THE SWIFT STALEY TEAM

Paducah Gaseous Diffusion Plant
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United States Enrichment Corporation
Air Emissions Annual Report
(40 CFR 61, Subpart H)
Calendar Year 2003

SITE INFORMATION

Site Name:

Paducah Gaseous Diffusion Plant

Operating Contractor:

United States Enrichment Corporation

Address:

Post Office Box 1410
Paducah, Kentucky 42002-1410

Contact:

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SECTION I FACILITY INFORMATION

INTRODUCTION

The Department of Energy (DOE) Paducah Site contains the Paducah Gaseous Diffusion Plant (PGDP), which is leased to the United States Enrichment Corporation (USEC). DOE manages the remaining, non-leased facilities at the Paducah Site. The DOE-managed facilities consist of various waste management facilities, inactive buildings, depleted uranium storage facilities, and environmental restoration facilities. This report analyzes emissions from USEC and DOE portions of the Paducah Site.

SITE DESCRIPTION

PGDP is an active uranium enrichment facility consisting of a diffusion cascade and extensive support facilities. The cascade, including product and tails withdrawal, is housed in 6 process buildings covering a total of approximately 80 acres. The plant is located on a reservation consisting of approximately 1,350 acres in western McCracken County approximately 10 miles west of Paducah, Kentucky, and approximately 3 miles south of the Ohio River. Roughly 740 acres of the reservation are enclosed within a fenced security area. An uninhabited buffer zone of at least 400 yards surrounds the entire fenced area. Beyond the DOE-owned buffer zone is an extensive wildlife management area consisting of approximately 2,100 acres either deeded or leased to the Commonwealth of Kentucky. During World War II, the Kentucky Ordnance Works (KOW), a trinitrotoluene production facility, was operated in an area southwest of the plant on what is now the wildlife management area. The water treatment plant used by PGDP was originally a KOW facility.

Construction of the PGDP facility began in 1951 and the plant was fully operational by 1955, supplying enriched uranium for commercial reactors and military defense reactors. Enriched uranium is defined as uranium in which the concentration of the fissionable uranium-235 (^{235}U) isotope has been increased from its natural assay. Natural uranium is mostly ^{238}U with about 0.71 percent ^{235}U and 0.0055 percent ^{234}U. Uranium mills process the ores to produce concentrated uranium oxide (U_3O_8), which is then commercially converted to uranium hexafluoride (UF_6) for enrichment at a gaseous diffusion plant.

The Paducah Plant enriches the uranium isotope, ^{235}U, by utilizing a physical separation process. The separation is based on the faster rate at which ^{235}U diffuses through a barrier compared with the heavier ^{238}U isotope. During enriching operations from 1953 to 1975, feed material (called "reactor tails") from government reactors was also used intermittently in addition to the UF_6 typically used. Reactor tails were the spent fuel from nuclear reactors that is depleted in ^{235}U content and has been reprocessed to remove most of the fission products. The reactor fuel rods were processed at other DOE facilities (where most of the fission products were removed) and the enriched uranium and the remaining fission products were fed into the PGDP cascade system. Use of the reactor tails resulted in the introduction of technetium-99 (^{99}Tc), a fission by-product, and transuranics, most notably neptunium-237 (^{237}Np) and plutonium-239 (^{239}Pu), into the cascade. ^{99}Tc is a man-made radioactive substance (radionuclide) having a half-life estimated at between 212,000 and 250,000 years. ^{99}Tc decays by emitting beta radiation.

Extensive support facilities are required to maintain the diffusion process. Some of the major support facilities include a steam plant, four major electrical switchyards, four cooling tower complexes, a chemical cleaning and decontamination building, a water treatment plant, a cooling water blowdown treatment facility, maintenance facilities, and laboratory facilities. Several inactive facilities are also located on the plant site.

The West Kentucky Wildlife Management Area and lightly populated farmlands are in the immediate environs of PGDP. The population within the 50-mile radius is approximately 531,000 persons. Of these, approximately 36,500 live within 10 miles of the plant and approximately 104,000 within 20 miles. The unincorporated communities of Grahamville and Heath are 1.24 and 1.86 miles east of the plant, respectively. Portions of 28 counties, 11 of which are in Kentucky, 4 in Missouri, 10 in Illinois, and 3 in Tennessee, are included within the 50-mile radius of the plant. Larger cities in the region include Paducah, Kentucky, located approximately 10 air miles east of the plant; Cape Girardeau, Missouri, located approximately 40 air miles to the west; and Metropolis, Illinois, located approximately 6 air miles to the northeast.

Paducah is located in the humid continental zone. Summers are generally dry; precipitation occurs mainly in the spring and fall. Winters are characterized by moderately cold days; the average temperature during the coldest month, January, is about 35° F. Summers are warm and humid; the average temperature in July is 79 F. Yearly precipitation averages about 44 inches. The prevailing wind direction is south to southwest.

In July 1993, USEC was formed as a government corporation and became a private corporation in July 1998. Although DOE still owns all the facilities at PGDP, the uranium enrichment enterprise is now the responsibility of USEC. According to the Lease Agreement between DOE and USEC, USEC retained responsibility for quantification of airborne radionuclide emissions and preparation of the annual report required by 40 CFR 61, Subpart H. DOE remains responsible for compliance with other requirements for DOE-operated sources.

On March 3, 1997, the Nuclear Regulatory Commission assumed regulatory responsibility for the USEC-leased portion of the plant. However, because DOE owns the entire facility, both the USEC and DOE facilities are subject to 40 CFR 61, Subpart H, requirements.

USEC SOURCE DESCRIPTIONS

The following are the potential USEC airborne radionuclide sources at the Paducah Plant. Although not all of them were used in 2003, they are included in this report due to their potential for future restart.

C-310 Stack

The primary source of potential radionuclide air emissions is the vent stack that serves the "top end" of the cascade process and the cylinder burping facility. This 200-foot stack, known as the C-310 stack, is located at the southwest corner of the C-310 Product Withdrawal Building. Low molecular weight gas compounds and contaminants, which have traveled up the cascade, are vented to the atmosphere via the C-310 purge vent stack. Small quantities of ^{234}U, ^{235}U, ^{238}U, ^{99}Tc, ^{237}Np, ^{239}Pu, and thorium-230 (^{230}Th) are also emitted. The cascade effluent is routed through alumina traps prior to being emitted via the C-310 stack. The alumina traps were upgraded in 1990 to provide greater criticality safety. The improved system consists of an on-line bank of 13 traps and a standby bank of 13 traps. Each trap contains approximately 200 pounds of alumina.

The cylinder burp facility, located on the east side of C-310, is used to vent the low molecular weight gases from product cylinders. This facility is also a potential source of uranium, ^{99}Tc, minute

quantities of transuranics, and ^{230}Th. The effluent from the burp facility is routed through a bank of sodium fluoride (NaF) traps prior to being emitted from the C-310 stack. There are 2 banks of chemical traps associated with this system. Each bank has 5 primary and 2 secondary traps. These traps contain approximately 130 pounds of NaF each. Uranium is recovered from the NaF traps back to the enrichment cascade.

Emissions from the C-310 stack were estimated based on daily results of the continuous potassium hydroxide bubbler stack sampling system, which was approved by the Environmental Protection Agency (EPA) in 1992.

As part of the Quality Assurance/Quality Control (QA/QC) requirements for the C-310 stack sampler, a range for the sample flow has been established. During 2003, there were 6 instances where the sample flow was outside of the established range. These instances did not compromise the integrity of the sample. From operational records, there were no indications of excess emissions during these periods; emissions immediately prior to and after the dates in question indicated that they were within normal ranges.

Seal Exhausts

Seals on the UF_6 compressors are supplied with an intricate array of air pressures to reduce any UF_6 release that may occur in the event of a seal failure. The seal exhaust flow is removed by large, oil-filled vacuum pumps and is routed from the seals through alumina traps, the pump, and to a common exhaust vent. There is one seal exhaust vent per cascade building, one on the C-310 Product Withdrawal Building and one on the C-315 Tails Withdrawal Building. Under normal operations, only trace amounts of UF_6 are present in the seal exhaust system. Occasionally, a seal or seal control system malfunction will allow greater quantities of UF_6 to enter the exhaust system. If UF_6 is allowed to enter the pump by virtue of trap breakthrough, it reacts with the pump oil creating a thick, gummy sludge, which overloads the pump in a short time. Due to the reaction between UF_6 and pump oil, the oil also serves as an excellent uranium emission control device; however, no credit is taken for the oil as a pollution abatement system because the oil is an integral part of the pumping system and in no way is included for emission control. The list below indicates locations of the six seal exhausts at PGDP:

C-310 Product Withdrawal Building
C-315 Tails Withdrawal Building
C-331 Process Building
C-333 Process Building
C-335 Process Building
C-337 Process Building

Emissions from the seal exhaust grouped source were originally estimated based on results of Method 5 stack sampling performed in 1992. The seal exhausts were resampled in 1997 and 2002 respectively. The 2002 sampling results were used for emission estimates for CY 2003.

A discussion of the potential to emit from the seal exhausts and wet air exhausts, and the conclusion that the alumina traps which protect the pump oil are not pollution control devices under 40 CFR 61, Subpart H, was forwarded to EPA on January 28, 1994.

Wet Air Exhaust

When maintenance is required on cascade piping and equipment, the process gas (UF_6) is evacuated to other sections of the cascade or surge drums. The subject equipment and piping are swept

in a series of purges with "dry" plant air. After maintenance, the system is closed and the ambient (wet) air is pumped from the system by the wet air pumps. In the dry air purges and wet air evacuations, the air is routed through alumina traps for uranium trapping to protect the wet air pump oil, and then to an exhaust vent. In process buildings C-310, C-333, C-335, and C-337, the exhaust vent is the same one that services the seal exhaust system for those buildings. Emissions from the wet air exhausts in 2002 were estimated based on results of Method 5 stack sampling performed in 2002. The list below indicates locations of the five wet air exhausts at PGDP:

C-310 Product Withdrawal Building (same as seal exhaust)
C-331 Process Building
C-333 Process Building (same as seal exhaust)
C-335 Process Building (same as seal exhaust)
C-337 Process Building (same as seal exhaust)

Cylinder Valve Connection Activities

Activities involving the connection and disconnection to UF_6 cylinders include cold pressure checks; sampling of feed, product, and tails cylinders; and product withdrawal, tails withdrawal, cylinder feeding, and cylinder burping. The cylinder valves are connected to the associated process via a "pigtail." Cylinder pigtails consist of a single length of copper tubing and threaded couplings. Pigtail disconnection procedures require a series of purges to ensure that no UF_6 remains in the pigtail prior to disconnection. Although adherence to these procedures minimizes UF_6 emissions, occasionally a "puff" of UF_6 is observed during disconnection of the pigtails. As an additional measure to control radionuclide emissions, personnel performing the pigtail disconnects employ the use of a glove box containment device and/or portable high efficiency particulate air (HEPA) vacuums (vacs). The HEPA vacs are placed so that any minute "whiff or puff" of UF_6 which is emitted from the pigtail disconnect process is captured by the HEPA vac.

Cylinder disconnection activities in CY 2003 were serviced by HEPA filter-equipped vac systems. The list below indicates the locations of the pigtail systems:

C-310	Burp Station (located outside portable HEPA vacs used).
C-310	Product Withdrawal Building.
C-315	Tails Withdrawal Building.
C-333-A	Feed Facility (UF_6 Vaporizer).
C-337-A	Feed Facility (UF_6 Vaporizer).
C-360	Toll Transfer and Sampling Facility.

Emissions from these systems were estimated by determining the total number of pigtail disconnections in each facility. An estimated quantity of UF_6 in each pigtail (based on the system volume, temperature, and pressure) multiplied by the number of disconnections was used to estimate the total quantity of UF_6 that could have been released.

Pigtails are evacuated and purged numerous times to reduce the quantity of UF_6 in the pigtail to very low levels. The method described above assumes that each pigtail has been evacuated or purged in accordance with operating procedures. Quantities of UF_6 released as observed puffs are added to the releases estimated from normal operations.

In the case of C-360, there are two stacks, one for the pigtail exhaust system and one for the sample cabinet exhaust.

Laboratory Hoods

The C-709/710 Laboratories are operated by Production Support and are the main facilities for sample analysis and research at PGDP. There are a total of 94 laboratory hoods and canopies in the C-709/710 buildings. Fifty-two of the hoods were used for radiological activities in CY 2003. The radionuclides involved in analyses consist primarily of uranium, with a slight potential for emissions of ^{99}Tc, ^{237}Np, ^{239}Pu, and the daughters of uranium (^{230}Th and ^{234}Th). In some cases, the hood exhausts combine with other hood exhausts, creating a discrepancy between the number of hoods and actual emission points. There are also 8 laboratory hoods in the C-409 Stabilization Facility. None of these hoods were used for work with radionuclides in 2003. The list below indicates the laboratory exhaust systems at PGDP:

Building	Hoods/Canopies	Hoods/Canopies Used in Radiological Areas in 2003
C-709/710 Laboratory	94	52
C-409	8	Not used

Four methods, depending on the type of operation occurring in the hood or radiological area in which the hood was located, were used to estimate emissions.

1. Estimation of the maximum quantity of uranium that could be lost based on laboratory methods (e.g., if an ASTM analytical method specifies a maximum of 1.6 percent loss of mass during analysis, all samples analyzed using the method were assumed to loose, as an emissions from the hood, 1.6 percent of the uranium in the sample.)

2. Use of 40 CFR 61, Appendix D, emission factors.

3. Use of chemical trap efficiencies and uranium throughput information.

4. Knowledge of the analytical or sample preparation process.

All methods used the total inventory of uranium processed in the hood or radiological area as the basis for the emission estimate.

