Office of Oversight
Environment, Safety and Health

Phase I
Independent Investigation
of the

Paducah
Gaseous Diffusion Plant

Environment, Safety, and Health Issues

October 1999

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OVERSIGHT

Executive Summary

EVALUATION:	Office of Oversight Investigation — Phase I
SITE:	Paducah Gaseous Diffusion Plant
DATES:	August-September 1999

Background/Scope

In August 1999, in response to a number of environment, safety, and health (ES&H) allegations and concerns, the Secretary of Energy initiated an independent investigation at the Paducah Gaseous Diffusion Plant (PGDP or Plant). These ES&H concerns centered on areas such as improper onsite and offsite disposal of hazardous and radioactive materials, release of contamination into site streams and drainage ditches, inadequate posting and control of contaminated areas, exposure of workers to uranium and transuranic elements, and ineffective communication of hazards to workers.

To provide timely feedback to the Secretary on the current status of environmental protection, worker and public health and safety, and the status of legacy issues, this Department of Energy (DOE) Office of Oversight investigation was divided into two phases. Phase I, the subject of this report, covers the period from 1990 to the present. Phase II, which will begin in October 1999, will evaluate ES&H performance and concerns about Plant operations prior to 1990. Various assessments in the early 1990s, including a DOE Tiger Team and the initial investigation under the DOE Environmental Protection Agency Consent Order, identified numerous concerns about environmental contamination, radiological protection, and the presence of transuranic materials.

This first phase of the investigation focused on legacy areas and activities—those that remain the responsibility of DOE and its current management and integrating contractor, Bechtel Jacobs, which took over operation of the DOE-controlled activities at PGDP in 1998. The investigation did not examine areas leased by the United States Enrichment Corporation (USEC) that are under Nuclear Regulatory Commission (NRC) jurisdiction. NRC has undertaken a separate confirmatory inspection to assess worker safety in those areas of the PGDP under NRC control.

Rather than separately investigating each of the many specific allegations and concerns, the Office of Oversight investigation team independently examined the implementation of PGDP ES&H programs within which the allegations and concerns fell. These programs include public and environmental protection, radiation protection, worker safety, and line management oversight. This approach was chosen to identify issues and programmatic weaknesses that need to be corrected and help DOE to implement long-term and effective improvements in ES&H performance, rather than merely addressing symptoms.

Results

Although weaknesses remain, significant corrective actions and improvements have been implemented in PGDP ES&H programs since the early 1990s. The PGDP site is being cleaned up under enforceable agreements established with the Commonwealth of Kentucky and the Environmental Protection Agency. The site is currently in compliance with the terms of Federal Facility Agreements. Compensatory measures have been taken to protect the public and to mitigate the impact of radiological and chemical contamination, such as connecting homes that are in the path of contamination plumes to public water. In the worker safety arena, the radiation protection program has been enhanced, radiation exposures to employees have been low, and injury and illness rates at PGDP are lower than at many other DOE sites.

Despite the improvements since 1990 and actions to clean up the site, this investigation identified a number of weaknesses in each of the areas reviewed. While the investigation team found no immediate threat to health and safety that would require immediate cessation of site activities, the cumulative impact of a number of deficiencies is cause for concern.

Public and Environmental Protection. Extensive efforts have been undertaken at PGDP to characterize major sources of groundwater contamination, and the extent of that contamination, as a result of the 1988 discovery of contaminated offsite residential drinking wells. Limited progress has been made, however, in accurrately isolating or remidiating the numerous sources of offsite contamination. Groundwater contamination plumes now extend over two miles offsite and continue to grow at approximately one foot per day, and, in some areas, PGDP has not adequately characterized the plumes, including defining the leading edges. Most of the site's funding has been devoted to characterizing contamination, operating and maintaining the site infrastructure, meeting regulatory requirements, and implementing compensatory measures in reaction to immediate threats. The funding available for cleanup and remediation has been much less than requested, and little progress has been made. As a result, two of PDGP's early major cleanup milestones under the Federal Facility Agreement, to remediate Drum Mountain (also known as Barrel Mountain) and to characterize the waste unit beneath it, are in significant jeopardy of not being met. Examples of other deficiencies in environmental and public protection include:

Several thousand tons of nickel and aluminum ingots were produced. These materials are currently stored outside with no protection.

- Large quantities of scrap metal and low-level and mixed waste (equivalent to approximately 50,000 barrels) are stored in conditions that cause degradation of the containers (e.g., drums stored outdoors without protection from the weather) and the potential for spread of contamination.

- Numerous contaminated areas and shutdown process facilities have not been adequately characterized and analyzed to identify potential exposure pathways and have not been controlled and maintained to prevent the spread of contamination.

- Information provided to stakeholders, including workers, the public, and the Site Specific Advisory Board, has not been comprehensive or presented in a manner that is easy for a non-technical audience to understand (e.g., annual environmental reports do not reflect data resulting from site remediation investigations).

Radiation Protection. Since the early 1990s, the PGDP radiological protection program has been enhanced by adding radiation protection staff and establishing numerous controls, such as dosimetry (monitoring radiation exposure by means of a film badge), bioassay (monitoring radiation exposure by sampling body fluids), and contamination controls. Despite these improvements, the PGDP radiation protection program is not implemented with the level of discipline, formality, and rigor required for DOE facilities. Examples of deficiencies in radiological protection include:

- Insufficient radiological postings and barriers for contaminated areas, some of which are outside the security fence and could be accessible to the public

- Inconsistent implementation of radiological control mechanisms including radiation work permits, procedures, surveys, and air monitoring

- Subcontractors working in radiological exposure areas without the required training or dosimetry.

Worker Safety and Health. Since the early 1990s when the DOE Tiger Team assessment identified numerous deficiencies in worker safety programs, significant improvements have been made. Most occupational and worker exposure hazards have been identified and analyzed, they are adequately controlled, and workers are more involved in work planning. However, improvements are needed in establishing, maintaining, and following procedures, particularly for work performed by subcontractors. Deficiencies in worker safety practices and controls indicate the lack of a disciplined, rigorous, and consistent approach to safety management. Other deficiencies were evident in such areas as:

DOE Material Storage Area

- Criticality safety hazards in DOE material storage areas (DMSAs) have not been characterized, analyzed, and resolved even though they were identified more than two years ago.

- Medical personnel have not been sufficiently involved in evaluating hazards to ensure the effectiveness of medical surveillance programs, particularly those for subcontractors.

- Worker training programs do not ensure familiarity with workplace hazards and have not adequately addressed the presence of transuranics (elements, such as plutonium, that have a higher atomic number than uranium). This shortcoming in training may have exacerbated workers' fear of exposure and contributed to instances of mistrust by workers.

Line Oversight. The operating gaseous diffusion facility was leased to USEC in 1993, and NRC's regulatory oversight of these leased facilities began in 1997. DOE retains regulatory oversight responsibility only for non-leased portions of the facilities. Line management oversight of ES&H by the DOE Oak Ridge Operations Office (OR) and the Paducah Site Office has been limited. DOE Headquarters ES&H oversight, including the program offices and the Office of Environment, Safety and Health, has also been very limited. Further, Bechtel Jacobs oversight of subcontractors' ES&H performance has not assured compliance with ES&H requirements. The lack of sufficient line oversight has contributed to situations in which previously identified problems and weaknesses have resurfaced and have remained uncorrected for extended periods.

Conclusions

Many improvements in ES&H programs have been made in the past ten years, and current operations do not present an immediate risk to workers or the public. However, the current radiation protection program and some elements of worker safety programs do not exhibit the required levels of discipline and formality. Further, there has been little progress in reducing or mitigating site hazards or sources of environmental contamination. Weaknesses in hazard controls are evident, ES&H oversight has not been sufficient, and communication with stakeholders and workers has not been comprehensive and responsive to stakeholder needs. In combination, these weaknesses undermine workers' and stakeholders' confidence and perpetuate the risks and hazards of legacy operations.

A key to regaining stakeholder, worker, and public support and confidence, reducing hazards and risks to as low as reasonably achievable, and ensuring the continuing operation of the PGDP is to begin to accelerate progress in the cleanup effort, including compliance with impending initial major cleanup milestones such as Drum Mountain and the waste buried beneath it. Timely progress in cleanup and remediation will require a reevaluation of priorities and funding allocations within the DOE Office of Environmental Management and OR and/or additional cleanup funding from Congress. Systematic progress needs to be demonstrated in key cleanup and hazard reduction efforts such as the elimination of the many sources of contamination, characterization and disposition of the DMSAs, including resolution of criticality safety concerns, the proper storage or shipment offsite of low-level waste, and the removal of hazards and proper upkeep or demolition of shutdown hazardous facilities. Other areas where timely improvement is needed include:

- Establishing a high level of discipline and rigor in the radiological protection program and other programs affecting worker safety, such as criticality safety. This effort should emphasize strict compliance with posting and barrier requirements, improved radiation work permits, comprehensive radiological training, strict use of and compliance with procedures, characterization of materials to improve effective hazard analysis, and the use of engineered hazard controls whenever possible.

- Strengthening communications and outreach to workers, the public, and stakeholders to ensure understanding, confidence in site operations, and empowerment in contributing to cleanup strategies, priorities, and decisions. This effort is particularly important for the Site Specific Advisory Board, whose charter is to contribute to site cleanup through involvement in establishing priorities and milestones and achieving public support.

- Restoring a reasonable level of DOE and contractor oversight of ES&H performance to ensure adequate subcontractor safety performance, accountability for compliance with DOE requirements, and continuous improvement.

Continued improvements in safety management will be particularly important as the PGDP initiates additional site cleanup and remediation activities. This work presents unique hazards (e.g., handling material that contains radioactive and chemical carcinogens and that has not been fully characterized) and has already resulted in several occurrences of workers being contaminated in the limited remediation efforts to date. The need for effective safety management is further highlighted by the fact that, under the management and integrating contractor concept, a large fraction of the potentially hazardous work will be performed by subcontractor employees, some of whom do not have a long-term knowledge of site hazards or controls. As subcontractors' cleanup and waste management activities increase, Bechtel Jacobs and DOE personnel who are knowledgeable of DOE requirements will need to increase their level of oversight.

OVERVIEW OF ISSUES

1. There has been limited progress in remediating and characterizing environmental contamination, low-level wastes, and stored hazardous materials that were produced by past industrial activities, and major cleanup milestones under the Federal Facility Agreement are jeopardized by funding constraints.

2. There are continuing weaknesses in the radiation protection management of known environmental contamination areas by both Bechtel Jacobs and DOE.

3. Radiological exposure pathways for DOE operations have not been fully assessed or documented.

4. Groundwater contamination has not been adequately characterized in some areas.

5. Unclear assignment of responsibilities and weaknesses in the integration and interpretation of environmental information have adversely impacted the understanding of environmental conditions.

6. Information to the public has sometimes been delayed and is in forms not clearly understood by the general public and other stakeholder groups, contributing to a perception that DOE and the contractor are withholding information from the public.

7. Incomplete radiological characterization of the workplace adversely affects the ability of the radiological control organization to identify hazards and institute controls as necessary to ensure consistent and appropriate radiological protection for workers.

8. There is a lack of rigor, formality, and discipline in the development, maintenance, and implementation of the Bechtel Jacobs radiation protection program.

9. Criticality safety deficiencies in DMSAs have not been resolved by DOE in a timely manner, posing an unnecessary hazard to workers in surrounding areas.

10. Safety and health procedures are not consistently applied and followed, and in some cases, hazards are not adequately addressed by those procedures.

11. Bechtel Jacobs has not assured that subcontracted medical personnel are sufficiently involved in the identification, evaluation, and integration of workplace hazards to ensure effective worker medical programs.

12. Bechtel Jacobs training programs do not ensure that all workers are knowledgeable of hazards and protection requirements, including those associated with transuranic contamination.

13. DOE has not conducted effective oversight of ES&H or ensured that Bechtel Jacobs and its subcontractors effectively implement all DOE and regulatory requirements.

14. Bechtel Jacobs has not conducted fully effective oversight of ES&H performance or ensured that its subcontractors effectively implement all DOE and regulatory requirements and are held accountable.

1.0 Introduction

1.1 Purpose and Scope

The Department of Energy (DOE) Office of Oversight, within the Office of Environment, Safety and Health, conducted an investigation of the Paducah Gaseous Diffusion Plant (PGDP or Plant) during August and September 1999. The purpose of this investigation was to determine whether current work practices for DOE-controlled areas of the site are sufficient to protect workers, the public, and the environment. This investigation was performed at the direction of the Secretary of Energy, who instructed the Office of Environment, Safety and Health to examine recent employee concerns with past operations and work practices, and current management of legacy materials at PGDP.

This investigation is being conducted in two phases. The first phase, the subject of this report, addressed DOE and site contractor activities and environment, safety, and health (ES&H) issues arising since 1990. The second phase will address legacy ES&H issues that occurred prior to 1990. This investigation is being coordinated with other organizations that have regulatory authority at PGDP, including the Commonwealth of Kentucky, the Nuclear Regulatory Commission (NRC), the Environmental Protection Agency (EPA), and the Occupational Safety and Health Administration (OSHA). Excluded from this investigation is any activity currently under NRC jurisdiction (i.e., the portions of the Plant leased to the United States Enrichment Corporation, or USEC).

The scope of the investigation includes: (1) facilities and properties under DOE jurisdiction; (2) ES&H issues associated with these facilities and properties from 1990 to the present, including interactions between DOE and stakeholders; and (3) ES&H issues associated with uranium enrichment facilities from 1990 to March 3, 1997 — the point when NRC assumed regulatory oversight of the gaseous diffusion processes, facilities, and personnel. The DOE-controlled operations that were examined include: landlord infrastructure; treatment, storage, and disposal of legacy waste remaining from past operations and newly generated waste; site remediation; uranium hexafluoride (UF_6) cylinder storage; facility decontamination and decommissioning; and polychlorinated biphenyl (PCB) collection, treatment, and cleanup. Consistent with the memorandum of understanding between the NRC and DOE regarding PGDP operation, any activities, operations, or facilities shared by USEC and DOE or its contractors were examined as part of this investigation.

1.2 Site Background, Operations, and Hazardous Materials

The PGDP is located in McCracken County, Kentucky, approximately 10 miles west of the city of Paducah and 3 miles south of the Ohio River. The site occupies about 3,425 acres, of which 750 acres are within a security fence and contain uranium enrichment process equipment and support facilities. The mission of the Plant is to "enrich" uranium for use in domestic and foreign commercial power reactors. Enrichment involves increasing the percentage of the uranium-235 isotope in the material used for creating reactor fuel (UF_6). Uranium-235 is highly fissionable, unlike the more common isotope uranium-238. The PGDP enriches the UF_6 from roughly 0.7 percent uranium-235 to about 2.75 percent uranium-235. This slightly enriched material is shipped to the Portsmouth Gaseous Diffusion Plant, where currently it is further enriched to 5 percent uranium-235. Figures 1, 2, and 3 are site maps and an aerial view of PGDP.

