

**Environmental Radiation Protection
Program for the
Paducah Gaseous Diffusion Plant,
Paducah, Kentucky**

This document is approved for public release per review by:

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FRNP Classification Support

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**Environmental Radiation Protection
Program for the
Paducah Gaseous Diffusion Plant,
Paducah, Kentucky**

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U.S. DEPARTMENT OF ENERGY
Office of Environmental Management

Prepared by
FOUR RIVERS NUCLEAR PARTNERSHIP, LLC,
managing the
Deactivation and Remediation Project at the
Paducah Gaseous Diffusion Plant
under Contract DE-EM0004895

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APPROVALS

**Environmental Radiation Protection
Program for the
Paducah Gaseous Diffusion Plant,
Paducah, Kentucky**

CP2-ES-0103/FR4

October 2021

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REVISION LOG

REVISION NUMBER	DATE	DESCRIPTION OF CHANGES	PAGES AFFECTED
FR0	October 12, 2017	Initial Release by FRNP	All
FR1	October 24, 2018	Annual update	All
FR2	January 30, 2019	Annual update	All
FR3	December 17, 2020	Annual update	All
FR4	October 19, 2021	<p>This Annual update includes the following:</p> <ul style="list-style-type: none"> • Addition of definitions and identification of the source of a definition. • Adjusted ALARA goals in Section 3.2. • Added paragraph to Section 4.1 that addresses DOE O 458.1 Attachment 1, paragraph 2.e.(1)(c). • Added footnote to Section 4.1, Table 1 that addresses DOE O 458.1 Attachment 1, paragraph 2.e.(1)(a)3. • Revised Section 5.1 to remove discussion of dose modeling for ambient air and referenced the EMP and NESHAP Plan in order to better align environmental documents. • Updated Section 6 to incorporate reference to DOE-STD-1196-2021, which was made effective July 7, 2021. • Added statement to Section 10.1 referencing site documents that contain information to institutional controls and long-term stewardship. • Added pre-approved authorized limit to Section 10.5. • Added listing of DOE Waste Treatment Basic Ordering Agreements to Section 10.6. • Updated references and editorial changes throughout document. 	<p>vii–xii</p> <p>6 7</p> <p>7</p> <p>9</p> <p>9</p> <p>15</p> <p>17</p> <p>17–18</p> <p>Various</p>

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ACRONYMS

AEA	Atomic Energy Act
ALARA	as low as reasonably achievable
ASER	Annual Site Environmental Report
BAT	best available technology
BCG	biota concentration guide
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
<i>CFR</i>	<i>Code of Federal Regulations</i>
D&R	deactivation and remediation
DAC	derived air concentration
DCS	Derived Concentration Standard
DOE	U.S. Department of Energy
EMP	Environmental Monitoring Plan
EMS	Environmental Management System
ERPP	Environmental Radiation Protection Program
ES	Environmental Services
GPP	Groundwater Protection Plan
ISSC	Infrastructure Support Services Contractor
<i>KAR</i>	<i>Kentucky Administrative Regulations</i>
KPDES	Kentucky Pollutant Discharge Elimination System
LLW	low-level waste
MEI	maximally exposed individual
MLLW	mixed low-level waste
NESHAP	National Emission Standards for Hazardous Air Pollutants
O	order
PGDP	Paducah Gaseous Diffusion Plant
PPPO	Portsmouth/Paducah Project Office
SI	International System of Units
TED	total effective dose
TENORM	Technologically Enhanced Naturally Occurring Radioactive Material

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DEFINITIONS

Terminology used in this Environmental Radiation Protection Program is consistent with the definitions provided in U.S. Department of Energy (DOE) Order (O) 458.1 Chg 4 (LtdChg), *Radiation Protection of the Public and the Environment*.

Absorbed Dose (D)—The average energy imparted by ionizing radiation to the matter in a volume element per unit mass of irradiated material. The absorbed dose is expressed in units of rad (or gray) (1 rad = 0.01 gray). (DOE O 458.1)

Actual or Likely Use Scenarios—The current uses and reasonably anticipated uses in the foreseeable future of real and personal property considering the history of use; use restrictions, designations, or controls; affected populations; ecosystems, or natural resources; and the property's historic or cultural significance. For real property considerations also include Federal and State use designations; local zoning and future land use plans; and proximity to residences, commercial or industrial areas, or areas of cultural or historic significance. (DOE O 458.1)

Airborne Discharges—Material released to the atmosphere in the form of dusts, fumes, particulates, mists, vapors, or gases. (DOE O 458.1)

ALARA (As Low As Reasonably Achievable)—An approach to radiation protection to manage and control releases of radioactive material to the environment, and exposure to the work force and to members of the public so that the levels are ALARA, taking into account societal, environmental, technical, economic, and public policy considerations. As used in DOE O 458.1, ALARA is not a specific release or dose limit, but a process which has the goal of optimizing control and management of releases of radioactive material to the environment and doses so that they are as far below the applicable limits of DOE O 458.1 as reasonably achievable. (DOE O 458.1)

ALARA Process—A graded process for evaluating alternative operations, processes, and other measures for optimizing releases of radioactive material to the environment, and exposure to the workforce and to members of the public taking into account societal, environmental, technical, economic, and public policy considerations to make a decision concerning the optimum level of public health and environmental protection. A graded approach provides the flexibility to perform qualitative or quantitative ALARA analyses. For low doses, qualitative evaluations normally will suffice. (DOE O 458.1)

ALARA Program—Refers to the set of design specifications, operating procedures, techniques, monitoring and surveillance programs, records, instructions, and other elements that have been used to implement the [environmental] ALARA process. (DOE-HDBK-1215-2014)

Ambient Air—The surrounding atmosphere, usually the outside air, as it exists around people, animals, plants, and structures. It does not include the air immediately adjacent to emission sources. (DOE-HDBK-1216-2015)

Aquatic Biota—Plant or animal life living in or on water. (DOE-STD-1153-2019)

Authorized Limit—A limit on the concentration or quantity of residual radioactive material on the surfaces or within property that has been derived consistent with DOE directives including the ALARA process requirements. An authorized limit may also include conditions or measures that limit or control the disposition of property. (DOE O 458.1)

Background Radiation—Radiation from: (1) naturally occurring radioactive materials that have not been technologically enhanced [i.e., background radiation does not include technologically enhanced naturally occurring radioactive material (TENORM)]; (2) cosmic sources; (3) global fallout as it exists in the environment (such as from the testing of nuclear explosive devices); (4) radon and its decay products in concentrations or levels existing in buildings or the environment which have not been elevated as a result of current or prior activities; and (5) consumer products containing nominal amounts of radioactive material or producing nominal amounts of radiation. (DOE O 458.1)

Best Available Technology (BAT)—The preferred technology for a particular activity, selected from among others after taking into account factors related to technology, economics, public policy, and other parameters. As used in DOE O 458.1, the BAT is not a specific level of treatment, but is the conclusion of a selection process in which several alternatives are evaluated. (DOE O 458.1)

BAT Selection Process—The evaluation of candidate alternative technologies in order to select the BAT after considering technology; economics; the age of equipment and facilities involved; the process employed; the engineering aspects of the application of various types of control techniques; process changes; other environmental impacts (including energy requirements); safety considerations; and policy considerations. (DOE O 458.1)

Biota Concentration Guide (BCG)—The limiting concentration of a radionuclide in soil, sediment, or water that would not cause dose rate criteria for protection of populations of aquatic and terrestrial biota (as used in DOE-STD-1153-2019) to be exceeded. (DOE-STD-1153-2019)

Clearance of Property—The removal of property that contains or may contain residual radioactive material from DOE radiological control under 10 *CFR* Part 835 and DOE O 458.1, current version. (DOE O 458.1)

Collective Dose—The sum of the total effective dose (TED) to all persons in a specified population received in a specified period of time. For clearance of property the collective dose refers to the population potentially exposed to the cleared property. Collective dose is expressed in units of person-roentgen equivalent man (rem) (or person-sievert). (DOE O 458.1)

Committed Effective Dose (E_{50})—The sum of the committed equivalent doses to various tissues or organs in the body ($H_{T,50}$), each multiplied by the appropriate tissue weighting factor (W_T)—that is, $E_{50} = \sum W_T H_{T,50} + W_{\text{Remainder}} H_{\text{Remainder},50}$, where $W_{\text{Remainder}}$ is the tissue weighting factor assigned to the remainder organs and tissues and $H_{\text{Remainder},50}$ is the committed equivalent dose to the remainder organs and tissues. Committed effective dose is expressed in units of rems (or sieverts). (DOE O 458.1)

Committed Equivalent Dose ($H_{T,50}$)—The equivalent dose calculated to be received by a tissue or organ over a 50-year period after the intake of a radionuclide into the body. It does not include contributions from radiation sources external to the body. Committed equivalent dose is expressed in units of rems (or sieverts). (DOE O 458.1)

Composite Sample—A sample of an environmental media where multiple individual sample increments have been combined into a single sample. Composite may be formed from either spatial or temporal increments. Spatial examples might include composite samples that represent land area soils, water sources or outfalls, and air monitoring stations. A temporal composite represents samples collected over a period of time. The samples may be collected from the same or different locations. They may or may not be collected at equal time intervals over a predefined period of time (e.g., 24 hours). (DOE-HDBK-1216-2015)

Controlled Area—Any area to which access is managed by or for DOE to protect individuals from exposure to radiation and/or radioactive material as defined by 10 *CFR* Part 835. (DOE O 458.1)

Derived Concentration Standard (DCS)—A derived concentration value for a radionuclide in water that would result in a dose of 100 mrem in a year to a gender- and age- weighted reference person using DOE approved dose coefficients and assuming continuous exposure. (DOE O 458.1)

