2O_4)_4$, Pu-238, neutrons	1961–1967
SM-20	Sealed sources	1961–1967
SM-21	PuO_2, Th-232 oxide (EDTA and citrates acted like chelating agents)	1961–1967

Room	Radionuclides and related compounds	Dates used
SM-26	$Pu(NO_3)_4$, PuO_2, $Pu(C_2O_4)_4$, $Pu(OH)_4$, PuF_4	1961–1967
SM-27,28	$Pu(NO_3)_4.5H_2O$, $Pu(NO_3)_6$, PuO_2, $Pu(C_2O_4)_4$, $PuO_2.5H_2O$, Pu(OH), PuF_4, $PuCl_4$	1961–1965
	$Pu(NO_3)_4$, $Pu(NO_3)_4.5H_2O$, PuO_2, $PuO_2.X\ H_2O$, $Pu(C_2O_4)_4$, Pu(OH)	1965–1967
SM-34	$Pu(NO_3)_4.5H_2O$, PuO_2, $Pu(SO_4)_2$, PuF_4, $Am(NO_3)_4$, AmO_2, $Am(SO_4)_2$, AmF_4, $Np(NO_3)_4$, UO_2, $U(SO_4)_2$, UF_4	1963–1967
SM-35,35A	$Pu(NO_3)_4.5H_2O$, $Pu(NO_3)_6$, PuO_2, $Pu(C_2O_4)_4$, $Pu(O_2).5H_2O$, $Pu(OH)_4$, PuF_4, $PuCl_4$	1961–1965
	$Pu(NO_3)_4$, $Pu(NO_3)_4.5H_2O$, PuO_2, $PuO_2.X\ H_2O$, $Pu(C_2O_4)_4$, $Pu(OH)_4$	1965–1967
SM-38 (SM-I)	$Pu(NO_3)_4$, PuO_2, $Pu(SO_4)_2$, PuF_4, $Am(NO_3)_4$, AmO_2, $Am(SO_4)_2$, AmF_4, $Np(NO_3)_4$, NpO_2, $Np(SO_4)_2$, NpF_4	1963–1967
	$Np(NO_3)_4$, UO_2, $U(SO_4)_2$, UF_4, $Pu(NO_3)_4.5H_2O$, $Pu(NO_3)_6$, PuO_2, $Pu(C_2O_4)_4$, PuO_2	1965–1970
SM-39	$Pu(NO_3)_4.5H_2O$, $Pu(NO_3)_6$, PuO_2, $Pu(C_2O_4)_4$, $PuO_2.5\ H_2O$, $Pu(OH)_4$, PuF_4, $PuCl_4$	1961–1965
	$Pu(NO_3)_4$, $Pu(NO_3)_4.5H_2O$, PuO_2, $PuO_2.X\ H_2O$, $Pu(C_2O_4)_4$, $Pu(OH)_4$	1965–1967
SM-58, 59 (A&B)	$Pu(NO_3)_4$, PuO_2, $Pu(SO_4)_2$, PuF_4, $Am(NO_3)_4$, AmF_4, AmO_2, $Am(SO_4)_2$, $Np(NO_3)_4$, NpO_2, $Np(SO_4)_2$, NpF_4, $U(NO_3)_4$, UO_2, $U(SO_4)_2$, UF_4	1963–1967
SM-60	PuO_2	1965–1967
SM-61,62	PuO_2, Th-232 (EDTA and citrates acted like chelating agents)	1961–1967

SW Building

The SW (Semi-Works) Building is similar to R Building in that it consists of many laboratories engaged in a variety of R&D, analytical, recovery, and surveillance activities. The Old Cave and New Cave areas consisted of several rooms that were set up for "hot" work with several types of alpha and gamma radiation and project capabilities. Other major programs were the thorium refinery project, rare isotope program, and the neutron source, ^{234}U separation, and the tritium programs. The tritium programs include the enrichment, effluent capture, process development, component evaluation, scrap recovery, and waste solidification.

SW Building was used in the Cotter Concentrate (St. Louis Airport Cake) program starting in the early 1970s and terminated late in that decade. Pilot plant operations in SW were to recover Th-230 and Pa-231. Table 2-6 lists the approximate composition of Cotter Concentrate.

Table 2-6. Cotter Concentrate composition.[a]

Component	Grams per drum
Uranium oxide	21,740
Th-232	99.9
Pa-231	0.060
Th-230	11.1

a. 47% average moisture content.

The Old Cave was built in the early 1950s and occupied approximately 1,000-ft^2 area in the Semi-Works (SW) Building. Radium-226 and ^{227}Ac were processed from 1951 to 1955 in this area. This process could result in possible contamination that required decontamination efforts at various times during operations. From 1955 until 1959, decontamination and decommissioning (D&D) activities occurred in the Old Cave as manpower and budgets permitted. The cave structure was removed, including the exhaust systems. In March 1959, the Old Cave was cleaned and decontaminated.

SW-19 was the Old Cave, where radium-actinium separation and processing was conducted. The area was originally drained by a concrete channel and sumps but later filled with several feet of gravel and concrete due to high concentrations of radium and radon. By 1957, the area was filled over with

additional concrete for radiation protection purposes. SW-19 had a history of elevated radon concentrations that were reduced by ventilation of the underground tunnel in 1980. NIOSH is unable to put an upper bound on the radon exposures in SW-19 until the point at which a ventilation system was installed in early 1980 (before March 5, 1980) to vent SW Building tunnel air. The lack of sufficient information to bound the dose from radon and its progeny formed the basis for the SEC class definition in SEC-00171.

SW-22 was the New Cave and had few radon problems.

The radionuclides and their respective compounds that were present in SW-1A cave (EG&G 1995) include:

Radium-226	Radium carbonate
Actinium-227	Radium nitrate
Radium bromide	Actinium oxalate
Actinium bromide	Potassium-40
Radon and progeny	Thorium-228, -229, -230

Table 2-7 summarizes rooms, dates, and radioisotopes for SW Building.

Table 2-7. Radionuclides and related compounds for SW Building.