The PGDP was constructed in the early 1950s, and the first product cylinders with enriched uranium were shipped to Oak Ridge in late 1952. Carbide and Chemicals Company (now Union Carbide) was the original site contractor and operated the Plant for the Atomic Energy Commission. In the mid-1960s, the mission of the Plant shifted from military to commercial applications, and the Plant began enriching uranium for use in nuclear power plants. In 1975, the Energy Research and Development Administration assumed responsibility for regulatory oversight of the uranium enrichment program from the Atomic

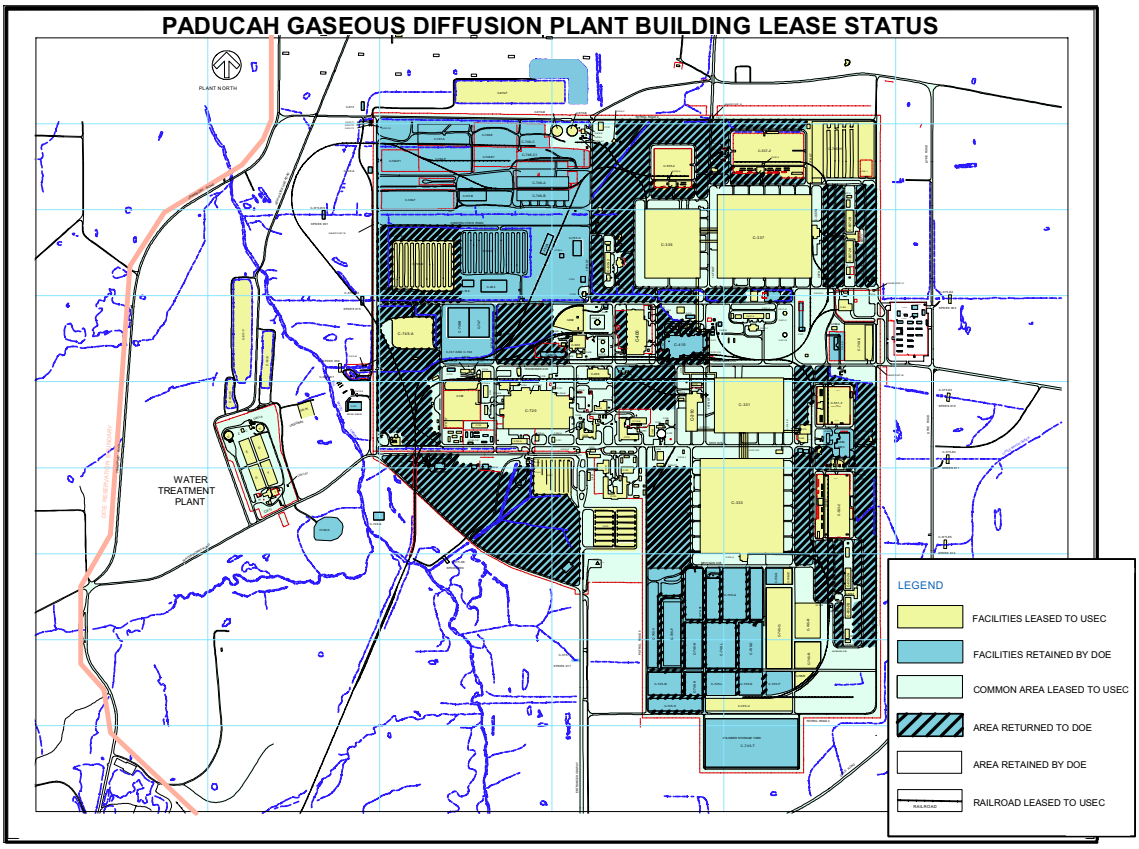


Figure 1. Map of Paducah Gaseous Diffusion Plant, Leased and Non-Leased Areas

Figure 2. Aerial View of Paducah Gaseous Diffusion Plant

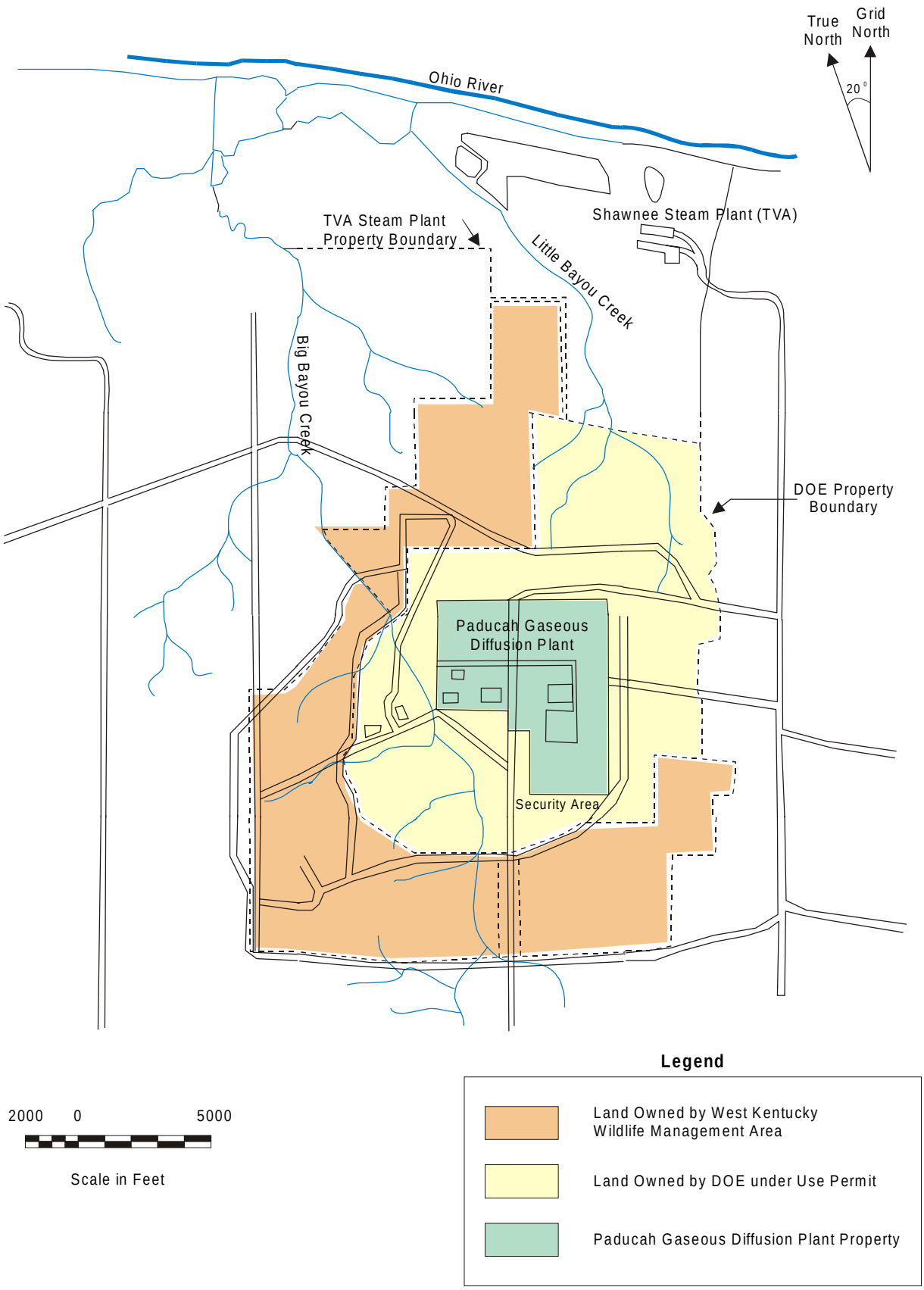


Figure 3. Map of Paducah Gaseous Diffusion Plant, Major Boundaries and Features

Energy Commission; in 1977, these functions were transferred to DOE. Martin Marietta became the operating contractor for the Plant, replacing Union Carbide, in 1984.

The Energy Policy Act of 1992 created USEC and was a first step in the process of privatizing the government's uranium enrichment enterprises. In July 1993, USEC leased portions of the Plant from DOE, assumed responsibility for uranium enrichment activities, and contracted with Martin Marietta Utility Services, a subsidiary of Martin Marietta, for operation and maintenance of enrichment activities. Through a June 1995 corporate merger, Martin Marietta Utility Services became Lockheed Martin Utility Services. NRC granted a certificate of compliance to the Plant in November 1996 under 10 CFR Part 76, and regulatory oversight of enrichment operations was transferred from DOE to NRC in March 1997. As a result of an initial public offering, USEC was privatized as an investor-owned corporation in July 1998. USEC took over direct operation of all enrichment activities at the Plant in May 1999, with most Lockheed Martin Utility Services personnel becoming employees of USEC.

DOE is the site "landlord," owns the physical plant, and is responsible for operation of the Northwest Groundwater Treatment Facility and three inactive landfills. DOE retains responsibility for the environmental restoration program, most elements of the waste management program, and all waste materials generated by past DOE activities. Bechtel Jacobs is the management and integrating contractor for DOE, having been awarded this contract in April 1998. Bechtel Jacobs relies on subcontractors to conduct environmental restoration and waste management functions. Simplified organization charts for the DOE Paducah Site Office and Bechtel Jacobs are shown in Figure 4.

USEC facilities consist of process buildings, electrical switchyards, a steam plant, a water treatment facility, a chemical cleaning and decontamination facility, and maintenance and laboratory facilities. Over its operating lifetime, PGDP has processed more than 1,000,000 tons of uranium. The process of enriching uranium at PGDP involves conversion of UF_6 to compressed gas, which is in turn fed through a series of diffusion stages; PGDP has over 1,800 diffusion stages. The diffusion process generates enriched uranium product and tailings. The product is then shipped to the Portsmouth Gaseous Diffusion Plant in Ohio for further enriching. The tailings, containing less than 0.5 percent uranium-235, remain on site in cylinders.

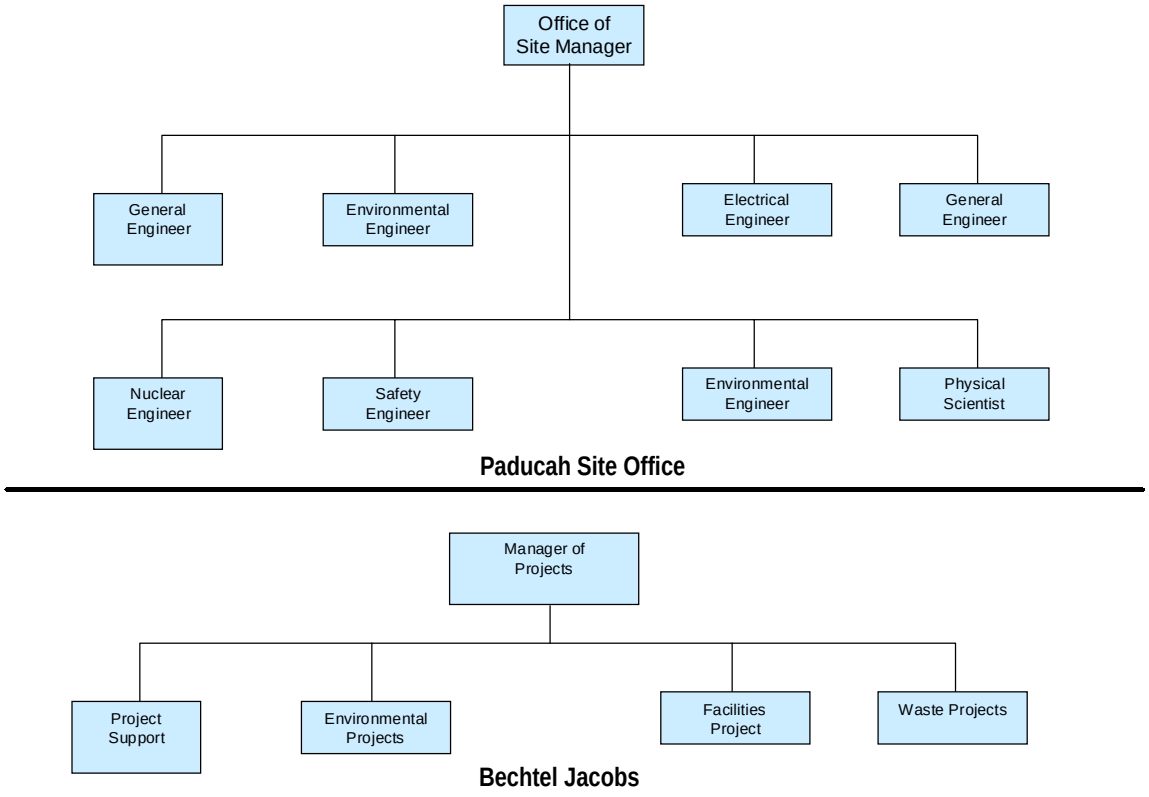


Figure 4. Simplified Organization Charts for the DOE Paducah Site Office and Bechtel Jacobs

During the Plant's operating history, the process of enriching uranium for military and commercial applications has — in addition to the product and the tailings — generated other radioactive and non-radioactive wastes, and has introduced other materials to the Plant not associated with naturally occurring uranium. These waste materials include transuranic elements (isotopes with atomic numbers greater than uranium) such as neptunium-237 and plutonium-239, fission products such as technetium-99, PCBs, and volatile organic compounds such as trichloroethene (TCE). These waste materials present differing levels of risk to workers and to the public depending upon their concentration, pathway of release, and method of exposure. Figure 5 shows the historic process of uranium enrichment and its byproducts. Characteristics of selected hazardous materials (i.e., radioactive and non-radioactive) at the Plant are described on the page following Figure 5.

1.3 Past Worker Safety, Public Safety, And Environmental Protection Assessments

Since the mid-1980s, there have been a number of assessments and regulatory actions related to PDGP operations. These events resulted in the identification of issues in worker safety, public safety, and environmental protection and established a series of actions required of DOE and contractor management to ensure resolution of the issues. Corrective actions were developed to address some of the issues and concerns identified in the studies discussed below. The investigation team did not individually evaluate the effectiveness of each corrective action.

The Report of the Joint Task Force on Uranium Recycle Materials Reprocessing. In April 1985, a DOE task force evaluated the adequacy of practices to support handling of radioactive contaminants in uranium recycle materials at the Oak Ridge Y-12 Plant, the Fernald Materials Production Center, and at the RMI Company (in Ashtabula, Ohio), and examined past operations at the PGDP and the Portsmouth Oxide Conversion Facility. The task force concluded that an in-depth examination of handling and processing practices at PGDP was warranted, that quantities of recycle materials with undetermined levels of contaminants were present at PGDP, and that PGDP was periodically receiving commercially-produced UF_6 containing trace levels of transuranic elements. This study recommended that PGDP line management assess worker exposures to transuranic elements and fission products from processing of recycled materials and recommend a feasible method for disposing of uranium recycle material.

Identification of Groundwater Contamination and Development of Administrative Consent Order. In 1988, concerns over residential water quality led to sampling of residential wells north of the Plant and discovery of TCE, an industrial degreaser, and technetium-99, a product of fissioning nuclear fuel. This discovery prompted the government to provide municipal water free of charge to all residences and businesses in an area bounded by the Ohio River to the north, by the DOE property to the south, by Metropolis Lake Road to the east, and by Bethel Church Road to the west. Under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), DOE and the EPA developed an Administrative Consent Order, effective November 23, 1988, that established a schedule to investigate and remediate offsite groundwater contamination. Phase I, conducted in 1989 and 1990, identified contaminants of concern and solid waste management units (SWMUs) that could have contributed to offsite contamination, outlined the physical characteristics of the SWMUs, and described the risk of offsite contamination. Phase II, conducted in 1990 and 1991, further assessed the risk of offsite contamination, characterized SWMUs that could have contributed to offsite contamination, and identified migration pathways for contaminants. A summary of key SWMUs, as characterized in Phase II, is provided in Appendix B.

Office of Environment, Safety and Health Assessments. In the late 1980s and early 1990s, the DOE Office of Environment, Safety and Health conducted a number of assessments of ES&H activities and programs at PGDP. These assessments examined such areas as radiation protection, health physics, industrial hygiene, and industrial safety. Among the weaknesses identified were inadequacies in construction area hazard posting and control, failure to consistently use personal protective equipment, limitations in the systems and equipment used to measure potential exposures to transuranic elements, and the absence of monitoring of stack effluents and waterborne pathways for the presence of transuranic activity. (e.g., neptunium). Improvements were noted in such areas as the process for conducting frisking for contamination and the hazard communication labeling program.