Chlorofluorocarbon-114 (CFC-114) UF_6 Separator

The CFC-114/UF_6 separator is located in C-335 and can be used to separate relatively large amounts of CFC-114 coolant, which has entered the cascade system and mixed with UF_6. The separator was installed in 1978 and initial operations were conducted in 1979. When in use, the separator effluent is passed through a cold trap at minus 30°F which condenses approximately 98.5% of the gaseous UF_6. The residual UF_6 in the effluent is trapped by two pairs of NaF traps. Uranium trapped by the NaF traps is recovered back to the gaseous diffusion cascade. The effluent passes from the NaF traps through alumina traps and a header to the C-335 wet air/seal exhaust system. The outlet of the alumina traps is monitored by a flow-through ionization chamber.

The emissions from this system also have to pass through the wet air/seal exhaust pump oil, which is an excellent scrubber of UF_6. Since this facility is used only when large amounts of CFC-114 leak into the cascade and is equipped with a two-stage control process, use of this facility is not expected to increase the emissions from the wet air/seal exhaust system. This facility was not operated in 2003.

C-400 Decontamination Spray Booth

This facility is used to decontaminate equipment. It consists of a large booth equipped with an ultra high-pressure sprayer, which sprays a water solution on the contaminated machinery. The potential of radionuclide emissions arises from entrainment of radionuclides in the spray solution during the decontamination process. The booth is equipped with a mist eliminator as an emission control device. The mist eliminator is not listed as a pollution control device in 40 CFR 61, Appendix D, and no credit is taken for it. Emissions were estimated in accordance with Appendix D. The concentration of radionuclides in the spray booth water multiplied by the total volume of water was considered as the curies "used."

C-400 No. 5 Dissolver/Rotary Vacuum Filter

This facility is used to dissolve and precipitate the uranium in the solutions from the C-400 cylinder wash and decontamination spray booth. It is also used to treat uranium salvaged from C-710. The solution is chemically treated to precipitate the uranium that forms a slurry. The slurry is then passed through a rotary vacuum filter, which collects the precipitate (filter cake) for future disposal. After sampling, the filtrate is then discharged via permitted Kentucky Pollutant Discharge Elimination System (KPDES) outfalls. The possibility for radionuclide emissions arises from the vent on the pump that pulls the slurry through the rotary vacuum filter. Emissions from this vent should be minimal because the pump and its vent are downstream of the rotary vacuum filter that should trap the uranium as filter cake. Emissions were estimated in accordance with 40 CFR 61, Appendix D. The concentrations of radionuclides in the filtrate multiplied by the filtrate volume were considered as the curies "used."

C-409 Dissolver/Rotary Vacuum Filter

This facility is used to dissolve and precipitate the high assay uranium in solutions from the C-710 Laboratory and various sources. The solution is chemically treated to precipitate the uranium that forms a slurry. The slurry is then passed through a rotary vacuum filter, which collects the precipitate (filter cake) for future disposal. After sampling, the filtrate is then discharged via permitted KPDES outfalls. The possibility for radionuclide emissions arises from the vent on the pump that pulls the slurry through the rotary vacuum filter. Emissions from this vent are expected to be minimal because the pump and its vent are downstream of the rotary vacuum filter that should trap the uranium as filter cake. Emissions are estimated in accordance with 40 CFR 61, Appendix D. The concentrations of radionuclides in the filtrate multiplied by the filtrate volume are considered as the curies "used."

C-400 Cylinder Drying Station

This facility is used to dry UF_6 cylinders after the "heel" has been removed in the C-400 cylinder washstand. Dry "plant air" is passed through the cylinder to evaporate any moisture from the washing and hydrostatic testing processes. Emissions were estimated in accordance with 40 CFR 61, Appendix D. The concentrations of radionuclides in water used to hydrostatically test the cylinders prior to drying, multiplied by the total volume of water used in the hydrostatic test, were considered as the curies "used."

Radiological Areas

Radiological areas are established under specific criteria listed in various worker protection procedures and standards. There are a number of radiological areas at PGDP that are monitored by Health Physics (HP) low-volume air samplers. The sampling systems consist of a low-volume pump (20 to 40 liters per minute) drawing the ambient building air through a Whatman No. 41 cellulose filter. The samplers run 24-hours per day and the filters are changed on 2-, 3-, 4-, or 5-day basis, depending upon weekend and holiday schedules. Typically, a minimum of 2 days of sample air is collected on each filter. After sample collection, the filters are counted for airborne radioactivity concentrations.

For the 2003 NESHAP report, PGDP estimated the building ventilation grouped source according to the method stated in Section 3.1 of the revised PGDP NESHAP Compliance Plan submitted to EPA in January 1992.

According to PGDP's compliance plan, building emissions from non-radiological areas are not estimated due to their lack of potential for airborne radiological emissions.

For CY 2003, the following is a list of PGDP's radiological areas from which emissions were evaluated using HP data:

C-310 Product Withdrawal Building
C-315 Tails Withdrawal Building
C-331 Uranium Enrichment Process Building
C-333 Uranium Enrichment Process Building
C-333-A Uranium Feed Facility
C-335 Uranium Enrichment Process Building
C-337 Uranium Enrichment Process Building
C-337-A Uranium Feed Facility
C-360 Toll Transfer/Sampling Building
C-400 Decontamination Building
C-710 Laboratory
C-720 Maintenance Building This building is the primary maintenance building at PGDP. Maintenance on contaminated and uncontaminated machinery is performed here. Transferable contamination has been removed prior to maintenance; however, there is a potential for airborne radionuclide emissions from fixed contamination during maintenance procedures. Portable negative air machines, which are equipped with HEPA filters, are utilized whenever there is a potential for airborne radionuclide emissions.

Buildings C-754, C-757, and the USEC-controlled side of C-746-Q are also categorized as radiological areas. However, these buildings have no ventilation systems. Any emissions from these buildings would be fugitive or diffuse in nature. Fugitive and diffused emissions are discussed later in this report.

Data from HP air sampling in radiological areas indicated that the trigger level of 10 percent of the most restrictive Derived Air Concentration (DAC) guideline in 10 CFR 20, Appendix B, (2E-12 uCi/ml for ^{237}Np) was exceeded multiple times in 2003. Using these samples, the maximum air concentration of alpha-emitting particles was calculated. Using a conservative approach, 10 percent of the alpha particles were assumed to be ^{237}Np and 90 percent of the particles were assumed to be uranium. Using the air exchange rates determined from facility engineering data, the total emissions from each facility were estimated for the periods during which the samples exceeded 10 percent of the ^{237}Np DAC.

The compliance plan states that non-radiological areas will not be evaluated as an airborne radiological source due to average concentrations of radionuclides less than 10 percent of the most stringent DAC. HP sample results indicate the average radionuclide air concentrations, even in radiological areas, are usually less than 10 percent of the most stringent DAC. Therefore, building ventilation emissions from non-radiological areas will not be considered an airborne radionuclide source and emissions will not be evaluated.

Finally, the dilution factor due to dispersion at PGDP based on 1992 meteorological data is 7.9E-7. Therefore, even if the average concentration of airborne nuclides was 10 percent of the most stringent DAC, the resulting off-site dose to the public due to dispersion would not exceed 0.0004 mrem/year (0.000004 millisieverts/year).

C-400 Laundry

The C-400 Laundry washes and dries coveralls and clothing used to prevent skin contamination on personnel working in radiological areas. The driers are equipped with lint filters. Emissions from the laundry are estimated using data from Health Physics surveys of the lint filters. The alpha radiation is assumed to be 10 percent due to ^{237}Np and 90 percent due to uranium. The beta emissions are assumed to be due to ^{99}Tc. The emission factor for cloth filters in 40 CFR 61, Appendix D, is used to estimate the emissions.

Nonpoint Sources

Guidance from EPA which stated that provisions of 40 CFR 61, Subpart H, applied to fugitive and diffused emissions, was contained in correspondence dated March 24, 1992. EPA also forwarded to PGDP on September 21, 1992, questions pertaining to 1992 ambient air sampling results and their use as indications that fugitive and diffused emissions from PGDP operations were insignificant. PGDP's reply satisfied all of EPA's questions except the one pertaining to resuspension of contaminated soil that could result from such activities as well drilling activities or vehicular traffic upon contaminated earth. The question as to whether such activities actually constitute fugitive or diffused sources was forwarded to EPA headquarters for resolution. USEC has not, as of this submittal, received guidance on this question. It is not expected that any activity that would result in fugitive or diffused emissions would result in emissions that would be distinguishable from background at off-site locations.

DOE SOURCE DESCRIPTION

Northwest Plume Interim Remedial Action Project

On September 1, 1995, DOE began operation of a groundwater treatment plant designed for the removal of trichloroethylene and ^{99}Tc. The facility is located at the northwest corner of the PGDP site security area. The facility consists of an air stripper to remove volatile organics from water and an ion exchange unit for the removal of ^{99}Tc. The air stripper is located upstream of the ion exchange unit.

Emissions of ^{99}Tc were estimated using the analysis of the influent groundwater and the effluent water leaving the air stripper. Comparison of the ^{99}Tc concentration in the influent and effluent of the air stripper and the quantity of the water passing through the stripper were used to estimate the total quantity of ^{99}Tc emitted from the facility. The exhaust from the air stripper is passed through a carbon adsorption unit prior to exhaust. Extensive sampling has shown that ^{99}Tc is not retained in the carbon; therefore, no reduction in ^{99}Tc emissions due to the use of the adsorption unit were assumed.

Fugitive and Diffuse Sources

DOE has identified the areas listed below as potential fugitive and diffuse sources. Based on prior health physics data and historical ambient air monitoring, it is unlikely that any of these potential sources are significant; however, ambient air monitoring is being conducted around the Paducah Site to verify this position. In addition, some of these sources are listed due to posting of direct radiation, not airborne radiation emissions.

List of DOE Fugitive and Diffuse Potential Emission Sources

1. C-745-T Cylinder Storage Yard
2. Area From C-745-U to East Perimeter Fence to Cylinder Yard
3. C-745-K Cylinder Storage Yard
4. Dirt Storage Area Near C-333
5. C-740 Material Yard
6. C-747 and C-748-B Burial Area
7. C-745-A Southeast Contamination Area
8. C-745-A Southwest Contamination Area
9. C-746-H3 Storage Area
10. C-410 Building
11. C-745-C
    C-749 Cylinder Storage Yards
    C-404 Burial Ground
12. C-746-P Scrap Material Storage Area
13. C-746-A and B Warehouses
    C-746-C Scrap Material Storage Yard
14. Burial Area North of C-746-F
15. C-746-P Burial Area
16. C-747-A Burial Area - Drum Mountain
17. C-747-A Burial Area - Burial Grounds
18. Rubble Pile - South of Perimeter Fence
19. Rubble Pile - South of Plant Near Ogden Landing Road
20. Rubble Pile - Southeast Between Perimeter Fence and Dyke Road
21. Rubble Pile - East of Plant Near Outfall K002
22. C-301 Low-Level Waste Storage Area
23. C-340 Building
24. Rubble Pile - East of Plant near Outfall K010
25. KPDES Outfall 011
26. Little Bayou Creek and Dyke Road
27. Little Bayou Creek Confluent with KPDES Outfall 002
28. Little Bayou Creek Crossing and McCaw Road
29. Little Bayou Creek and Ogden Landing Road
30. North-South Diversion Ditch and Ogden Landing Road
31. Contaminated Ditch Flowing to KPDES Outfall 001
32. Contamination Area West of Plant
33. C-615 Sewage Treatment Facility
34. North-South Diversion Ditch Near Perimeter Fence
35. North-South Diversion Ditch Near Ogden Landing Road
36. C-746-U Landfill

*37. C-746-S and C-746-T Landfills

*38. C-746-S and C-746-T Landfill Area

* DOE monitored the C-746-S Landfill vents for radionuclides on October 6, 1999. No radionuclides were detected either in air emissions or smears of the inside surface of the vent pipe surfaces.

Scrap Metal Project

The Scrap Metal Project removed scrap metal from the northwest portion of the Paducah Site as well as the C-746-D yard in the eastern portion of the site. During 2003, airborne radionuclide emissions may have resulted from dust created by removal, size reduction, and loading the scrap into transportation containers. The amount of radionuclides released was estimated based on emission factors from the Environmental Protection Agency, Document AP-42.

North/South Ditch Basin Construction

Remediation of the North/South Ditch has begun. Activities include construction of a surge basin inside the plant. Airborne radionuclide emissions may have been created by moving contaminated soil. The amount of radionuclides released was estimated based on emission factors from the Environmental Protection Agency, Document AP-42.

C-752-A Waste Treatment

Corrosive waste was neutralized in C-752-A during 2003. The waste contained radionuclides that may have become airborne during the neutralization. The airborne concentration of radionuclides was monitored during the project. This monitoring information was used to estimate the quantity of radionuclides emitted.

Miscellaneous Sources

Another minor potential fugitive or diffuse source of radionuclides results from the decontamination of machinery and equipment used in remediation activities such as well drilling. The equipment is washed with high-powered sprayers to remove any contaminants (radiological or non-radiological). The cleansing solutions and wash products could contain small amounts of radionuclides. No emission controls are used during the decontamination process. The contaminants originate from the soil and groundwater.

In accordance with PGDP DOE NESHAP Management Plan (BJC/PAD-141, dated February 2000), DOE utilized ambient air monitoring data to verify insignificant levels of radionuclides in off-site ambient air. Ambient air stations collect radionuclide samples at sites surrounding the plant. The ambient air monitors capture airborne radionuclides emitted from all sources including fugitive and diffuse. Potential fugitive or diffuse sources and ambient air monitoring locations are shown in Fig. 1. The Radiation/Environmental Monitoring Section of the Radiation Health and Toxic Agents Branch of the Department for Public Health of the Kentucky Cabinet for Health Services has operated the ambient air monitors during CY 2003. Based on observations for CY 2003, plant derived radionuclides were not detected. The results of the ambient air monitoring are in Table A-1 of this report.