Dose—A general term for absorbed dose, equivalent dose, effective dose, committed equivalent dose, committed effective dose, or TED, as defined in DOE O 458.1. (DOE O 458.1)

Effective Dose (E)—The summation of the products of the equivalent dose received by specified tissues or organs of the body (H_T) and the appropriate tissue weighting factor (W_T)—that is, $E = \sum W_T H_T$. It includes the dose from radiation sources internal and/or external to the body. For purposes of compliance with DOE O 458.1, equivalent dose to the whole body may be used as effective dose for external exposures. The effective dose is expressed in units of rems (or sieverts). (DOE O 458.1)

Effluent Monitoring—The collection and analysis of samples of liquid and gaseous effluents or measurements of liquid and gaseous effluents performed to characterize and quantify radiological contaminants and process stream characteristics, assess radiation exposures of members of the public, and demonstrate compliance with applicable standards. (DOE O 458.1)

Environmental Surveillance—The collection and analysis of samples of air, water, soil, foodstuffs, biota, and other media at the DOE Site and surrounding environs and the measurement of external radiation to demonstrate compliance with applicable standards, assess radiation exposure of members of the public, and assess effects, if any, on the environment. (DOE O 458.1)

Equivalent Dose (H_T)—The product of average absorbed dose ($D_{T,R}$) in rad (or gray) in a tissue or organ (T) and a radiation (R) weighting factor (W_R). For external dose, the equivalent dose to the whole body is assessed at a depth of 1 cm in tissue; the equivalent dose to the lens of the eye is assessed at a depth of 0.3 cm in tissue, and the equivalent dose to the extremity and skin is assessed at a depth of 0.007 cm in tissue. Equivalent dose is expressed in units of rems (or sieverts). (DOE O 458.1)

External Dose or Exposure—That portion of the dose received from radiation sources outside the body (i.e., external sources). (DOE O 458.1)

Facility—Something that is built, installed, or established to serve a particular DOE radiological activity. (DOE O 458.1)

General Employee—An individual who is either a DOE or DOE contractor employee; an employee of a subcontractor; or an individual who performs work for or in conjunction with DOE or utilizes DOE facilities. (DOE O 458.1)

Internal Dose or Exposure—That portion of the dose received from radioactive material taken into the body (i.e., internal sources). (DOE O 458.1)

Liquid Discharge—The release to the environment of radioactive material in a liquid medium. The discharge generally occurs at a point, such as the end of a pipe, where it is released to any of several receptors in the environment, such as a waterway, land, sewer system, etc. (DOE O 458.1)

Maximally Exposed Individual—A hypothetical individual who—because of realistically assumed proximity, activities, and living habits—would receive the highest radiation dose, taking into account all pathways, from a given event, process, or facility. (DOE O 458.1)

Measurement Quality Objectives—A statement of a performance objective or requirement for a particular method performance characteristic. (DOE O 458.1)

Member of the Public—An individual who is not a general employee. An individual is not a member of the public during any period in which the individual receives an occupational dose. (DOE O 458.1)

Monitoring—The measurement of radiation levels, discharges or environmental releases, residual radioactive levels, quantities of radioactive material, or exposure to members of the public and the use of the results of these measurements to evaluate radiological discharges or releases or potential and actual dose resulting from exposures to radioactive material or radiation. (DOE O 458.1)

Personal Property—Property of any kind, except for real property. (DOE O 458.1)

Potential Dose—A calculated dose based on a postulated set of exposure conditions that have a reasonable probability of occurrence. (DOE O 458.1)

Public Dose—The dose received by members of the public from exposure to radiation and to radioactive material released by a DOE radiological activity whether the exposure is within a DOE site boundary or off-site. (DOE O 458.1)

Radiation—Ionizing radiation: alpha particles, beta particles, gamma rays, X-rays, neutrons, high-speed electrons, high-speed protons, and other particles capable of producing ions. Radiation, as used in DOE O 458.1, does not include non-ionizing radiation, such as radio waves or microwaves, or visible, infrared, or ultraviolet light. (DOE O 458.1)

Radiation Weighting Factor (W_R)—The modifying factor used to calculate the equivalent dose from the average tissue or organ absorbed dose; the absorbed dose (expressed in rad or gray) is multiplied by the appropriate radiation weighting factor. (DOE O 458.1)

Radioactivity—The property or characteristic of radioactive material to undergo spontaneous transformations (disintegrations or decay) with the emission of energy in the form of radiation. It is measured by the rate of spontaneous transformations of a radionuclide. The unit of radioactivity is the curie, Ci (or becquerel, Bq) ($1 \text{ Ci} = 3.7 \times 10^{10} \text{ Bq}$). (DOE O 458.1)

Radiological Activity—Any activity taken for, or by, DOE that has the potential to result in releases of radioactive material to the environment or exposures of members of the public to include all doses both present and future, from clearance activities and radiation generating devices. The activity may involve a single DOE facility, or combination of facilities and operations, possibly including an entire site or no fixed site at all. (DOE O 458.1)

Real Property—Land and anything permanently affixed to the land such as buildings, fences, and those things attached to the buildings, such as light fixtures, plumbing and heating fixtures, or other such items, that would be personal property if not attached. (DOE O 458.1)

Reference Person—A hypothetical aggregation of human (male and female) physical and physiological characteristics arrived at by international consensus for the purpose of standardizing radiation dose calculations. (DOE O 458.1)

Remedial Actions—Those actions, consistent with permanent remedy, taken to control or remove radiological contaminants to prevent or to minimize doses to members of the public. (DOE O 458.1)

Representative Person—An individual receiving a dose that is representative of the more highly exposed individuals in the population. This term is equivalent of, and replaces, “average member of the critical group” (Source: *ICRP Publication 103*, page 32). (DOE O 458.1)

Residual Radioactive Material—Any radioactive material that is in or on soil, air, water, equipment, or structures as a consequence of past operations or activities of the Department or its predecessors. (DOE O 458.1)

Sanitary Sewerage—A system of public sewers for carrying off waste water and refuse, but excluding sewage treatment facilities, septic tanks, and leach fields owned or operated by or for DOE. (DOE O 458.1)

Settleable Solids—(i) that matter in waste water which will not stay in suspension during a preselected settling period, such as one hour, but settles to the bottom; (ii) in the Imhoff cone test, the volume of matter that settles to the bottom of the cone in one hour; or (iii) suspended solids that can be removed by conventional sedimentation processes. (DOE O 458.1)

Sewer—An artificial conduit, usually underground, for carrying off wastewater and refuse. (DOE O 458.1)

Site—Land or property upon which DOE facilities or activities are located and access to which is subject to DOE or DOE contractor control. (DOE O 458.1)

Site Boundary—The perimeter of a DOE Site, within which DOE or a DOE contractor normally can control access or restrict activities. (DOE O 458.1)

Soil Column—An *in situ* volume of soil through which liquid waste streams percolate from ponds, cribs, trenches, drain fields, or other areas or facilities used for the primary purpose of removing or retaining the suspended or dissolved radionuclides contained within the liquid process waste stream. (DOE O 458.1)

Technologically Enhanced Naturally Occurring Radioactive Material (TENORM)—Any naturally occurring radioactive materials whose radionuclide concentrations or potential for human exposure have been increased above levels encountered in the natural state by human activities. (DOE O 458.1)

Terrestrial Biota—Plant and animal life living on or in land. (DOE-STD-1153-2019)

Tissue Weighting Factor (W_T)—The fraction of the overall health risk, resulting from uniform, whole body irradiation, attributable to specific tissue (T). The equivalent dose to tissue, (H_T), is multiplied by the appropriate tissue weighting factor to obtain the effective dose (E) contribution from that tissue. (DOE O 458.1)

Total Effective Dose—Sum of the effective dose (for external exposures) and the committed effective dose. (DOE O 458.1)

Whole Body—For the purposes of external exposure, head, trunk (including male gonads), arms above and including the elbow, or legs above and including the knee. (DOE O 458.1)

Working Level—The potential alpha energy concentration of radon decay products in 1 liter of air, without regard to the degree of equilibrium, that will result in the emission of 1.3×10^5 MeV of alpha particle energy. (DOE O 458.1)

CONVERSION TABLES

Prefix	Symbol	Exponential Value	E Notation	Numeric Value
pico	p	10^{-12}	1E-12	0.000000000001
nano	n	10^{-9}	1E-9	0.000000001
micro	μ	10^{-6}	1E-6	0.000001
milli	m	10^{-3}	1E-3	0.001
kilo	k	10^3	1E3	1,000
mega	M	10^6	1E6	1,000,000
giga	G	10^9	1E9	1,000,000,000
tera	T	10^{12}	1E12	1,000,000,000,000

Examples of use:	
pCi =	picocurie
mrem =	millirem

1. PROGRAM ORGANIZATION AND ADMINISTRATION

1.1 ENVIRONMENTAL RADIATION PROTECTION PROGRAM

1.1.1 Purpose and Scope

The Deactivation and Remediation (D&R) Contractor is under contract with the U.S. Department of Energy (DOE) to perform facility modification, stabilization, and deactivation; decontamination and demolition; and environmental services (ES) at the Paducah Gaseous Diffusion Plant (PGDP). The purpose of this Environmental Radiation Protection Program (ERPP) is to set forth the approach for the deactivation work scope in a manner that meets the requirements of DOE Order (O) 458.1, Chg 4 (LtdChg), *Radiation Protection of the Public and the Environment*. This ERPP provides an overview of the measures implemented by the D&R Contractor to ensure compliance with the requirements of DOE O 458.1 Chg 4 (LtdChg), Attachment 1. The D&R Contractor has implemented an appropriate structure of management and administrative measures, as necessary, to ensure the authorized activities are conducted in accordance with this ERPP.