Drum Spill. In March 1990, an accident during routine waste handling operations in Building C-746-Q Warehouse resulted in the breaching of one drum waste controlled under the Resource Conservation and Recovery Act (RCRA). High levels of alpha contamination were present at the spill site, and review of storage records prompted radiological control personnel to conduct transferable contamination surveys for isotopic analyses. Transuranic contaminants in the spilled material included americium-241, plutonium-239, plutonium-240, and neptunium-237. These results led

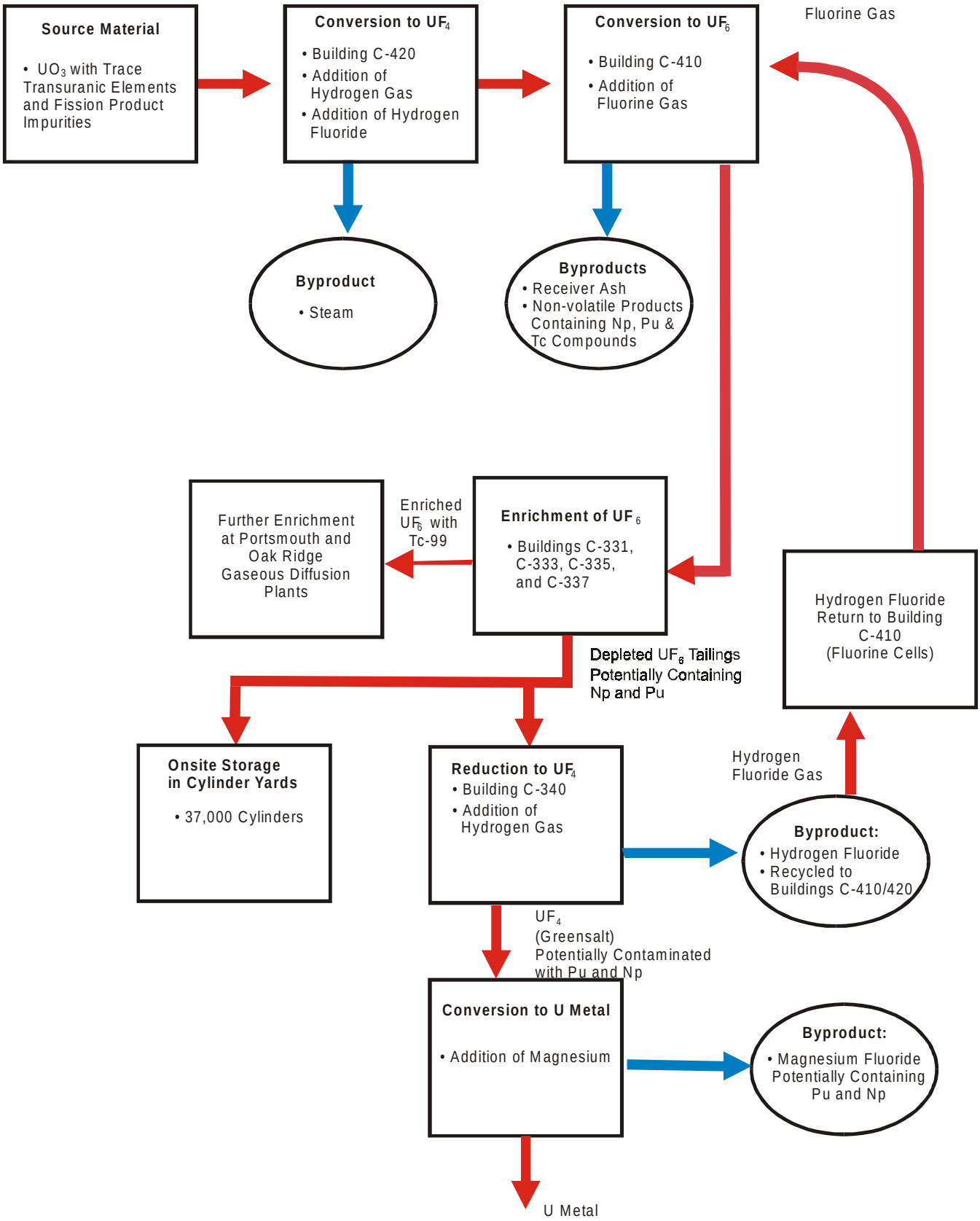


Figure 5. Schematic of Historic Uranium Enrichment Process

CHARACTERISTICS OF SELECTED HAZARDOUS MATERIALS AT PGDP

Radioactive Materials

- ***Uranium*** *– An element that naturally occurs in the earth and is mined for commercial purposes. Natural uranium is 99.3 percent U-238 and 0.7 percent U-235; U-235 is used as nuclear reactor fuel. Enriched uranium contains more U-235 and depleted uranium contains less U-235 than natural uranium. U-238 has a radioactive half-life of 4,470,000,000 years (the period of time for material to decay to half of its initial radioactive amount). Once in the body, uranium may concentrate in the kidneys and bones or lungs, depending on its solubility. As a heavy metal, uranium is toxic and can damage the kidney. At enrichments less than 10 percent (PGDP's maximum enrichment is less than 5 percent), uranium's chemical toxicity to the kidney predominates over its radiological hazards.*

- ***Transuranic Elements*** *– A series of elements whose atomic numbers are greater than 92 (i.e., greater than uranium) and can be produced when U-238 absorbs neutrons as part of a nuclear reaction. Among the transuranic elements are neptunium and plutonium. Transuranics were introduced to the Plant when spent reactor fuel was processed.*

  - ***Neptunium-237*** *– Np-237 has a radioactive half-life of 2,140,000 years. Once in the body, Np-237 concentrates in the bones and liver.*

  - ***Plutonium-239 –*** *Pu-239 has a radioactive half-life of 24,065 years. Once in the body, Pu-239 concentrates in the bones.*

- ***Fission Products*** *– A series of elements that are created when U-235 is split by neutrons as part of a nuclear reaction. The products of this splitting are typically elements with atomic mass numbers in the range of 80 to 108 and 125 to 153. Among the fission product elements are technetium and strontium. Fission products were introduced to the Plant when recycled uranium from spent reactor fuel was received from other DOE sites.*

  - ***Technetium-99*** *– Tc-99 has a radioactive half-life of 213,000 years. Tc-99 is highly mobile in groundwater and is readily absorbed throughout the body, contributing relatively little radioactive dose compared to transuranic elements. If deposited in the lung, Tc-99 would only remain in the lung for a period of weeks.*

  - ***Strontium-90*** *– Sr-90 has a radioactive half-life of 29 years. Similar to Pu-239, Sr-90 concentrates in the bones. However, if inhaled, Sr-90 would only remain in the lung for a period of days.*

Hazardous Materials

- ***Trichloroethene*** *– TCE is a colorless liquid with a chloroform-like odor that is often used as an industrial degreaser. TCE is a mild irritant to the respiratory tract and the skin. Critical exposure pathways are inhalation, ingestion, and skin or eye contact. When humans are exposed, TCE concentrates in the respiratory system, heart, liver, kidneys, central nervous system, and skin.*

- ***Chlorodiphenyl or Polychlorinated Biphenyl*** *– PCB is colorless to lightly-colored, viscous liquid with a mild odor that is generally used as a cooling medium in transformers and at PGDP in ventilation system gaskets as a fire retardant. The critical pathways of exposure are inhalation, ingestion, and absorption. When humans are exposed, PCBs concentrate in the skin, eyes, and liver.*

to surveys of other Plant areas. Several transuranic areas were posted as hazards, and controls commensurate with the potential hazard were established.

DOE Tiger Team Assessment. A concern regarding ES&H conditions at all DOE sites led a Tiger Team assessment of PGDP in June-July 1990. The assessment concluded that ceasing PGDP operations was not warranted, that compliance issues were known by Federal and State agencies issuing permits, and that the following ES&H and management issues required prompt attention:

- Environmental monitoring and evaluation programs were not being effectively implemented due to a lack of technical direction, formal procedures, and a coordinated quality assurance program.
- Formal procedures for implementing environmental protection activities were lacking, and quality assurance programs had not been implemented for many environmental activities.
- Compliance with DOE orders and mandatory standards for worker safety and health was deficient, as was the system for managing administrative control documents.
- Training and certification programs did not meet site needs.
- Instrument calibration practices did not always meet minimum standards.
- There was no long-range plan for safe storage of UF_6 cylinders.
- No integrated sitewide management system was available to track and correct identified deficiencies.
- DOE was not performing effective oversight to ensure that ES&H initiatives were being implemented.
- The site contractor did not have a corporate strategic plan to accomplish DOE's ES&H objectives.

DOE Office of Nuclear Safety Radiological Oversight. In 1994, DOE's Office of Nuclear Safety evaluated the PGDP radiological protection program. The evaluation identified two strengths and five programmatic issues. The strengths included a highly competent and experienced contractor management team that was aware of the elements of effective radiological control. The programmatic issues included (1) the need to establish standards for the sitewide radiological control program, (2) the need for substantive improvement in management systems that affect contamination control, (3) the need to improve radiological control technical bases, and (4) the need to improve the radiological control training program.

Defense Nuclear Facilities Safety Board (DNFSB) Recommendation 95-1. In May 1995, the DNFSB issued recommendation 95-1 in response to a concern over the deteriorating conditions of cylinders housing solid UF_6 across the DOE complex. At PGDP, there are more than 37,000 cylinders The DNFSB concluded that poor maintenance and storage conditions, combined with mechanical damage suffered during handling, led to corrosion and subsequent breaching of several cylinders. It was the DNFSB's view that prompt remedial actions should include: (1) a program to renew the protective coating of cylinders; (2) an evaluation of additional measures to protect these cylinders from the damaging effects of exposure to the elements; and (3) a study to determine whether a more suitable chemical form should be selected for long-term storage of the depleted uranium.

DOE Office of Occupational Medicine and Medical Surveillance "Needs Assessment." In 1996, the Paducah Site Office asked the Office of Occupational Medicine and Medical Surveillance, within the Office of Environment, Safety and Health, to determine whether the available occupational medicine services were sufficient to meet the needs of the DOE Office of Emergency Management and USEC contractor and subcontractor personnel at PGDP. The assessment concluded that the occupational medicine program provides good medical services to workers, although services were more oriented to family practice than to occupational health. Advanced life support services were judged to be sophisticated and of high quality. Occupational health services were found to lack formal linkage between the health and safety organization and the onsite medical department of DOE and USEC. The lack of information sharing among health professionals was also cited as a weakness.

Department of Health and Human Services (DHHS) Public Health Assessment. DHHS completed a draft public health assessment of PGDP in the fall of 1999, which is required for all sites on the EPA's National Priorities List; the Plant was designated as such in May 1994. A draft of the assessment concluded that, under normal operating conditions, PGDP does not currently pose a health hazard to offsite populations, although members of the public near PGDP may be exposed to low levels of contamination. This conclusion assumes that access restrictions and fish advisories remain in effect. DHHS also concluded that a future groundwater pathway could exist if new wells are drilled into plumes northeast and northwest of PGDP by future landowners. Contaminated surface water, soil

and sediment, and biota surrounding the Plant were judged to pose no health hazard due to the low levels of exposure. Offsite transportation of cylinders containing depleted uranium was examined as a potential public health hazard. DHHS concluded that a transportation accident involving a fire and rupture of a cylinder would pose an urgent public health hazard to individuals within 70 meters of the ruptured cylinder, although the probability of this event is very low.

1.4 Recently Identified Concerns

There have been recently identified concerns associated with prior operations, past work practices, and the management of legacy materials (those remaining from past operations) at PGDP. These concerns, described in more detail in a series of disclosure statements made by three current and/or former Plant employees and one member of a private interest group, can be characterized as follows:

- Information provided to DOE, the Commonwealth of Kentucky, and the public regarding the nature of occupational risks and levels of offsite contamination was incomplete and/or not fully accurate.
- Safety-related roles and responsibilities were not clearly assigned, so key safety responsibilities are not being properly addressed.
- Contractor management discouraged personnel from raising safety issues, and/or concerns that were raised were not addressed in a timely manner.
- Information on site hazards was not communicated to workers in a timely manner and/or training programs were not sufficient or rigorous enough to convey these hazards to workers.
- Hazard controls (administrative and engineering controls, and use of personal protective equipment) for workers in radiation areas did not ensure adequate protection.
- Occupational radiation exposures were not accurately communicated to workers.
- Radioactive and hazardous materials were disposed of in unapproved onsite and offsite locations, were improperly shipped, and/or were not surveyed before leaving the site.

Quantities of uranium materials are clearly evident at product handling points in Building 340.

1.5 Investigative Approach

To support the overall objective of determining whether current work practices are sufficient to protect workers, the public, and the environment, the Office of Oversight investigation team interviewed personnel; observed work activities; performed walkdowns of facilities, work areas, and the site grounds; sampled and analyzed groundwater, surface water, sediment, and soil; conducted radiological surveys; and reviewed documents. Issues identified by the investigation team are summarized in Appendix A of this report.

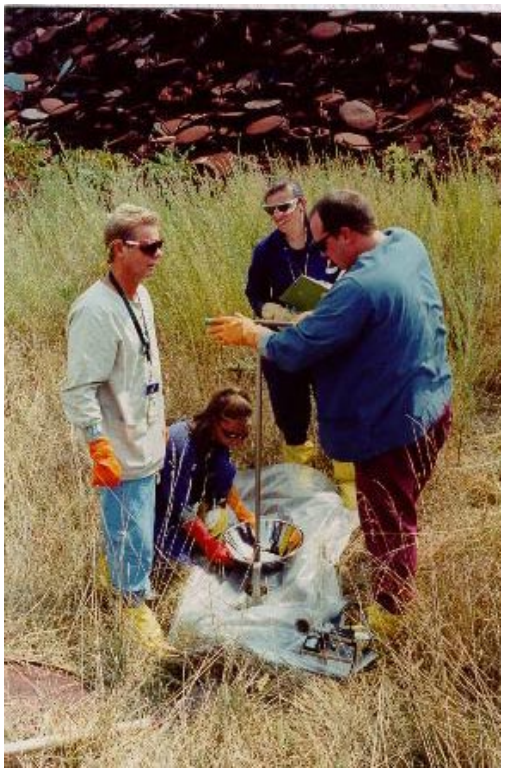
Over 100 interviews were conducted with DOE Headquarters, Oak Ridge Operations Office (OR), and Paducah Site Office personnel; Bechtel Jacobs and subcontractor managers, supervisors, and workers; selected USEC personnel; and stakeholders. USEC personnel were interviewed to clarify the nature of DOE activities conducted in USEC-controlled space and to better understand how USEC performs work for Bechtel Jacobs under a subcontracting arrangement. To ensure that an accurate record of interviews was maintained, 25 formal interviews with DOE and Bechtel Jacobs personnel were captured in transcripts.

The investigation team observed numerous facilities and work areas to familiarize themselves with Plant operations, work practices, and hazard controls. Essentially all DOE-controlled Plant facilities, waste and material storage areas, and site grounds were visited by the investigation team. Many facilities and storage areas were

examined multiple times. A variety of job planning, maintenance, and operational activities were also observed to understand how work activities are planned and executed.

The investigation team collected over 30 samples from groundwater wells, surface water sources, sediments, and soil, as well as from materials, equipment, and facilities (see Section 2.1 for more information). Samples were collected both inside and outside the perimeter security fence. These samples were evaluated for the presence of radioactive and non-radioactive contaminants. Most samples were "split" or separated into two samples for purposes of running a parallel test, and samples were maintained under a strict chain of custody.

To supplement the interview, observation, and sampling processes, hundreds of documents — including plans, procedures, and assessments — were reviewed by the investigation team. These reviews provided crucial perspectives on the assignment of roles and responsibilities, conduct of work activities, and the record of assessment findings. This extensive process for gathering information enabled the team to proceed in a structured fashion to: (1) understand conditions as they existed in 1990; (2) fully comprehend the issues being raised regarding past operations, past work practices, and management of legacy materials; (3) evaluate the effectiveness of actions taken by the Plant in the last decade to address ES&H issues; and (4) assess current conditions at the site and their impact on worker safety, public safety, and the protection of the environment. These evaluations are documented in the remainder of this report.



The sampling team collected soil samples at the base of Drum Mountain. Grass areas were surveyed at 8 million disintegrations per minute with visible uranium materials present.

2.0 Assessment of Current Conditions

In keeping with the investigation team's mission of evaluating current conditions at the Plant and their impact on ES&H, the results of these evaluations are organized in three main sections — Public and Environmental Protection (Section 2.1), Radiation Protection and Worker Safety (Section 2.2), and Line Oversight (Section 2.3). The Public and Environmental Protection section examines existing pathways for hazardous materials to be transported to the environment, the types of effluents that are being transported, legacy sources of contamination, the extent of contamination in groundwater and in surface waters, the site's efforts undertaken by the site to control contamination, key results from the sampling and analysis conducted by the investigation team, and the effectiveness of efforts to provide information to the public and other stakeholders. The Radiation Protection and Worker Safety section outlines the nature and extent of risks that workers face at the site from both radiological and non-radiological hazards, the use of engineering and administrative controls to mitigate these hazards, and the effectiveness of systems for planning and managing work at the site. The Line Oversight section examines the effectiveness of DOE and contractor management functions that are necessary to ensure protection of workers, the public, and the environment.