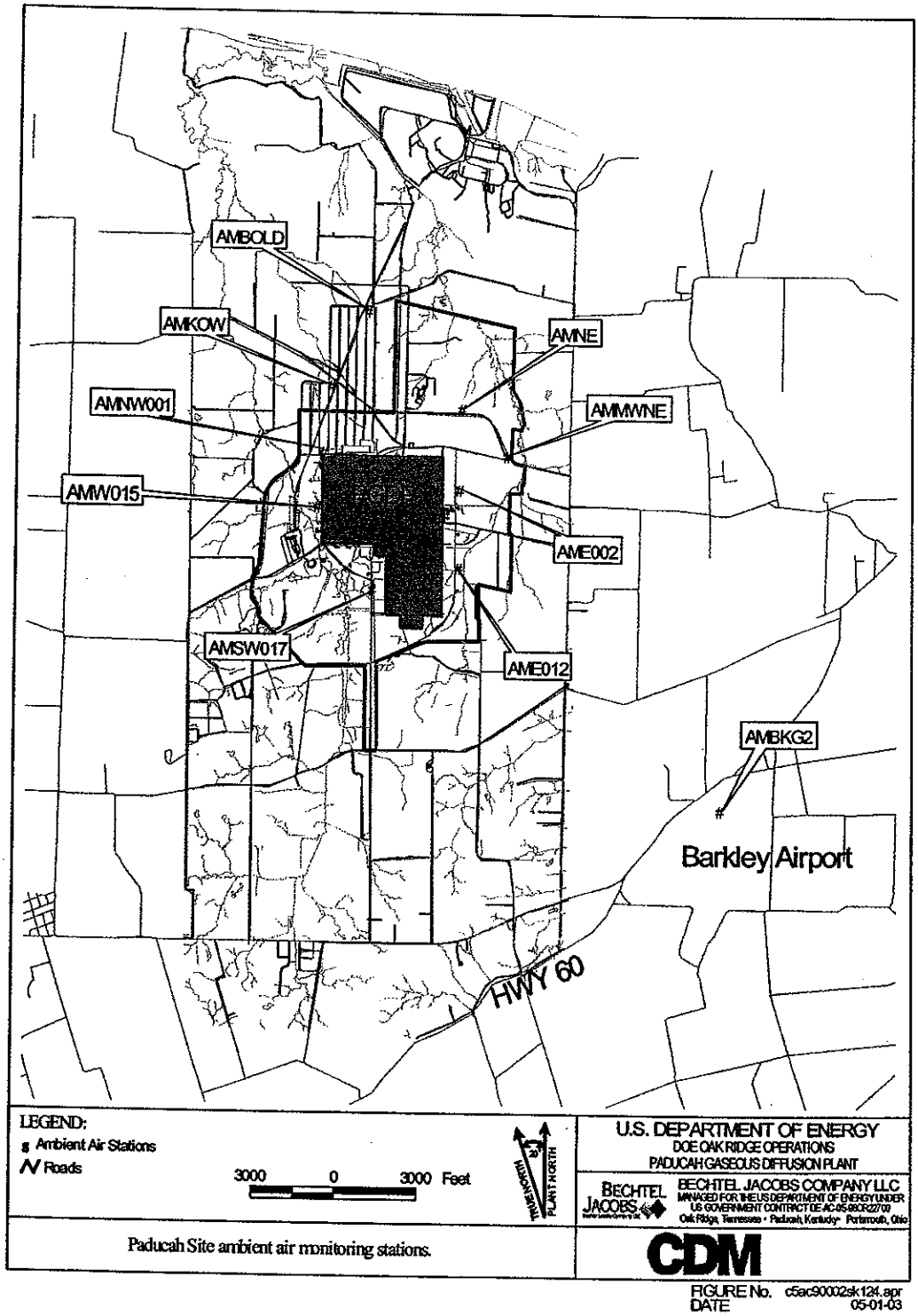

Figure 1. Location of Paducah Site ambient air monitors.

SECTION II SOURCE CHARACTERISTICS AND AIR EMISSIONS DATA

USEC SOURCE CHARACTERISTICS AND RADIONUCLIDE EMISSIONS

MAJOR POINT SOURCE

Major Point Source	Type Control	Efficiency %	Distance (m) and Direction to Nearest Receptor[1]
C-310 Purge Stack	NaF Traps[2]	>99.9	1740 ESE
	Alumina Traps[3]	~98.6	

MINOR POINT AND AREA SOURCES

Minor Point and Area Sources	Type Control	Efficiency %	Distance (m) and Direction to Nearest Receptor[1]
C-360[3]	None	0	1180 SE
C-400 Cylinder Drying Station[3]	None	0	1900 ESE

MINOR GROUPED SOURCES

Minor Grouped Sources	Type Control	Efficiency %	Distance (m) and Direction to Nearest Receptor[1]
Seal/Wet Air exhausts (6)	Alumina Traps[2]	~98.6	1490 ESE
Cylinder valve connection activities not included above (i.e., not serviced by a stack) (7).[3]	HEPA Vacuums[4]	99.0 (Appendix D)	1490 ESE
C-400 grouped sources (3)[3]	None	0	1920 ESE
C-710 laboratory hoods (61)[3]	None	0	1960 ESE
Building ventilation (10)	None	0	1490 ESE

NOTE: The building ventilation and cylinder valve connection activities not serviced by a stack are grouped with the Seal/Wet Air Exhausts Group in further analyses.

[1]Distances to receptors were resurveyed in 2003 due to residential construction in the vicinity of the plant.

[2]See January 28, 1994 correspondence from D. F. Hutcheson to W. A. Smith discussing "Potential to Emit."

[3] Emissions estimated in accordance with 40 CFR 61, Appendix D.

[4]Credit for the use of HEPA vacuums for pigtail operations is not taken for the purposes of estimating emissions.

USEC SOURCE CHARACTERISTICS

Source Name	Type	Height (m)	Diameter (m)	Gas Exit Velocity (m/s)	Gas Exit Temperature (°C)	Distance (m) and Direction to Maximally Exposed Individual	
						Source	Plant
C-310	Point	61.0	0.3	0	21.7	3040 NNE	2430 N
C-360	Point[1]	16.0	N/A	0	Ambient	1180 SE	2370 NNW
C-400 Group	Point[1]	11.3	N/A	0	Ambient	2040 N	2040 N
C-400 Cylinder Drying Station	Point[1]	2.4	0.5	0	Ambient	2120 N	2120 N
C-709/C-710 Lab	Point[1]	7.1	N/A	0	Ambient	2370 N	2370 N
Seal/Wet Air Exhaust Group[2]	Point[1]	21.0	N/A	0	Ambient	2350 N	2350 N

Source Name	Distances (m) to Selected Receptors		
	Nearest Individual/Farm	Nearest Business	Nearest School
C-310	1740	2705	3840
C-360	1180	2000	3840
C-400 Group	1920	2819	4225
C-400 Cylinder Drying Station	1900	2819	4100
C-709/C-710 Lab	1960	2705	3900
Seal/Wet Air Exhaust Group	1490	2438	3840

[1] Modeling was performed assuming a theoretical stack located at the approximate center of each grouped source.

[2]Grouped source includes building ventilation and cylinder valve disconnections from systems not served by permanent HEPA filter systems.

PGDP USEC RADIONUCLIDE EMISSIONS

Radionuclide Emissions (Ci)[1] During 2003									
Emission Source			C-310	C-709/ C-710 Lab	Seal/Wet Air Exhaust Grouped Sources	C-400 Grouped Sources	C-400 Cylinder Drying Station	C-360 Sampling	Total
Nuclide	Solubility	AMAD							
^{99}Tc	W	1	1.86E-03	3.07E-05	8.36E-03	7.97E-03	6.19E-06	5.52E-05	1.83E-02
^{230}Th	W	1	5.76E-06	NA[2]	1.94E-06	2.00E-11	3.65E-12	NA[2]	7.70E-06
^{234}U	D	1	5.00E-04	2.26E-03	1.67E-02	5.28E-04	4.15E-04	5.20E-06	2.04E-02
^{235}U	D	1	1.73E-05	7.84E-05	5.73E-04	1.83E-05	1.43E-05	1.81E-07	7.01E-04
^{238}U	D	1	4.57E-05	2.10E-04	4.20E-03	1.21E-04	1.08E-04	4.56E-07	4.69E-03
^{237}Np	W	1	6.79E-06	3.74E-06	3.26E-04	6.70E-05	5.28E-05	6.44E-07	4.57E-04
^{239}Pu	W	1	1.29E-06	NA[2]	1.18E-06	5.30E-12	3.39E-13	NA[2]	2.47E-06
Total Ci/year			2.44E-03	2.58E-03	3.02E-02	8.70E-03	5.96E-04	6.17E-05	4.46E-02

[1] 1 Curie = $3.7x10^{10}$ Becquerels
[2] NA = Not Analyzed

DOE SOURCE CHARACTERISTICS AND RADIONUCLIDE EMISSIONS DATA

Minor Point and Area Sources	Type Control	Efficiency%	Distance (m) and Direction to Nearest Receptor[1]
Northwest Plume Treatment Facility	None	0	1080 NNE
C-746 P Scrap Metal Project	None	0	1234 N
C-746 D Scrap Metal	None	0	1220 ESE
C-752 A Waste Treatment	HEPA	99.9	1695 N
N/S Ditch Basin Construction	None	0	1525 NNW

Radionuclide Emissions (Ci)[2] During 2003					
Emission Source	NW Plume Treatment Facility	C-746 P Scrap Metal Project	C-746 D Scrap Metal Project	C-752 A Waste Treatment	N/S Ditch Basin Construction
^{99}Tc	9.7E-5	1.8E-5	7.2E-9	2.6E-11	8.2E-5
^{234}U		2.6E-6	1.0E-11	2.6E-12	6.0E-6
^{235}U		1.0E-7	3.0E-10	2.0E-12	7.0E-7
^{238}U		7.7E-7	3.0E-10	2.6E-12	8.6E-6
^{237}Np		2.5E-7	9.9E-11	3.5E-12	1.7E-6
^{239}Pu		5.5E-7	8.6E-11	9.6E-14	5.4E-6
^{241}Am				3.9E-12	
^{214}Bi				1.1E-17	
^{134}Cs				4.7E-15	
^{137}Cs				2.0E-14	
^{60}Co				5.8E-15	
^{238}Pu				7.7E-15	
^{40}K				2.7E-16	
^{233}Pa				1.8E-16	
^{226}Ra				7.3E-17	
^{228}Th				1.6E-15	
^{230}Th				2.0E-13	
^{231}Th				5.5E-17	
^{232}Th				1.7E-15	
^{234}Th				4.4E-15	
$^{233/234}U$				5.1E-15	
Total Ci/year	**9.7E-5**	**2.23E-05**	**8.00E-09**	**4.09E-11**	**1.04E-04**

[1]Distances to receptors were resurveyed in CY 2003 due to residential construction in the vicinity of the plant.

[2]1 Curie = 3.7×10^{10} Becquerels.

Source Name	Distances (m) to Selected Receptors		
	Nearest Individual/Farm	Nearest Business	Nearest School
Northwest Plume Treatment Facility	1080	2550	5150
C-746 P Scrap Metal Project	1234	3033	5490
C-746 D Scrap Metal	1220	2105	3873
C-752 A Waste Treatment	1695	3202	4270
N/S Ditch Basin Construction	1525	3020	5033

Source Name	Type	Height (m)	Diameter (m)	Gas Exit Velocity (m/s)	Gas Exit Temperature (°C)	Distance (m) and Direction to Maximally Exposed Individual (MEI) Source MEI
Northwest Plume Treatment Facility	Point	7.0	0.3556	9.45	37.8	1080 NNE
C-746 P Scrap Metal Project	Point	1	NA	0	Ambient	1205 NNE
C-746 D Scrap Metal	Point	1	NA	0	Ambient	2750 SSE
C-752 A Waste Treatment	Point	5.5	0.3	0	Ambient	1700 N
N/S Ditch Basin Construction	Area	1	119	0	Ambient	1530 NNW

SECTION III DOSE ASSESSMENT

DESCRIPTION OF DOSE MODEL

The radiation dose calculations were performed using the Clean Air Act (CAA) Assessment Package-88 of computer codes. This package contains EPA's most recent version of the AIRDOS-EPA computer code which implements a steady-state, Gaussian plume, atmospheric dispersion model to calculate environmental concentrations of released radionuclides and Regulatory Guide 1.109 food chain models to calculate human exposures, both internal and external, to radionuclides deposited in the environment. The human exposure values are then used by EPA's latest version of the DARTAB computer code to calculate radiation doses to man from radionuclides released during the year. The dose calculations use dose conversion factors in the latest version of the RADRISK data file, which is provided by EPA with CAA Assessment Package-88.

SUMMARY OF INPUT PARAMETERS

Except for the radionuclide parameters given in Section II and those given below, all important input parameter values used are the default values provided with the CAP-88 computer codes and databases.

Joint frequency distribution:	Five-year STAR distribution from 60-meter station on PGDP meteorological tower for the years 1988 through 1992.
Rainfall rate:	121 centimeters/year
Average air temperature:	20° C
Average mixing layer height:	930 meters

Fraction of foodstuffs from:	Local Area	50-Mile Radius	Beyond 50 Miles
Vegetables and produce[1]:	0.700	0.300	0.000
Meat:	0.442	0.558	0.000
Milk:	0.399	0.601	0.000

DISCUSSION OF RESULTS

Due to the conservative nature of the estimates, it is likely that the actual radiological dose from site operations was significantly lower than the calculated dose. Using the conservative estimates, however, PGDP was in compliance with requirements of 40 CFR 61 because the total dose from all airborne radionuclides is less than the standard of 10 mrem per year.