The goals of this ERPP are as follows:

1. To conduct radiological activities so that exposure to members of the public is maintained within the dose limits established by DOE O 458.1;
2. To control the radiological clearance of DOE real and personal property;
3. To ensure that potential radiation exposures to members of the public as low as reasonably achievable (ALARA);
4. To monitor routine and nonroutine radiological releases and to assess the radiation dose to members of the public; and
5. To provide protection of the environment from the effects of radiation and radioactive material.

This ERPP incorporates ALARA policies in CP2-RP-0002, *Radiological Control Manual*; and DOE-HDBK-1215-2014, *Optimizing Radiation Protection of the Public and the Environment for Use with DOE O 458.1, ALARA Requirements*, (DOE 2014) using a graded approach to the application of environmental ALARA reviews, environmental monitoring, and environmental radiological performance metrics to assure accomplishment of annually established environmental performance goals and objectives.

This ERPP has been prepared consistent with the requirements of DOE O 458.1, Attachment 1, "Contractor Requirements Document." This ERPP describes the general requirements for ensuring that members of the public and the environment are protected from the effects of radiation and radioactive material during the execution of remediation and decommissioning activities within the scope of the DOE contract.

This ERPP applies to all work activities associated with the completion of the scope of work defined under Contract DE-EM0004895 and conducted on behalf of DOE by the D&R Contractor and all respective subcontractors and suppliers that involve radioactive materials. The upper level requirements described in this ERPP are implemented through a variety of mechanisms, including written procedures, plans, instructions, and employee training and qualifications. Additionally, the scope of the ERPP applies to all operations at locations, facilities, activities, and sites that are within the contract scope of work where the D&R Contractor performs work for DOE. These locations, facilities, and sites may extend beyond the

boundaries of the DOE Reservation in some instances. Consequently, the D&R Contractor employees, subcontractors, and sub tier subcontractor personnel are obligated to comply with the applicable environmental radiation protection procedures that implement this ERPP. Implementing guidance and requirements contained in this ERPP are intended to help itemize and clarify environmental radiation protection responsibilities and performance expectations.

This ERPP is intended to address all of the requirements of paragraph 2 of Attachment 1 to DOE O 458.1 that are applicable to the D&R Contractor. The responsible DOE Field Element Manager performs oversight of the D&R Contractor ERPP Program. The responsible DOE Field Element Manager for DOE activities at PGDP currently is the Portsmouth/Paducah Project Office (PPPO) Manager (or designee).

The Depleted Uranium Hexafluoride (DUF₆) Contractor and the Infrastructure Support Services Contractor (ISSC) share the Paducah Site (see also Section 1.1.5). Detectable results are shared promptly with other site contractors and DOE to ensure actions to achieve ALARA are implemented in a timely manner to minimize potential exposure.

1.1.2 Plans, Schedules, and Other Measures for Achieving Compliance

Should any conditions constituting noncompliance be discovered during the course of program implementation, the D&R Contractor will take prompt action to assess the condition, ensure the safety of the public and the environment, and restore the conditions to be in compliance with DOE O 458.1. If the condition is caused by another contractor, that contractor is responsible for corrective actions, and the D&R Contractor will continue monitoring.

1.1.3 ERPP Approval and Changes

DOE line management must approve this ERPP in accordance with paragraph 1.d of Attachment 1 to DOE O 458.1. Changes to this ERPP will be instituted, as necessary, to reflect changes in the scope of the covered activities, changes in the environmental radiological controls instituted for those activities, or changes to DOE O 458.1. Any change that does not reduce the effectiveness of the ERPP and that continues to meet the requirements of DOE O 458.1 will be made, as necessary, without prior DOE approval. Any proposed change that may reduce the effectiveness of the ERPP will be approved by DOE prior to implementation.

1.1.4 Performance Documents and Other Administrative Controls

The ERPP is not intended to be a working-level document. The provisions of the ERPP are implemented through lower level administrative controls, including performance documents and other guidance documents. The D&R Contractor develops and implements performance documents and other administrative controls, as needed, to ensure compliance with the requirements of DOE O 458.1. Consequently, employees and subcontractor personnel are obligated to comply with the performance documents and other administrative controls that implement this ERPP.

1.1.5 Other Site Tenants

Tenants at the Paducah Site complete work according to their respective contracts. Coordination among the tenants is meant to ensure efforts are not duplicated. Issues that arise may be addressed through the site committee.

DUF₆ Activities. The DOE DUF₆ Contractor operates a conversion facility (DUF₆ Project) to convert UF₆ stored in cylinders, which were depleted of uranium-235 (U-235) in the enrichment process, to hydrogen

fluoride and triuranium octoxide to render the material in a form safer for storage, transportation, and disposal. Activities performed by the DUF₆ Contractor specific to their work are not addressed specifically under this ERPP.

Infrastructure Activities. The DOE ISSC is responsible for facility surveillance and maintenance of roads and grounds. The ISSC also provides mowing, janitorial services, records management, site security programs, site dosimetry, site radiological instrumentation maintenance/calibration, computing and telecommunications, and fleet management. Activities performed by the ISSC specific to their work are not addressed specifically under this ERPP.

1.2 ENVIRONMENTAL RADIOLOGICAL HAZARD ASSESSMENT

The potential environmental radiological hazards found at PGDP are related to the following categories:

- a) Direct gamma and beta radiation exposure from controlled and inadvertent releases of radioactive material;
- b) Inhalation or ingestion of controlled and inadvertent releases of airborne radioactivity; and
- c) Ingestion of loose surface contamination, contaminated liquids, contaminated soil, and other environmental media contaminated as the result of a controlled and inadvertent release of radioactive material.

The level of radiological hazard on-site varies by location and is attributed to chemically processed uranium (including enriched, natural, and depleted) and associated daughter products; consequently, the level of environmental hazard and the potential exposure to the public varies, as well. Due to the legacy processing of reprocessed uranium from the Hanford and Savannah River sites, mixed fission products such as technetium-99 and, to a lesser degree, transuranic elements—notably plutonium, americium, and neptunium—also are found at the Paducah Site.

2. ORGANIZATIONAL ROLES AND RESPONSIBILITIES

Organizational roles and responsibilities within the D&R Contract for environmental radiation protection are discussed in the following sections. This organization is shown in Figure 1.

2.1 ENVIRONMENTAL RADIATION PROTECTION

Environmental Radiation Protection is managed within the ES organization. The ES Director is responsible for all aspects of project execution, including implementation of environmental protection measures, as required by this ERPP, written environmental procedures, and other documents. The Environmental Stewardship Manager is a senior line manager who is empowered fully to control project resources and has cradle-to-grave responsibility for project planning and execution. The Environmental Radiation Protection organization is supported by the Environmental Monitoring organization and is part of the Environmental Stewardship organization, including the Environmental Field Compliance organization, the Water Policy organization, and other personnel.

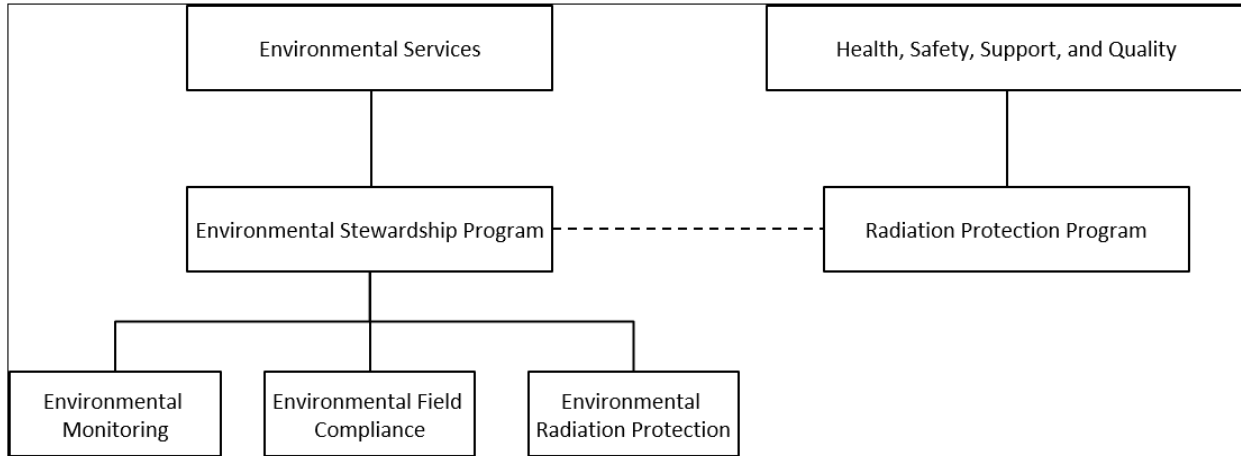


Figure 1. Environmental Stewardship Program

2.2 ENVIRONMENTAL FIELD COMPLIANCE

Environmental Field Compliance also is managed within the Environmental Stewardship program. Environmental Field Compliance is responsible for aspects of the ERPP, as defined in lower-level performance documents [e.g., CP2-ES-0006, *Environmental Monitoring Plan (EMP)*, and CP3-WM-0022, *Waste Water Accumulation, Storage, and Disposal*]. Environmental Field Compliance provides guidance and oversight with regard to the implementation of DOE O 458.1 and its supporting guidance, as it applies to the work activities associated with the D&R contract. Environmental Field Compliance changes that affect the ERPP are provided to Environmental Radiation Protection for review and concurrence. To ensure there are no conflicts with production goals, Environmental Field Compliance reports to upper management through a chain that is independent of Environmental Radiation Protection.