2.1 Public and Environmental Protection

Since the 1950s, past industrial operations at PGDP produced large quantities of legacy materials that have been disposed of in landfills or burial grounds, released into the environment, or placed in long-term storage. Current DOE operations at PGDP focus primarily on the administration of programs to address legacy materials and on infrastructure maintenance.

DOE has the responsibility to characterize and control emissions of contaminants into the environment from DOE operations or past practices. To characterize chemical and radionuclide effluents into the environment from DOE operations at PGDP, the site has established an environmental monitoring program as required by DOE Order 5400.1, *General Environmental Protection Program*. Compliance with the terms of the Commonwealth of Kentucky permit for discharges of liquid effluents is also monitored on a routine basis. In addition to routine environmental monitoring, DOE, with oversight by the EPA and the Commonwealth of Kentucky, is conducting extensive investigations into the nature and magnitude of contamination in the environment as provided for in agreements and permits.

Current Pathways for Contaminant Transport in the Environment from DOE Operations Include:

- *Discharges of process and stormwater runoff from the site into local surface water bodies*
- *Sediment transport through erosion and surface water runoff*
- *Air emissions from diffuse sources, such as wind-blown dispersion of surface contamination and suspension of contaminated dusts by vehicle traffic*
- *Rainwater infiltration, leaching, and transport of contamination into the groundwater from former spills, burial grounds, and landfills*

Investigations conducted in 1990 and 1991 reported that the offsite contaminated groundwater plumes are some of the largest in the DOE complex.

Investigations conducted in 1990 and 1991 reported that the offsite contaminated groundwater plumes are some of the largest in the DOE complex. Additionally, numerous areas of radiological and chemical contamination have been discovered within the site security fence, outside the security fence on surrounding DOE property, and in offsite areas now managed by the State of Kentucky Fish and Wildlife Service.

Sources of contamination include waste burial grounds, old sanitary landfills, scrap yards, waste lagoons, spill sites, and leaks from contaminated buildings. These areas will be examined in more detail in Phase II of this investigation.

Interim steps have been taken since 1990 to protect the environment and public health. Groundwater pumping and treating efforts have helped to impede some of the highest areas of contamination. In a defined area referred to as the water policy area, alternative sources of water have been provided to residents with contaminated wells. These steps have reduced public risk, but contamination sources still exist, and the groundwater plumes have continued to spread from the site at approximately one foot per day.

Cleanup plans and strategies have been developed in accordance with Federal environmental regulations. The site is currently in compliance with the provisions of the Federal Facility Agreement. DOE developed a Site Management Plan that includes program management requirements and a Site Remediation Strategy to coordinate RCRA and CERCLA cleanup requirements. The Site Remediation Strategy defines remediation priorities and provides a framework for establishing site-specific goals that are consistent with the overall cleanup goals and priorities outlined in the OR document, "U.S. DOE Accelerating Cleanup: Paths to Closure," revised May 1999.

Activities to Control Migration of and Exposure to Contaminants at PGDP

- *Supplying public water to residents and businesses with the potential for contaminated drinking water wells*
- *Installing limited groundwater pump and treatment systems on the Northwest and Northeast Plumes*
- *Placing sediment fences around the scrap yard*
- *Diverting the discharge from the North-South Diversion Ditch through the wastewater treatment plant*
- *Installing clay caps on some old landfills*
- *Excavating "hot spot" PCB contamination*
- *Retrieving contaminated material from the Ballard Wildlife Area*

DOE has taken a number of steps to improve the efficiency of site cleanup operations.

DOE has taken a number of steps to improve the efficiency of site cleanup operations. A management and integration contract was established to increase accountability for meeting cleanup milestones. DOE waste areas were organized into a smaller number of operable units to accelerate regulatory review and approval of cleanup methods and strategies. Actions have been taken to control waste management activities at the point of generation and in the facilities regulated by external environmental requirements. These actions include developing and implementing procedures for managing and disposing of waste generated by DOE operations at the site. In part, these procedures were developed to address findings from the 1990 DOE Tiger Team assessment involving waste management, waste characterization, and the scrap yard and landfill operations.

In addition, the site constructed two new waste management facilities, built a new landfill, and adequately maintains existing waste management facilities for regulated waste streams including hazardous waste, asbestos and PCB wastes, and sanitary waste. The site's waste acceptance criteria document, revised in May 1999, provides guidance and requirements for meeting the acceptance criteria for these facilities for most waste streams generated by DOE operations at the site.

Radiological and chemical contamination from past industrial activities at PGDP has been released into the surrounding ground, soil, and air.

Radiological and chemical contamination from past industrial activities at PGDP has been released into the ground, soil, and air around the Plant. Effluents from current DOE operations appear to be in compliance with State discharge limits. Radiological and chemical contamination has spread from the site boundary into the groundwater and surface sediments, particularly into the Big and Little Bayou Creeks, and is documented in investigation reports published by DOE. Contamination continues to propagate in these media, prompting DOE and regulatory organizations to take precautionary steps to protect public health, such as connecting local residents to public water supplies and limiting public use of lakes and sections of local streams and ditches. Contamination continues to migrate from source areas into the environment. However, based on the limited duration of public exposure to contamination and the

mitigation measures taken to prevent the consumption of contaminated water and foodstuffs, DOE operations at PGDP do not now present a significant public health risk.

Limited progress has been made in remediating hazardous material source areas.

Despite the limited public health risk, significant improvements in protecting the public and the environment are needed. Limited progress has been made in remediating hazardous material source areas such as landfills, burial grounds, and waste and scrap piles. Limited funding has played a significant role. Additionally, weaknesses in characterization of groundwater and surface contamination were identified. Controls to prevent the spread of contamination have not yet been fully implemented. While limited in magnitude, some radiological exposure pathways to the public have not been fully assessed or evaluated. These include airborne fugitive emissions from contaminated areas and the direct radiation from cylinder yards. Although improvements were noted in most waste management practices, the investigation team noted a number of concerns, primarily relating to inappropriate storage of legacy waste materials. Additionally, program management weaknesses were identified within the Paducah Site Office and Bechtel Jacobs regarding their ability to integrate and interpret environmental information. Technical personnel are not assigned or available in sufficient numbers to interpret the vast amounts of data associated with specific environmental disciplines, such as groundwater and environmental radiation protection. Finally, public communication has not been effective in providing information regarding environmental contamination and cleanup initiatives, contributing to the perception among some stakeholders that DOE and the contractor are withholding information.

Issues

1. **There has been limited progress in remediating and characterizing environmental contamination, low-level wastes, and stored hazardous materials that were produced by past industrial activities, and major cleanup milestones under the Federal Facility Agreement are jeopardized by funding constraints.** A key element contributing to the lack of progress is limited available funding. DOE has not provided sufficient funds to significantly reduce sources of contamination, such as buried wastes, soil contaminated by previous spills and releases, exposed contaminated scrap metal and waste materials, and degrading contaminated buildings. The scope of PGDP work funded by DOE has been limited primarily to characterizing contamination, operating and maintaining the site infrastructure, meeting regulatory requirements, and controlling the spread of contamination. While the site is currently in compliance with the 1998 Federal Facility Agreement, near-term milestones are in jeopardy. Progress has been limited in the following areas.

Contamination continues to propagate at one foot per day and now extends for over two miles.

- Most of the sources of contamination identified in 1991 still remain. Contaminated materials from burial grounds, old landfills, inactive waste lagoons, or spill sites have not been removed or treated. Groundwater plumes containing TCE and technetium-99 that have resulted from some of these sources continue to propagate at one foot per day and now extend for over two miles.

One ash receiver in Building 410 remains in place after 22 years, held in place by corroded C-Clamps. Uranium materials were clearly migrating from the receiver.

Shutdown buildings have been allowed to deteriorate and are subject to animal infestation, broken windows, and leaking roofs.

- Contaminated process buildings, which were shut down over 20 years ago and for which no future use is expected, have not been adequately maintained or taken down. Residual materials have not been fully analyzed or removed, and surveys indicate that contamination is spreading within the buildings. Large volumes of low-level radioactive wastes remain stored within the buildings. These shutdown buildings have been allowed to deteriorate and are subject to animal infestation, broken windows, and leaking roofs. They are not included in the 2010 cleanup schedule, and they are increasing in risk and cost to decommission.

- A large volume of contaminated waste materials (Drum Mountain) and scrap metal that has accumulated since the 1950s is stored outside in piles and inside the Plant security fence. These areas continue to contribute contamination to the environment through surface water runoff and dispersion. The Federal Facility Agreement requires removal of this material from Drum Mountain and beneath it by 2003. The site estimated and requested funding, but current budget proposals provide only $1.3M (versus $3.6M required) for fiscal year 2000 and $3.2M (versus $13.7M required) for fiscal year 2001 (see Figure 6).

Disposal of low-level waste has received low funding priority because there are no regulatory requirements or identified safety concerns requiring near-term disposition.

- A total of 6,444 cubic meters (equivalent to approximately 31,000, 55-gallon drums) of low-level waste are stored onsite at PGDP. This includes 1,775 m^3 stored outside in over 8,000 containers that were not designed for long-term storage. Many of the containers stored outside are severely degraded, and some have leaked as a result. Much of the site's low-level waste is not fully characterized for shipment, and some may contain transuranic materials. Disposal of this waste has received low funding priority because there are no regulatory requirements or identified safety concerns requiring near-term disposition. As a result, only 157 m^3 have been shipped from the site since 1990. The schedule for completing disposal has subsequently changed from fiscal year 2006 to fiscal year 2012. Additionally, current funding targets assume that no new waste management facilities will be needed to accomplish the site mission. This assumption does not take into account necessary efforts to open, inspect, and characterize the thousands of low-level and mixed waste drums currently stored onsite. Elsewhere in the DOE complex (Rocky Flats Environmental Technology Site and Nevada Test Site), engineered facilities are used to conduct these characterization and segregation efforts. Such facilities would significantly reduce the risk to the workers who open the containers for inspection and characterization.

Outdoor drum storage

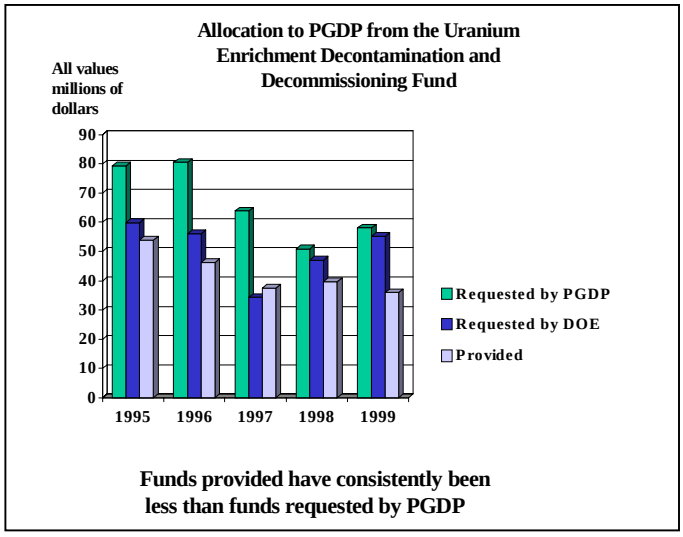


Figure 6. PGDP Funding History (Budget information provided by Bechtel Jacobs)

DMSAs contain large amounts of uncharacterized material.

- DOE Material Storage Areas (DMSAs) belonging to DOE but located in facilities that have been leased to USEC, contain large amounts of uncharacterized material that includes drums labeled as asbestos waste, drums labeled as containing detectable levels of PCBs, and old electrical equipment. A multiyear project to characterize this material has identified waste regulated under RCRA. DOE is not managing DMSAs pursuant to either RCRA or CERCLA regulatory requirements.

- The nearly 37,000 UF_6 cylinders stored on site in the open at PGDP constitute a radiological exposure hazard and a potential threat to worker and public health in the event of fire and rupture. In 1995, the DNFSB recommended upgrading the condition of the cylinders and converting the UF_6 to a more stable form. Plans to paint 1,400 cylinders (to seal them) were cancelled due to funding constraints, and funds for a UF_6 conversion facility have not yet been appropriated.

Approximately 37,000 cylinders of UF_6, each containing up to 14 tons, remain stored on site pending conversion to more stable forms.

- The published accelerated cleanup schedule for remediation of environmental hazards at PGDP is not realistic. PGDP received a total of $36M for fiscal year 1999. Site estimates indicate that PGDP will require significant increases in funding, up to $160M in fiscal year 2008, to meet the completion goal of fiscal year 2012. The scheduled completion date is based on an assumed increase in funding for PGDP. Nevertheless, appropriations have decreased significantly since 1995, despite requests for increases, and have been significantly below the targets necessary to accomplish the accelerated cleanup. The funding necessary to accomplish the 2012 goal will not be available without a significant change in appropriations. As indicated in Figure 7, current funding levels will extend site cleanup until 2020, well beyond the required 2012 milestone.

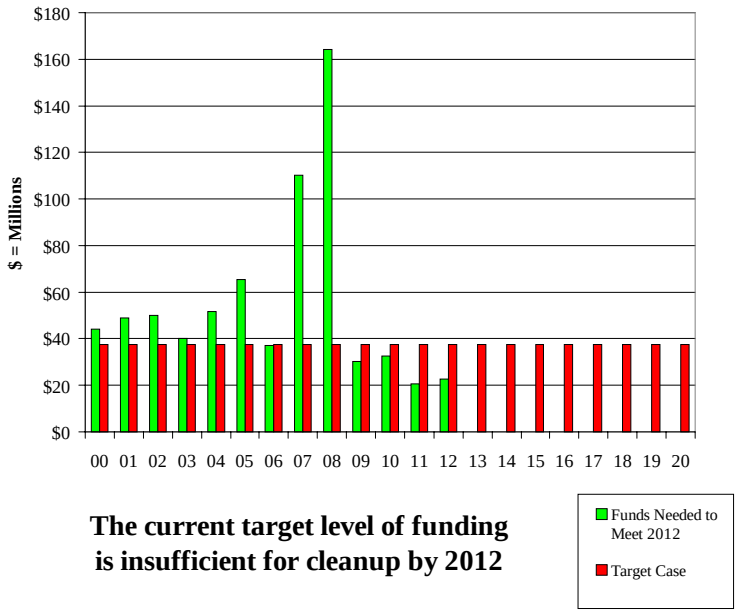


Figure 7. PGDP Funding Requirements vs. Target, Fiscal Years 2000-2020

The Site Remediation Strategy does not reflect the increasing risk and cleanup costs associated with decontamination and decommissioning of shutdown process buildings.

- The Site Remediation Strategy does not reflect the increasing risk and cleanup costs associated with decontamination and decommissioning of shutdown process buildings. The schedule also assumes the success of cost-saving initiatives, such as reduction of overhead expenses by use of an management and integrating contractor, use of a revised documentation strategy to limit the number of remedial investigations and feasibility studies, significant cost savings by recycling scrap left on site, and reduction of long-term site maintenance costs by replacing the current pump-and-treat approach to groundwater remediation with a passive alternative. Achieving the necessary cost savings through these initiatives has not been demonstrated.

DOE has not been successful in conveying needs and obtaining congressional funding for cleanup of PGDP.

- DOE has not been successful in conveying needs and obtaining congressional funding for cleanup of PGDP. PGDP has consistently been allocated less funding than requested for waste management and environmental remediation. These reductions occurred during a period when environmental risks and regulatory commitments for cleanup were increasing. Cleanup activities at PGDP have been funded almost entirely from the Uranium Decontamination and Decommissioning Fund. A 1998 report to Congress by DOE on the use of this fund did not identify the need for additional funds to keep the contamination at PGDP from spreading to the surrounding environment. This OR-prepared report emphasized accomplishments, but did not discuss the challenges faced at the site to reduce and prevent spread of contamination to the environment within a declining budget.

2. **There are continuing weaknesses in the radiation protection management of known environmental contamination areas by both Bechtel Jacobs and DOE.** These include deficiencies in radiological characterization, posting, contamination control, and application of principles to reduce environmental hazards as low as reasonably achievable (ALARA). Such weaknesses are contrary to sound health physics practices and the radiological expectations delineated by DOE in orders, regulations, and standards.