[1]Rural default values.

COMPLIANCE ASSESSMENT

Effective dose equivalent (mrem)[1] to maximally exposed individual for each individual source and the plant:

USEC Emission Sources	Maximum for Source	Maximum for Plant
C-310	5.00E-04	4.80E-04
C-360	6.10E-05	2.70E-05
C-400 Group	5.00E-03	5.00E-03
C-400 Cylinder Drying Station	3.50E-03	3.50E-03
C-709/C-710 Lab	1.60E-03	1.60E-03
Seal/Wet Air Exhaust Group	2.40E-02	2.40E-02
Total From USEC Sources	**N/A**	**3.46E-02**
DOE Emission Sources	**Maximum for Source**	**Maximum for Plant**
Northwest Plume Treatment Facility	1.80E-05	1.80E-05
C-746 P Scrap Metal Project	1.60E-04	1.60E-04
C-746 D Scrap Metal	2.40E-08	7.00E-09
C-752 A Waste Treatment	7.00E-10	7.00E-10
N/S Ditch Basin Construction	6.00E-4	6.00E-04
Total From DOE Sources	**N/A**	**7.78E-04**
Total From All Sources	**N/A**	**3.54E-02**

Maximum effective dose equivalent to the maximum exposed individual for the plant = 3.54E-02 mrem.

Location of maximally exposed individual: 2,350 meters north of greatest contributor to dose which is the SX/WA Group Source.

NOTE: Based on estimated 2003 census data, the total collective effective dose equivalent (CEDE) to the 50-mile population (approximately 531,000 persons) was 0.2 person-rem.

[1] 1 mrem=0.01 millisieverts.

CERTIFICATION

This certification pertains to the following USEC emission sources:

C-310 Purge and Vent Stack
C-360
C-400 Group
C-400 Cylinder Drying Station
C-709/C-710 Lab
Seal Exhaust/Wet Air Group

I certify under penalty of law that I have personally examined and am familiar with the information submitted herein, and based on my inquiry of those individuals immediately responsible for obtaining the information, I believe that the submitted information is true, accurate, and complete. I am aware that there are significant penalties for submitting false information including the possibility of fine and imprisonment.
(See 18 U.S. C1001.)

W S Hanley Jr
United States Enrichment Corporation

6/28/04
Date

CERTIFICATION

This certification pertains to the following DOE emission source:

C-746-D Scrap Metal Project
C-746-P Scrap Metal Project
C-752-A Waste Treatment
N/S Ditch Basin Construction
Northwest Plume Treatment Facility
Fugitive and Diffuse Sources

I certify under penalty of law that I have personally examined and am familiar with the information submitted herein, and based on my inquiry of those individuals immediately responsible for obtaining the information, I believe that the submitted information is true, accurate, and complete. I am aware that there are significant penalties for submitting false information including the possibility of fine and imprisonment.
(See 18 U.S. C1001.)

Department of Energy

6/25/04
Date

SECTION IV ADDITIONAL INFORMATION

UNPLANNED RELEASES – USEC

There were 4 unplanned releases in USEC facilities occurring outside of a building not included in HP air sampling program during CY 2003. The estimated total quantity of uranium released was less than 20g. These releases were included in the seal/wet air exhaust group.

DIFFUSE/FUGITIVE EMISSIONS – DOE

Diffuse/fugitive sources include any source that is spatially distributed, diffuse in nature, or not emitted with forced air from a stack, vent, or other confined conduit. Diffuse/fugitive sources also include emissions from sources where forced air is not used to transport the radionuclides to the atmosphere. In this case, radionuclides are transported entirely by diffusion and/or thermally driven air currents. Typical examples of diffuse/fugitive sources include emissions from building breathing; resuspension of contaminated soils, debris, or other materials; unventilated tanks; ponds, lakes, and streams; wastewater treatment systems; outdoor storage and processing areas; and leaks in piping, valves, or other process equipment.

EPA has not identified a methodology or requirements for determining airborne radionuclide source terms for many unique fugitive and diffuse emission sources characteristic of DOE facilities, nor does the Paducah Site currently have any available methods to selectively and accurately quantify airborne radionuclide source terms from specific fugitive emission sources. However, consistent with the April 1995 memoranda of understanding between DOE and EPA Headquarters, information on diffuse/fugitive emissions is being provided to EPA as additional information. On February 8, 2000, DOE submitted to Kentucky Division for Air Quality and EPA Region IV the *Paducah Gaseous Diffusion Plant Department of Energy National Emission Standards for Hazardous Air Pollutants (NESHAP) Management Plan*. This plan outlined the DOE Paducah Site plans for using ambient air monitors to demonstrate that total emissions (from point, diffuse, and fugitive sources) result in doses significantly less than the 10-mrem/year (0.1-mSv/year) standard. Section I provides a list of potential fugitive/diffuse sources on the Paducah Site.

The Radiation/Environmental Monitoring Section of the Radiation Health and Toxic Agents Branch of the Department for Public Health of the Kentucky Cabinet for Health Services has conducted ambient air monitoring around the Paducah Site during CY 2003. The Radiation Health and Toxic Agents Branch reports that weekly air filters were screened for gross alpha and beta activity and then composited on a quarterly basis. The quarterly composites were analyzed by gamma spectroscopy using a thin window 40 percent high purity germanium detector, which allows for detection of low energy gamma emitters. Americium-241 (^{241}Am) and ^{234}Th were not detected by gamma spectroscopy for the quarterly composites.

Because ^{241}Am and ^{234}Th were not detected, plutonium and uranium isotopic analyses were not performed on the quarterly composites. Since ^{241}Am and ^{234}Th were not present, the quarterly composites were analyzed for ^{99}Tc. ^{99}Tc was also not detected in the quarterly composites. ^{210}Pb and ^{40}K were detected on filters, which accounts for the presence of the gross alpha and beta activities.

Based on observations for CY 2003, plant derived radionuclides were not detected by the Radiation Health and Toxic Agents Branch's air monitoring network.

STATUS OF NESHAP MONITORING REQUIREMENTS, SUBPART H COMPLIANCE

The status of compliance with the new NESHAP monitoring requirements is described in the revised NESHAP Compliance Plan which was submitted to EPA January 1992. PGDP has only one stack subject to the continuous monitoring requirements of Subpart H, the C-310 Stack.[1] Particulate stack sampling was performed on the C-310 Purge Cascade Stack February 1992. Results of the sampling project were forwarded to EPA by March 31, 1992. Documentation from EPA[2] stated that PGDP is exempted from the requirement to install an isokinetic sampling system.

Minor Sources: The periodic confirmatory measurement plan for minor sources is outlined in detail in the Revised NESHAP Compliance Plan for PGDP, which was submitted to EPA on January 15, 1992. The initial plan for confirmatory measurements is to estimate emissions using Appendix D and/or mass balance methods on an annual basis, and to stack sample those sources for which stack sampling is the only feasible estimation method on a five-year basis.

On May 26, 1992, PGDP and EPA entered into a Federal Facility Compliance Agreement (FFCA) to bring PGDP into compliance with the sampling provisions established in accordance with 40 CFR 61, Subpart H. Appendix A of the FFCA contains a schedule establishing compliance commitments. The major effort of the compliance schedule was the site evaluation in which all potential sources of airborne radionuclides were identified and emissions were determined. The radionuclide sources were identified through a preliminary stack vent survey, which was completed in 1991. In November 1992, a more in-depth survey was completed which did not discover any previously unknown airborne radionuclide sources. In September 1992, representatives from EPA inspected PGDP for NESHAP compliance. Correspondence from EPA summarizing the inspection stated there were no NESHAP violations identified during the inspection. PGDP fulfilled all commitments in accordance with Appendix A of the FFCA in June 1992; submitted results of the updated, in-depth vent stack survey in December 1992; and officially requested a Certification of Completion of the FFCA on March 11, 1993. EPA issued the Certification of Completion on March 26, 1993. Certification of Completion of the FFCA indicates that PGDP is in compliance with the provisions in accordance with 40 CFR 61, Subpart H.

DOE has remained in compliance since 1993. KDAQ received a delegation of authority to administer the NESHAP program in July 1999. A NESHAP Management Plan has been developed by DOE, which addresses fugitive and diffuse emissions. EPA Region 4 concurred with the DOE NESHAP Management Plan on September 19, 2000. In accordance with the management plan, ambient air monitoring was utilized to verify compliance of the Paducah Site with 40 CFR 61, Subpart H for all emissions. Ambient air monitoring conducted by the Kentucky Radiation Health and Toxics Branch did not detect plant derived radionuclides during CY 2003. The concentration detected is less than the 40 CFR 61 Appendix E, Table 2 value for environmental compliance.

The actual results, even though less than the measurement error, of each air monitor are listed in Table A-1 of this report. The ratio of each isotopic concentration to the standard for that isotope in 40 CFR 61, Appendix E, Table 2, was calculated. The sum of all of these ratios should be less than one to meet the standard. The sum of the ratios is listed for each monitoring station for each quarter in Table A–1.

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[1]See correspondence from D. F. Hutcheson to D. C. Booher, dated January 28, 1994, discussing "Potential to Emit."

[2]See correspondence from W. A. Smith to D. C. Booher, dated April 20, 1992.

Table A-1. Kentucky Radiation Health and Toxics Branch Ambient Air Monitoring Results[1]

Quarter	Nuclide	AMSW017 Ci/m3	AMW015 Ci/m3	AMNW001 Ci/m3	AMNE Ci/m3	AME002 Ci/m3	AME012 Ci/m3	AMBKG2 Ci/m3	AMBOLD Ci/m3	AMKOW Ci/m3	AMMWNE Ci/m3
1	Am-241	4.64E-16	1.65E-16	2.61E-16	1.87E-16	1.05E-16	4.53E-16	4.30E-16	4.85E-16	1.18E-16	3.34E-16
	Np-237	9.00E-17	9.93E-17	-3.06E-16	2.85E-16	-3.60E-17	-2.16E-16	-5.73E-17	-3.74E-17	1.29E-16	1.74E-16
	Tc-99	1.47E-16	4.85E-17	-1.89E-17	7.57E-18	1.62E-16	-1.89E-17	2.45E-16	2.80E-16	1.47E-16	-6.81E-17
	U-238	2.04E-16	2.13E-16	2.81E-16	2.77E-16	2.40E-16	2.35E-16	2.16E-16	2.44E-16	2.69E-16	2.46E-16
	Sum of ratios	0.35	0.20	-0.08	0.37	0.06	0.09	0.21	0.26	0.20	0.35
2	Am-241	-3.23E-16	1.66E-16	3.06E-16	3.90E-17	2.09E-16	-6.50E-17	-2.62E-16	-3.10E-16	2.82E-16	4.49E-17
	Np-237	-9.72E-17	-8.36E-17	5.32E-16	-1.86E-16	-2.93E-16	6.26E-17	-1.94E-17	1.32E-16	7.34E-17	1.92E-16
	Tc-99	3.00E-16	1.81E-16	-3.18E-17	6.52E-16	5.89E-16	3.47E-17	5.47E-16	2.01E-16	8.96E-17	3.88E-16
	U-238	3.28E-16	2.76E-16	2.39E-16	3.63E-16	3.80E-16	3.81E-16	2.67E-16	2.61E-16	2.54E-16	2.98E-16
	Sum of ratios	-0.21	0.05	0.63	-0.09	-0.08	0.06	-0.12	-0.02	0.24	0.22
3	Am-241	-6.53E-16	4.02E-16	2.01E-16	2.96E-16	-8.62E-17	-1.13E-16	3.60E-17	-1.03E-15	1.86E-16	2.50E-16
	Np-237	-3.03E-16	-2.67E-16	-8.69E-17	-2.42E-16	-2.59E-16	-2.86E-16	3.48E-16	3.02E-16	-1.04E-16	2.20E-16
	Tc-99	-1.87E-16	2.44E-16	3.10E-16	1.17E-16	2.07E-16	2.08E-16	-2.69E-16	-2.38E-16	1.77E-16	3.70E-16
	U-238	2.34E-16	2.70E-16	3.42E-16	3.34E-16	2.83E-16	2.68E-16	1.89E-16	3.35E-16	2.43E-16	2.65E-16
	Sum of ratios	-0.57	0.02	0.08	0.0	-0.23	-0.26	0.33	-0.25	0.04	0.35
4	Am-241		6.36E-18	1.50E-16	1.56E-16	-8.35E-16	-1.20E-16	-8.04E-16	3.51E-16	-1.81E-16	1.76E-16
	Np-237	2.54E-16	9.25E-17	-5.46E-16	-5.11E-17	-1.71E-17	3.60E-17	1.58E-16	-2.61E-16	-1.23E-16	-1.46E-16
	Tc-99	2.92E-17	9.46E-16	8.54E-16	3.03E-16	-7.35E-18	2.80E-16	-3.00E-16	5.03E-16	2.26E-16	2.81E-16
	U-238	1.85E-16	1.61E-16	1.98E-16	2.03E-16	1.95E-16	1.67E-16	1.89E-16	1.76E-16	2.65E-16	1.51E-16
	Sum of ratios	0.23	0.11	-0.35	0.07	-0.43	-0.01	-0.27	-0.01	-0.16	-0.01

[1] 40 CFR 61, Table 2, Limiting Values (Ci/m3): ^{241}Am 1.9E-15, ^{237}Np 1.2E-15, ^{99}Tc 1.4E-13, and ^{238}U 8.3E-15.