Room	Radionuclides and related compounds[a]	Dates used
SW-2	H-3	1973–present
SW-8	H-3, tritides(Li, Ba, Ti, Ca, U-238, others), U-235	1957–present
	Xe (all isotopes)	1957–1960
	U(238)(D,T), Li(D,T), Ba(D,T), Ti(D,T)	1960–1985
SW-9	H-3, tritides (Type F, S),	1965–present
	U(D,T), Li(D,T), U/Al(D,T), other tritides (Type F, S)	1989–present
SW-10	H-3	1967–1972
SW-11 to 16	Ru-106, Cs-137, Sb-125, Te-121,127, Zr-93, -95, Nb-94, Sr-90, Pu-238, -239, Y-88, -90, -91, rare earths (especially Ce)	1951–1953
	Th-228, -232, U-238, Ra-224, -228, Th-232 progeny	1955
	Fe-55, -59, Al-26, Ca-45, Co-60, Pa-231, Cu-65	1956
	H-3, Li tritide	1959–1965
	H-3, U(D,T), Li(D,T), LiO(D,T), U-238, U-235, sOBT, other tritides (Type F)	1959–1978
	H-3, U-238, U tritide	1964–1974
	H-3, U(D,T), U-238, Pu-239, other tritides (type F, S)	1968–present
	H-3, tritides (type S)	1964–1975
	H-3 oxide	1975–1985
	H-3, U-238, sOBT, tritides (Type F)	1975–1978
SW-19 (Old Cave)	Ra-226, $Ra(CO_3)$, $Ra(NO_3)_2$, $RaBr_2$, Ac-227, $Ac(C_2O_4)_4$, AcF_4, K-40, Th-228, -229, -230, Rn-219, -220,- 222 and progeny	1951–1953
	H-3, Pu-239, U-238, U-235, tritides (Type F, S), Rn-222 and progeny	1962–1988
	H-3, Pu-239, U-238, tritides (Type F) Ra progeny	1973–present
SW-20, 21	H-3	1961–1973
SW-22 (New Cave and Laboratory Area)	U-232, -233, Th-228, -229, Ra-224, -225, Ac-225, Fr-221, At-217, Th-228 progeny	1966–1975
	Th-230, -232, U-234, -235, -238, Pa-231, Ac-227, Ra-223, -224, -226, $Ac(NO_3)$, AcO2.	1970–1979
	Po-208, -209, -210, Po-210 progeny	1976–1979
	Pu-238, Pu-239, U-233 (type F, M)	1984–1986
SW -128 to 130, 134	Th-230, -232, U- -234, -235, -238, Pa-231, Ac-227, Ra-223, -224, -226	1970–1979

Room	Radionuclides and related compounds[a]	Dates used
SW-132	Th-230, -232, U-234, -235, -238, Pa-231, Ac-227, Ra-223, -224, -226, $Ac(NO_3)$, AcO_2	1970–1979
	Po-208, -209, -210, Po-210 progeny	1976–1979
SW-136, 137	Th-230, -232, U-234, -235, -238, Pa-231, Ac-227, Ra-223, -224, -226, $Ac(NO_3)$, AcO_2	1964–1979
SW-140	Ac-227, $Ac(NO_3)_2$, AcO_2	1964–1968
	Th-230, -232, U-234, -235, -238, Pa-231, Ac-227, $Ac(NO_3)$, AcO_2, Ra-223, -224, -226	1974–1979
	Po-208, -209, -210, Po-210 progeny	1976–1979
SW-142	Ra-226, $Ra(CO_3)$, $Ra(NO_3)_2$, $RaBr_2$, Ac-227, $Ac(C_2O_4)_4$, AcF_2, K-40, Th-228, -229, -230, Po-208, -209, -210, radon and progeny	1950–1961
	H-3, Li tritide	1959–1969
	H-3, U-238, U(D,T), Pu-239, other tritides (Type F, S), U-233	1969–1985
SW-146, 147	H-3, U-238, U(D,T)	1967–1985
	Tritiated stainless steel	1985–present
SW-149, 149A	All radionuclides in SW Building	1965–1968
	H-3, HTO, tritiated organics	1969–present
SW-150, 152	H-3, U-238(D,T), other tritides (Type F, S)	1968–present
	H-3, U-238 tritides (Type F, S)	1973–present
SW-200	H-3	1958–present
SW-202	Po-210	1958–1962
	H-3	1963–present
SW-205	H-3	1958–present
SW-208	H-3, U-238(D,T), Pu-239, other tritides (Type F)	1965–present
SW-210	H-3, U-238(D,T), Pu-239, other tritides (Type F)	1968–1989
SW-219	Pu-238/Be, Pu-239/Be, Am-241, Pu-239	1962–1965
	Po-210, Pu-238, -239	1966–1971
	H-3	1968–1978
	H-3, U-238(D,T), tritides (Type F, S)	1968–1980
	H-3, U-238(D,T), tritides (Type F)	1985–present
SW-231	H-3, HTO	1970–present
SW-238, 240	H-3, U-238(D,T), U-238, U-235, natural U, other tritides (Type F, S)	1968–present

a. sOBT = physiologically soluble, organically bound tritium.

T Building

T (Technical) Building was host to a number of R&D and production programs with various radioisotopes. The two major programs were the polonium and tritium programs. From 1949 to 1973, ^{210}Po programs included processing and separation, fuels R&D, neutron source, and other R&D and production programs. This work was performed on the first and second floors of T Building.

An extensive renovation program from 1966 to 1968 prepared the way for additional R&D work, but the renovations were never used due to unanticipated funding reductions. T Building was essentially dormant from 1969 to 1972 due to this loss of funding. Tritium programs resumed in the 1970s.

Other activities in T Building included nondestructive testing, environmental testing, gamma and mass spectroscopy, calorimetry, neutron activation analysis, and safeguards R&D. Table 2-8 summarizes T Building rooms, dates, and radioisotopes.

Table 2-8. Radionuclides and related compounds for T Building.