The full extent of radiological contamination both inside and outside the site security fence has still not been characterized through a sitewide survey and sampling program.

This area was recently discovered near the S&T Landfill. Black "ooze" was discovered to be radiologically contaminated. This area has been covered and posted, pending further investigation.

- The areas of most significant radiological contamination have been identified during past investigations; however, the full extent of radiological contamination both inside and outside the site security fence has still not been characterized through a sitewide survey and sampling program. For example, an area of contamination adjacent to the S Landfill was recently identified. At this location, a tar-like substance reading 43,000 disintegrations per minute was discovered and subsequently covered and posted to control access. There is no documented listing or database of radiologically contaminated areas other than what is included in the SWMU list, which is not maintained by the radiological control organization and does not clearly designate contaminants of concern for each SMWU.

Areas of contamination that exceed Bechtel Jacobs radiological posting criteria were noted.

- The investigation team noted areas of contamination that exceed Bechtel Jacobs radiological posting criteria in Kentucky Permit Discharge Elimination System Outfall 011, the North-South Diversion Ditch, and along Little Bayou Creek at some distance from the site security boundary. Under the Bechtel Jacobs health physics procedures, these areas would require posting as soil contamination areas and/or contamination areas, and appropriate measures would be needed to prevent inadvertent entry. Some of these areas are currently posted with signage and wording that are the result of CERCLA Records of Decision or interim corrective measures, but these postings are not consistent and, in some cases, do not specify the presence of a radiological hazard. Neither DOE nor Bechtel Jacobs could provide a basis for not controlling such areas in accordance with the Bechtel Jacobs radiation protection program. The relationship among the radiation protection program, DOE orders, 10 CFR 835 (Occupational Radiation Protection), and CERCLA requirements has not been adequately defined. It appears that DOE and Bechtel Jacobs believed that the provisions of 10 CFR 835 were not applicable, because these areas are outside the security fence. However, the scope of 10 CFR 835 includes protecting individuals from ionizing radiation resulting from DOE activities. Since the contamination of these areas is the direct result of DOE activities, 10 CFR 835 would apply.

- Radiological contamination has migrated from known sources at PGDP. These environmental problems may impact areas previously free from radiological contamination. Resuspension of wind-blown, radiologically contaminated soils or the impact of radiologically contaminated surface water runoff represent potential problems, further complicated by the potential tracking of contamination by personnel and vehicle traffic. Only limited and incomplete mitigation measures for these potential sources have been implemented on site, such as at Drum Mountain, the scrap yards, or the three decontamination and decommissioning buildings. Sediment fencing has been installed but does not eliminate sediment runoff.

Drum Mountain contains residual uranium materials that are contributing to contamination of the environment.

Environmental ALARA considerations have not been integrated into all processes.

- Environmental ALARA considerations have not been integrated into all processes, and appropriate controls have not always been incorporated into design, construction, and remediation activities. An effort was made to develop an environmental ALARA program in 1995 in anticipation of 10 CFR 834, Radiation Protection of the Public and the Environment, but the process is not fully documented or implemented. Environmental ALARA considerations have not been formally integrated into environmental programs as required by DOE Order 5400.5, *Radiation Protection of the Public and the Environment.* The manner in which liquid and airborne radiological discharges are subjected to the ALARA process is not defined.

- The current waste acceptance criteria for the sanitary landfill do not specifically prohibit disposal of objects that could be classified as low-level radioactive waste based on exceeding DOE Order 5400.5 surface contamination limits. The current landfill waste acceptance criteria fail to specify any limits for surface contamination and rely solely on a uranium limit of 30 pCi per gram as the only radiological criterion to determine the suitability of waste for disposal. The technical basis document that established waste acceptance criteria for the landfill does

not address surface contaminated objects, such as roofing material, concrete, rubble, and debris that are disposed of in the landfill. It is unclear whether, or how, such materials are to be sampled volumetrically, or whether waste disposal practices would allow for disposal of materials that exceed DOE Order 5400.5 radiological limits in the sanitary landfill. This technical basis, although approved by the Field Office Manager, contained items that exceeded the Field Office approval criteria. Therefore, pursuant to DOE Order 5400.5, this technical basis document should have been approved by the Office of Environment, Safety and Health.

3. **Radiological exposure pathways for DOE operations have not been fully assessed or documented.** While projected doses are expected to remain low, weaknesses are evident in the assessment and reporting of all possible air emission sources and in the accuracy of public dose calculations.

The magnitude of "fugitive" emissions at PGDP DOE facilities is not known.

- The magnitude of "fugitive" emissions at PGDP DOE facilities is not known, and this pathway has not been fully evaluated or documented. Radionuclide calculations do not include any contribution to dose from fugitive emissions as required under the National Emission Standards for Hazardous Air Pollutants. Fugitive emissions from a number of diffuse sources — such as contaminated ground resuspension, scrap piles, rooftop dispersion, and vehicular traffic — are inevitable and could contribute significantly to the calculated public dose (estimated to be 1.14 mrem in 1997). In lieu of actual source term data, the concentration of uranium and transuranic contaminants in soils has never been used in estimating a release fraction or fugitive emission source term for input to the dose model. Instead, the site assumes that fugitive emissions are insignificant and reports negligible contributions to dose from this pathway; this assumption is not supported by any documented technical basis. The absence of measurable readings on the ambient air monitors used by USEC and the Commonwealth of Kentucky is not a valid basis for concluding that fugitive emissions from DOE activities are insignificant, since the sensitivity and location of the air monitors are not sufficient to make that determination.

Many locations in shutdown buildings contain degraded lagging probably containing asbestos.

Public dose estimates from ingestion of contaminated sediment are not consistent.

- Estimates of radiation doses to the public from ingestion of contaminated sediment are not consistent. Although no remediation of contamination has occurred, the reported dose changed from 2 mrem per year in 1992 to 0.07 mrem per year in 1995. The main difference is the use of sediment sampling results obtained during the current year for dose calculations. While actual radionuclide concentrations may be decreasing because contamination is spreading downstream, only one or two sediment samples are taken in each location annually. This variation raises questions about the use of such data as accurate, representative, and conservative. In lieu of a complete characterization or remediation of sediments, the highest reported historical values would be more appropriate for use in the public dose calculations. In addition, even though transuranics and thorium were found in some samples, dose calculations are only based on uranium and technetium data.

- The 1998 draft Annual Site Environmental Report provides data on studies of thermoluminescent dosimetry conducted in the vicinity of the UF_6 cylinder storage yards. Before 1998, direct exposure to penetrating radiation from cylinder storage was not considered in the public dose calculations. The 1998 data indicates that up to 1,000 mrem in a year could be accrued just outside the security fence; however, the 1998 draft Annual Site Environmental Report indicates no actual public dose from this pathway. DOE and Bechtel Jacobs justify this assessment by using the nearest resident as the "maximally exposed receptor point" when calculating radiation exposures. This is not the most conservative or realistic receptor point, given that there are members of the public who have access to areas in close enough proximity to potentially receive a dose (e.g., staged truck drivers awaiting offload, joggers, hunters, and hikers) greater than the nearest resident.

4. **Groundwater contamination has not been adequately characterized in some areas.** Extensive efforts have been undertaken to characterize the major sources and the extent of groundwater contamination as a result of the discovery in 1988 of contaminated residential drinking water wells near the site. DOE has generally defined the nature and extent of contamination in the Regional Gravel Aquifer and the McNairy Formation, has established a water policy to ensure that the public is adequately protected, and has taken interim pump-and-treat actions. While these characterization and control efforts were appropriate, some areas have not been fully characterized.

Sufficient data are lacking on the leading edges of both the Northeast and the Northwest Plumes.

- Sufficient data are lacking on the leading edges of both the Northeast and the Northwest Plumes. The density and positioning of monitoring wells are not adequate to assess the furthest movement or the discharge locations, such as streams, of the two northern plumes. The most recent plume map shows that movement has occurred under a portion of the Tennessee Valley Authority (TVA) property (see Figure 8). Groundwater samples taken by the site in the early 1990s indicated low concentrations of technetium-99 on TVA property. Those sampling efforts were discontinued in the early 1990s. The TVA Shawnee Steam Plant borders the Ohio River.

The pump-and-treat facility for the Northeast Plume was installed to slow the spread of TCE.

- The Southwestern Plume was recently discovered. The rate of movement and the direction have not yet been characterized, but the apparent movement is initially toward the southwest. After a short distance it bends toward the north. Because groundwater flow may be influenced by the abundant gravel in river deposits in this area, this plume will require additional characterization. Recent field studies have bounded the plume to the north and the south as it exists in the fenced area.

- Several sources are responsible for the groundwater contamination in the two major plumes. A major contributor to the Northwest Plume is a facility that used large volumes of TCE for degreasing equipment (Building C-400). High concentrations of TCE dissolved in groundwater near C-400 and characterization studies suggest that TCE exists in pure form in the subsurface. Building C-400 is also a major source of technetium-99 contributing to the

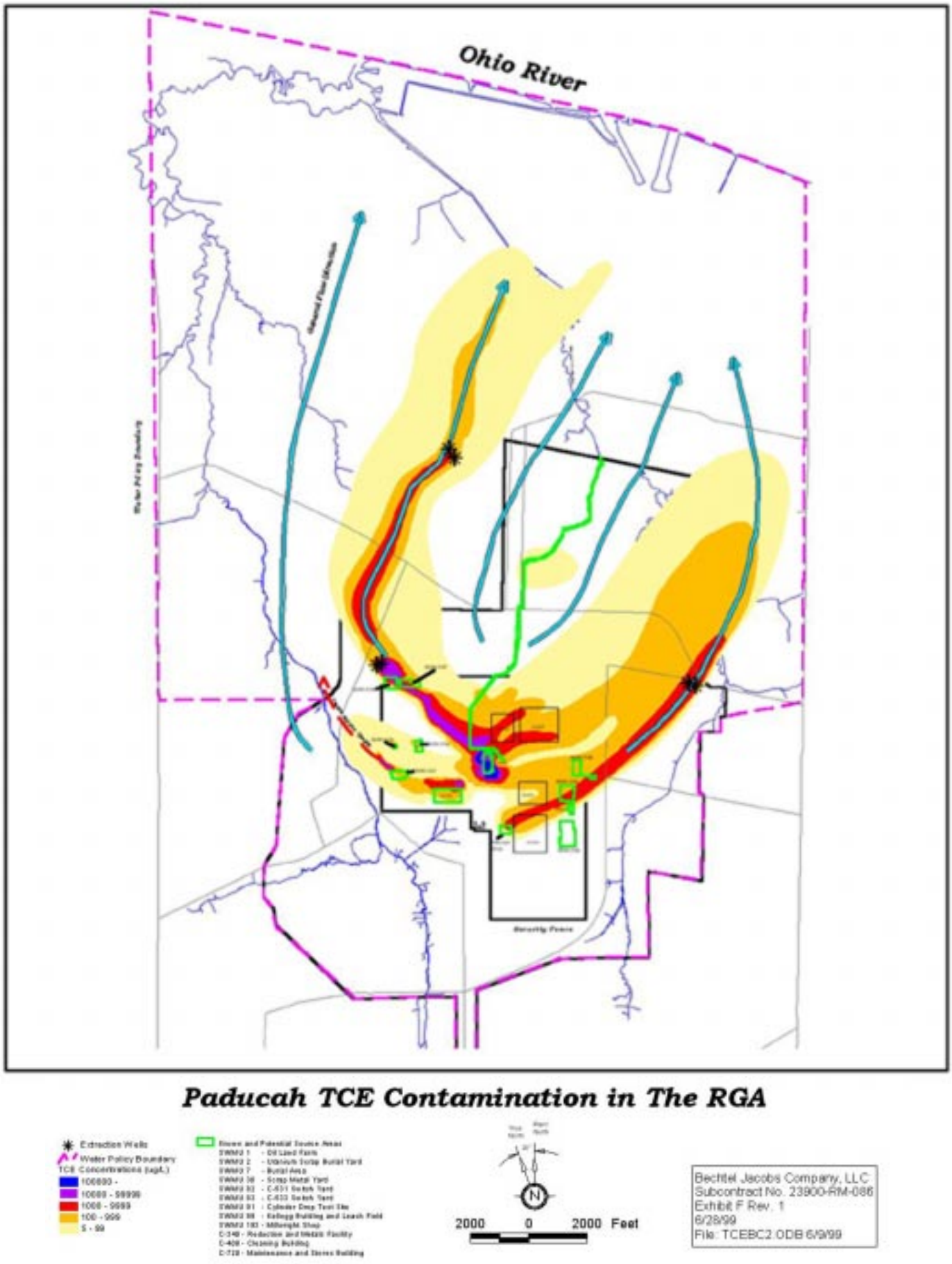


Figure 8. Northeast and Northwest Plumes

Northwest Plume. Building C-400, which contributes to both northern plumes, indicates the complexity of the source areas. Because of this complexity and interaction of plumes and source areas at PGDP, it is necessary to analyze these elements as one interactive system in the subsurface. However, since 1992, plumes and sources have been analyzed individually or in limited groups, resulting in redundant work and limiting the effectiveness of the sitewide analysis. The recently established Groundwater Operable Unit concept is designed to consider all sources and plumes in an integrated fashion.

Removal or treatment of the sources of groundwater contamination has not begun.

- Removal or treatment of the sources of groundwater contamination has not begun, although extensive characterization studies and treatability studies have been conducted. Innovative removal technologies have been reviewed for application, and the Lasagna treatment technology will be initiated on one major source in the near future. The site has also installed two groundwater pump-and-treat systems to contain and reduce concentrations in the Northeast and Northwest Plumes. During the Office of Oversight investigation, the Northeast Treatment System was not operational due to maintenance of the cooling towers. These systems were installed as interim measures to contain contamination existing in the most concentrated portions of the plumes. Limited pumping rates decrease the effectiveness of the plume removal systems, as confirmed by subcontractors' calculations. Small portions of the contaminated groundwater plumes with the highest concentrations are being treated by the systems.

5. **Unclear assignment of responsibilities and weaknesses in the integration and interpretation of environmental information have adversely impacted the understanding of environmental conditions.** DOE and Bechtel Jacobs staff at the site do not have the requisite comprehensive knowledge of the nature of existing contamination in the various environmental media (surface water, sediment, soils, groundwater, and air). In this area, sufficient technical personnel are not assigned or available to interpret the vast amounts of data associated with specific environmental disciplines. The site has not established clear staff responsibilities for environmental radiation protection functions. The site's outsourcing strategy will compound this weakness, at least in the near term, as additional environmental professionals are transitioned to subcontractor positions or find other employment. Specific weaknesses were identified in the following areas.

- Although the TCE and technetium-99 plume maps have been updated regularly, their interpretation has not been reported. Such a report would discuss data used in preparing the map, changes in the plumes from previous interpretations, and recommended actions. A comprehensive sitewide discussion of hydrogeology is available in an investigation released in November 1992. In 1995, two reports were issued regarding further characterization efforts on the Northeast and the Northwest Plumes. However, since 1992 there has been no integrated interpretation of groundwater data; such an interpretation would include water level and plume maps prepared for selected dates to support assessment projection of contaminant transport.

Existing landfills have been capped, monitoring wells have been put in place, and controls have been installed to limit erosion of sediments and spread of contamination.

- Accountability and protection issues have not been clearly defined. Neither DOE nor Bechtel Jacobs has defined clear responsibilities or designated specific individuals for managing environmental radiation protection issues including pathway analysis, public dose, environmental ALARA, postings, and contamination control. One

subcontracted individual has addressed some of these issues, but his current contract does not include radiological support. Such support is handled on a task-specific basis through contract extensions.

- While the scope of DOE and USEC responsibilities was adequately delineated in lease agreements, the magnitude of continuing DOE environmental responsibilities following the transition may have been underestimated by DOE and site contractors, adversely impacting effective environmental management. For example, in the area of radiological air emissions, the initial assumption was that process air emissions constitute the only emissions from the site. This assumption has led to inaccurate representations in the DOE environmental monitoring plan that there are no airborne radioactive emissions resulting from DOE legacy operations.

The site has not included technical data gathered from remedial investigations in the Annual Site Environmental Report since 1993.