United States Department of Energy
Air Emissions Annual Report
(40 CFR 61, Subpart H)
Calendar Year 2003

Site Name: Paducah Gaseous Diffusion Plant

OPERATIONS OFFICE INFORMATION

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SECTION I FACILITY INFORMATION

INTRODUCTION

The Department of Energy (DOE) Paducah Site contains the Paducah Gaseous Diffusion Plant (PGDP), which is leased to the United States Enrichment Corporation (USEC). DOE manages the remaining, non-leased facilities at the Paducah Site. The DOE-managed facilities consist of various waste management facilities, inactive buildings, depleted uranium storage facilities, and environmental restoration facilities. This report analyzes emissions from USEC and DOE portions of the Paducah Site.

SITE DESCRIPTION

PGDP is an active uranium enrichment facility consisting of a diffusion cascade and extensive support facilities. The cascade, including product and tails withdrawal, is housed in 6 process buildings covering a total of approximately 80 acres. The plant is located on a reservation consisting of approximately 1,350 acres in western McCracken County approximately 10 miles west of Paducah, Kentucky, and approximately 3 miles south of the Ohio River. Roughly 740 acres of the reservation are enclosed within a fenced security area. An uninhabited buffer zone of at least 400 yards surrounds the entire fenced area. Beyond the DOE-owned buffer zone is an extensive wildlife management area consisting of approximately 2,100 acres either deeded or leased to the Commonwealth of Kentucky. During World War II, the Kentucky Ordnance Works (KOW), a trinitrotoluene production facility, was operated in an area southwest of the plant on what is now the wildlife management area. The water treatment plant used by PGDP was originally a KOW facility.

Construction of the PGDP facility began in 1951 and the plant was fully operational by 1955, supplying enriched uranium for commercial reactors and military defense reactors. Enriched uranium is defined as uranium in which the concentration of the fissionable uranium-235 (^{235}U) isotope has been increased from its natural assay. Natural uranium is mostly ^{238}U with about 0.71 percent ^{235}U and 0.0055 percent ^{234}U. Uranium mills process the ores to produce concentrated uranium oxide (U_3O_8), which is then commercially converted to uranium hexafluoride (UF_6) for enrichment at a gaseous diffusion plant.

The Paducah Plant enriches the uranium isotope, ^{235}U, by utilizing a physical separation process. The separation is based on the faster rate at which ^{235}U diffuses through a barrier compared with the heavier ^{238}U isotope. During enriching operations from 1953 to 1975, feed material (called "reactor tails") from government reactors was also used intermittently in addition to the UF_6 typically used. Reactor tails were the spent fuel from nuclear reactors that is depleted in ^{235}U content and has been reprocessed to remove most of the fission products. The reactor fuel rods were processed at other DOE facilities (where most of the fission products were removed) and the enriched uranium and the remaining fission products were fed into the PGDP cascade system. Use of the reactor tails resulted in the introduction of technetium-99 (^{99}Tc), a fission by-product, and transuranics, most notably neptunium-237 (^{237}Np) and plutonium-239 (^{239}Pu), into the cascade. ^{99}Tc is a man-made radioactive substance (radionuclide) having a half-life estimated at between 212,000 and 250,000 years. ^{99}Tc decays by emitting beta radiation.

Extensive support facilities are required to maintain the diffusion process. Some of the major support facilities include a steam plant, four major electrical switchyards, four cooling tower complexes, a chemical cleaning and decontamination building, a water treatment plant, a cooling water blowdown treatment facility, maintenance facilities, and laboratory facilities. Several inactive facilities are also located on the plant site.

The West Kentucky Wildlife Management Area and lightly populated farmlands are in the immediate environs of PGDP. The population within the 50-mile radius is approximately 531,000 persons. Of these, approximately 36,500 live within 10 miles of the plant and approximately 104,000 within 20 miles. The unincorporated communities of Grahamville and Heath are 1.24 and 1.86 miles east of the plant, respectively. Portions of 28 counties, 11 of which are in Kentucky, 4 in Missouri, 10 in Illinois, and 3 in Tennessee, are included within the 50-mile radius of the plant. Larger cities in the region include Paducah, Kentucky, located approximately 10 air miles east of the plant; Cape Girardeau, Missouri, located approximately 40 air miles to the west; and Metropolis, Illinois, located approximately 6 air miles to the northeast.

Paducah is located in the humid continental zone. Summers are generally dry; precipitation occurs mainly in the spring and fall. Winters are characterized by moderately cold days; the average temperature during the coldest month, January, is about 35° F. Summers are warm and humid; the average temperature in July is 79 F. Yearly precipitation averages about 44 inches. The prevailing wind direction is south to southwest.

In July 1993, USEC was formed as a government corporation and became a private corporation in July 1998. Although DOE still owns all the facilities at PGDP, the uranium enrichment enterprise is now the responsibility of USEC. According to the Lease Agreement between DOE and USEC, USEC retained responsibility for quantification of airborne radionuclide emissions and preparation of the annual report required by 40 CFR 61, Subpart H. DOE remains responsible for compliance with other requirements for DOE-operated sources.

On March 3, 1997, the Nuclear Regulatory Commission assumed regulatory responsibility for the USEC-leased portion of the plant. However, because DOE owns the entire facility, both the USEC and DOE facilities are subject to 40 CFR 61, Subpart H, requirements.

USEC SOURCE DESCRIPTIONS

The following are the potential USEC airborne radionuclide sources at the Paducah Plant. Although not all of them were used in 2003, they are included in this report due to their potential for future restart.

C-310 Stack

The primary source of potential radionuclide air emissions is the vent stack that serves the "top end" of the cascade process and the cylinder burping facility. This 200-foot stack, known as the C-310 stack, is located at the southwest corner of the C-310 Product Withdrawal Building. Low molecular weight gas compounds and contaminants, which have traveled up the cascade, are vented to the atmosphere via the C-310 purge vent stack. Small quantities of ^{234}U, ^{235}U, ^{238}U, ^{99}Tc, ^{237}Np, ^{239}Pu, and thorium-230 (^{230}Th) are also emitted. The cascade effluent is routed through alumina traps prior to being emitted via the C-310 stack. The alumina traps were upgraded in 1990 to provide greater criticality safety. The improved system consists of an on-line bank of 13 traps and a standby bank of 13 traps. Each trap contains approximately 200 pounds of alumina.

The cylinder burp facility, located on the east side of C-310, is used to vent the low molecular weight gases from product cylinders. This facility is also a potential source of uranium, ^{99}Tc, minute

quantities of transuranics, and ^{230}Th. The effluent from the burp facility is routed through a bank of sodium fluoride (NaF) traps prior to being emitted from the C-310 stack. There are 2 banks of chemical traps associated with this system. Each bank has 5 primary and 2 secondary traps. These traps contain approximately 130 pounds of NaF each. Uranium is recovered from the NaF traps back to the enrichment cascade.

Emissions from the C-310 stack were estimated based on daily results of the continuous potassium hydroxide bubbler stack sampling system, which was approved by the Environmental Protection Agency (EPA) in 1992.

As part of the Quality Assurance/Quality Control (QA/QC) requirements for the C-310 stack sampler, a range for the sample flow has been established. During 2003, there were 6 instances where the sample flow was outside of the established range. These instances did not compromise the integrity of the sample. From operational records, there were no indications of excess emissions during these periods; emissions immediately prior to and after the dates in question indicated that they were within normal ranges.

Seal Exhausts

Seals on the UF_6 compressors are supplied with an intricate array of air pressures to reduce any UF_6 release that may occur in the event of a seal failure. The seal exhaust flow is removed by large, oil-filled vacuum pumps and is routed from the seals through alumina traps, the pump, and to a common exhaust vent. There is one seal exhaust vent per cascade building, one on the C-310 Product Withdrawal Building and one on the C-315 Tails Withdrawal Building. Under normal operations, only trace amounts of UF_6 are present in the seal exhaust system. Occasionally, a seal or seal control system malfunction will allow greater quantities of UF_6 to enter the exhaust system. If UF_6 is allowed to enter the pump by virtue of trap breakthrough, it reacts with the pump oil creating a thick, gummy sludge, which overloads the pump in a short time. Due to the reaction between UF_6 and pump oil, the oil also serves as an excellent uranium emission control device; however, no credit is taken for the oil as a pollution abatement system because the oil is an integral part of the pumping system and in no way is included for emission control. The list below indicates locations of the six seal exhausts at PGDP:

C-310 Product Withdrawal Building
C-315 Tails Withdrawal Building
C-331 Process Building
C-333 Process Building
C-335 Process Building
C-337 Process Building

Emissions from the seal exhaust grouped source were originally estimated based on results of Method 5 stack sampling performed in 1992. The seal exhausts were resampled in 1997 and 2002 respectively. The 2002 sampling results were used for emission estimates for CY 2003.

A discussion of the potential to emit from the seal exhausts and wet air exhausts, and the conclusion that the alumina traps which protect the pump oil are not pollution control devices under 40 CFR 61, Subpart H, was forwarded to EPA on January 28, 1994.

Wet Air Exhaust

When maintenance is required on cascade piping and equipment, the process gas (UF_6) is evacuated to other sections of the cascade or surge drums. The subject equipment and piping are swept

in a series of purges with "dry" plant air. After maintenance, the system is closed and the ambient (wet) air is pumped from the system by the wet air pumps. In the dry air purges and wet air evacuations, the air is routed through alumina traps for uranium trapping to protect the wet air pump oil, and then to an exhaust vent. In process buildings C-310, C-333, C-335, and C-337, the exhaust vent is the same one that services the seal exhaust system for those buildings. Emissions from the wet air exhausts in 2002 were estimated based on results of Method 5 stack sampling performed in 2002. The list below indicates locations of the five wet air exhausts at PGDP:

C-310 Product Withdrawal Building (same as seal exhaust)
C-331 Process Building
C-333 Process Building (same as seal exhaust)
C-335 Process Building (same as seal exhaust)
C-337 Process Building (same as seal exhaust)

Cylinder Valve Connection Activities

Activities involving the connection and disconnection to UF_6 cylinders include cold pressure checks; sampling of feed, product, and tails cylinders; and product withdrawal, tails withdrawal, cylinder feeding, and cylinder burping. The cylinder valves are connected to the associated process via a "pigtail." Cylinder pigtails consist of a single length of copper tubing and threaded couplings. Pigtail disconnection procedures require a series of purges to ensure that no UF_6 remains in the pigtail prior to disconnection. Although adherence to these procedures minimizes UF_6 emissions, occasionally a "puff" of UF_6 is observed during disconnection of the pigtails. As an additional measure to control radionuclide emissions, personnel performing the pigtail disconnects employ the use of a glove box containment device and/or portable high efficiency particulate air (HEPA) vacuums (vacs). The HEPA vacs are placed so that any minute "whiff or puff" of UF_6 which is emitted from the pigtail disconnect process is captured by the HEPA vac.

Cylinder disconnection activities in CY 2003 were serviced by HEPA filter-equipped vac systems. The list below indicates the locations of the pigtail systems:

C-310	Burp Station (located outside portable HEPA vacs used).
C-310	Product Withdrawal Building.
C-315	Tails Withdrawal Building.
C-333-A	Feed Facility (UF_6 Vaporizer).
C-337-A	Feed Facility (UF_6 Vaporizer).
C-360	Toll Transfer and Sampling Facility.

Emissions from these systems were estimated by determining the total number of pigtail disconnections in each facility. An estimated quantity of UF_6 in each pigtail (based on the system volume, temperature, and pressure) multiplied by the number of disconnections was used to estimate the total quantity of UF_6 that could have been released.

Pigtails are evacuated and purged numerous times to reduce the quantity of UF_6 in the pigtail to very low levels. The method described above assumes that each pigtail has been evacuated or purged in accordance with operating procedures. Quantities of UF_6 released as observed puffs are added to the releases estimated from normal operations.

In the case of C-360, there are two stacks, one for the pigtail exhaust system and one for the sample cabinet exhaust.

Laboratory Hoods

The C-709/710 Laboratories are operated by Production Support and are the main facilities for sample analysis and research at PGDP. There are a total of 94 laboratory hoods and canopies in the C-709/710 buildings. Fifty-two of the hoods were used for radiological activities in CY 2003. The radionuclides involved in analyses consist primarily of uranium, with a slight potential for emissions of ^{99}Tc, ^{237}Np, ^{239}Pu, and the daughters of uranium (^{230}Th and ^{234}Th). In some cases, the hood exhausts combine with other hood exhausts, creating a discrepancy between the number of hoods and actual emission points. There are also 8 laboratory hoods in the C-409 Stabilization Facility. None of these hoods were used for work with radionuclides in 2003. The list below indicates the laboratory exhaust systems at PGDP:

Building	Hoods/Canopies	Hoods/Canopies Used in Radiological Areas in 2003
C-709/710 Laboratory	94	52
C-409	8	Not used

Four methods, depending on the type of operation occurring in the hood or radiological area in which the hood was located, were used to estimate emissions.

1. Estimation of the maximum quantity of uranium that could be lost based on laboratory methods (e.g., if an ASTM analytical method specifies a maximum of 1.6 percent loss of mass during analysis, all samples analyzed using the method were assumed to loose, as an emissions from the hood, 1.6 percent of the uranium in the sample.)

2. Use of 40 CFR 61, Appendix D, emission factors.

3. Use of chemical trap efficiencies and uranium throughput information.

4. Knowledge of the analytical or sample preparation process.

All methods used the total inventory of uranium processed in the hood or radiological area as the basis for the emission estimate.