Room	Radionuclides and related compounds	Dates used
T-1W, 2W, 4E	Pu-238, -239, U-233,- 235, -238, H-3	1965–1987
T-5W	H-3, HTO	1956–1962
		1975–1982
T-5E	Pu-238, -239, H-3, Co-60, Ir-192, Fe-55, -59, Ra-226, Am-241,	1955–present

Room	Radionuclides and related compounds	Dates used
	Cd-109	
T-8	Po-210	1949–1965
T-9, 9A	H-3, Pu-238 (encapsulated)	1987–present
T-13	Po-210	1949–1953
T-15B, 18	Neutron generator, neutron activation on surfaces	1963–present
T-16A	H-3, tritiated organics	1984–present
T-19, 19A	Pu-238, -239, H-3, Co-60, Ir-192, Fe-55, Ra-226, Am-241, Cd-109; all were encapsulated	1985–present
	H-3, tritiated organics	1985–present
T-20	No radioactive work performed	1985–present
T-22	Ag-Po, Te-Po, $PoCl_2$, Po-208, -209, -210, Bi-210, $Po(NO_3)_2$, Fe-55, -59, Si-31, Co-60, Pb-209, Sb-124, Sn-121, Z-65, Cr-55, V-52, Ga-70,72, Cs-137, Sr-90, Se-75, Ag-112, Te-121 -134, Hg-203	1949–1969
	Pu-238, -239	1979–present
T-25 to 27	Ag-Po, Te-Po, $PoCl_2$, Po-208, -209, -210, Bi-210, $Po(NO_3)_2$, Fe-55, -59, Si-31, Co-60, Pb-209, Sb-124, Sn-121, Zn-65, Cr-55, V-52, Ga-70,72, Cs-137, Sr-90, Se-75, Ag-112, Te-121-134, Hg-203	1949–1969
	Pu-238,239 (encapsulated)	1979–present
T-28 to 35	Ag-Po, Te-Po, $PoCl_2$, Po-208, -209, -210, Bi-210, $Po(NO_3)_2$, Fe-55, -59, Si-31, Co-60, Pb-209, Sb-124, Sn-121, Zn-65, Cr-55, V-52, Ga-70, -72, Cs-137, Sr-90, Se-75, Ag-112, Te-121-134, Hg-203	1949–1969
T-36, 36A	Ag-Po, Te-Po, $PoCl_2$, Po-208, -209, -210, Bi-210, $Po(NO_3)_2$, Fe-55, -59, Si-31, Co-60, Pb-209, Sb-124, Sn-121, Zn-65, Cr-55, V-52, Ga-70, -72, Cs-137, Sr-90, Se-75, Ag-112, Te-121-134, Hg-203	1949–1969
	Classified	1985–present
T-37	H-3, U-238(D,T), Pu-238 (encapsulated), tritiated organics	1985–present
T-40	H-3, Pu-238 (encapsulated)	1985–present
T-41	H-3	1985–present
T-46	Po-210	1949–1969
T-48 to 50	H-3, U-238, tritides (Type F, S)	1983–present
T-53 to 55, 55A	Ag-Po, Te-Po, $PoCl_2$, Po-208, -209, -210, Bi-210, $Po(NO_3)_2$, Fe-55, -59, Si-31, Co-60, Pb-209, Sb-124, Sn-121, Zn-65, Cr-55, V-52, Ga-70, -72, Cs-137, Sr-90, Se-75, Ag-112, Te-121-134, Hg-203	1949–1969
T-57	Ag-Po, Te-Po, $PoCl_2$, Po-208, -209, -210, Bi-210, $Po(NO_3)_2$, Fe-55, -59, Si-31, Co-60, Pb-209, Sb-124, Sn-121, Zn-65, Cr-55, V-52, Ga-70, -72, Cs-137, Sr-90, Se-75, Ag-112, Te-121-134, Hg-203	1949–1971
	H-3	1985–present
T-58	H-3	1985–present
T-59	Ag-Po, Te-Po, $PoCl_2$, Po-208, -209, -210, Bi-210, $Po(NO_3)_2$, Fe-55, -59, Si-31, Co-60, Pb-209, Sb-124, Sn-121, Zn-65, Cr-55, V-52, Ga-70, -72, Cs-137, Sr-90, Se-75, Ag-112, Te-121-134, Hg-203	1949–1969
	H-3, U(D,T)	1985–present
T-61, 61A	Po-210, Pu-238, -239	1960–1963
	Po-210	1964–1966
	H-3, U(D,T)	1973–present
T-63	H-3, HTO	1973–present
T-72 to 75, 92, 93, 96 to 98	Ag-Po, Te-Po, $PoCl_2$, Po-208, -209, -210, Bi-210, $Po(NO_3)_2$, Fe-55, -59, Si-31, Co-60, Pb-209, Sb-124, Sn-121, Zn-65, Cr-55, V-52, Ga-70, -72, Cs-137, Sr-90, Se-75, Ag-112, Te-121-134, Hg-203	1949–1969
T-99	$AlCl_3$, $BiCl_4$, Ag-Po, Te-Po, $PoCl_2$, Po-210, Bi-210, $Po(NO_3)_2$, Fe-55, -59, Si-31, Co-60, Pb-209, Sb-124, Sn-121, Zn-65, Cr-55, V-52, Ga-70, -72, Cs-137, Sr-90, Se-75, Ag-112, Te-121-134, Hg-203	1947–1969
	H-3	1984–present