- Another programmatic weakness noted was in the information collected from the environmental monitoring program, which forms the basis of the information reported in Annual Site Environmental Reports. While these reports make generic statements about the types and kinds of remedial investigations, the site has not included technical data gathered from remedial investigations in the Annual Site Environmental Report since 1993. This is contrary to the intent of DOE Order 5400.1, which states that results of sampling conducted as part of the environmental monitoring program or as part of a special study should be summarized in Annual Site Environmental Reports. By omitting this data, site management is not providing a complete description regarding the nature and extent of the presence and transport of environmental contamination at the site. Bechtel Jacobs has indicated that DOE site management concurred with the decision to provide only a generic summary rather than a quantitative report.

6. **Information to the public has sometimes been delayed and is in forms not clearly understood by the general public and other stakeholder groups, contributing to a perception that DOE and the contractor are withholding information from the public.** Public participation and communications are fundamental components in DOE program operations, planning activities, and decision-making. Pursuant to the Department's public participation policy (DOE Policy 1210.1, Public Participation), the public is entitled both to provide input to Departmental decision-making and to fully understand the impacts of the site's activities on their quality of life. Upon discovery of groundwater contamination in 1988, the site prepared a Community Relations Plan in response to CERCLA requirements. Initially, the communication mechanisms used by the site pertaining to groundwater contamination were useful, such as public meetings, information bulletins, press releases, personal contacts, and advisory committees. While some improvements have been initiated, a review of current public participation and community outreach programs and activities identified a number of weaknesses resulting primarily from the lack of clearly defined roles and responsibilities for public communication activities at PGDP. This shortcoming has contributed to deficiencies in the planning, development, implementation, and evaluation of public affairs and community relations efforts. Specific concerns include the following.

- There are limited DOE and Bechtel Jacobs personnel trained to communicate technical information to the public in such areas as risk communication, public involvement, and media relations. This has contributed to instances where information was presented to members of the public in a manner that was difficult to understand.

- The site has not implemented all the elements outlined in its 1997 Community Relations Plan. From 1996 to 1998, the site significantly reduced public communication efforts. For example, the site did not provide significant public information in the forms of information bulletins, public meetings, personal contacts, and speaker bureaus as outlined in the Plan. In addition, public information bulletins were not published for this three-year period. Furthermore, the evaluation conducted for the 1997 update included recommendations for program enhancements, such as providing information in language that the public can easily understand. These recommendations have not been implemented, indicating a lack of attention by DOE and Bechtel Jacobs management.

- Members of the public may have difficulty in understanding ES&H conditions and initiatives from the available technical information. For example, annual environmental reports published by the site did not contain a clear summary of site conditions and public health risks. Other materials prepared by the site have generally not been effective in communicating to the public the presence and hazards of transuranic materials at the site.

Some members of the SSAB are dissatisfied with the quality of information they are receiving.

- The site has developed a public participation process through the Site Specific Advisory Board (SSAB), which was established under the Federal Advisory Committee Act in 1996**.** However, some members of the SSAB are dissatisfied with the quality (type, amount, completeness, and timeliness) of information they are receiving. Some members also expressed concerns about not being included in the planning process for environmental restoration activities. Additionally, the Paducah Site Office is partially reliant on the SSAB as their vehicle for notifying the public of activities and issues at PDGP. Although the SSAB has a written mission statement, discussions with SSAB members determined that the mission and function of the SSAB are not well understood.

- Members of the public believe that DOE does not adequately disclose information about hazards and risks and does not provide information that meets their needs. Some have stated that they have not received complete information on health data, health risks, or general cleanup activity for the site and often find it difficult to obtain such information from the site. In addition, many stakeholders question the availability of the Environmental Information Center, which is open only during normal business hours and not on nights or weekends.

Independent Investigation Team Sampling Results

Environmental samples were collected and analyzed by the investigation team in an effort to confirm that the current analytical results being reported by the site are accurate and representative of environmental conditions. The types of environmental samples and the locations where they were taken are shown in Figure 9. The total sampling effort consisted of 15 groundwater, 9 surface water, and 8 soil/sediment samples. All samples but one were collected outside the Plant security fenced area, some on DOE property. Site subcontractor personnel collected all the samples in accordance with approved procedures that follow the guidelines established by the EPA. The Oversight investigators witnessed the collection of all samples, and chain-of-custody forms were completed. The Oversight investigators affixed adhesive labels to the containers in the field to ensure sample integrity. The Oversight investigators also observed all samples being placed in locked refrigerators at the end of the sampling day and subsequently accompanied them to the USEC Laboratory, where the samples were held until shipment off site. Additionally, to witness the condition of the samples as they arrived, one of the investigators met the samples upon arrival at the independent analytical laboratory that performed the analysis.

The team used historical sampling results and local topography to map out their sampling locations.

Groundwater, surface water, soil, and stream sediment were sampled and analyzed for several key radionuclides and volatile organic compounds.

In general, the groundwater samples were taken at the extremities of the reported plumes to confirm the extent of contaminant migration. Surface water samples were taken at major site outfalls flowing during the sampling period and

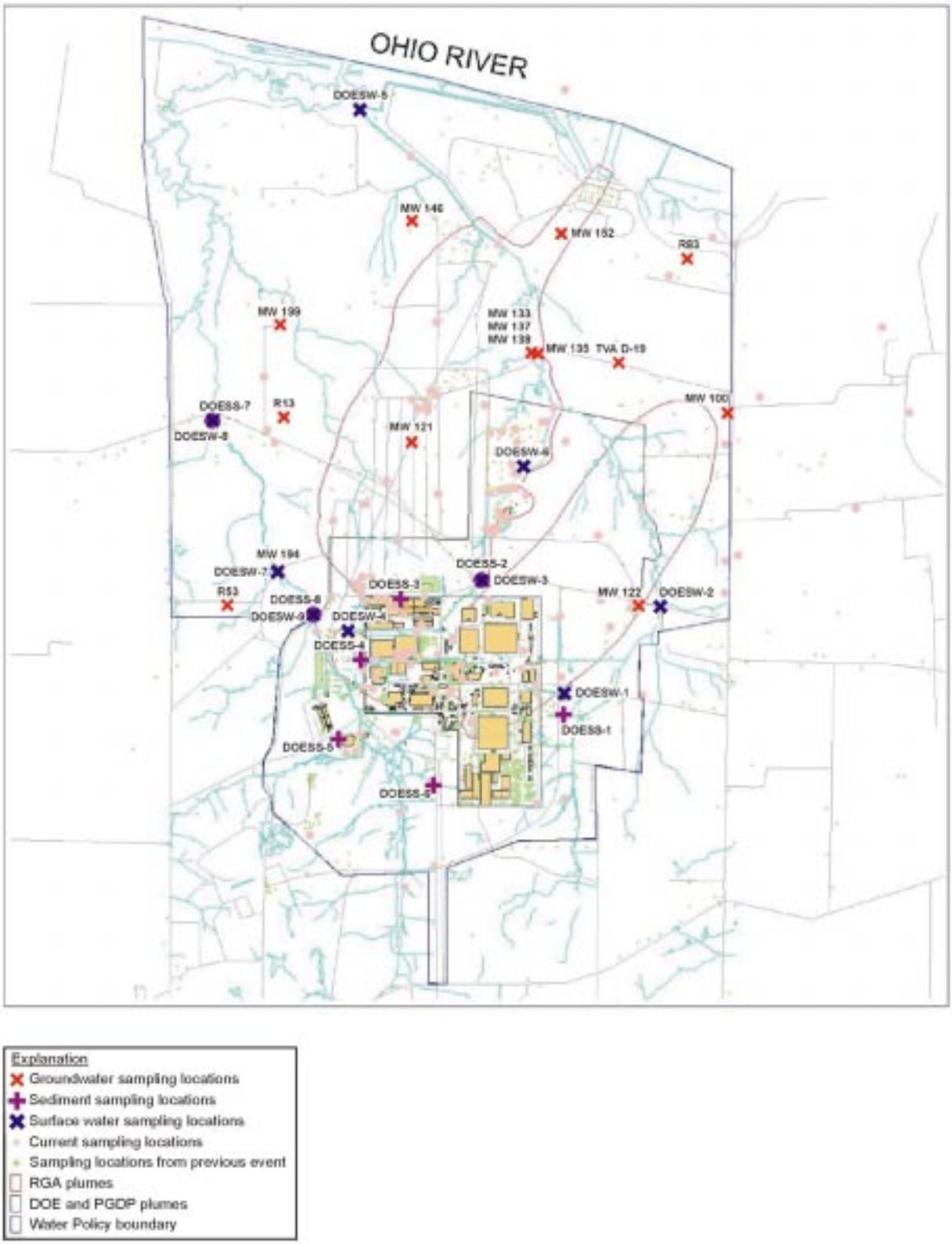


Figure 9. Locations of Samples
(Plume Delineation Performed by Bechtel Jacobs)

Radionuclides	Chemicals
Technetium-99 Plutonium-239/240 Neptunium-237 Uranium-238 Thorium-230 Americium-241 Cesium-137	Volatile organic compounds, including trichloroethene (TCE) Polychlorinated biphenyls (PCBs)

at points associated with surface waterways in the vicinity of the Plant. Soil and sediment were primarily sampled at outfalls and ditches near source areas of contamination. Groundwater, surface water, soil, and stream sediment were sampled and analyzed for several key radionuclides and volatile organic compounds, focusing on the compounds listed in the box above. Some analytical results were not available in time to be considered in this report. Any abnormal results from this remaining analytical work will be incorporated into subsequent reports. Laboratory analytical detection limits were designed to be low enough to ensure that contaminants would be detected at levels well below those that could be significant to public health.

Summary of Sampling Results

The types and levels of contamination detected in samples analyzed independently were generally consistent with the site's past environmental monitoring results.

Radiological and chemical contamination in groundwater, surface water, and soils/sediment was detected in some of the samples taken for this investigation. With a few exceptions, the types and levels of contamination detected in the samples were consistent with the levels identified by past environmental monitoring conducted by the site. At some locations, contamination was not detected, or was detected at insignificant levels or at levels representing background conditions. The analysis of split samples by the site produced results that were in general agreement with results produced by the independent analyses undertaken by the Oversight investigation team. The broad agreement between data produced by the site and the results from this independent investigation provide a level of assurance that the site can produce, and has produced, accurate environmental monitoring results. However, for two media—surface water and sediments—the site performs only very limited sampling annually and does not include all analytes in all sets of samples. Therefore, it is not clear that the site's environmental monitoring and surveillance results are fully representative of actual conditions. In two instances, independent soil/sediment sample analyses identified concentrations of isotopes other than uranium and technetium at levels not previously reported by the site for locations outside the site security fence. These were in Outfall 15 and in the North-South Diversion Ditch, where the independent analyses detected transuranics and cesium-137 at significant environmental concentrations. The site has not routinely taken samples from these locations as part of the environmental surveillance program.

Groundwater

The Oversight investigation team's groundwater sampling strategy involved taking a sample ahead of the plume in the direction of the plume movement in order to confirm the advance of the contamination. In a one-to-one comparison using previous data from the same wells, analytical results agreed with the site database and the chemical analyses of contaminants being reported by the site. The numerical values for key parameters are tabulated in Table 1.

Table 1. Measured Values of Activities and Concentrations of Constituents in Groundwater Samples Taken from Fifteen Wells

Well Identification	Pu-239/240 (pCi/L)	Pu-238 (pCi/L)	Tc-99 (pCi/L)	Am-241 (pCi/L)	Sr-90 (µg/L)	U-238 (µg/L)	TCE[1] (µg/L)
MW-199	0.008	0.007	ND[2]	<0.02	NA	0.79	ND
MW-146	0.009	ND	ND	0.24	NA	0.008	ND
MW-152	ND	ND	148	<0.03	NAV	0.006	0.8
MW-100	ND	ND	ND	<0.03	NA	0.006	ND
TVA D-47, W-1[3]	NA[4]	NA	0.9	NAV[5]	NA	15.4	ND
R83	ND	ND	ND	<0.02	NA	0.004	ND
R53	NA	NA	ND	NAV	NA	1.87	ND
MW-194	0.008	ND	0.6	<0.02	NA	0.004	ND
R-13	ND	ND	ND	NAV	NA	0.02	ND
MW-121	0.014	ND	ND	<0.01	NA	0.04	ND
MW-122	ND	ND	ND	<0.02	NA	0.03	ND
MW-133	0.010	ND	ND	<0.02	NA	0.29	ND
MW-138	NA	NA	20	NAV	NA	6.40	ND
MW-137	0.006	ND	87	<0.03	NAV	0.01	3.0
MW-135	ND	ND	81	<0.03	NAV	0.19	3.5

[1] TCE samples experienced elevated temperatures during shipping.
[2] ND = analyzed value at or below detection limit
[3] Water contained suspended solids.
[4] NA = not analyzed
[5] NAV = not available - analysis in progress

The Northwest and Northeast Plumes are contained within the water policy boundaries.

The technetium-99 results confirm that the Northwest Plume is contained within the water policy boundaries and that it is migrating northward in the vicinity of MW-152 through the TVA property. The concentration of technetium-99 reported in MW-152 was 148 pCi/L. In other sampled well water, technetium-99 was not detected or was found in lower concentrations. These values were consistent with site information obtained from previous monitoring and investigations. Of the wells sampled in this study, none had detectable levels of other radionuclides above background levels.

Trace concentrations of TCE were detected in MW-135, MW-137, and MW-152. The highest concentration detected, 3.5 parts per billion (ppb), is below the drinking water standard of 5 ppb. The presence of TCE is in agreement with the TCE plume location maps prepared by the site. The absence of TCE in MW-100 confirms the eastward extent of the Northeast Plume. This plume is within the eastern boundary of the water policy area. In addition, residential wells sampled by the investigation team that were outside, but near the plume boundaries, were found to be free of contaminants. These results indicate that the offsite groundwater contamination is currently within the water policy area. Elevated uranium values were reported for a subset of the well water samples. These wells are scattered throughout the water policy area and do not occur in any pattern associated with the plumes or the groundwater flow system.

Surface Water

Surface water samples were collected from nine selected locations along the Little and Big Bayou Creeks, as well as at several Plant Outfalls where surface water was present. Since there were drought conditions during this sampling event, surface water samples could not be collected from some of the desired Outfalls, such as K015 and K017, west and southwest of the Plant. A sample was collected from the Lagoon by the S and T Landfill and from a location in the North-South Diversion Ditch where enough standing water was found. Analytical results for key parameters are shown in Table 2.

Table 2. Measured Values of Activities and Concentrations of Six Constituents in Surface Water Samples Taken at PGDP

Sample Number	Pu-239/240 (pCi/L)	Pu-238 (pCi/L)	Am-241 (pCi/L)	Tc-99 (pCi/L)	U-238 (μg/L)	TCE[1] (μg/L)
SW 01	ND[2]	ND	<0.05	0.5	1.73	ND
SW 02	ND	ND	<0.05	0.8	1.68	ND
SW 03	0.352	ND	0.172	26	37.1	ND
SW 04	ND	ND	<0. 2	5.3	1.16	0.4
SW 05	ND	ND	<0.03	5.5	0.79	ND
SW 06	ND	ND	<0.03	ND	0.25	ND
SW 07	ND	ND	<0.04	1.4	0.83	ND
SW 08	ND	ND	<0.03	2.0	0.76	ND
SW 09	ND	ND	0.054	1.9	0.96	ND

[1] TCE samples experienced elevated temperatures during shipping.
[2] ND = analyzed value at or below detection limit

Surface waters showed minimal levels of contaminants.

Sampling for volatile organics at K001 Outfall

Radioactivity analyses for surface waters showed relatively low concentrations for all isotopes, with the North-South Diversion Ditch sample showing the highest levels of uranium and technetium-99 at 37 mg/L (12.5 pCi/L) and 26 pCi/L, respectively. Transuranic and thorium isotopes were either not detected or were present in very low concentrations, consistent with prior sampling results conducted by the site. For comparison purposes, one may note that the surface water results are all well below the Derived Concentration Guidelines (DCGs) established by DOE Order 5400.5. The DCGs can be used to evaluate the risk associated with the presence of radionuclides in surface water. The DCG for water is the concentration of a radionuclide that, under conditions of normal ingestion of water for one year, would result in an effective dose equivalent of 100 mrem. As a condition of DOE Order 5400.5, DOE sites are prohibited from releasing process effluents to surface waters in excess of the DCG guidelines.