2.3 RADIATION PROTECTION ORGANIZATION

Radiation Protection is managed within the Health, Safety, Support, and Quality organization. Radiation Protection is responsible for aspects of the ERPP, as defined in lower-level performance documents (e.g., CP2-RP-0002, *Radiological Control Manual*). Radiation Protection also provides support to the Environmental Stewardship program in complying with program requirements. Radiation Protection changes that affect the ERPP are provided to Environmental Radiation Protection for review and concurrence. To ensure there are no conflicts with production goals, the Radiation Protection organization reports to upper management through a chain that is independent of the Environmental Stewardship program.

3. ENVIRONMENTAL ALARA PROGRAM

The D&R Contractor ALARA Program has been developed in a manner consistent with DOE O 458.1. The Environmental ALARA Program has been developed and implemented using a combination of physical design features, environmental monitoring, and administrative controls. The Environmental ALARA program is integrated into the occupational ALARA program through CP3-RP-1114, *ALARA Program*. During routine operations, these controls ensure that the radiation doses to the public and the environment

are ALARA. The Environmental ALARA Program process is applied to activities that could present potential exposures to the public and potential environmental releases.

The Environmental ALARA Program incorporates a graded approach. The method of implementing the Environmental ALARA Program depends on the complexity and magnitude of potential radiological consequences. Complex activities with greater potential for exposure involve more engineering, monitoring, and administrative control measures to control exposures. Environmental air monitoring, area dosimetry, personnel monitoring, etc., play key roles in ensuring that releases of radioactive contamination is prevented/mitigated in accordance with site ALARA goals.

3.1 ALARA POLICY

The ALARA Policy for the D&R project is presented in CP2-RP-0002, *Radiological Control Manual*. The ALARA Policy establishes a management policy for both occupational and environmental radiological exposure.

The ALARA philosophy is predicated upon the theory that any radiation exposure, however small, carries with it some risk that should be balanced by an offsetting benefit. The D&R Contractor ensures that any activity that involves exposure to radiation or radioactive materials is assessed to determine the most appropriate exposure controls for those activities having a net beneficial outcome.

The D&R Contractor's policy requires the performance of activities in a safe/environmentally protective manner that meets or exceeds the applicable requirements of DOE O 458.1. The D&R Contractor Project Management affirms the following:

1. Excellent performance is evident when site missions are completed and public and environmental radiation exposures are maintained below limits, radioactivity is controlled, radiological releases are reviewed and evaluated, and radiological spills or uncontrolled releases are prevented.
2. Continuing improvement is essential to excellence in environmental radiological control.
3. It is the responsibility of management and each worker to practice ALARA and to comply with the applicable performance documents and other administrative controls that implement this ERPP.
4. Cooperate with other site contracts to meet DOE goals for radiological effluents, including but not limited to, sharing information, identifying causes of anomalies, and reporting effluent release concentrations.

3.2 ENVIRONMENTAL ALARA GOALS

The D&R Contractor uses the ALARA process to evaluate the environmental program. Performance tracking mechanisms are used to identify and, as appropriate, to correct adverse trends. The ALARA reviews of the environmental program are performed, as necessary, to accommodate changes in the scope, unanticipated tasks, or radiological conditions. Environmental ALARA goals for the site include the following:

- Number of radiological environmental-related occurrence reports, excluding legacy contamination, is zero;

- Number of unplanned effluent discharges to the environment greater than 50 mrem/year calculated using the DOE-approved Derived Concentration Standard (DCS) values is zero;
- Number of unplanned airborne radioactivity discharges to the environment resulting in any member of the public receiving a dose greater than 50% of the 40 CFR § 61.92, *National Emission Standards for Hazardous Air Pollutants, Subpart H, National Emission Standards for Emissions of Radionuclides Other Than Radon from Department of Energy Facilities*, standard of 10 mrem/yr, is zero;
- The annual average concentration of a given radionuclide in surface water is less than 50% of the DOE-approved DCS value for water or, for multiple radionuclides, the composite DCS must be the sum of the fractional DCS values derived from DOE-approved DCS values [the composite DCS value is less than 1]; and
- No discharge contributes greater than 5 mrem annual total effective dose (TED) to members of the public.

The environmental ALARA process follows the methods and techniques described in CP2-RP-0002, *Radiological Control Manual*; DOE-HDBK-1215-2014, *Optimizing Radiation Protection of the Public and the Environment for Use with DOE O 458.1, ALARA Requirements* (DOE 2014); or another appropriate ALARA process that is vetted and approved by DOE. The level of formality associated with these analyses depends on a number of factors, including the expected radiation doses, the complexity of the hazards and controls, and the types of work to be performed. The analysis can be either quantitative or qualitative, but in either case, the results will be documented. As the project progresses, the types of physical design controls and administrative controls used to implement the environmental ALARA process and the balance between design features and administrative controls may change due to changes in the types of work being performed and the radiological hazards associated with that work. In all cases, the combination of physical design features and administrative controls will be adequate to ensure that public and environmental radiation exposures are within the limits established per the requirements of DOE O 458.1.

4. DOSE LIMITS

4.1 PUBLIC DOSE LIMITS

Public doses resulting from radiation exposures associated with deactivation and remediation activities will be controlled ALARA and within the DOE O 458.1 limits identified in Table 1. The public dose limits apply to members of the public located off the DOE Reservation and on the DOE Reservation outside of controlled areas and to those exposed to residual radioactive material subsequent to any remedial action or clearance of property.

While the dose to the maximally exposed individual (MEI) for members of the public from DOE-related exposure sources has historically been an order of magnitude less than the 25 mrem/year action level and future projected DOE-related doses are not expected to exceed this action level, if the DOE-related dose is greater than 25 mrem in a year, the D&R Contractor will include both major non-DOE sources of exposure (excluding dose from radon and its decay products in air, background radiation dose, occupational doses and doses due to medical exposures) and DOE-related sources when determining dose to members of the public.

Table 1. Public Dose Limits

Category	Type of Dose	Dose Limit
Member of the Public ^a	TED ^b	100 mrem per year
	Lens of the eye equivalent dose ^b	1,500 mrem per year
	Sum of the equivalent dose to the skin or extremities ^b	5,000 mrem per year
	Temporary dose limit of TED to a member of the public. This temporary dose limit is only at the request of the DOE Field Element Manager and may be employed only with the approval of a Cognizant DOE Secretarial Officer in consultation with the DOE Chief Health, Safety, and Security Officer.	No more than 500 mrem, provided that the average over any 5 contiguous years does not exceed 100 mrem per year
	Radiological activities from management and storage of radioactive waste from all exposure pathways and radiation sources associated with the waste, except for transportation and radon and its decay products.	TED of 25 mrem per year
	Emissions of radionuclides to the ambient air from D&R Contractor activities (40 <i>CFR</i> § 61.92).	10 mrem per year
	Annual average dose equivalent to the total body or any internal organ from beta particle and photon radioactivity from man-made radionuclides in drinking water [40 <i>CFR</i> § 141.66(d)].	4 mrem per year

^a Excludes dose from radon and its decay products in air, dose received by patients from medical sources of radiation, dose received by volunteers in medical research programs, dose from background radiation, and dose from occupational exposure under Nuclear Regulatory Commission, Agreement State License, or to general employees under 10 *CFR* Part 835. [DOE O 458.1 Attachment 1 paragraphs 2.b.(1)(a)1 thru 4].

^b If it is suspected that any of the dose limits may be exceeded or the estimated TED for members of the public exceeds 25 mrem in a year, then dose to the lens of the eye, skin, and extremities must be evaluated [DOE O 458.1, Attachment 1, paragraph 2.e.(1)(a)3].

4.2 TEMPORARY DOSE LIMITS

If special circumstances could affect a D&R Contractor's radiological activity in such a manner that the potential dose to a member of the public could exceed a TED of 100 mrem in a year, then the D&R Contractor will submit a request for specific authorization for a temporary public dose limit higher than 100 mrem in a year to the responsible DOE Field Element Manager, per the requirements of DOE O 458.1, Attachment 1, paragraph 2.c, which includes plans for ensuring no more than 500 mrem TED provided that the average TED over any contiguous five-year period does not exceed 100 mrem per year.

4.3 DIRECT RADIATION

An identified source of potential exposure to the public from radiation emanating from radionuclides contained in structures and other objects at the Paducah Site is from the uranium cylinder storage yards. Historical monitoring has shown that the potential annual dose for routine DOE operations at the Paducah Site for the direct radiation pathway has been less than 10 mrem/year due to limited exposure time, distance from access points of the public to cylinder yards, and shielding.

The External Radiation Monitoring Program is designed to provide exposure data on direct radiation from DOE operations to members of the public. The primary factor in selecting the monitoring locations is the potential for a member of the public to be exposed to direct radiation. The highest potential radiation exposure to the public is at the plant perimeter. The monitoring program conducts area gamma and neutron radiation dose monitoring using thermoluminescent dosimeters and optically stimulated luminescence

dosimeters. Devices of this type are capable of measuring exposure resulting from gamma and neutron radiation and are used throughout the industry to perform Environmental Monitoring.

Environmental Monitoring of direct radiation is performed as described in the current fiscal year version of the EMP.

Annual external gamma and neutron radiation monitoring results are reported in the Annual External Radiation Monitoring Report. Summary information from this report is also included in the Annual Site Environmental Report (ASER).

4.4 RADIATION EXPOSURE CONTROL

4.4.1 Physical Design Features

In addition to meeting the public radiation dose limits established in Table 1, the D&R Contractor has instituted measures to control radiation doses at levels that are ALARA. To the extent practicable, the ALARA process will be implemented through the use of physical design features and Best Available Technology (BAT).

Because of the comprehensive scope associated with the project, a mix of short-term and long-term controls are used to ensure exposures remain ALARA. The physical design features and engineered controls include, but are not limited to, portable and fixed ventilation systems, confinement and containment structures, and other BAT. Administrative controls also may be used; however, engineered controls and design features are preferred. The type and application of specific controls to be used are determined during project planning and hazard assessment activities; additional monitoring may be performed to verify the effectiveness of these controls and to determine the amount of radioactivity discharged to the environment as a result of the specific controls used.