Chlorofluorocarbon-114 (CFC-114) UF_6 Separator

The CFC-114/UF_6 separator is located in C-335 and can be used to separate relatively large amounts of CFC-114 coolant, which has entered the cascade system and mixed with UF_6. The separator was installed in 1978 and initial operations were conducted in 1979. When in use, the separator effluent is passed through a cold trap at minus 30°F which condenses approximately 98.5% of the gaseous UF_6. The residual UF_6 in the effluent is trapped by two pairs of NaF traps. Uranium trapped by the NaF traps is recovered back to the gaseous diffusion cascade. The effluent passes from the NaF traps through alumina traps and a header to the C-335 wet air/seal exhaust system. The outlet of the alumina traps is monitored by a flow-through ionization chamber.

The emissions from this system also have to pass through the wet air/seal exhaust pump oil, which is an excellent scrubber of UF_6. Since this facility is used only when large amounts of CFC-114 leak into the cascade and is equipped with a two-stage control process, use of this facility is not expected to increase the emissions from the wet air/seal exhaust system. This facility was not operated in 2003.

C-400 Decontamination Spray Booth

This facility is used to decontaminate equipment. It consists of a large booth equipped with an ultra high-pressure sprayer, which sprays a water solution on the contaminated machinery. The potential of radionuclide emissions arises from entrainment of radionuclides in the spray solution during the decontamination process. The booth is equipped with a mist eliminator as an emission control device. The mist eliminator is not listed as a pollution control device in 40 CFR 61, Appendix D, and no credit is taken for it. Emissions were estimated in accordance with Appendix D. The concentration of radionuclides in the spray booth water multiplied by the total volume of water was considered as the curies "used."

C-400 No. 5 Dissolver/Rotary Vacuum Filter

This facility is used to dissolve and precipitate the uranium in the solutions from the C-400 cylinder wash and decontamination spray booth. It is also used to treat uranium salvaged from C-710. The solution is chemically treated to precipitate the uranium that forms a slurry. The slurry is then passed through a rotary vacuum filter, which collects the precipitate (filter cake) for future disposal. After sampling, the filtrate is then discharged via permitted Kentucky Pollutant Discharge Elimination System (KPDES) outfalls. The possibility for radionuclide emissions arises from the vent on the pump that pulls the slurry through the rotary vacuum filter. Emissions from this vent should be minimal because the pump and its vent are downstream of the rotary vacuum filter that should trap the uranium as filter cake. Emissions were estimated in accordance with 40 CFR 61, Appendix D. The concentrations of radionuclides in the filtrate multiplied by the filtrate volume were considered as the curies "used."

C-409 Dissolver/Rotary Vacuum Filter

This facility is used to dissolve and precipitate the high assay uranium in solutions from the C-710 Laboratory and various sources. The solution is chemically treated to precipitate the uranium that forms a slurry. The slurry is then passed through a rotary vacuum filter, which collects the precipitate (filter cake) for future disposal. After sampling, the filtrate is then discharged via permitted KPDES outfalls. The possibility for radionuclide emissions arises from the vent on the pump that pulls the slurry through the rotary vacuum filter. Emissions from this vent are expected to be minimal because the pump and its vent are downstream of the rotary vacuum filter that should trap the uranium as filter cake. Emissions are estimated in accordance with 40 CFR 61, Appendix D. The concentrations of radionuclides in the filtrate multiplied by the filtrate volume are considered as the curies "used."

C-400 Cylinder Drying Station

This facility is used to dry UF_6 cylinders after the "heel" has been removed in the C-400 cylinder washstand. Dry "plant air" is passed through the cylinder to evaporate any moisture from the washing and hydrostatic testing processes. Emissions were estimated in accordance with 40 CFR 61, Appendix D. The concentrations of radionuclides in water used to hydrostatically test the cylinders prior to drying, multiplied by the total volume of water used in the hydrostatic test, were considered as the curies "used."

Radiological Areas

Radiological areas are established under specific criteria listed in various worker protection procedures and standards. There are a number of radiological areas at PGDP that are monitored by Health Physics (HP) low-volume air samplers. The sampling systems consist of a low-volume pump (20 to 40 liters per minute) drawing the ambient building air through a Whatman No. 41 cellulose filter. The samplers run 24-hours per day and the filters are changed on 2-, 3-, 4-, or 5-day basis, depending upon weekend and holiday schedules. Typically, a minimum of 2 days of sample air is collected on each filter. After sample collection, the filters are counted for airborne radioactivity concentrations.

For the 2003 NESHAP report, PGDP estimated the building ventilation grouped source according to the method stated in Section 3.1 of the revised PGDP NESHAP Compliance Plan submitted to EPA in January 1992.

According to PGDP's compliance plan, building emissions from non-radiological areas are not estimated due to their lack of potential for airborne radiological emissions.

For CY 2003, the following is a list of PGDP's radiological areas from which emissions were evaluated using HP data:

- C-310 Product Withdrawal Building
- C-315 Tails Withdrawal Building
- C-331 Uranium Enrichment Process Building
- C-333 Uranium Enrichment Process Building
- C-333-A Uranium Feed Facility
- C-335 Uranium Enrichment Process Building
- C-337 Uranium Enrichment Process Building
- C-337-A Uranium Feed Facility
- C-360 Toll Transfer/Sampling Building
- C-400 Decontamination Building
- C-710 Laboratory
- C-720 Maintenance Building This building is the primary maintenance building at PGDP. Maintenance on contaminated and uncontaminated machinery is performed here. Transferable contamination has been removed prior to maintenance; however, there is a potential for airborne radionuclide emissions from fixed contamination during maintenance procedures. Portable negative air machines, which are equipped with HEPA filters, are utilized whenever there is a potential for airborne radionuclide emissions.

Buildings C-754, C-757, and the USEC-controlled side of C-746-Q are also categorized as radiological areas. However, these buildings have no ventilation systems. Any emissions from these buildings would be fugitive or diffuse in nature. Fugitive and diffused emissions are discussed later in this report.

Data from HP air sampling in radiological areas indicated that the trigger level of 10 percent of the most restrictive Derived Air Concentration (DAC) guideline in 10 CFR 20, Appendix B, (2E-12 uCi/ml for ^{237}Np) was exceeded multiple times in 2003. Using these samples, the maximum air concentration of alpha-emitting particles was calculated. Using a conservative approach, 10 percent of the alpha particles were assumed to be ^{237}Np and 90 percent of the particles were assumed to be uranium. Using the air exchange rates determined from facility engineering data, the total emissions from each facility were estimated for the periods during which the samples exceeded 10 percent of the ^{237}Np DAC.

The compliance plan states that non-radiological areas will not be evaluated as an airborne radiological source due to average concentrations of radionuclides less than 10 percent of the most stringent DAC. HP sample results indicate the average radionuclide air concentrations, even in radiological areas, are usually less than 10 percent of the most stringent DAC. Therefore, building ventilation emissions from non-radiological areas will not be considered an airborne radionuclide source and emissions will not be evaluated.

Finally, the dilution factor due to dispersion at PGDP based on 1992 meteorological data is 7.9E-7. Therefore, even if the average concentration of airborne nuclides was 10 percent of the most stringent DAC, the resulting off-site dose to the public due to dispersion would not exceed 0.0004 mrem/year (0.000004 millisieverts/year).

C-400 Laundry

The C-400 Laundry washes and dries coveralls and clothing used to prevent skin contamination on personnel working in radiological areas. The driers are equipped with lint filters. Emissions from the laundry are estimated using data from Health Physics surveys of the lint filters. The alpha radiation is assumed to be 10 percent due to ^{237}Np and 90 percent due to uranium. The beta emissions are assumed to be due to ^{99}Tc. The emission factor for cloth filters in 40 CFR 61, Appendix D, is used to estimate the emissions.

Nonpoint Sources

Guidance from EPA which stated that provisions of 40 CFR 61, Subpart H, applied to fugitive and diffused emissions, was contained in correspondence dated March 24, 1992. EPA also forwarded to PGDP on September 21, 1992, questions pertaining to 1992 ambient air sampling results and their use as indications that fugitive and diffused emissions from PGDP operations were insignificant. PGDP's reply satisfied all of EPA's questions except the one pertaining to resuspension of contaminated soil that could result from such activities as well drilling activities or vehicular traffic upon contaminated earth. The question as to whether such activities actually constitute fugitive or diffused sources was forwarded to EPA headquarters for resolution. USEC has not, as of this submittal, received guidance on this question. It is not expected that any activity that would result in fugitive or diffused emissions would result in emissions that would be distinguishable from background at off-site locations.

DOE SOURCE DESCRIPTION

Northwest Plume Interim Remedial Action Project

On September 1, 1995, DOE began operation of a groundwater treatment plant designed for the removal of trichloroethylene and ^{99}Tc. The facility is located at the northwest corner of the PGDP site security area. The facility consists of an air stripper to remove volatile organics from water and an ion exchange unit for the removal of ^{99}Tc. The air stripper is located upstream of the ion exchange unit.

Emissions of ^{99}Tc were estimated using the analysis of the influent groundwater and the effluent water leaving the air stripper. Comparison of the ^{99}Tc concentration in the influent and effluent of the air stripper and the quantity of the water passing through the stripper were used to estimate the total quantity of ^{99}Tc emitted from the facility. The exhaust from the air stripper is passed through a carbon adsorption unit prior to exhaust. Extensive sampling has shown that ^{99}Tc is not retained in the carbon; therefore, no reduction in ^{99}Tc emissions due to the use of the adsorption unit were assumed.

Fugitive and Diffuse Sources

DOE has identified the areas listed below as potential fugitive and diffuse sources. Based on prior health physics data and historical ambient air monitoring, it is unlikely that any of these potential sources are significant; however, ambient air monitoring is being conducted around the Paducah Site to verify this position. In addition, some of these sources are listed due to posting of direct radiation, not airborne radiation emissions.

List of DOE Fugitive and Diffuse Potential Emission Sources

1. C-745-T Cylinder Storage Yard
2. Area From C-745-U to East Perimeter Fence to Cylinder Yard
3. C-745-K Cylinder Storage Yard
4. Dirt Storage Area Near C-333
5. C-740 Material Yard
6. C-747 and C-748-B Burial Area
7. C-745-A Southeast Contamination Area
8. C-745-A Southwest Contamination Area
9. C-746-H3 Storage Area
10. C-410 Building
11. C-745-C
    C-749 Cylinder Storage Yards
    C-404 Burial Ground
12. C-746-P Scrap Material Storage Area
13. C-746-A and B Warehouses
    C-746-C Scrap Material Storage Yard
14. Burial Area North of C-746-F
15. C-746-P Burial Area
16. C-747-A Burial Area - Drum Mountain
17. C-747-A Burial Area - Burial Grounds
18. Rubble Pile - South of Perimeter Fence
19. Rubble Pile - South of Plant Near Ogden Landing Road
20. Rubble Pile - Southeast Between Perimeter Fence and Dyke Road
21. Rubble Pile - East of Plant Near Outfall K002
22. C-301 Low-Level Waste Storage Area
23. C-340 Building
24. Rubble Pile - East of Plant near Outfall K010
25. KPDES Outfall 011
26. Little Bayou Creek and Dyke Road
27. Little Bayou Creek Confluent with KPDES Outfall 002
28. Little Bayou Creek Crossing and McCaw Road
29. Little Bayou Creek and Ogden Landing Road
30. North-South Diversion Ditch and Ogden Landing Road
31. Contaminated Ditch Flowing to KPDES Outfall 001
32. Contamination Area West of Plant
33. C-615 Sewage Treatment Facility
34. North-South Diversion Ditch Near Perimeter Fence
35. North-South Diversion Ditch Near Ogden Landing Road
36. C-746-U Landfill

*37. C-746-S and C-746-T Landfills

*38. C-746-S and C-746-T Landfill Area

* DOE monitored the C-746-S Landfill vents for radionuclides on October 6, 1999. No radionuclides were detected either in air emissions or smears of the inside surface of the vent pipe surfaces.

Scrap Metal Project

The Scrap Metal Project removed scrap metal from the northwest portion of the Paducah Site as well as the C-746-D yard in the eastern portion of the site. During 2003, airborne radionuclide emissions may have resulted from dust created by removal, size reduction, and loading the scrap into transportation containers. The amount of radionuclides released was estimated based on emission factors from the Environmental Protection Agency, Document AP-42.

North/South Ditch Basin Construction

Remediation of the North/South Ditch has begun. Activities include construction of a surge basin inside the plant. Airborne radionuclide emissions may have been created by moving contaminated soil. The amount of radionuclides released was estimated based on emission factors from the Environmental Protection Agency, Document AP-42.

C-752-A Waste Treatment

Corrosive waste was neutralized in C-752-A during 2003. The waste contained radionuclides that may have become airborne during the neutralization. The airborne concentration of radionuclides was monitored during the project. This monitoring information was used to estimate the quantity of radionuclides emitted.

Miscellaneous Sources

Another minor potential fugitive or diffuse source of radionuclides results from the decontamination of machinery and equipment used in remediation activities such as well drilling. The equipment is washed with high-powered sprayers to remove any contaminants (radiological or non-radiological). The cleansing solutions and wash products could contain small amounts of radionuclides. No emission controls are used during the decontamination process. The contaminants originate from the soil and groundwater.

In accordance with PGDP DOE NESHAP Management Plan (BJC/PAD-141, dated February 2000), DOE utilized ambient air monitoring data to verify insignificant levels of radionuclides in off-site ambient air. Ambient air stations collect radionuclide samples at sites surrounding the plant. The ambient air monitors capture airborne radionuclides emitted from all sources including fugitive and diffuse. Potential fugitive or diffuse sources and ambient air monitoring locations are shown in Fig. 1. The Radiation/Environmental Monitoring Section of the Radiation Health and Toxic Agents Branch of the Department for Public Health of the Kentucky Cabinet for Health Services has operated the ambient air monitors during CY 2003. Based on observations for CY 2003, plant derived radionuclides were not detected. The results of the ambient air monitoring are in Table A-1 of this report.