With respect to other analytes, surface water samples were also analyzed for volatile organic compounds and PCBs. Only trace amounts of volatile organic compounds were detected, and none of these exceeded the Maximum Contaminant Levels (MCLs), which are considered the maximum acceptable levels for drinking water. For PCBs, only the North-South Diversion Ditch sample showed any positive results. The level detected (0.00035 mg/L) is also below the MCL for PCBs (0.0005 mg/L), although there have been previous PCB results in surface water that exceeded the MCL.

Soil and Sediments

Results for soil and sediment samples varied greatly, and some analyses showed higher concentrations of contaminants than noted in the past.

The results of the soil and sediment sampling are shown in Table 3. A total of eight soil/sediment locations were sampled for radionuclide and PCB contaminants. Seven of the samples were collected from outfalls and ditches

Table 3. Measured Values of Activities and Concentrations of Constituents in Soil and Sediment Samples Taken at PGDP

Sample Number	Pu-239/240 (pCi/g)	Pu-238 (pCi/g)	Np-237 (pCi/g)	Tc-99 (pCi/g)	Cs-137 (pCi/g)	Th-230 (pCi/g)	U-238 (pCi/g)	U (total) (µg/g)	Am-241 (pCi/g)	PCBs (µg/kg)
SS-1	0.009	ND[1]	<0.007	NAV[2]	1.02	NAV	100	232	<0.3	84,121[3]
SS-2	52.3	0.68	7.89	NAV	NAV	808	NAV	NAV	NAV	10,549
SS-3	0.38	ND	<0.3	NAV	NAV	NAV	NAV	NAV	NAV	1,832
SS-4	18.5	0.199	<0.3	NAV	44.6	14	77	160	0.88	790
SS-5	0.004	ND	<0.003	NAV	ND	NAV	<2	0.44	<0.2	19
SS-6	0.013	ND	<0.004	NAV	0.35	NAV	<4	2.14	<0.2	44
SS-7	0.012	ND	<0.003	NAV	0.04	NAV	1.2	2.21	<0.3	11
SS-8	0.022	ND	<0.005	NAV	0.05	NAV	<3	1.43	<0.3	23

[1] ND = analyzed value at or below detection limit
[2] NAV = not available - analysis in progress
[3] Duplicate sample result reported at this location

adjacent to the site, and one was collected inside the site security fence near the Drum Mountain area. The magnitude of the radionuclide results was generally in keeping with historical data reported by the site in the Outfall and Big Bayou locations. Sediments collected at Outfalls 11 and 15 and the North-South Diversion Ditch clearly exhibited radioactivity levels above what would be expected from natural background or radioactive fallout and are of sufficient magnitude to warrant management as soil contamination areas under the DOE/Bechtel Jacobs radiological protection program. In fact, Outfall 15 exhibited relatively high levels of plutonium, thorium, and cesium, at 18.5, 14, and 44.6 pCi/g respectively, which are higher than has been reported for transuranic and fission product isotopes at similar locations in the past. The North-South Diversion Ditch contained plutonium at 52.3 pCi/g and thorium-230 at up to 808 pCi/g. Results for split samples analyzed by the site are consistent with these results. PCB contaminants were also detected in all of the soil/sediment samples at levels similar to past reporting with one exception: Outfall 11 exhibited a PCB concentration of 84,121 mg/kg, which is approximately five times the highest reported level from prior sampling. The possibility of high variability and lack of homogeneity of contaminants in these media highlights the uncertainty associated with the process of limited soil sampling conducted annually by Bechtel Jacobs. This uncertainty also demonstrates the need for conservative decision-making and assumptions, including the use of historical data when drawing conclusions or conducting pathway analyses using data from sample results.

Conclusions

Radiological and chemical contamination from PGDP industrial activities has been released into the ground, soil, and air around PGDP. These conditions have prompted DOE and regulatory organizations to take a number of steps to protect public health. Because of the limited duration of exposure of the public to contamination and the mitigation measures taken, DOE operations at PGDP do not present a significant public health risk at this time. Nevertheless, significant improvements in DOE's protection of the public and the environment are needed. Increased funding and management emphasis on actual remediation activities are needed to address the sources of continuing contamination, to limit the degradation of contaminated buildings, and to control the continued spread of contamination pending cleanup. Exposure pathways need to be better analyzed to fully document the technical basis and the site's conclusion that no significant public exposures to radiation sources, such as fugitive air emissions, are occurring. Site management also needs to improve the characterization of groundwater in several areas, such as the extent of progression of the Northwest Plume towards the Ohio River. Improvements in waste management practices are needed to address storage of materials in DMSAs and the degrading containers of low-level waste. Additionally, DOE and Bechtel Jacobs need to supplement staff assignments and subcontractor support to ensure that site personnel can effectively integrate, interpret, and communicate environmental information.

2.2 Radiation Protection and Worker Safety

2.2.1 Radiation Protection

The Bechtel Jacobs radiation protection program exists to protect individuals from radiological exposures that could occur as a result of DOE activities at the PGDP. These activities have changed during the 1990s with the transition of gaseous diffusion operations to USEC. Currently, DOE's responsibilities include environmental restoration and management of legacy contamination and the large quantity of radioactive wastes present at the site. Despite the mission change, the nature, extent, and magnitude of contaminated facilities and uncharacterized materials at the site present unique challenges and highlights the importance and need for a comprehensive and robust radiological protection program.

During the early 1990s, radiological assessments identified fundamental program weaknesses in the site's ability to control potential exposures to transuranics.

During the early 1990s, radiological assessments, including the 1990 DOE Tiger Team, identified fundamental program weaknesses in the site's ability to control potential exposures to transuranics and to conduct an effective contamination survey program. In response, the site enhanced the quality and sensitivity of radiological survey equipment and increased the number of radiological control technician staffing from just a few to more than 50 to handle the increased survey workload caused by the discovery of transuranics in the workplace. Also the use of personal protective equipment was upgraded, and more emphasis was placed on posting and access control. Finally, the bioassay program was continued. When the radiological control program transitioned to USEC, many of the resources went to USEC, creating a shortage of resources for DOE activities.

To meet current 10 CFR 835 requirements for comprehensive assessment of the radiological control program, Bechtel Jacobs developed checklists of topical questions for 12 functional areas. The checklists are completed by the project health physicist, who describes how the site meets each of the requirements. Audit teams from the site Quality Assurance organization typically do not include health physics expertise. Radiological control audits by the radiological control organization in 1995 and 1997 identified similar weaknesses (e.g., auditors with no audit training, auditors assessing their own work, and audits that did not assess the adequacy of procedures and programs). In general, audit findings were minimal and did not reflect an extensive scope of audit review or an examination of the adequacy of corrective actions, although some recent improvement was noted.

OR conducted regulatory oversight reviews from July 1993 to March 1997. Radiological findings, the second most common deficiency after operations, were tracked to closure. At the termination of the DOE regulatory oversight program in 1997, there were no outstanding or unresolved radiological control issues at PGDP.

The lack of formality and rigor in radiological controls is exacerbated by an absence of DOE or Bechtel Jacobs oversight of radiological work practices.

The transition of gaseous diffusion activities to USEC has essentially created two distinct radiological protection programs at PGDP. Tiger Team issues attributable to the health physics activities associated with gaseous diffusion operations were not reviewed since those activities are now under USEC and regulated by NRC. On the DOE-regulated side, Bechtel Jacobs has a functional radiological control program that workers consider superior to the program as it was in the early 1990s. While the investigation team found deficiencies similar to those raised by the 1990 Tiger Team report, their magnitude (in areas such as postings, procedures, air monitoring, and contamination control) is less. Nevertheless, the number of deficiencies, combined with legacy radiological hazards, widespread contamination, uncharacterized materials and waste, and deteriorating contaminated facilities, is cause for concern. The lack of formality and rigor in radiological controls is exacerbated by an absence of DOE or Bechtel Jacobs oversight of radiological work practices.

At the time of the investigation, worker training on transuranic contamination and health effects had not been incorporated into current training. Other radiation protection training weaknesses include a lack of effective oversight of radiation protection training programs and a lack of assurance that individuals have received training before work is initiated in radiological areas. The current program was also found to be inconsistent with several requirements of Federal regulations on Occupational Radiation Protection (10 CFR 835) and Quality Assurance (10 CFR 830.120). Additional information on radiation protection training weaknesses can be found under Worker Safety and Health (Section 2.2.2).

Issues

7. Incomplete radiological characterization of the workplace adversely affects the ability of the radiological control organization to identify hazards and institute controls as necessary to ensure consistent and appropriate radiological protection for workers.

The North-South Diversion Ditch inside the Controlled Area was not controlled as a transuranic area.

- There is a lack of knowledge as to the isotopic mix of radionuclides present in various work areas. This information has never been obtained through comprehensive characterization, nor is it available in technical basis documentation. Radiological control technicians need this information to analyze the hazards and establish proper radiological controls. Lacking this information, they generally have established radiological control limits based upon the most restrictive radionuclides thought to be present (e.g., Np-237). However, the North-South Diversion Ditch inside the Controlled Area was not controlled as a transuranic area. This area has not been adequately controlled because the radiological control technicians are not aware of isotopic analysis information indicating the transuranic levels in the ditch.

- The procedures for planning and implementing radiological controls in the workplace presume knowledge of radiological control personnel about the isotopic mix in work areas.

8. There is a lack of rigor, formality, and discipline in the development, maintenance, and implementation of the Bechtel Jacobs radiation protection program.

Bechtel Jacobs RWPs lack information required by procedure to control radiological work effectively.

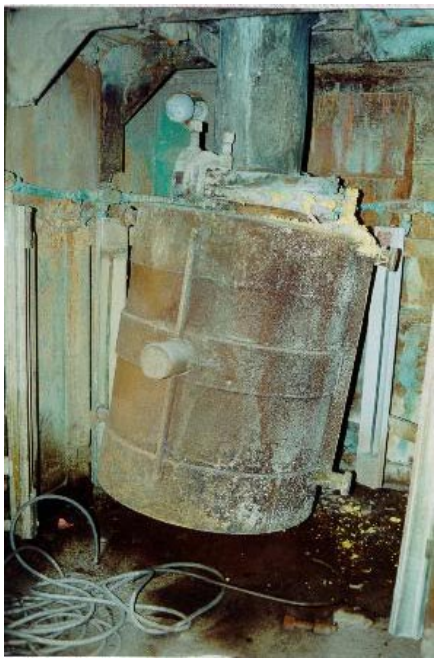
- Bechtel Jacobs radiological work permits (RWPs) lack information required by procedure to control radiological work effectively. They do not provide required survey information or the anticipated radiological conditions to be expected, such as the presence of transuranics. No radiological suspension limits are delineated to stop work if conditions are encountered beyond the scope of the designated radiological controls. Further, training requirements are not specified on RWPs. The investigation team noted specific instances where personnel were unaware that the radiological conditions at the work site were beyond what was appropriate for the scope of the general RWP in use. In these cases, the radiological control supervisors, who were contacted by the team, concurred that the activities should be stopped pending more complete planning and preparation of more specific RWPs.

In many cases, the monitored work activity was already completed before the final air sample activity was determined.

- Air sampler placement is not always consistent or adequate to sample the air in the work area or representative of the air breathed by the worker. In addition, analysis of air samples is not timely. Many air sample analyses are

delayed from six to ten days to allow radon progeny to decay. This site does not perform a more timely (e.g., four-hour decay count) screening count of air samples (even though Bechtel Jacobs' procedures address how to screen samples) to evaluate whether appropriate radiological controls are in place. In many cases, the monitored work activity was already completed before the final air sample activity was determined. Also, site procedures do not identify the conditions that require isotopic analysis of air samples.

A survey of the interior of one work area inaccurately showed radiation levels a factor of ten lower than those observed by the investigation team.



The Building 410 ash receiver, held in place with corroded C-Clamps.

- Line management's initial determination that no dosimetry or radiological worker training was needed for construction personnel working at the cylinder yard project was inappropriate. This Bechtel Jacobs decision was initially based on an April 1999 survey that focused on the perimeter of the cylinder yard work area. Another survey, taken June 3, 1999, to confirm the initial determination included only the perimeter area and not the interior of the work area. On June 4, 1999, a survey of the interior of the work area inaccurately showed radiation levels a factor of ten lower than those observed by the investigation team on August 30, 1999. Contrary to Bechtel Jacobs' initial assessment, independent dose rate measurements of the work area by the investigation team (see Figure 10) indicated that, based on an anticipated six-month job duration, worker doses would likely exceed the 100 mrem threshold for such controls, and workers should have been monitored and provided Radiation Worker I training. This finding led to a shutdown of work and implementation of radiation monitoring (thermoluminescent dosimeters) and radiological training for workers. One worker escort who was monitored recorded a dose of 24 mrem in 35 days on the job in May and June. A subsequent Bechtel Jacobs evaluation indicated that worker doses would probably not have exceeded 100 mrem. However, this evaluation assumed an average work area dose rate that was two to three times lower than the dose rate that the investigation team observed in the work area.

- The Bechtel Jacobs program for auditing and assessing the radiation protection program was not effective in identifying programmatic deficiencies such as those observed by the investigation team.

- The project health physicist's expectations for day-to-day operations are not effectively communicated to the radiological control technicians. Radiological control technicians believe that they have the authority to allow work in certain areas (North-South Diversion Ditch) or decide not to take the air samples required by ALARA reviews. These beliefs are contrary to the project health physicist's expectation for control of the work.

Bechtel Jacobs cannot adequately demonstrate that the unconditional release of equipment from the site is consistent with DOE requirements.

- Bechtel Jacobs cannot adequately demonstrate that the unconditional release of equipment from the site, such as the release of fluorine cells, is consistent with DOE requirements. Bechtel Jacobs does not have a technical basis for determining how to meet the DOE requirements for unconditional release of equipment, including appropriate criteria for determining when it is necessary to use more restrictive transuranic limits versus uranium

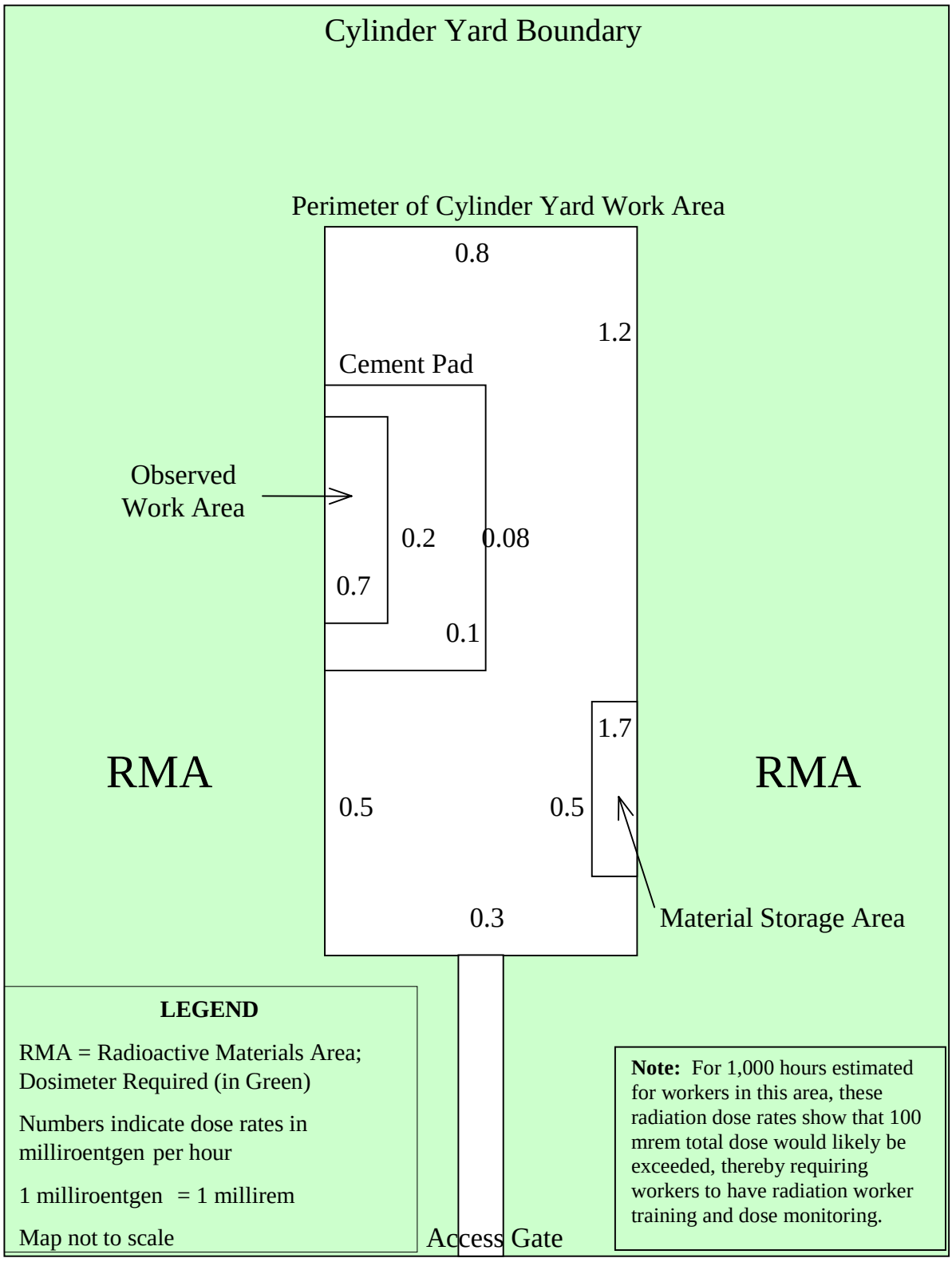


Figure 10. L Cylinder Yard Survey Readings

limits. While Bechtel Jacobs does have a procedure for unrestricted release of equipment, they did not apply it during the process of releasing the fluorine cells.