4.4.2 Administrative Controls

Administrative controls are used to supplement the prescribed physical design features and where physical design features are demonstrated to be impractical.

Administrative controls used to implement the ALARA process may include, as appropriate for the planned activities, administrative control levels, performance goals, written procedures, and postings to restrict access.

5. AIRBORNE RADIOACTIVE EFFLUENTS

5.1 AIRBORNE EFFLUENTS MONITORING AND SURVEILLANCE

Airborne radioactive effluents are monitored in accordance with the EMP and CP2-EC-0002, *National Emission Standards for Hazardous Air Pollutants Management Plan for Emission of Radionuclides for the U.S. Department of Energy Operations at the Paducah Site, Paducah, Kentucky*, current version. CP2-EC-0002 was developed to ensure the program is managed in accordance with regulatory requirements and to assist DOE in demonstrating activities for the Paducah Site are in compliance with National Emission Standards for Hazardous Air Pollutants (NESHAP) requirements of 40 *CFR* Part 61, Subpart H. Unplanned discharges to the environment are evaluated when detected to determine potential impacts to off-site

personnel and the environment. Results from radioactive air monitoring are used to ensure ALARA is properly implemented, to track performance, and to effect changes, as needed, to minimize radioactive air pollution.

The D&R Contractor works under CP2-EC-0002 and prepares the Annual Summary of Radionuclide Air Emissions (NESHAP Report).

5.2 RADON

PGDP has no 11e (2) by-product material, as defined in the Atomic Energy Act (AEA) (as amended). The AEA, as amended, states that discrete sources of radium-226 must be treated like 11e (2) by-product material; therefore, the limit on radon-222 emissions of 20 pCi/m²-sec would apply to any radium-226 sources managed by the D&R Contractor. An evaluation of radium-containing waste at PGDP was performed in the *Authorized Limits Request for Solid Waste Disposal at C-746-U Landfill at the Paducah Gaseous Diffusion Plant* (DOE 2011a) and support documents.¹ Results of the evaluation demonstrate that radon emissions will not be a significant concern. Without a significant source of radon emissions to the site, radon monitoring is not performed, and this section is not applicable to PGDP operations.

6. CONTROL AND MANAGEMENT OF RADIONUCLIDES IN LIQUID DISCHARGES

Control and management of radionuclides in liquid discharges is confirmed by monitoring of the effluent discharge through the outfalls, site environmental surveillance sampling, and evaluations of planned and unplanned liquid discharges. The EMP documents the rationale, sampling frequency, and parameters for environmental monitoring relevant to this ERPP. The EMP additionally documents the parameters used to calculate the dose from exposure to surface water and sediments to the MEI. Characterization is dependent on the potential for on- and off-site impacts. Assessment of radiological consequences and modeling is presented in the ASER.

Radionuclide analysis is performed on selected samples as outlined in the EMP to evaluate the compliance of site discharges. Results from radionuclide analyses are converted to dose using the DCS dose conversion factors for drinking water. DCS values established in DOE-STD-1196-2021, *Derived Concentration Technical Standard*, are “radiological quantities used in the development and conduct of environmental and public radiation protection programs implemented at DOE sites and for DOE activities. DCS values are reference concentrations of radionuclides in environmental media that provide a basis for the control of effluent releases from DOE facilities. These DCS values may be used in implementation of the “as low as reasonably achievable” (ALARA) principle for environmental programs.” (DOE 2021a).

Except for tritium² and sanitary sewers, DOE O 458.1, paragraph 2.g.(5), requires application of a BAT if at the point of discharge any of the following occurs:

- The discharge contributes greater than 10 mrem annual TED to members of the public.

¹ Authorized limits for the C-746-U Landfill are implemented under DOE 2019a.

² Tritium has not been identified as a radionuclide of concern at the Paducah Site.

- The collective dose from all DOE sources is greater than 100 person-rem, and the liquid discharge contributes 50% or more of this collective dose.
- The annual average concentration of a given radionuclide is greater than the DOE-approved DCS value for water contained in DOE-STD-1196-2021, or for multiple radionuclides, the composite DCS must be the sum of the fractional DCS values derived from DOE-approved DCS values. The composite DCS value is greater than 1.

To ensure multiple sources will not result in doses exceeding the DOE public dose limit of 100 mrem/year, the D&R Contractor follows the DOE recommendation in DOE-HDBK-1216-2015, *Environmental Radiological Effluent Monitoring and Environmental Surveillance* (DOE 2015a) that potential doses from a single pathway to a maximally exposed individual be constrained so as not to exceed 10% to 25% of the public dose limit of 100 mrem/year. The D&R Contractor uses scenarios from the current version of DOE/LX/07-0107&D2, *Methods for Conducting Risk Assessment and Risk Evaluations at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky Volume 1. Human Health*, as a basis for identifying exposure pathways.

6.1 EFFLUENT DISCHARGE

The DOE site routinely discharges liquids from treatment of wastewater, planned activities, or startup of new activities to the environment. Each of these events is evaluated prior to discharge per the requirements of DOE O 458.1 and site ALARA goals. Effluent description, analytical data or process knowledge of the contents of the effluent, Environmental Field Compliance concurrence, along with the concurrence of the facility owner, if processed through a treatment unit, are documented.

Permitted surface water discharges at the Paducah Site include rainfall runoff from cylinder yards, landfills, and effluent from site processes. The EMP sets forth the sampling requirements and parameters for these outfalls. The outfalls are sampled for radionuclides as required by DOE O 458.1 and as specified each year in the EMP for planned activities, and site ALARA goals (Section 3.2). Collection of radiological parameters to assess dose per DOE O 458.1, which is not permit required, will be collected immediately downstream of the Kentucky Pollutant Discharge Elimination System (KPDES) compliance sampling points at each site outfall. The ASER presents the analytical results and an assessment of any radiological consequences to demonstrate compliance with DOE O 458.1.

6.2 SETTLEABLE SOLIDS

DOE O 458.1 requires that liquid discharges containing radionuclides from DOE activities do not exceed an annual average at the point of discharge of either of the following:

- 5 pCi per gram above background of settleable solids for alpha-emitting radionuclides, or
- 50 pCi per gram above background of settleable solids for beta-gamma-emitting radionuclides.

The radioactivity of settleable solids will be determined as described in DOE-HDBK-1216-2015, *Environmental Radiological Effluent Monitoring and Environmental Surveillance* (DOE 2015a). The gravimetric test (APHA 2012, Section 2540 F, Settleable Solids) will be used to determine settleable solids in mg/L in the water sample. The gravimetric test method in Section 2540 F, 3.b, will be used to determine both the total suspended solids and nonsettleable solids. The solid fractions of the total suspended solids and nonsettleable solids samples should be retained for later radioactivity measurements. The radioactivity of alpha-emitting radionuclides in pCi/g and the radioactivity of beta-emitting radionuclides in pCi/g will

be determined in the recovered solid fraction of each of the total suspended solids and nonsettleable solids samples.

6.3 SANITARY SEWER SYSTEM

The D&R Contractor operates a permitted sanitary sewer system for PGDP in accordance with the current KPDES Permit and DOE Orders (see text in Section 6 introduction of this document). Environmental radiological protection guidelines are incorporated into site plans and procedures to minimize radiological contamination discharges. Discharge of liquids containing radionuclides into the sanitary sewer complies with the ALARA process and applicable procedures. Potential sources of radiological contamination into the sanitary sewer include the on-site laboratory, if operating, and C-746-U Landfill leachate, if being disposed of at C-615.

The sanitary sewer treatment plant is operated in accordance with CP4-UT-0618, *Operation of C-615 Sewage Treatment Plant*. Effluent from the sewage treatment plant flows through KPDES Outfall 004. Sampling for radiological parameters in the effluent and sewer sludge is performed in accordance with the EMP. The D&R Contractor notifies the responsible DOE Field Element Manager of unusual discharges to sanitary sewers from DOE facilities.

6.4 ENVIRONMENTAL SURVEILLANCE SAMPLING

Environmental surveillance sampling at the site is conducted to verify the effectiveness of in-plant measures used for controlling the release of radioactive materials, evaluate the buildup of environmental radioactivity, capture areas not normally captured in routine plant effluents, and for public information purposes. The off-site environmental surveillance sampling is established on the basis of an evaluation of radionuclide composition of the liquid waste discharges from the facility and the environmental parameters that affect their dispersion and dilution in the environment. The EMP defines radionuclides and frequencies of sampling events as required by DOE O 458.1 and planned activities. Locations for these sites are evaluated based on available data each time the EMP is revised. Since most radionuclide levels in the surrounding plant sediment and surface water have been historically low it is anticipated that effluents will pose minimal risk and that only a few sample locations will be necessary each year for surveillance sampling. Priority of locations are given to areas where members of the public have access and which capture the sum discharges of all site activities present and historical, identify radionuclides, evaluate changes in the site effluent characteristics, and identify areas protective of the public and the environment. Consistent with this plan, information obtained from environmental surveillance sampling is used to effect changes in controls implemented to prevent/control releases and achieve ALARA goals.

6.5 UNPLANNED DISCHARGES

Unplanned discharges to the environment will be evaluated following release as soon as possible to determine contaminants of concern, number of samples and necessary protective actions. The site strives to have no unplanned discharges to the environment.

7. RADIOACTIVE WASTE AND SPENT NUCLEAR FUEL

7.1 RADIOACTIVE WASTE

The D&R Contractor has implemented procedures, practices, and monitoring in accordance with Section 4 of this ERPP to ensure that management, storage, and disposal of radioactive waste is maintained ALARA and does not result in a TED of greater than 25 mrem/year to the public or any releases to the environment. Radioactive waste is managed to meet the requirements of DOE O 435.1, *Radioactive Waste Management*.