Room	Radionuclides and related compounds	Dates used
T-100 to 104	Ag-Po, Te-Po, $PoCl_2$, Po-208, -209, -210, Bi-210, $Po(NO_3)_2$, Fe-55, -59, Si-31, Co-60, Pb-209, Sb-124, Sn-121, Zn-65, Cr-55, V-52, Ga-70, -72, Cs-137, Sr-90, Se-75, Ag-112, Te-121-134, Hg-203	1949–1969
	H-3	1972–present
T-208A	Pu-238, -239, H-3, Co-60, Ir-192, Fe-55, Ra-226, Am-241, Cd-109, Po-210; all were encapsulated	1947–present
T-229	Po-210, Pu-238, -239	1963–1964
	Rn-222, Po-210,214,218, Bi-210, Pb-210,214	1978–1988
	Pu-238, -239 (encapsulated)	1989–present
T-234	H-3, U-238 tritides, other tritides (Type F)	1988–present
T-236	Ag-Po, Te-Po, $PoCl_2$, Po-208, -209, -210, Bi-210, $Po(NO_3)_2$, Fe-55, -59, Si-31, Co-60, Pb-209, Sb-124, Sn-121, Zn-65, Cr-55, V-52, Ga-70, -72, Cs-137, Sr-90, Se-75, Ag-112, Te-121-134, Hg-203	1949–1973
	H-3, U-235, -238, -239, Pu-238, -239 (Pu was encapsulated)	1985–present
T-237	Ag-Po, Te-Po, $PoCl_2$, Po-208, -209, -210, Bi-210, $Po(NO_3)_2$, Fe-55, -59, Si-31, Co-60, Pb-209, Sb-124, Sn-121, Zn-65, Cr-55, V-52, Ga-70, -72, Cs-137, Sr-90, Se-75, Ag-112, Te-121-134, Hg-203	1949–1971
	H-3, Pu-238, -239 (Pu was encapsulated)	1985–present
T-238	H-3, Pu-238, -239 (Pu was encapsulated)	1985–present
T-242	Po-210	1949–1964
T-243	H-3, HTO	1956–1982
T-245	Po-210	1949–1969
	Pu-238 (encapsulated)	1968–1974
T-246	H-3	1972–1980
T-247	Po-210, classified	1949–1958
	Po-208, -209, -210, rare-earth polonides, Pm-147	1966–1969
T-248 to 259	Po-210, neutrons	1949–1965
	Room T-257 only, orphan sources	1993–present
T-260	Po-210	1949–1969
	Po-208, -209, -210, rare-earth polonides, Pm-147	1966–1969
T-266, 267	Po-210, Bi-209, -210	1949–1969
	Po-208, -209, -210, rare-earth polonides, Pm-147	1963–1966
	H-3, U-238(D,T), other tritides (Type F)	1988–present
T-270	Po-210, Bi-209, -210	1949–1963
T-274	External dose only	1948–1971
	Po-210, Bi-210, Fe-55, -59, Si-31, Co-60, Pb-209, Sb-124, Sn-121, Zn-65, Cr-55, V-52, Ga-70, -72, Cs-137, Sr-90, Se-75, Ag-112, Te-121 -134, Hg-203	1966–1969
	H-3, U-238(D,T)	1986–present
T-275, 276	$AlCl_3$, $BiCl_4$, Ag-Po, Te-Po, $PoCl_2$, Po-210, Bi-210, $Po(NO_3)_2$, Fe-55, -59, Si-31, Co-60, Pb-209, Sb-124, Sn-121, Zn-65, Cr-55, V-52, Ga-70, -72, Cs-137, Sr-90, Se-75, Ag-112, Te-121-134, Hg-203	1949–1969
T-277, 279	Am-241, Pu-239, neutrons	1949–1964
	Po-210	1949–1969
	Bi-209, -210	1964–1969
T-300A	Orphan sources, sources left in containers	
T-307	Po-210	1949–1964
	H-3	1972–present
T-310	$AlCl_3$, $BiCl_4$, Ag-Po, Te-Po, $PoCl_2$, Po-210, Bi-210, $Po(NO_3)_2$, Fe-55, -59, Si-31, Co-60, Pb-209, Sb-124, Sn-121, Zn-65, Cr-55, V-52, Ga-70, -72, Cs-137, Sr-90, Se-75, Ag-112, Te-121-134, Hg-203	1949–1969
	Pu-238, -239, -240, -241, Pm-147, U-233, -235, Am-241, H-3	1969–1983
	Pu-238, -239 (encapsulated)	1986–present
T-311	Po-210	1949–1969
	Pu-238, -239 (encapsulated)	1986–present

Room	Radionuclides and related compounds	Dates used
T-319	Pu-238, -239, -240, -241, Pm-147, U-233, -235, Am-241, H-3, HTO	1949–present

WD and WDA Buildings

WD Building, which became operational in February 1949, is the central facility at Mound for the treatment of radioactive liquid wastes. From its inception, this facility included a low-level alpha wastewater system, with SW, R, PP, SM, HH, T, B, and H Buildings as sources. On arriving at WD Building, wastewater was precipitated, coagulated, and filtered, and the sludge is solidified so it can be shipped off the site. The supernatant from the clarifloculator is filtered, neutralized to the proper pH, monitored to see if below standard, and released to the Great Miami River.

The WDA Building alpha wastewater treatment facility was built in 1966 as an annex to WB Building for the treatment of plutonium wastewater from the PP and SM Buildings. It was designed as both a high-risk drumming station and a low-risk wastewater treatment facility. Table 2-9 summarizes rooms, dates, and radioisotopes for WD and WDA Buildings.

Table 2-9. Radionuclides and related compounds for WD and WDA Buildings.