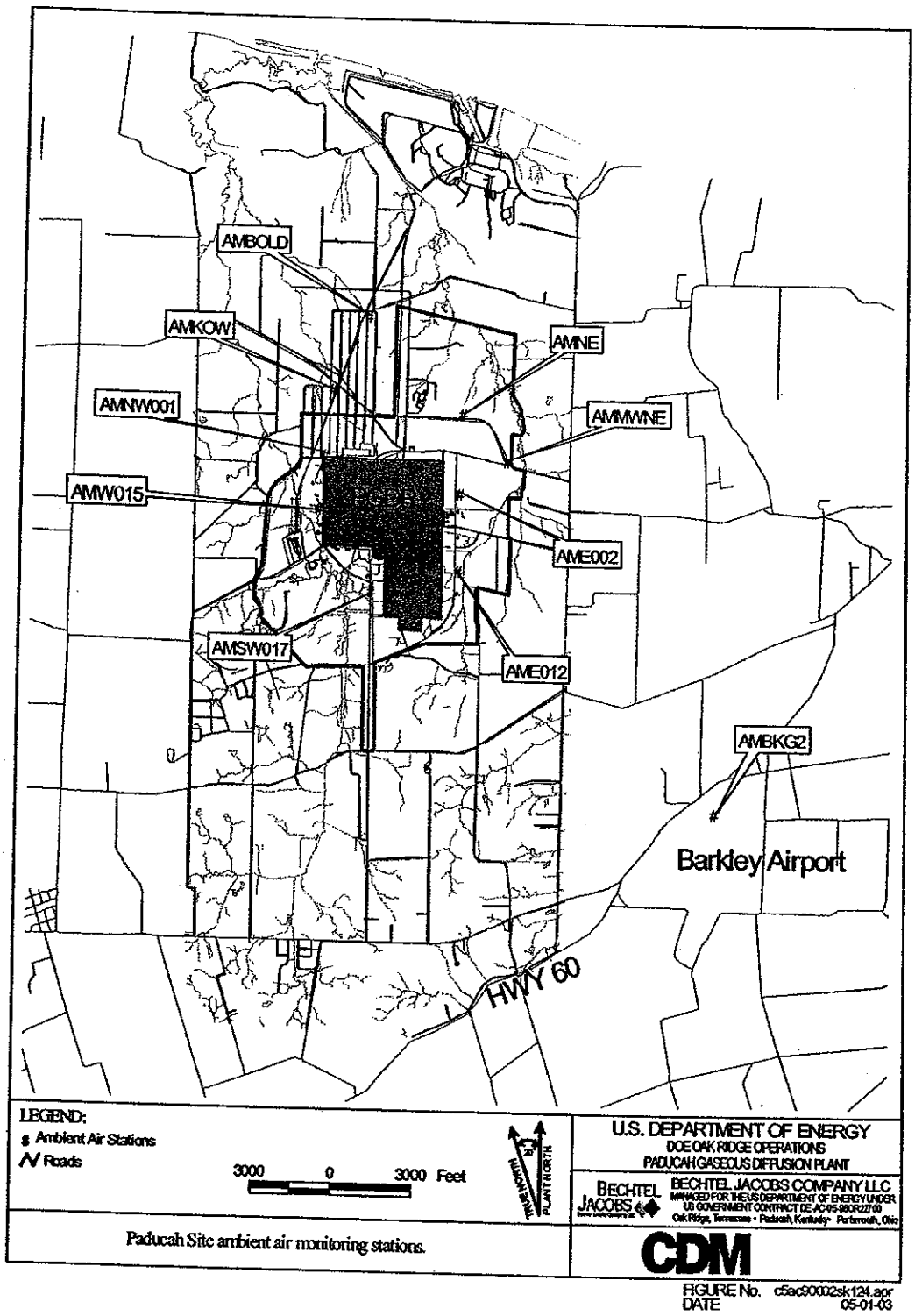

Figure 1. Location of Paducah Site ambient air monitors.

SECTION II SOURCE CHARACTERISTICS AND AIR EMISSIONS DATA

USEC SOURCE CHARACTERISTICS AND RADIONUCLIDE EMISSIONS

MAJOR POINT SOURCE

Major Point Source	Type Control	Efficiency %	Distance (m) and Direction to Nearest Receptor[1]
C-310 Purge Stack	NaF Traps[2]	>99.9	1740 ESE
	Alumina Traps[3]	~98.6	

MINOR POINT AND AREA SOURCES

Minor Point and Area Sources	Type Control	Efficiency %	Distance (m) and Direction to Nearest Receptor[1]
C-360[3]	None	0	1180 SE
C-400 Cylinder Drying Station[3]	None	0	1900 ESE

MINOR GROUPED SOURCES

Minor Grouped Sources	Type Control	Efficiency %	Distance (m) and Direction to Nearest Receptor[1]
Seal/Wet Air exhausts (6)	Alumina Traps[2]	~98.6	1490 ESE
Cylinder valve connection activities not included above (i.e., not serviced by a stack) (7).[3]	HEPA Vacuums[4]	99.0 (Appendix D)	1490 ESE
C-400 grouped sources (3)[3]	None	0	1920 ESE
C-710 laboratory hoods (61)[3]	None	0	1960 ESE
Building ventilation (10)	None	0	1490 ESE

NOTE: The building ventilation and cylinder valve connection activities not serviced by a stack are grouped with the Seal/Wet Air Exhausts Group in further analyses.

[1]Distances to receptors were resurveyed in 2003 due to residential construction in the vicinity of the plant.

[2]See January 28, 1994 correspondence from D. F. Hutcheson to W. A. Smith discussing "Potential to Emit."

[3] Emissions estimated in accordance with 40 CFR 61, Appendix D.

[4]Credit for the use of HEPA vacuums for pigtail operations is not taken for the purposes of estimating emissions.

USEC SOURCE CHARACTERISTICS

Source Name	Type	Height (m)	Diameter (m)	Gas Exit Velocity (m/s)	Gas Exit Temperature (°C)	Distance (m) and Direction to Maximally Exposed Individual	
						Source	Plant
C-310	Point	61.0	0.3	0	21.7	3040 NNE	2430 N
C-360	Point[1]	16.0	N/A	0	Ambient	1180 SE	2370 NNW
C-400 Group	Point[1]	11.3	N/A	0	Ambient	2040 N	2040 N
C-400 Cylinder Drying Station	Point[1]	2.4	0.5	0	Ambient	2120 N	2120 N
C-709/C-710 Lab	Point[1]	7.1	N/A	0	Ambient	2370 N	2370 N
Seal/Wet Air Exhaust Group[2]	Point[1]	21.0	N/A	0	Ambient	2350 N	2350 N

Source Name	Distances (m) to Selected Receptors		
	Nearest Individual/Farm	Nearest Business	Nearest School
C-310	1740	2705	3840
C-360	1180	2000	3840
C-400 Group	1920	2819	4225
C-400 Cylinder Drying Station	1900	2819	4100
C-709/C-710 Lab	1960	2705	3900
Seal/Wet Air Exhaust Group	1490	2438	3840

[1] Modeling was performed assuming a theoretical stack located at the approximate center of each grouped source.

[2] Grouped source includes building ventilation and cylinder valve disconnections from systems not served by permanent HEPA filter systems.

PGDP USEC RADIONUCLIDE EMISSIONS

Radionuclide Emissions (Ci)[1] During 2003									
Emission Source			C-310	C-709/ C-710 Lab	Seal/Wet Air Exhaust Grouped Sources	C-400 Grouped Sources	C-400 Cylinder Drying Station	C-360 Sampling	Total
Nuclide	Solubility	AMAD							
^{99}Tc	W	1	1.86E-03	3.07E-05	8.36E-03	7.97E-03	6.19E-06	5.52E-05	1.83E-02
^{230}Th	W	1	5.76E-06	NA[2]	1.94E-06	2.00E-11	3.65E-12	NA[2]	7.70E-06
^{234}U	D	1	5.00E-04	2.26E-03	1.67E-02	5.28E-04	4.15E-04	5.20E-06	2.04E-02
^{235}U	D	1	1.73E-05	7.84E-05	5.73E-04	1.83E-05	1.43E-05	1.81E-07	7.01E-04
^{238}U	D	1	4.57E-05	2.10E-04	4.20E-03	1.21E-04	1.08E-04	4.56E-07	4.69E-03
^{237}Np	W	1	6.79E-06	3.74E-06	3.26E-04	6.70E-05	5.28E-05	6.44E-07	4.57E-04
^{239}Pu	W	1	1.29E-06	NA[2]	1.18E-06	5.30E-12	3.39E-13	NA[2]	2.47E-06
Total Ci/year			2.44E-03	2.58E-03	3.02E-02	8.70E-03	5.96E-04	6.17E-05	4.46E-02

[1] 1 Curie = 3.7×10^{10} Becquerels
[2] NA = Not Analyzed

DOE SOURCE CHARACTERISTICS AND RADIONUCLIDE EMISSIONS DATA

Minor Point and Area Sources	Type Control	Efficiency%	Distance (m) and Direction to Nearest Receptor[1]
Northwest Plume Treatment Facility	None	0	1080 NNE
C-746 P Scrap Metal Project	None	0	1234 N
C-746 D Scrap Metal	None	0	1220 ESE
C-752 A Waste Treatment	HEPA	99.9	1695 N
N/S Ditch Basin Construction	None	0	1525 NNW

Radionuclide Emissions (Ci)[2] During 2003					
Emission Source	NW Plume Treatment Facility	C-746 P Scrap Metal Project	C-746 D Scrap Metal Project	C-752 A Waste Treatment	N/S Ditch Basin Construction
^{99}Tc	9.7E-5	1.8E-5	7.2E-9	2.6E-11	8.2E-5
^{234}U		2.6E-6	1.0E-11	2.6E-12	6.0E-6
^{235}U		1.0E-7	3.0E-10	2.0E-12	7.0E-7
^{238}U		7.7E-7	3.0E-10	2.6E-12	8.6E-6
^{237}Np		2.5E-7	9.9E-11	3.5E-12	1.7E-6
^{239}Pu		5.5E-7	8.6E-11	9.6E-14	5.4E-6
^{241}Am				3.9E-12	
^{214}Bi				1.1E-17	
^{134}Cs				4.7E-15	
^{137}Cs				2.0E-14	
^{60}Co				5.8E-15	
^{238}Pu				7.7E-15	
^{40}K				2.7E-16	
^{233}Pa				1.8E-16	
^{226}Ra				7.3E-17	
^{228}Th				1.6E-15	
^{230}Th				2.0E-13	
^{231}Th				5.5E-17	
^{232}Th				1.7E-15	
^{234}Th				4.4E-15	
$^{233/234}U$				5.1E-15	
Total Ci/year	**9.7E-5**	**2.23E-05**	**8.00E-09**	**4.09E-11**	**1.04E-04**

[1]Distances to receptors were resurveyed in CY 2003 due to residential construction in the vicinity of the plant.

[2]1 Curie = 3.7×10^{10} Becquerels.

Source Name	Distances (m) to Selected Receptors		
	Nearest Individual/Farm	Nearest Business	Nearest School
Northwest Plume Treatment Facility	1080	2550	5150
C-746 P Scrap Metal Project	1234	3033	5490
C-746 D Scrap Metal	1220	2105	3873
C-752 A Waste Treatment	1695	3202	4270
N/S Ditch Basin Construction	1525	3020	5033

Source Name	Type	Height (m)	Diameter (m)	Gas Exit Velocity (m/s)	Gas Exit Temperature (°C)	Distance (m) and Direction to Maximally Exposed Individual (MEI) Source MEI
Northwest Plume Treatment Facility	Point	7.0	0.3556	9.45	37.8	1080 NNE
C-746 P Scrap Metal Project	Point	1	NA	0	Ambient	1205 NNE
C-746 D Scrap Metal	Point	1	NA	0	Ambient	2750 SSE
C-752 A Waste Treatment	Point	5.5	0.3	0	Ambient	1700 N
N/S Ditch Basin Construction	Area	1	119	0	Ambient	1530 NNW

SECTION III DOSE ASSESSMENT

DESCRIPTION OF DOSE MODEL

The radiation dose calculations were performed using the Clean Air Act (CAA) Assessment Package-88 of computer codes. This package contains EPA's most recent version of the AIRDOS-EPA computer code which implements a steady-state, Gaussian plume, atmospheric dispersion model to calculate environmental concentrations of released radionuclides and Regulatory Guide 1.109 food chain models to calculate human exposures, both internal and external, to radionuclides deposited in the environment. The human exposure values are then used by EPA's latest version of the DARTAB computer code to calculate radiation doses to man from radionuclides released during the year. The dose calculations use dose conversion factors in the latest version of the RADRISK data file, which is provided by EPA with CAA Assessment Package-88.

SUMMARY OF INPUT PARAMETERS

Except for the radionuclide parameters given in Section II and those given below, all important input parameter values used are the default values provided with the CAP-88 computer codes and databases.

Joint frequency distribution:	Five-year STAR distribution from 60-meter station on PGDP meteorological tower for the years 1988 through 1992.
Rainfall rate:	121 centimeters/year
Average air temperature:	20° C
Average mixing layer height:	930 meters

Fraction of foodstuffs from:	Local Area	50-Mile Radius	Beyond 50 Miles
Vegetables and produce[1]:	0.700	0.300	0.000
Meat:	0.442	0.558	0.000
Milk:	0.399	0.601	0.000

DISCUSSION OF RESULTS

Due to the conservative nature of the estimates, it is likely that the actual radiological dose from site operations was significantly lower than the calculated dose. Using the conservative estimates, however, PGDP was in compliance with requirements of 40 CFR 61 because the total dose from all airborne radionuclides is less than the standard of 10 mrem per year.