7.2 BY-PRODUCT MATERIAL

As defined by the Section 11e.(2) of the AEA, there is no by-product material at PGDP. Material defined as Section 11e.(3) or 11e.(4) by-product material in the AEA (e.g., sealed radioactive sources) is managed under 10 *CFR* Part 835.

8. PROTECTION OF DRINKING WATER AND GROUNDWATER

Pathway assumptions considered in the assessments of radiological exposures are presented in the EMP.

8.1 ON-SITE DRINKING WATER TREATMENT PLANT

The D&R Contractor operates a permitted drinking water system in accordance with 401 *KAR* Chapter 8, *Public Water Supply*, for on-site use. Water is withdrawn from the Ohio River and treated to meet regulatory standards. Because groundwater is not used for drinking water, there is no potential from plant-derived radiological contamination within the drinking water system. No members of the public are supplied drinking water from this system.

8.2 PROTECTION OF GROUNDWATER

The potential for migration of radiological constituents present in liquid discharges to act as a source of radiological contamination to groundwater was evaluated to meet the requirements set forth in DOE O 458.1 that requires groundwater be protected from radiological contamination to ensure compliance with dose limits in DOE O 458.1 and consistent with ALARA process requirements. To this end, this program ensures the following are performed:

1. Baseline conditions of the groundwater quantity and quality are documented;
2. Possible sources of, and potential for, radiological contamination are identified and assessed;
3. Strategies to control radiological contamination are documented and implemented;
4. Monitoring methodologies are documented and implemented; and
5. Groundwater monitoring activities are integrated with other environmental monitoring activities.

Based on previous remedial investigations conducted at PGDP, radiological contamination is present in the groundwater due to past practices at PGDP. The PGDP began implementation of a Groundwater Protection Plan (GPP) in August 1995 (MMES 1995). The objectives of the GPP are to ensure protection for all current and future uses of groundwater and to prevent additional groundwater pollution at the PGDP. The GPP

includes a description of the facility history and operations; a summary of the physical characteristics of the site, including geology and hydrology; a listing of activities that have the potential to impact groundwater; and practices selected to protect groundwater from future impacts. The groundwater protection practices that have been implemented at PGDP include the following:

- Groundwater monitoring,
- Environmental surveillance monitoring,
- KPDES outfall discharge monitoring,
- Surface water observation and monitoring,
- Surface and subsurface soil sampling,
- Well sampling,
- Subsurface penetrations,
- Implementation of the site Spill Prevention, Control, and Countermeasure Plan (PAD-REG-1005),
- Appropriate storage of bulk quantities of materials, recyclables, and wastes,
- Waste management,
- Release prevention and control,
- Transfer of material off-site, and
- Groundwater treatment and source remediation.

To eliminate exposure to contaminated groundwater, a removal action (the PGDP Water Policy) was put into place.

Site sampling per the EMP evaluates if there is potential for radionuclides from the D&R Contractor's radiological activities contained in liquid effluents to cause private or public drinking water systems to exceed the drinking water maximum contamination levels in 40 *CFR* § Part 141.66(d), *National Primary Drinking Water Regulations, Subpart G, Maximum contaminant levels for radionuclides*.

8.3 PROTECTION OF SURFACE WATER

The D&R Contractor evaluates processes and activities with liquid effluents prior to discharge per the requirements of DOE O 458.1, the KPDES permit, and site ALARA goals. Discharges from PGDP enter Bayou Creek and Little Bayou Creek from either side of PGDP, with the on-site North-South Diversion Ditch flowing from the landfill area into Little Bayou Creek. These two creeks combine shortly before flowing into the Ohio River north of the plant. Planned or unplanned discharges typically flow into one of these two streams prior to flowing to the river. Planned discharges are evaluated prior to release into the streams and unplanned discharges are evaluated when detected to determine protective actions necessary to protect soils and groundwater. Analytical results and potential dose exposure calculations are presented in the ASER.

9. PROTECTION OF BIOTA

Sampling of aquatic organisms over previous years in the streams that directly receive plant discharges (Bayou Creek and Little Bayou Creek) has been extensive and the sampling was eliminated under direction of the KPDES permit as it could result in deleterious effects on the aquatic community. Sediment sampling is used as the predictive environmental media sampled in accordance with the EMP. Sediment surveillance sampling is performed to monitor the behavior of the radionuclides in the environment. Sediment sampling concentrations and liquid discharge concentrations are compared to biota concentration guides (BCGs)

using RESRAD-BIOTA. If the sum of the fractions for all radionuclides data/BCG comparisons are less than one, then sampling indicate levels sufficient to protect biota in the environment. A sum of fractions for sediment sampling concentrations and liquid discharge concentrations/BCG greater than one indicate further evaluation is needed in accordance with DOE O 458.1 and DOE-STD-1153-2019, *A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota* (DOE 2019b). Additional information regarding the biota pathway is presented in the EMP.

10. RELEASE AND CLEARANCE OF PROPERTY

The D&R Contactor has an established process for release/clearance of material and equipment (personal property) that have entered radiological areas. This process is documented within the Radiation Protection organization in CP2-RP-0002, *Radiological Control Manual*; Article 421, *Release to Controlled Areas*; and Article 422, *Release to Uncontrolled Areas*. In addition to the provisions listed in Article 422, DOE has provided the D&R Contractor a letter that provides direction on oversight of the free release process of radiologically contaminated equipment and materials from PPPO facilities (DOE 2019c). This letter implements DOE O 226.1B, *Implementation of Department of Energy Oversight Policy*, for the free release of materials from the PPPO facilities. The requirements of this letter are captured in CP3-RP-1125, *Unrestricted Release of Material and Equipment*.

DOE O 458.1, Attachment 1, and associated guidance documents describe the process for release/clearance of surface contaminated material, equipment, or real property based on authorized limits. Further discussion concerning Authorized Limits is covered in Sections 10.3 through 10.9.

Unless alternative dose constraints are approved by issuance of a directive or memorandum by the DOE Chief Health, Safety, and Security Officer or for National Nuclear Security Administration, the Cognizant DOE Secretarial Officer, in consultation, with the DOE Chief Health, Safety and Security Officer, the following dose constraints for DOE residual radioactive material must be applied to each specific clearance of property for any actual or likely future use of the property:

- Real property—a TED of 25 mrem (0.25 mSv) above background in any calendar year, and
- Personal property—a TED of 1 mrem (0.01 mSv) above background in any calendar year.

10.1 EVALUATION OF THE NEED FOR MAINTAINING INSTITUTIONAL CONTROLS FOR REAL PROPERTY

Real property under evaluation for clearance from DOE radiological controls must be evaluated against the need for maintaining institutional controls or impacting long-term stewardship of adjacent DOE real property. In situations where transfer of the real property to other use would impact long-term radiological protection of adjacent DOE properties, it must be demonstrated that the impact of the property clearance would not result in noncompliance for the adjacent property with the requirements of applicable statutes, regulations, or DOE Directives.

The current Five-Year Review for Remedial Actions and the Site Management Plan contain information pertaining to institutional controls and long-term stewardship.

10.2 PROCESS AND HISTORICAL KNOWLEDGE

For radiological clearance of personal property that relies on process knowledge, in part as a basis for clearance decisions, the D&R Contractor uses the process outlined in CP3-RP-1125, *Unrestricted Release of Material and Equipment*.

For radiological clearance of real property that relies on process knowledge, in part, as a basis for clearance decisions, the process must address each specific property individually. If several parcels of land are contiguous, or if several structures are located in the same area and have a common operational history, a single evaluation for all the properties is acceptable.

If available process and historical knowledge cannot demonstrate that personal or real property does not contain residual radioactive materials, radiological monitoring or surveys must be conducted to supplement process and historical knowledge evaluations.

If not supplemented by radiological surveys, process and historical knowledge evaluations must be adequate to determine the following information:

- Whether the property has ever been used for radiological activities or in areas that could have resulted in the presence of residual radioactive material within or on the property; or
- Whether property formerly containing residual radioactive material has been decontaminated and demonstrated to meet DOE Authorized Limits and has not been used in a manner or in areas that could have resulted in the recontamination of the property.

For property that is determined potentially to contain residual radioactive material, the process and historical knowledge evaluation also must include an assessment of the types and quantities of residual radioactive material and the sources and pathways by which the property became contaminated.

10.3 AUTHORIZED LIMITS

Authorized Limits for the clearance of any property with residual radioactive material must provide reasonable assurance that the ALARA process in Section 3 is followed, the public dose limits in Section 4.1 are met, and the dose constraints in Section 10 are applied.

Authorized Limits may be applied to property for which process knowledge cannot establish the absence of residual radioactive material and in which the presence of residual radioactive material cannot be determined.

Authorized Limits must meet the requirements of DOE O 458.1, Attachment 1, paragraphs 2.k.(6)(b) and 2.k.(6)(c).

Property covered by Authorized Limits is subject to 10 *CFR* Part 835 requirements, unless the criteria in DOE O 458.1, Attachment 1, paragraphs 2.k.(6)(a) through (c), have been met and the Authorized Limits have been approved by a Cognizant DOE Secretarial Officer in consultation with the DOE Chief Health, Safety, and Security Officer, as required by the 10 *CFR* Part 835 exclusion.

10.4 REVISION OF AUTHORIZED LIMITS

If established Authorized Limits are found to be not protective, appropriate, or practical to apply for a specific type or portion of property, further clearance for that specific type or portion of property must not proceed without revised Authorized Limits.

If there is a need to revise Authorized Limits, the D&R Contractor uses the process outlined in DOE O 458.1, Attachment 1, paragraph 2.k.(6)(e).