Room	Radionuclides and related compounds	Dates used
WD-1, 8, 101, 104	Ag-Po, Te-Po, $PoCl_2$, Bi-210, $Po(NO_3)_2$, Si-31, Sb-124, Sn-121, Zn-65, Cr-55, V-52, Ga-70, –72, Se-75, Ag-112, Hg-203	1949–1958
	Am-241, Ac-227, Ra-223, -226, $Ac(C_2O_4)_4$, Th-228, -229, -230, U-234, -235, -238, Pu-238, -239, Po-208, -209, -210, Cs-137, Pa-231, AcO_2, $Ac(NO_3)_2$, $AcBr_4$, AcF_4, K-40, $Ba(NO_3)_2$, Np-237, H-3, rare-earth isotopes, tritiated octane, Co-60, Sr-90, Fe-55, -59, Te-121 to -134, UO_2	1949–1990
	Th-228, -232, Ra-224, -228, U-238	1955
	Pu-236, -238, -239, -240, -241, -242, $Pu(NO_3)_4$, PuO_2, $Pu(SO_4)_2$, $Pu(OH)_4$, PuF_4 (also nitrate, sulfate, oxide, and fluoride compounds of Am-241, Np-237, U-234)	1961–1974
	Th-230, -232, U-234, -235, -238, Pu-238, -239, Pa-231, Ac-227, Ra-223, -224, -226	1974–1979
WD-9	H-3, U-239(D,T), U-235, -238, -239, Pu-238, -239, Am-241, Rn-222, Po-208, -209, -210 Po-210 progeny, Bi-210, -214, Pb-210, -214, Ra-223, -224, -226 Ra progeny, U(D,T), Li(D,T), U/Al(D,T)	1973–present
WD-10	Pu-236, -238, -239, -240, -241, -242, $Pu(NO_3)_4$, PuO_2, $Pu(SO_4)_2$, $Pu(OH)_4$, PuF_4 (also nitrate, sulfate, oxide, and fluoride compounds of Am-241, Np-237, U-234)	1961–1974
WD-107	Cs-137, Am-241, Np-237, U-235,238	1976–1981
WD-108	Pu-236, -238, -239, -240, -241, -242, $Pu(NO_3)_4$, PuO_2, $Pu(SO_4)_2$, $Pu(OH)_4$, PuF_4 (also nitrate, sulfate, oxide, and fluoride compounds of Am-241, Np-237, U-234)	1949–1981
WDA-110	Pu-236, -238, -239, -240, -241, -242, $Pu(NO_3)_4.5H_2O$, $Pu(NO_3)_6$, PuO_2, $Pu(C_2O_4)_4$, $Pu(O_2).5H_2O$, $Pu(OH)_4$, PuF_4 (also nitrate, sulfate, oxide, fluoride compounds of Am-241, Np-237, U-234)	1966–1970
	H-3	1967–present
WDA-112	Pu-236, -238, -239, -240, -241, -242, $Pu(NO_3)_4.5H_2O$, $Pu(NO_3)_6$, PuO_2, $Pu(C_2O_4)_4$, $Pu(O_2).5H_2O$, $Pu(OH)_4$, PuF_4 (also nitrate, sulfate, oxide, fluoride compounds of Am-241, Np-237, U-234)	1966–1979
	Cs-137	1980–1984
WDA-113	Cs-137, Co-60, I-131, Pu-238, -239	1979–1994
WDA-118A	Co-60, Cs-137, I-131, Sr-90	1977–1981
WDA-118B	Pu-238, -239, H-3	1975–1985
	Co-60, Cs-137, Mn-54, Sr-90	1981–present
WD-penthouse	Th-230, -232, U-234, -235, -238, Pu-238, -239, Pa-231, Ac-227,	1949–present

	Ra-223, -224, -226, -228, Co-60, Cs-137, Np-237, Sr-90, Po-208, -209, -210, Am-241, H-3, Te-121-134, Fe-55, -59	

Warehouse 9 (1953)
All of the drums stored in Warehouse 13 from the plutonium-uranium extraction (PUREX)/bismuth phosphate materials decontamination were moved to Warehouse 9 in preparation for shipment off the site. The following radionuclides (as well as their compounds) are of equal concern:

Antimony-125	Ruthenium-106
Cesium-137	Strontium-90
Niobium-94	Tellurium-121 and -127
Plutonium-238 and -239	Yttrium-88, -90, and -91
Rare earths (especially cerium)	Zirconium-93 and -95

Warehouse 13 (1953)
This warehouse was used for the storage and shipment of several drums of sludge from the PUREX/bismuth phosphate decontamination program. The settling and mixing tanks were also taken there. The following radionuclides (as well as their compounds) are of equal concern:

Antimony-125	Ruthenium-106
Cesium-137	Strontium-90
Niobium-94	Tellurium-121 and -127
Plutonium-238 and -239	Yttrium-88, -90, and -91
Rare earths (especially cerium)	Zirconium-93, -95

This warehouse was also used for temporary storage for drums of low-level contamination from the $^{226}Ra/^{227}Ac$ decontamination operations. Radioisotopes of concern and their compounds are:

Actinium fluoride	Radium nitrate
Actinium oxalate	Radium-226
Actinium-227	Radon and progeny
Barium nitrate	Thorium-228
Potassium-40	Thorium-229
Radium bromide	Thorium-230
Radium carbonate	

Actinium-227 is the major radionuclide of concern. Radium-226 and ^{228}Th are of nearly equal concern, and ^{208}Po, ^{209}Po, and ^{210}Po are of much less concern. The remaining isotopes are of small concern.

Warehouse 15 (1955 to 1961)
This warehouse stored 1,650 t of the ^{232}Th refinery program (Monex) sludge. It was highly corrosive and continually leaked through the barrels causing much contamination. More than 34 isotopes were identified from the feedstock of this program with most being nonradioactive. Radioisotopes of concern and their compounds are:

- Radium-228 and -224
- Thorium-232 progeny (especially thallium-208)
- Thorium-232 and -228
- Uranium-238

Thorium-228 and -232 and ^{224}Ra are equal as major radionuclides of concern. Uranium-238 is a secondary concern. However, when considering the quantity or mass of radionuclides, and not activity, 99% are ^{232}Th.

Building 21
This building was constructed in 1964 for bulk storage of thorium ores and sludge from the old Monex project, a ^{232}Th refinery program. It was originally designed like a silo with no doors or windows; oxalate sludge was stored in one side and hydroxide sludge in the other. Until 1973 at least 117 55-gal leaky drums remained outside the building. Contamination of the surrounding grounds occurred from fugitive dust from the dumping of this sludge into this silo. From October 1974 to July 1975, the sludge was repackaged in 55-gal drums and shipped off the site. Radionuclide contents of the sludge were primarily thorium isotopes, rare-earth isotopes, uranium, and others.

A total of 1,252 55-gal drums of Cotter Concentrate were stored in Building 21 from 1975 until 1987 when they were shipped off the site. This concentrate contained significant quantities of the following, which are radionuclides of concern:

- Actinium nitrate
- Actinium oxide
- Actinium-227
- Protactinium-231
- Radium-223, -224, and -226
- Thorium-230 and-232
- Uranium-234, -235, and -238

Thorium-230 was the major radionuclide of concern with more than 95% of the activity.

Fourteen elements beside the isotopes listed above are in the Cotter Concentrate. There is no indication that these 14 elements are radioactive.

The surrounding grounds served as storage for ^{238}Pu waste packages in 1967. There was leakage of the plutonium waste packages. The area around Building 21 was contaminated because of the leakage of the Monex sludge drums, the debris from dumping sludge through the roof, and repackaging into drums.