[1]Rural default values.

COMPLIANCE ASSESSMENT

Effective dose equivalent (mrem)[1] to maximally exposed individual for each individual source and the plant:

USEC Emission Sources	Maximum for Source	Maximum for Plant
C-310	5.00E-04	4.80E-04
C-360	6.10E-05	2.70E-05
C-400 Group	5.00E-03	5.00E-03
C-400 Cylinder Drying Station	3.50E-03	3.50E-03
C-709/C-710 Lab	1.60E-03	1.60E-03
Seal/Wet Air Exhaust Group	2.40E-02	2.40E-02
Total From USEC Sources	**N/A**	**3.46E-02**
DOE Emission Sources	**Maximum for Source**	**Maximum for Plant**
Northwest Plume Treatment Facility	1.80E-05	1.80E-05
C-746 P Scrap Metal Project	1.60E-04	1.60E-04
C-746 D Scrap Metal	2.40E-08	7.00E-09
C-752 A Waste Treatment	7.00E-10	7.00E-10
N/S Ditch Basin Construction	6.00E-4	6.00E-04
Total From DOE Sources	**N/A**	**7.78E-04**
Total From All Sources	**N/A**	**3.54E-02**

Maximum effective dose equivalent to the maximum exposed individual for the plant = 3.54E-02 mrem.

Location of maximally exposed individual: 2,350 meters north of greatest contributor to dose which is the SX/WA Group Source.

NOTE: Based on estimated 2003 census data, the total collective effective dose equivalent (CEDE) to the 50-mile population (approximately 531,000 persons) was 0.2 person-rem.

[1] 1 mrem=0.01 millisieverts.

CERTIFICATION

This certification pertains to the following USEC emission sources:

C-310 Purge and Vent Stack
C-360
C-400 Group
C-400 Cylinder Drying Station
C-709/C-710 Lab
Seal Exhaust/Wet Air Group

I certify under penalty of law that I have personally examined and am familiar with the information submitted herein, and based on my inquiry of those individuals immediately responsible for obtaining the information, I believe that the submitted information is true, accurate, and complete. I am aware that there are significant penalties for submitting false information including the possibility of fine and imprisonment.
(See 18 U.S. C1001.)

W S Stanley Jr
United States Enrichment Corporation

6/28/04
Date

CERTIFICATION

This certification pertains to the following DOE emission source:

C-746-D Scrap Metal Project
C-746-P Scrap Metal Project
C-752-A Waste Treatment
N/S Ditch Basin Construction
Northwest Plume Treatment Facility
Fugitive and Diffuse Sources

I certify under penalty of law that I have personally examined and am familiar with the information submitted herein, and based on my inquiry of those individuals immediately responsible for obtaining the information, I believe that the submitted information is true, accurate, and complete. I am aware that there are significant penalties for submitting false information including the possibility of fine and imprisonment.
(See 18 U.S. C1001.)

Department of Energy

6/25/04
Date

SECTION IV ADDITIONAL INFORMATION

UNPLANNED RELEASES – USEC

There were 4 unplanned releases in USEC facilities occurring outside of a building not included in HP air sampling program during CY 2003. The estimated total quantity of uranium released was less than 20g. These releases were included in the seal/wet air exhaust group.

DIFFUSE/FUGITIVE EMISSIONS – DOE

Diffuse/fugitive sources include any source that is spatially distributed, diffuse in nature, or not emitted with forced air from a stack, vent, or other confined conduit. Diffuse/fugitive sources also include emissions from sources where forced air is not used to transport the radionuclides to the atmosphere. In this case, radionuclides are transported entirely by diffusion and/or thermally driven air currents. Typical examples of diffuse/fugitive sources include emissions from building breathing; resuspension of contaminated soils, debris, or other materials; unventilated tanks; ponds, lakes, and streams; wastewater treatment systems; outdoor storage and processing areas; and leaks in piping, valves, or other process equipment.

EPA has not identified a methodology or requirements for determining airborne radionuclide source terms for many unique fugitive and diffuse emission sources characteristic of DOE facilities, nor does the Paducah Site currently have any available methods to selectively and accurately quantify airborne radionuclide source terms from specific fugitive emission sources. However, consistent with the April 1995 memoranda of understanding between DOE and EPA Headquarters, information on diffuse/fugitive emissions is being provided to EPA as additional information. On February 8, 2000, DOE submitted to Kentucky Division for Air Quality and EPA Region IV the *Paducah Gaseous Diffusion Plant Department of Energy National Emission Standards for Hazardous Air Pollutants (NESHAP) Management Plan*. This plan outlined the DOE Paducah Site plans for using ambient air monitors to demonstrate that total emissions (from point, diffuse, and fugitive sources) result in doses significantly less than the 10-mrem/year (0.1-mSv/year) standard. Section I provides a list of potential fugitive/diffuse sources on the Paducah Site.

The Radiation/Environmental Monitoring Section of the Radiation Health and Toxic Agents Branch of the Department for Public Health of the Kentucky Cabinet for Health Services has conducted ambient air monitoring around the Paducah Site during CY 2003. The Radiation Health and Toxic Agents Branch reports that weekly air filters were screened for gross alpha and beta activity and then composited on a quarterly basis. The quarterly composites were analyzed by gamma spectroscopy using a thin window 40 percent high purity germanium detector, which allows for detection of low energy gamma emitters. Americium-241 (^{241}Am) and ^{234}Th were not detected by gamma spectroscopy for the quarterly composites.

Because ^{241}Am and ^{234}Th were not detected, plutonium and uranium isotopic analyses were not performed on the quarterly composites. Since ^{241}Am and ^{234}Th were not present, the quarterly composites were analyzed for ^{99}Tc. ^{99}Tc was also not detected in the quarterly composites. ^{210}Pb and ^{40}K were detected on filters, which accounts for the presence of the gross alpha and beta activities.

Based on observations for CY 2003, plant derived radionuclides were not detected by the Radiation Health and Toxic Agents Branch's air monitoring network.

STATUS OF NESHAP MONITORING REQUIREMENTS, SUBPART H COMPLIANCE

The status of compliance with the new NESHAP monitoring requirements is described in the revised NESHAP Compliance Plan which was submitted to EPA January 1992. PGDP has only one stack subject to the continuous monitoring requirements of Subpart H, the C-310 Stack.[1] Particulate stack sampling was performed on the C-310 Purge Cascade Stack February 1992. Results of the sampling project were forwarded to EPA by March 31, 1992. Documentation from EPA[2] stated that PGDP is exempted from the requirement to install an isokinetic sampling system.

Minor Sources: The periodic confirmatory measurement plan for minor sources is outlined in detail in the Revised NESHAP Compliance Plan for PGDP, which was submitted to EPA on January 15, 1992. The initial plan for confirmatory measurements is to estimate emissions using Appendix D and/or mass balance methods on an annual basis, and to stack sample those sources for which stack sampling is the only feasible estimation method on a five-year basis.

On May 26, 1992, PGDP and EPA entered into a Federal Facility Compliance Agreement (FFCA) to bring PGDP into compliance with the sampling provisions established in accordance with 40 CFR 61, Subpart H. Appendix A of the FFCA contains a schedule establishing compliance commitments. The major effort of the compliance schedule was the site evaluation in which all potential sources of airborne radionuclides were identified and emissions were determined. The radionuclide sources were identified through a preliminary stack vent survey, which was completed in 1991. In November 1992, a more in-depth survey was completed which did not discover any previously unknown airborne radionuclide sources. In September 1992, representatives from EPA inspected PGDP for NESHAP compliance. Correspondence from EPA summarizing the inspection stated there were no NESHAP violations identified during the inspection. PGDP fulfilled all commitments in accordance with Appendix A of the FFCA in June 1992; submitted results of the updated, in-depth vent stack survey in December 1992; and officially requested a Certification of Completion of the FFCA on March 11, 1993. EPA issued the Certification of Completion on March 26, 1993. Certification of Completion of the FFCA indicates that PGDP is in compliance with the provisions in accordance with 40 CFR 61, Subpart H.

DOE has remained in compliance since 1993. KDAQ received a delegation of authority to administer the NESHAP program in July 1999. A NESHAP Management Plan has been developed by DOE, which addresses fugitive and diffuse emissions. EPA Region 4 concurred with the DOE NESHAP Management Plan on September 19, 2000. In accordance with the management plan, ambient air monitoring was utilized to verify compliance of the Paducah Site with 40 CFR 61, Subpart H for all emissions. Ambient air monitoring conducted by the Kentucky Radiation Health and Toxics Branch did not detect plant derived radionuclides during CY 2003. The concentration detected is less than the 40 CFR 61 Appendix E, Table 2 value for environmental compliance.

The actual results, even though less than the measurement error, of each air monitor are listed in Table A-1 of this report. The ratio of each isotopic concentration to the standard for that isotope in 40 CFR 61, Appendix E, Table 2, was calculated. The sum of all of these ratios should be less than one to meet the standard. The sum of the ratios is listed for each monitoring station for each quarter in Table A–1.

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[1]See correspondence from D. F. Hutcheson to D. C. Booher, dated January 28, 1994, discussing "Potential to Emit."

[2]See correspondence from W. A. Smith to D. C. Booher, dated April 20, 1992.

Table A-1. Kentucky Radiation Health and Toxics Branch Ambient Air Monitoring Results[1]

Quarter	Nuclide	AMSW017 Ci/m3	AMW015 Ci/m3	AMNW001 Ci/m3	AMNE Ci/m3	AME002 Ci/m3	AME012 Ci/m3	AMBKG2 Ci/m3	AMBOLD Ci/m3	AMKOW Ci/m3	AMMWNE Ci/m3
1	Am-241	4.64E-16	1.65E-16	2.61E-16	1.87E-16	1.05E-16	4.53E-16	4.30E-16	4.85E-16	1.18E-16	3.34E-16
	Np-237	9.00E-17	9.93E-17	-3.06E-16	2.85E-16	-3.60E-17	-2.16E-16	-5.73E-17	-3.74E-17	1.29E-16	1.74E-16
	Tc-99	1.47E-16	4.85E-17	-1.89E-17	7.57E-18	1.62E-16	-1.89E-17	2.45E-16	2.80E-16	1.47E-16	-6.81E-17
	U-238	2.04E-16	2.13E-16	2.81E-16	2.77E-16	2.40E-16	2.35E-16	2.16E-16	2.44E-16	2.69E-16	2.46E-16
	Sum of ratios	0.35	0.20	-0.08	0.37	0.06	0.09	0.21	0.26	0.20	0.35
2	Am-241	-3.23E-16	1.66E-16	3.06E-16	3.90E-17	2.09E-16	-6.50E-17	-2.62E-16	-3.10E-16	2.82E-16	4.49E-17
	Np-237	-9.72E-17	-8.36E-17	5.32E-16	-1.86E-16	-2.93E-16	6.26E-17	-1.94E-17	1.32E-16	7.34E-17	1.92E-16
	Tc-99	3.00E-16	1.81E-16	-3.18E-17	6.52E-16	5.89E-16	3.47E-17	5.47E-16	2.01E-16	8.96E-17	3.88E-16
	U-238	3.28E-16	2.76E-16	2.39E-16	3.63E-16	3.80E-16	3.81E-16	2.67E-16	2.61E-16	2.54E-16	2.98E-16
	Sum of ratios	-0.21	0.05	0.63	-0.09	-0.08	0.06	-0.12	-0.02	0.24	0.22
3	Am-241	-6.53E-16	4.02E-16	2.01E-16	2.96E-16	-8.62E-17	-1.13E-16	3.60E-17	-1.03E-15	1.86E-16	2.50E-16
	Np-237	-3.03E-16	-2.67E-16	-8.69E-17	-2.42E-16	-2.59E-16	-2.86E-16	3.48E-16	3.02E-16	-1.04E-16	2.20E-16
	Tc-99	-1.87E-16	2.44E-16	3.10E-16	1.17E-16	2.07E-16	2.08E-16	-2.69E-16	-2.38E-16	1.77E-16	3.70E-16
	U-238	2.34E-16	2.70E-16	3.42E-16	3.34E-16	2.83E-16	2.68E-16	1.89E-16	3.35E-16	2.43E-16	2.65E-16
	Sum of ratios	-0.57	0.02	0.08	0.0	-0.23	-0.26	0.33	-0.25	0.04	0.35
4	Am-241		6.36E-18	1.50E-16	1.56E-16	-8.35E-16	-1.20E-16	-8.04E-16	3.51E-16	-1.81E-16	1.76E-16
	Np-237	2.54E-16	9.25E-17	-5.46E-16	-5.11E-17	-1.71E-17	3.60E-17	1.58E-16	-2.61E-16	-1.23E-16	-1.46E-16
	Tc-99	2.92E-17	9.46E-16	8.54E-16	3.03E-16	-7.35E-18	2.80E-16	-3.00E-16	5.03E-16	2.26E-16	2.81E-16
	U-238	1.85E-16	1.61E-16	1.98E-16	2.03E-16	1.95E-16	1.67E-16	1.89E-16	1.76E-16	2.65E-16	1.51E-16
	Sum of ratios	0.23	0.11	-0.35	0.07	-0.43	-0.01	-0.27	-0.01	-0.16	-0.01

[1] 40 CFR 61, Table 2, Limiting Values (Ci/m3): ^{241}Am 1.9E-15, ^{237}Np 1.2E-15, ^{99}Tc 1.4E-13, and ^{238}U 8.3E-15.