10.5 PRE-APPROVED AUTHORIZED LIMITS

Pre-Approved Authorized Limits may be used for any radiological activity instead of developing specific Authorized Limits if their use is documented in this ERPP and the specific application of the Authorized Limits is approved by the responsible DOE Field Element Manager.

The following values have been pre-approved by DOE for use as Authorized Limits and may be used as specified below instead of developing specific Authorized Limits.

- For radium-226 and radium-228 in soil—5 pCi/gram (0.2 Bq/gram) in excess of background levels, averaged over 100 m², in the first 15 cm depth of the surface layer of soil; and 15 pCi/gram (0.56 Bq/gram) in excess of background levels, averaged over any subsequent 15 cm subsurface layer of soil plus an ALARA assessment. If both thorium-230 and radium-226 or both thorium-232 and radium-228 are present and not in secular equilibrium, the appropriate pre-approved limit must be applied to the radionuclide with the higher concentration.
- Previously approved guidelines and limits [such as the surface activity guidelines (DOE O 5400.5 Chg 2 and DOE 2002)] may continue to be applied and used as Pre-Approved Authorized Limits until they are replaced or revised by Pre-Approved Authorized Limits issued by DOE.
- Operating Experience Level 3, *Implementation of Pre-Approved Authorized Limits for Release and Clearance of Volumetric Radioactivity of Personal Property at Department of Energy Field Elements*, OE-3:2021-01, March 2021 (DOE 2021b).

10.6 APPROVED AUTHORIZED LIMITS

In addition to the Pre-Approved Authorized Limits listed in Section 10.5, the following Authorized Limits are approved for use:

- Release Limits for Hydrofluoric Acid and Calcium Fluoride from Depleted Uranium Hexafluoride (DUF₆) Conversion (DOE 2005);
- C-746-U Landfill Authorized Limits Approval and Implementation Requirements (DOE 2011a, DOE 2011b, DOE 2019a);
- Authorized Limits for the U.S. Department of Energy Owned Property Outside the Limited Area in Paducah, Kentucky Approval and Implementation Requirements (DOE 2016; DOE 2020a);
- Authorized Limits for Lube Oil and Dielectric Fluids (DOE 2015b) allow for incineration at the following facilities:

- Veolia Environmental Services in Port Authur, Texas, and
- Clean Harbors Environmental Services, Inc. in Deer Park, Texas.
- Authorized Limits for Freon (DOE 2020b; DOE 2020c) allow for incineration at the following facilities:
 - Clean Harbors Aragonite in Dugway, Utah,
 - Clean Harbors El Dorado in El Dorado, Arkansas, and
 - Veolia North America/Port Authur in Beaumont, Texas.
- Authorized Limits for Paducah and Portsmouth Personal Property Being Dispositioned Through the Bulk Survey for Release Process for Disposal to the Carter Valley Landfill in Tennessee (DOE 2015c; DOE 2015d);
- In 2021, DOE approved the D&R Contractor request to use the following DOE Waste Treatment Basic Ordering Agreements (DOE 2021c):
 - 89303321GEM000016—EnergySolutions, LLC, Clive, Utah—low-level waste (LLW) and mixed low-level waste (MLLW);
 - 89303321GEM000017—Perma-Fix Environmental Services including Perma-Fix Diversified Scientific Services, Inc., Kingston, Tennessee, and Oak Ridge, Tennessee; and Perma-Fix Northwest, Richland, Washington—LLW and MLLW; and
 - 89303321GEM000020—Waste Control Specialists, LLC, Andrews, Texas—LLW, MLLW, and low activity waste.

10.7 CLEARANCE OF ENVIRONMENTAL RESTORATION, DEACTIVATION AND DECOMMISSIONING, AND OTHER CLEANUP MATERIALS

Clearance of property with residual radioactive material from environmental remediation activities, including deactivation and decommissioning, must meet the specific requirements of DOE O 458.1, Attachment 1. Environmental restoration activities using the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) process may demonstrate compliance with DOE O 458.1, Attachment 1 (including public dose assessments, ALARA analysis, and consideration of scenarios) using documentation from the CERCLA process and any necessary supplemental information.

For the purpose of clearance of real or personal property, approved CERCLA remediation criteria may be considered equivalent to Authorized Limits, if the appropriate DOE Field Element Manager has determined that the criteria meet the specific requirements of DOE O 458.1, Attachment 1 for Authorized Limits, and provided that the use of the criteria as DOE Authorized Limits is documented and approved as would be an Authorized Limit. Compliance with all specific requirements of DOE O 458.1 Attachment 1 not met through the CERCLA process also must be demonstrated.

If the D&R Contractor performs environmental restoration activities involving clearance of real or personal property with residual radioactive material under CERCLA that use the CERCLA analysis and documentation in lieu of analysis and documentation developed specifically to demonstrate compliance with the specific requirements of DOE O 458.1, Attachment 1, the D&R Contractor will submit the relevant CERCLA documentation and any additional information necessary to demonstrate that the requirements for Authorized Limits have been met to the responsible DOE Field Element Manager.

DOE has instituted a moratorium on the clearance of potentially contaminated materials for recycling. If metal has been located in a radiological area, as defined by 10 *CFR* Part 835, and was not appropriately released from the radiological area prior to July 13, 2000, it may not be cleared from recycling. For metal that had been in a radiological area which has been appropriately down-posted and is no longer subject to 10 *CFR* Part 835, radiological controls may be cleared for unrestricted use. The posting cannot be removed for the purpose of clearing metal. Metal may be cleared provided it will continue to be used in its current form, or transferred as radioactive material to a licensed individual. Metals with potential volumetric contamination cannot be cleared without application of DOE-approved authorized release limits. In April 2021, DOE issued an update to *Frequently Asked Question on the Suspension on Release for Recycling of Metal from Radiation Areas*, which provides updated guidance pertaining to the restriction on recycling metals from radiologically controlled areas.

As discussed previously in Section 10, the D&R Contactor has an established process for release/clearance of material and equipment (i.e., personal property) that have entered radiological areas. This process is documented in CP2-RP-0002, *Radiological Control Manual*; Article 421, *Release to Controlled Areas*; and Article 422, *Release to Uncontrolled Areas*. In addition to the provisions listed in Article 422, DOE has provided the D&R Contractor direction on the free release process of radiologically contaminated equipment and materials from DOE PPPO facilities (DOE 2019c). This direction implements DOE O 226.1B, *Implementation of Department of Energy Oversight Policy*, for the free release of materials from DOE PPPO facilities. The requirements are captured in CP3-RP-1125, *Unrestricted Release of Material and Equipment*.

10.8 RADIOLOGICAL MONITORING OR SURVEYS

All radiological monitoring or surveys performed in support of clearance of property must adhere to the following guidelines:

- Use methodologies sufficient to meet measurement objectives such as those in the *Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM)*, the *Multi-Agency Radiation Survey and Assessment of Materials and Equipment Manual (MARSAME)* or other methodologies approved by DOE;
- Meet measurement quality objectives;
- Use DOE-approved sampling and analysis techniques, if applicable; and
- Include an evaluation of nonuniformly distributed residual radioactive material, if applicable.

Instrumentation used for radiological monitoring or surveys must be capable of detecting and quantifying residual radioactive material consistent with the applicable Authorized Limits, and meet the following guidelines:

- Be periodically maintained and calibrated on an established frequency;
- Appropriate for the type(s) levels, and energies of the radiation(s) encountered; and
- Appropriate for existing environmental conditions and routinely tested for operability.

10.9 DOCUMENTATION AND VERIFICATION

The D&R Contractor will ensure that final radiological monitoring or surveys are conducted and that documentation is prepared that shows that the clearance meets applicable DOE Authorized Limits, or other applicable requirements, including associated restrictions or institutional controls [See current version DOE Policy 454.1, *Use of Institutional Controls*].

Information on approved Authorized Limits, any approved revised Authorized Limits, use of Pre-Approved Authorized Limits, results of radiological monitoring and surveys of cleared property with type and quantity of property cleared, and independent verification results must be summarized in the ASER.

Final clearance of property must be documented. The contents of the documentation or the mechanism for documenting information may be tailored to the need, situation, and type of property being cleared. For ongoing routine clearances (e.g., clearance of personal property from controlled areas), such documentation may be based on the general process(es) rather than each specific clearance. In general, the documentation must describe the clearance process(es) and the property being cleared. The documentation must serve to demonstrate requirements have been met, show criteria used for clearance, identify the property's destination or disposition, as appropriate, and provide additional confidence to DOE and assurance to other interested parties that the public and the environment are being protected. The documentation must indicate any Authorized Limits, including any revised or Pre-Approved Authorized Limits used for clearance that contain information and data supporting the clearance of property such as radiological certification and independent verification results. An annual summary of cleared property must be prepared and submitted to the DOE Field Element Manager.

11. RECORDS RETENTION AND REPORTING REQUIREMENTS

11.1 ERPP RECORDS

The records of ERPP-related activities are managed in accordance with CP2-RD-0001, *Records Management Plan at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*. Required records are retained until final disposition is authorized by DOE. ERPP records include the following.

- a) Information and data necessary to identify and characterize releases of radioactive material to the environment, their fate in the environment, and their probable impact on radiation dose to members of the public, and any impacts on ecological systems.
- b) Documentation of individual and collective dose to members of the public due to radiological activities. This includes documentation of site-specific information on radiation source dispersion patterns, location, and demography of members of the public in the vicinity of the radiological activity and assumed default values or site-specific parameters used in calculations.
- c) Requests for specific authorization for temporary public dose limits, and subsequent approvals and other related actions.
- d) Identification of radiological activities subject to environmental radiological protection program requirements and descriptions of the measures to be used in implementing these requirements.
- e) Documentation of actions taken to implement the ALARA process.