Building 34
This building has a dual purpose: it was a drop test area for waste packages and an area for simulation of pyrophoric metal training for the firefighters. The empty low specific activity (LSA) containers were dropped in various ways to test and ensure their structural integrity. Similar tests were done on drums.

Depleted uranium and metal shavings of various types were used in firefighting practice to simulate pyrophoric situations. Radioisotopes of concern include ^{238}U oxide.

Building 50
Building 50 is designated as the assembly and testing building for RTGs. In Building 50, RTGs are assembled in an inert atmosphere. All plutonium used as the heat source is encapsulated, which gives little probability for a radionuclide release. External dose is still possible from gamma and neutron flux.

A testing program is associated with the RTG program. Approximately 20 tests (vibration, space simulation, extreme heat, extreme cold, shock, vacuum performance, etc.) are done on the RTG module.

Building 59
This building contains a subcritical assembly, which has the ability to produce fission products. However, all fission products were sealed in aluminum containers, so the probability of contamination is remote. The water surrounding the containers inside the assembly is constantly monitored and contamination has been observed.

Californium-252 and enriched uranium were used for irradiation. These radioisotopes were encapsulated in metal cladding, so there is no concern for internal dosimetry. Some intentional irradiation is done, with the major contaminants being ^{55}Fe, ^{59}Fe, and ^{60}Co. Radionuclides of concern are:

- Californium-252
- Cobalt-60
- Iron-55 and -59
- Uranium-234, -235, and -238

The historical radionuclides of major concern were ^{252}Cf and ^{235}U, equally. This building has not been operational since 1990 and is not likely to operate again. In the future, radionuclides of concern will be ^{235}U and ^{59}Fe in the form of rust during building demolition.

Building 68
This building functions as a D&D staging area and handles the radionuclide waste from R Building.

A corollary activity of this area is to perform testing on empty LSA containers. These are dropped in various ways to test and ensure their structural integrity. Similar tests are also done on drums. Radioisotopes of concern are ^{238}Pu oxide and ^{239}Pu oxide.

B Building
From around 1950 to about 1955, this building was used for biological research of the effects of ^{210}Po, ^{227}Ac, and other alpha emitters on animals. The results were used to estimate the effects of radionuclides that were used at Mound on humans. Biological testing was discontinued in about 1955 when detonator manufacturing began.

A *Biological Research Quarterly* from June 1954 (EG&G 1995 p. 263) discusses mice and rat experiments, which were conducted over a 2-year period with ^{210}Po. In another experiment rats were given a ^{227}Ac solution that also contained ^{227}Th, ^{223}Ra, ^{219}Rn, ^{215}Po, and ^{211}Bi.

A report by Anthony et al. (EG&G 1995 p. 263) discusses experimental results of single acute and multiple exposures of ^{210}Po to rats with higher dosages of polonium than previously reported. In addition, studies with plutonium were done with a special emphasis on ^{238}Pu. Other reports discuss experimental work using ^{226}Ra and ^{227}Ac.

Room B-146
This was a laboratory where early research was done. Radioisotopes of concern and their compounds are:

Actinium-227	Polonium-215
Bismuth-211	Radium-223 and -226
Plutonium-238	Radon-219
Polonium-210	Thorium-227

Polonium-210 was the major radionuclide of concern with ^{227}Ac being secondary. B-Building was decontaminated by July of 1955.

Rooms E-141, -142, -144, -155
In use from 1981 to the present, Room E-141 uses small amounts of radionuclide standards of varying amounts and kinds as tracers for environmental testing. The tracers are in liquid form with only ^{210}Pb being encapsulated. They are used and stored in Room E-141, and are used in Rooms E-142, -144, and -155, which are also environmental laboratories. Radionuclides of concern are:

Plutonium-238, -239	Thorium-229, -230
Tritium	Uranium-232, -234, -236, -238
Lead-210	

Rooms E-174, -175, -177, -185, -194
These rooms have been used for cold storage and, therefore, were thought not to contain radionuclides. However, recent surveys found items in these rooms contaminated with alpha, beta, and gamma radiation. The following specific results were found:

- Room E-174, alpha from an unknown source;
- Room E-175, beta and gamma from an unknown source;
- Room E-177, beta and gamma from a ^{235}U rod, epoxy metallurgical sample, metal chips;
- Room E-185 (~1985-present), alpha and beta on metallurgical sample contaminated with ^{235}U, a second sample with suspected contamination from ^{232}Th; and
- Room E-194, alpha from possible plutonium, beta and gamma from possible ^{235}U or ^{238}U.

An overview of operations in E Building includes nitrate and chloride solutions of:

Lead-210	Thorium-229 and -230
Plutonium-238, -239, and -242	Tritium
Polonium-210	Uranium-232, -234, -235, -236, and -238

Plutonium-238 was the major radionuclide of concern with ^{210}Po second and tritium third.

H Building
Although this building houses many innocuous functions such as the credit union and change rooms, there are activities that have the potential for radionuclide intakes.

The laundry had a “hot laundry” ability to handle clothes that were exposed to radionuclides, which is the primary reason the structure was built. Bioassay and other environmental laboratories in H Building have the potential for low levels of exposure. Most radionuclides are tracer nitrate and chloride solutions of ^{238}Pu, ^{239}Pu, ^{242}Pu, ^{232}U, ^{236}U, and ^{229}Th. Tritium and ^{210}Po could be included. It has been suggested that ^{226}Ra, ^{228}Th, and ^{227}Ac be included in the list.

Radionuclides and related compounds of concern are:

Actinium-227	Thorium-228 and -229
Plutonium-238, -239, and -242	Tritium
Polonium-210	Uranium-232 and -236
Radium-226	

Plutonium-238 was the major radionuclide of concern with ^{210}Po second and ^{227}Ac third.

I Building
I Building refers to the Isolation Building, where low-level counting of bioassay (urine and fecal) samples and environmental counting for soil, vegetation, etc., were performed from 1955 to the present. There is little concern about the possibility of uptakes. This area is used for nondestructive testing and the assembly of explosive devices. No radionuclides are used.