- f) Documentation of actions taken to demonstrate compliance with the public dose limit.
- g) Documentation of actions taken to implement the BAT selection process in regulating liquid discharges, including documentation of analyses and factors considered to be important, including alternative processes, for the BAT selection process.
- h) Effluent monitoring and environmental surveillance information and data, including the following information:
 1. Results of effluent monitoring for determining sources of radiation and radioactive material that provide direct exposure to members of the public and releases of radioactive material in liquid or airborne effluent;
 2. Results of survey for radiation and radioactive material in the environment;
 3. Results of surveys, measurements, and calculations used to determine the dose to members of the public and ecological receptors from external and internal radiation sources;
 4. Meteorological data used in assessing dose; and
 5. Results of pre-operational monitoring.
- i) Documentation related to the long-term management of radioactive waste and residual radioactive material.
- j) Final documentation for clearance of property containing residual radioactive material.
- k) Documentation of the following items:
 1. Approved Authorized Limits for routine clearance of property for unrestricted or restricted use and the scenarios evaluated in selecting the limits; and
 2. Approved revised Authorized Limits for clearance of property.
- l) Annual summaries related to clearance of property.

11.2 RADIOLOGICAL UNITS

Unless otherwise specified, the quantities used in the reports and records required by this ERPP must be clearly indicated in special units of curie, rad, roentgen, or rem, including multiples and subdivisions of these units, or other conventional units such as dpm, dpm/100cm², or mass units. The International System of Units (SI), becquerel (Bq), gray (Gy), and sievert (Sv), may be provided parenthetically for reference with scientific standards. Use of SI units should be limited to calculational, scientific, or reference purposes. Other radiological units that have been specified and are allowable for ERPP records include these:

- a) Multiples and subdivisions of derived air concentration (DAC) and DAC-hours for measurements of airborne radioactivity and individual exposure to airborne radioactivity.
- b) Analytical results from environmental samples typically are reported in pCi/g (for soil and sediment) and pCi/L for surface water and groundwater.

11.3 REPORTING

The D&R Contractor reports information in the ASER per requirements in DOE O 458.1, Attachment 1. Other annual reports are submitted to summarize information on particular pathways in accordance with their applicable regulations. These reports include, but are not limited to, the NESHAP Annual Report and the External Radiation Monitoring Annual Report. Additional trending reports of site environmental radiological parameters are provided at DOE request to support comparison, trending, and decisions.

Reports of identification of radioactive material or contamination off-site due to DOE operations/activities, determination of a dose that exceeds limits of DOE 458.1, Attachment 1, paragraph 2.b.(1)(a), or 40 *CFR* Part 61.92 requirements under DOE O 232.2, *Occurrence Reporting and Processing of Operations Information*, current version, are submitted to DOE in accordance with applicable occurrence reporting requirements and CP3-QA-3005, *Occurrence Reporting*. Other identified issues not meeting the above criteria are reported using the D&R Contractor's issues management procedures.

12. RESOURCE ASSESSMENT

Funding required to develop and implement a fully compliant ERPP has been factored into the D&R Contractor project work. Appropriate levels of funding have been assigned for management of this ERPP, development of programmatic documents, and acquisition of equipment, sampling, analysis, training, and personnel to meet all commitments.

13. PRIORITIZATION

The D&R Contractor recognizes the applicable elements of DOE O 458.1 with priority given to *CFR* requirements as applicable. Other elements of DOE O 458.1 are implemented as applicable, with a lower priority than *CFR* requirements, if they do not conflict. In the event of a conflict between the *CFR* and DOE Order, the *CFR* will take priority. DOE O 458.1 objectives are accomplished through integration with the Environmental Management System (EMS). An EMS is a continuing cycle of planning, implementing, evaluating, and improving processes and actions undertaken to achieve environmental goals. The D&R Contractor's EMS (CP2-ES-0101) is designed to describe the environmental policy and document the integration of environmental protection and compliance, waste minimization and pollution prevention, and site sustainability into the D&R Contractor's Integrated Safety Management System and safety culture.

14. REFERENCES

CP2-EC-0002, *National Emission Standards for Hazardous Air Pollutants Management Plan for Emission of Radionuclides for the U.S. Department of Energy Operations at the Paducah Site, Paducah, Kentucky.*

CP2-ES-0006, *Environmental Monitoring Plan Fiscal Year 2021 Paducah Gaseous Diffusion Plant, Paducah, Kentucky.*

CP2-ES-0101, *Environmental Management System for the Deactivation and Remediation Project, Paducah Gaseous Diffusion Plant, Paducah, Kentucky.*

- CP2-RD-0001, *Records Management Plan for the Paducah Gaseous Diffusion Plant Paducah, Kentucky.*
- CP2-RP-0002, *Radiological Control Manual.*
- CP3-QA-3005, *Occurrence Reporting.*
- CP3-RP-1114, *ALARA Program.*
- CP3-RP-1125, *Unrestricted Release of Material and Equipment.*
- CP3-WM-0022, *Waste Water Accumulation, Storage, and Disposal.*
- CP4-UT-0618, *Operation of C-615 Sewage Treatment Plant.*
- DOE (U.S. Department of Energy) 2002. *Draft Implementation Guide: Control and Release of Property with Residual Radioactive Material for use with DOE 5400.5, Radiation Protection of the Public and the Environment, DOE G 441.1-XX*, U.S. Department of Energy, Washington, DC, April.
- DOE 2005. Memorandum from W. Murphie to A. Wallow, “Release Limits for Hydrofluoric Acid and Calcium Fluoride from Depleted Uranium Hexafluoride (DUF₆) Conversion,” PPPO-01-402-05, dated August 12.
- DOE 2011a. *Authorized Limits Request for Solid Waste Disposal at C-746-U Landfill at the Paducah Gaseous Diffusion Plant*, U.S. Department of Energy, Paducah, KY.
- DOE 2011b. Memorandum from W. Murphie to R. Knerr, “C-746-U Authorized Limits Approval and Implementation Requirements,” PPPO-01-1120911-11C, dated October 17.
- DOE 2014. *Optimizing Radiation Protection of the Public and the Environment for use with DOE O 458.1, ALARA Requirements*, DOE-HDBK-1215-2014, U.S. Department of Energy, Washington, DC, October.
- DOE 2015a. *Environmental Radiological Effluent Monitoring and Environmental Surveillance*, DOE-HDBK-1216-2015, U.S. Department of Energy, Washington, DC, March.
- DOE 2015b. Letter from J. Woodard to C. Murphy, “Contract No. DE-EM001131, Task Order DE-DT0007774: Fluor Federal Services, Inc., Paducah Deactivation Project Authorized Limits for Lube Oil and Dielectric Fluids,” PPPO-02-2910425-15B, dated June 5.
- DOE 2015c. “Authorized Limits for Paducah and Portsmouth Personal Property Being Dispositioned Through the Bulk Survey for Release Process for Disposal in Certain Class I Landfills,” PPPO-02-2862713-15, April 2.
- DOE 2015d. Memorandum from M. A. Gilbertson to W. E. Murphy, “Authorized Limits for Paducah and Portsmouth Personal Property Being Dispositioned Through the Bulk Survey for Release Process for Disposal in Certain Class I Landfills,” PPPO-02-2862713-15, May 15.
- DOE 2016. Letter from J. Woodard to B. Smith, “Authorized Limits for the U.S. Department of Energy Owned Property Outside the Limited Area in Paducah, Kentucky Approval and Implementation Requirements,” PPPO-02-3652503-16, dated July 13.

- DOE 2019a. Letter from J. Woodard to J. Bradford, “C-746-U Landfill Authorized Limits Implementation Requirements,” PPPO-02-5683395-19, dated August 16.
- DOE 2019b. *A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota*, DOE-STD-1153-2019, U.S. Department of Energy, Washington, DC, February.
- DOE 2019c. Letter from J. Woodard to M. Redfield, “Oversight of the Free Release of Radiologically Contaminated Equipment and Materials from Portsmouth/Paducah Project Office Facilities,” PPPO-03-5656986-19B, dated August 21.
- DOE 2020a. Letter from J. Woodard to M. Redfield, “Amendment to the Authorized Limits for the Department of Energy-Owned Property Outside the Limited Area in Paducah, Kentucky Approval and Implementation Requirements,” PPPO-02-10004903-20B, dated May 5.
- DOE 2020b. Memorandum from W. White to R. Edwards III, “Authorized Limits for Volumetric Release Limits for R-114 (Freon) at the Paducah Gaseous Diffusion Plant in Paducah, Kentucky,” dated July 23.
- DOE 2020c. Letter from J. Woodard to M. Redfield, “Implementation Requirements for Authorized Limits for Freon,” PPPO-02-0007687-20, dated August 10.
- DOE 2021a. *Derived Concentration Technical Standard*, DOE-STD-1196-2021, U.S. Department of Energy, Washington, DC, July 7.
- DOE 2021b. *Implementation of Pre-Approved Authorized Limits for Release and Clearance of Volumetric Radioactivity of Personal Property at DOE Field Elements*, OE-3: 2021-01, U.S. Department of Energy, Washington DC, March.
- DOE 2021c. Letter from M. Fultz to D. Ruckstuhl, “Approval of Request to Use Department of Energy Waste Treatment Basic Ordering Agreements,” PPPO-02-10011802-21, dated June 16.
- EPA (U.S. Environmental Protection Agency) 2000. *Meteorological Monitoring Guidance for Regulatory Modeling Applications*, EPA-454/R-99-005, U.S. Environmental Protection Agency, Research Triangle Park, NC, February.
- MMES (Martin Marietta Energy Systems, Inc.) 1995. *Paducah Gaseous Diffusion Plant Groundwater Protection Program Plan*, KY/ER-2 Addendum 2 Rev. 2, Martin Marietta Energy Systems, Inc., Paducah, KY, February.

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