M Building
Room M-20 had a Livermore dry box. In addition, ^{238}U was machined in this building.

R&R Building
This small building between the SM and PP Buildings was used for sorting plutonium solid waste, some of which could be reprocessed. The compound forms of the plutonium and lung solubility types are as follows:

- Plutonium oxide, PuO_2, type S; this could also take the form of a plutonium oxide hydrate—$PuO_2.XH_2O$;
- Plutonium hydroxide, $Pu(OH)_4$, type S; and
- Plutonium nitrate, $Pu(NO_3)_4$, type M; this could also take the form of plutonium nitrate pentadhydrate, $Pu(NO_3)_4.5H_2O$.

Plutonium-238 was the major radionuclide of concern; ^{239}Pu was second.

SD Building (57, 112, and 113) (1947 to 1970)
The SD Building was a sanitation building that could have had some contaminated sludge from broken lines or pipes. Contamination would have been minor in concentration but could have contained radionuclides from polonium processing. Radionuclides of concern and related compounds are:

Antimony-124
Bismuth-210
Cesium-137
Chromium-55
Cobalt-60
Gallium-70 and -72
Iron-55,59
Lead-209
Mercury-203
Plutonium-238 and -239
Polonium chloride
Polonium nitrate
Polonium-208, -209, and -210
Selenium-75
Silicon-31
Silver polonide
Tellurium polonide
Silver-112
Strontium-90
Tellurium-121 and possibly Te--134
Tin-121
Vanadium-52
Zinc-65

Polonium-210 was the major radionuclide of concern, with ^{238}Pu second and ^{65}Zn third.

Building 19
This 4,800-ft^2 Quonset hut contains a small office and an area for storing Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) materials. The building was constructed in 1962 for Mound Salvage storage and sales. Since 1988 it has been used to store CERCLA soil drums and empty drums. Low-level waste (LLW) and LSA drums have also been stored in this building. Plutonium-238 and ^{232}Th were the primary isotopes in the LLW and LSA drums.

Building 22
Building 22 is a 9,090-ft^2 one-story steel-frame building that was constructed in 1966 for office space and storage of items to be sold. In 1995 the building was modified to handle radioactive LLW solid waste.

Building 23
Building 23 is a 3,422-ft^2 one-story steel-frame building that was constructed in 1966 as a warehouse used for preparation and shipping of LLW. It was later used to store mixed and transuranic (TRU) mixed waste. The building was modified in 1994 to contain spills.

Building 30
Building 30 contains a counting laboratory. Liquid scintillation counting for tritium and gross alpha and beta counting were performed in this building. The facility performed gamma scans of drums and boxes. Several years ago the facility was converted from office space to a counting laboratory.

Building 31
Building 31 is a 3,000-ft^2 metal fabricated building that was constructed in 1966. The building is used for storage and preparation of LLW waste.

Building 31A
Building 31A is a 2,650-ft^2 metal fabricated building that was constructed in 1986 to store LSA and TRU waste. The building is currently used for storage of TRU wastes.

Building 35
Building 35 is a 2,500-ft^2 metal fabricated building that was constructed in 1967 for X-ray and eddy-ray current nondestructive testing. The facility was also used as the control room for the ^{252}Cf multiplier neutron radiography facility.

Building 39
Building 39 is a 3,515-ft^2 metal fabricated building that was constructed in 1967 to build fiberglass wooden boxes for radioactive trash for the D&D activities. Indications are that gamma spectroscopy on these boxes was also performed in this building. From 1984 to 1988 the building was either inactive or used for storage. Since 1988 the building has been used as a maintenance shop.

Building 45
Building 45 is a 9,582-ft^2 concrete building that was constructed in 1967. The building is the health physics calibration laboratory. The facility has equipment for calibration of health physics instrumentation and dosimeters. The facility houses a well calibration area, a beta calibration area, a calibration and repair area, a dosimeter preparation area, an X-ray calibration area, and a low-scatter neutron and maximum field calibration area.

Building 58
Building 58 is a 6,100-ft^2 concrete building that was constructed in 1977. The building is the alpha and beta filter and plenum exhaust for SW Building.

Building 72
Building 72 is a 2,400-ft^2 metal frame building that was constructed in 1984. The building is the site hazardous storage waste facility. Liquid scintillation vials are stored in this facility.

Building 90
Building 90, which was constructed in 1985, housed the unit controls and feed operations for the retort unit (rotary kiln thermal treatment unit) located in the burn area. Operations ended in January 1996.

Building 94
Building 94 is a 1,240-ft^2 metal building that was constructed in 1985. The building is used for CERCLA contractor staging and storage of soil and water samples.

Building 123 (Rubb)
In addition to fulfilling a variety of uses, this temporary structure has also had different names, including WTS Rubb from 1989 into the 1990s and the Rubb Building later in the 1990s. More recently, it has been called Rubb Building 123.

Rubb Building 123 was constructed in 1989 and was deconstructed in 2001. The building was used to store heavy equipment in 1989. Beginning in 1994, LSA boxes containing soils from the WTS line cleanup were emptied and sampled in the building. The boxes being opened were randomly selected from a population of nearly 700 boxes to achieve a 95% confidence level. The purpose of this process was to conduct content verifications of the boxes. The results of this verification sampling eventually led to the ability to ship the boxes as LLW.

In the 1990s the Rubb Building 123 was also used for storage of heavy-duty equipment for the D&D group. Heavy-duty equipment stored in this structure was likely used in the demolition of site buildings and in the cleanup of contaminated areas on the plant site.

The Brickmaker
The Brickmaker, which was built in 1992, was a temporary structure to house equipment to compress and dewater low-level radioactively contaminated soils into extruded bricks that could be placed in LLW boxes for disposal off the site. The project area consisted of two temporary steel-framed Rubb-brand buildings, an office trailer, and a lined in-ground pit to receive water from the process.

Building 124, Consolidated Waste Processing Facility (CH2M Hill 2003)
Building 124, also known as the Consolidated Waste Processing Facility (CWPF), was constructed in 1998. Building 124 performed various volume reduction or repackaging functions that are routinely performed at Mound. The building processed LLW from various demolition sites and safe shutdown activities as well as legacy waste streams. Building 124 is in an Underground Radiological Materials Area.

The Auditable Safety Analysis ASA included a list of expected process input materials, as described in Section 2.3. The list included, but was not limited to:

- Nonstructural equipment and debris (soft objects such as rags and bags for compaction);
- Structural steel for decontamination, size reduction, and release;
- Soils and other demolition debris for blending to reduce the radioactive material content to meet specific waste profiles;
- Drums, boxes, and other types of containers in order to puncture the container lids to vent gas, sample and analyze the released gas, and to install filter vents;
- Liquids generated by the air recirculation unit or tritium-contaminated liquids collected during opening or repackaging containers with tritium contamination;
- Various types of waste packages for sampling, consolidation, or repackaging, or other activities that ensure that the waste is packaged in a form suitable for shipment off the site and final disposal.

At Building 124 the stack was monitored for potential air emissions of:

- Tritium
- Plutonium-238
- Plutonium-239 and -240
- Uranium-233 and -234
- Uranium-238

Area 8, Thorium Contaminated Soils from Areas 1 and 9
The area is northwest of Building 31 on the SM/PP hill on the eastern side of Mound site. The area is approximately 25,000 ft^2. Soil was buried in this area from decontamination activities from repackaging of ^{232}Th sludges in 1965 and 1966. Plutonium-238 was detected at a maximum concentration of 24 pCi/g. The maximum thorium concentration was 254.3 pCi/g.

Area 10, Debris from Dayton Units
The area is west of Building 30 on the slope of the SM/PP hill on the East Central portion of Mound site. It was used for disposal of contaminated concrete from Dayton Units. One hundred and sixty truckloads from Unit IV and 100 truckloads from Unit III were deposited here. The area is approximately 15,000 ft^2. The primary contaminant was ^{210}Po. Soil was buried in this area in 1950.

Area 12, Thorium Contaminated Soil
The area is west of Building 38 on the SM/PP hill on the East Central portion of Mound site. Soil contaminated with ^{232}Th and ^{238}Pu from SM Building and with thorium from Area 1 were placed in this area in 1965.

WTS Pipeline
The pipeline line ran from SM Building and Building 38 to the WD Building. In 1969 the high-risk waste line ruptured below the WD Building. The pipeline may have leaked in other locations as well along its path.

Buildings without Radionuclide Activity
The following buildings have not supported radionuclide activities: 1, 2, 3, 13, 14, 16, 17, 24, 25, 26, 27, 28, 29, 33, 36, 37, 40, 41, 42, 43, 44, 46, 47, 49, 51, 55, 56, 60, 61, 63E, 63W, 65, 66, 67, 69, 70, 71, 73, 74, 79, 85, 87, 88, 49, 91, 92, 93, 95, 96, 98, 99, 100, 101, 102, 104, 105, 106, 120, A (Administration), C (Old Cafeteria), COS, G, Generator-1, Generator-6, GH, GP-1, GP-5, GP-8, GP-44, GS, GW, Modular 4, OSE, OSW, P (Power Plant), PH, SST, W, WH-1, WH-2, WH-3, and Magazines 5, 6, 7, 8, 10, 11, 20, 52, 53, 54, 64, 80, 81, 82, 83, and 84.

2.3 ATTRIBUTIONS AND ANNOTATIONS

All information requiring identification was addressed via references integrated into the reference section of this document.

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GLOSSARY

Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA; 42 U.S.C. § 9601 *et seq.*)

Federal law that governs the removal, remediation, and response to hazardous substance contamination.

curie (Ci)

Traditional unit of radioactivity equal to 37 billion (3.7×10^{10}) becquerels, which is approximately equal to the activity of 1 gram of pure ^{226}Ra.

decontamination

Reduction or removal of radioactive material from a structure, area, object, or person. Decontamination can occur through (1) treating the surface to remove or decrease the contamination or (2) allowing natural radioactive decay to occur over a period of time.

enriched uranium

Uranium in which processing has increased the proportion of ^{235}U to ^{238}U to above the natural level of 0.7% by mass. Reactor-grade uranium is usually about 3.5% ^{235}U; weapons-grade uranium contains greater than 90% ^{235}U.

exposure

(1) In general, the act of being exposed to ionizing radiation. See *acute exposure* and *chronic exposure*. (2) Measure of the ionization produced by X- and gamma-ray photons in air in units of roentgens.

metal tritide

Metal that absorb tritium atoms in the crystalline structure of the metal. Metal hydrides and tritides are the most compact way to store hydrogen or tritium. Because of that, metal tritides are most often used as a method of retaining or storing tritium.

pitchblende

Mineral containing uranium oxide (UO_X) of variable composition ranging between UO_2 and U_3O_8 as well as radium.

polonium (Po)

Radioactive element with atomic number 84. Polonium mixed or alloyed with beryllium provides a source of neutrons for dosimeter calibration.

plutonium–uranium extraction (PUREX)

Process for separating used nuclear fuel into components that produces pure plutonium and uranium along with a waste remainder. The separation uses a water-based acid dissolution of the used nuclear fuel.

radiation

Subatomic particles and electromagnetic rays (photons) with kinetic energy that interact with matter through various mechanisms that involve energy transfer. See *ionizing radiation*.

radioactive contamination

Radioactive material where it is not wanted.

radioactive waste

Radioactive solid, liquid, and gaseous materials for which there is no further use. Wastes are generally classified as high-level (with radioactivity as high as hundreds of thousands of curies

per gallon or cubic foot), low-level (in the range of 1 microcurie per gallon or cubic foot), intermediate level (between these extremes), mixed (also contains hazardous waste), and transuranic.

radioisotopic thermoelectric generator (RTG)

Generator that obtains its power from passive (natural) radioactive decay using thermocouples to convert the heat of decay into electricity.

sealed source

Radioactive material encased in a capsule designed to prevent leakage or escape of the material.

transuranic (TRU) elements

Elements with atomic numbers above 92 (uranium). Examples include plutonium and americium.

tritium (hydrogen-3, ^{3}H, T)

Radioactive isotope of hydrogen that contains one proton and two neutrons in its nucleus. It decays by beta emission and has a radioactive half-life of about 12.5 years.