Contamination levels in excess of eight million disintegrations per minute per 100 cm^2 were measured in outdoor contamination areas.

- Outdoor contamination areas, particularly in the vicinity of Drum Mountain, were not adequately posted and barricaded, even though contamination levels in excess of eight million disintegrations per minute per 100 cm^2 were measured in these areas. Other onsite areas, primarily drainage ditches, were posted as contamination areas in the absence of specific information on the radiological or chemical hazards being present. Removable contamination levels were in excess of 10 CFR 835 Appendix D. Because there is no contamination monitoring of individuals leaving the site, there is the potential for contamination to be taken off site. Items, such as manhole covers, with "fixed" contamination were not labeled to warn individuals of the radiological hazards. Postings for some areas were either missing or not visible to personnel accessing the area, and in other cases were not consistent with the work controls in the area.

- During the 1980s and early 1990s (before Buildings 340, 410, and 420 were controlled as contamination areas), the security force conducted daily patrols, periodic security drills, and joint exercises with the Paducah Police Department, the McCracken County Sheriff's Department, and Kentucky State Police in Building 340. There were no controls in place at that time to prevent exercise participants from potentially becoming contaminated and unknowingly carrying the contamination off the site.

Uranium materials at product handling points in Building 340.

Subcontractor personnel attributed the lack of postings to inadequate funding.

- Bechtel Jacobs subcontractor personnel attributed the lack of postings to inadequate funding for maintenance of the barricades and postings, and the assertion that workers knew the areas where they were allowed to go.

- Bechtel Jacobs procedures do not always contain specific instructions on required radiological control activities, including entry control, posting and labeling, radiation surveys, and radioactive contamination control and monitoring.

- Numerous instances of a failure to follow procedures were noted, including radiation safety training, generating and implementing RWPs, performing contamination surveys, and implementing the pre-job ALARA review requirements.

- Bechtel Jacobs allows individuals who lack the requisite training to work for up to 40 hours in radiological areas and potentially receive occupational exposure. This practice is not consistent with DOE radiation safety training requirements.

- The practice of allowing individuals to work at different company-managed sites using their home site's dosimetry is inconsistent with the DOE exposure reporting requirements. USEC employees performing work for DOE continue to wear USEC-issued dosimeters. USEC dosimetry, which is accredited by the National Voluntary Laboratory Accreditation Program (and accepted by NRC) and is not accredited under the DOE system (DOE

Description of PGDP 1990 Bioassay Issue

Background. The 1990 bioassay results of urine specimens taken from PGDP workers and evaluated by an outside analytical laboratory were subsequently declared invalid by the PGDP contractor (Martin Marietta Energy Systems, or MMES). This declaration continues to be an issue of great concern to the union (Paper, Allied-Industrial, Chemical, and Energy, or PACE), and there is a great deal of misunderstanding about the facts.

Sequence of Events. On March 22, 1990, radioactive waste was spilled in warehouse C-746-Q. Workers involved in the spill were sent to Fernald for whole body/lung counts on June 8-14, 1990. On July 8-10, 1990, a first set of urine samples was sent to an offsite analytical laboratory for evaluation; the results, received on August 7, 1990, indicated that all samples tested positive for the presence of plutonium. On August 13, 1990, additional workers provided urine samples. On August 22, 1990, MMES questioned the analytical laboratory on the validity of the results, and they also met with the analytical laboratory and DOE on September 10, 1990. A second set of samples was taken from workers on September 26, 1990; the samples were "split" and provided to the Oak Ridge National Laboratory (ORNL) and the original analytical laboratory for evaluation. During this period, MMES conducted two audits of the analytical laboratory (September 12, 1990, and October 18, 1990). On January 11, 1991, MMES officially declared the original analytical laboratory results invalid. MMES provided a briefing to workers and to PACE on the urinalysis results on March 6, 1991.

Actions Taken by Oversight Investigation Team. Records associated with the bioassay process were reviewed in the USEC Building 710 vault. Additional records from the Building C-100 vault, which included whole count data, were also examined. The investigation team attempted to interpret the raw data and also reviewed supporting documents.

Results. The investigation team's review of information indicated the following:

1. The results for all 23 original bioassay sample results were reported as positive for the presence of plutonium. The samples included 20 from workers, 2 unexposed control samples, and a blank water sample. Blind samples "spiked" by Martin Marietta Energy Systems with plutonium were reported high by a factor of 2.5.
2. The plutonium blind spike samples sent to the analytical laboratory by MMES were 1,000 times too high due to a misunderstanding between MMES and ORNL of typical spike levels. MMES interpreted the ORNL recommendations as disintegrations per minute/milliliter rather than disintegrations per minute/liter. Since the spiked samples were abnormally radioactive (hot), compared to the samples typically encountered by the analytical laboratory, these samples could have contaminated the laboratory equipment. If this occurred, it would account for the reported results.
3. The initial uranium results were not consistent with what would be expected for actual exposures to uranium contaminated with transuranic elements.
4. MMES audits of the analytical laboratory revealed problems in procedural compliance, quality assurance and quality control, failure to meet contractual requirements for Minimum Detectable Activities, and failure to subtract natural background radiation before reporting results.
5. All results of the whole body/lung counts conducted by Fernald were negative for the presence of uranium-235, uranium-238, plutonium-239, neptunium-237, and americium-241.
6. All results of the resampled urine samples split between the analytical laboratory and ORNL were also negative for the presence of plutonium-238, plutonium-239, and americium-241.

Assessment. Based upon the investigation team's review of the available information, there is no evidence to invalidate the MMES basic conclusions that the original sample results were false and that worker intakes did not occur from the original spill. The sampling and analysis approach used by the contractor, which bases a determination of intake on the predominance of the sample trial results (i.e., if two out of three trials are negative, the results are judged to be negative), is consistent with the Internal Dosimetry Implementation Guide and Internal Dosimetry Technical Standards as issued by DOE Headquarters. A determination of intakes is rarely confirmed based on the results of a single sample. As a general practice, follow-up or confirmatory samples are always prescribed. Also, due to the slow excretion of transuranic elements from the body, samples taken years after the initiating event would detect the presence of transuranic elements if significant intakes were involved.

Laboratory Accreditation Program), is therefore used to monitor exposures from DOE activities. This practice is not approved under the DOE Laboratory Accreditation Program as required.

- Procedural requirements for establishing airborne radioactivity areas are inconsistent and conflicting. One section calls for use of the uranium Derived Air Concentration if the isotopic mixture is unknown. This conflicts with another section that specifies use of the most restrictive Derived Air Concentration for the radionuclides known to be present when the percentage of radionuclides is unknown. In some cases, following the uranium Derived Air Concentration guidance would result in airborne controls that are much less restrictive than those required for the transuranic contaminants present.

Conclusions

Records indicate that the external doses to employees from the types of radiation present at PGDP are very low, and there have been no recent significant intakes of radioactive material. However, the multiple deficiencies that were identified in radiological protection are symptomatic of a site that has had to cope with the same legacy hazards for many years and that is no longer in an operational mode. The site has increasingly relied on the workers' knowledge of and sensitivity to radiological hazards. The site radiation protection program exhibits a level of informality, rather than a disciplined and rigorous application of controls such as detailed radiation work permits, procedures, postings, barriers, and air monitoring. An event in which multiple personnel were contaminated with technetium-99, the presence of contamination with legacy materials in shutdown hazardous facilities, and the site's failure to monitor and train all workers in radiation protection are indications of program weaknesses. While some of these deficiencies are not significant, collectively they are of concern because of the remaining uncharacterized hazards, the unique and challenging risks associated with future hazardous material cleanup, and the move toward almost total reliance on subcontractors —some of whom lack the historical knowledge of site radiological hazards, including transuranics, and the applicable precautions and controls.

In conclusion, it is important that DOE and Bechtel Jacobs recognize that the cumulative deficiencies, in what could be a viable and effective radiological protection program, represent a weakness that warrants management attention. A level of discipline, rigor, and formality needs to be established in the process to protect worker health and safety during hazardous material characterization and onsite cleanup activities. DOE and Bechtel Jacobs also need to accept increased responsibility for the oversight of subcontractor radiological safety and performance, including holding them accountable for adhering to applicable DOE requirements.

2.2.2 Worker Safety and Health

The 1990 DOE Tiger Team identified significant deficiencies in worker safety programs and practices at PGDP. Corrective actions were taken and performance improved. Since that time, DOE contractors at PGDP and the nature of work performed by these contractors have changed. In 1993, USEC assumed full responsibility for managing enrichment operations. In 1997, regulatory oversight of enrichment operations was transferred from DOE to NRC. The nature of work by DOE contractors since that transition has focused on maintenance of UF_6 cylinders, maintenance and characterization of packaged waste, and assessment of environmental impacts. Completion of the cleanup mission at PGDP will require a significant increase in hazardous activities, such as removing buried waste and inspecting the contents of thousands of drums of radioactive waste. This work presents risks because it involves handling material containing radioactive and chemical carcinogens, much of which has not been fully characterized. There have already been several occurrences of drum pressurization due to improper drum handling practices, one of which resulted in the contamination of workers.

Most occupational physical hazards and worker exposure hazards at PGDP have been adequately identified and characterized.

Most occupational physical hazards (e.g., electrical hazards) and worker exposure hazards (e.g., to chemicals) at PGDP have been adequately identified and characterized. Bechtel Jacobs has developed a comprehensive set of

safety and health procedures for identifying, evaluating, and controlling occupational hazards. A review of selected work activities indicated that most physical hazards are adequately identified, and job hazard analyses and/or activity hazard analyses are performed in accordance with procedures. However, some safety and health procedures are not being followed, and some hazards are not sufficiently analyzed, particularly for work performed by subcontractors. The type, quantity, enrichment, and configuration of fissionable materials in DMSAs have not been fully characterized, and the risk of a criticality accident occurring in several of these DMSAs is unknown.

Limited safety and health resources have resulted in overreliance on personal protective equipment in lieu of performing hazard analyses and implementing engineering controls. Assessment of employee exposures relies heavily on screening mechanisms (e.g., chemical detector tubes) and professional judgment. Record keeping for air and noise sampling data is weak. Locating historical sampling data is difficult, and reconstructing personnel exposures is not always possible, particularly for subcontractors. Access to worker exposure and job hazard information by medical personnel is a longstanding weakness that has never been fully resolved.

Workers are generally involved in the work planning process, and the workers and line managers who were interviewed expressed satisfaction with the level of management attention to worker safety. The monthly safety committee meeting is well attended by DOE, Bechtel Jacobs management and workers, and subcontractors. Injury and illness rates at the PGDP are lower than at many DOE sites, and lower than the other two DOE sites managed by Bechtel Jacobs. Notwithstanding these positive attributes, many precursor conditions are developing that, if not addressed, will lead to decreased safety performance and an increased risk to workers.

Issues

9. **Criticality safety deficiencies in DMSAs have not been resolved by DOE in a timely manner, posing an unnecessary hazard to workers in surrounding areas.** Lockheed Martin Utility Services documented these deficiencies in an occurrence report to the DOE identifying the issue as a potential unreviewed safety question on January 15, 1997 (ORO-LMES-PGDPENVRES-1997-001). This issue was subsequently upgraded to an unreviewed safety question on July 21, 1998, based on the results of non-destructive analysis performed on an axial compressor in DMSA 31 inside the C-333 process building at PGDP. The analysis indicated that the compressor contains less than 1,737 grams uranium-235 at an assay of 1.157 weight percent. No nuclear criticality safety analysis documentation had been prepared for this compressor as required by DOE orders, Work Smart standards, and American National Standards Institute standards when the mass of uranium exceeds 700 grams. Corrective actions have not been taken in the higher-risk DMSAs, and current compensatory measures are not adequate.

In several of the DMSAs, the risk of a criticality accident is not known.

- In several of the DMSAs, the risk of a criticality accident is not known. However, non-destructive assay data obtained from some, but not all, of the equipment that originated at Portsmouth or Oak Ridge indicate that there is insufficient localized fissile mass in the equipment surveyed to make a criticality accident possible.

- The type, quantity, enrichment, and configuration of fissionable materials in these areas have not been fully characterized.

DOE Material Storage Area

DOE Material Storage Area Weaknesses

Background. Uncharacterized radiological and chemical equipment, materials, and waste in DMSAs (as shown in the picture) continue to present unnecessary and avoidable risk to workers and the environment. In 1996, DOE accepted responsibility for large amounts of legacy materials (e.g., uncharacterized scrap, equipment, drums, and other wastes) that were stored in the leased facilities so that USEC could obtain a certificate of compliance from the NRC. These materials are currently stored in 148 DMSAs located across the site, including "islands" within in the USEC operating facilities. Eleven DMSAs have been identified as high-priority areas based on nuclear criticality safety concerns. These 11 DMSAs include equipment that could contain large deposits and fissile materials with enrichments as high as 93 percent.

- **Continuing Management Weaknesses**
  - Responsibilities and accountabilities for DMSAs have not been clearly established.
  - Although problems and corrective actions were identified and submitted to the Paducah Site Office in 1997, an acceptable plan and schedule for disposition of the materials have not been developed.
  - DOE has not provided the funds to disposition the materials.
  - Almost no actions to disposition the material have been accomplished.

- **Criticality Concerns**
  - The risk of an inadvertent criticality is not known.
  - The fissionable material content has not been quantified.
  - Acceptable safeguards to preclude reconfiguration of fissionable materials have not been established.
  - Protection from introduction of moderator (e.g., sprinklers, pipe ruptures, fire hose locations, and flooding) has not been established.
  - Double-contingency protection against criticality has not been established.

- **Environmental Concerns**
  - Only limited action has been taken to inventory and characterize the hazardous materials that are known to be present.
  - DMSAs are not managed in accordance with RCRA waste storage requirements.
  - On at least two occasions, USEC has introduced new materials without DOE 's prior knowledge or authorization.

- Safeguards are not sufficient to preclude unauthorized movement of material in DMSAs.

- Procedures are not in place nor have workers been trained to properly respond in the event of inadvertent addition of moderator due to activation of sprinkler systems or flooding. There is a remote possibility that such an event could initiate a criticality accident.

- The DMSAs do not comply with DOE Order 420.1, Section 4.3 and American Nuclear Standards Institute/ American Nuclear Society Criticality Safety Standards that require that no single abnormal event can cause a criticality accident. Such an event cannot be precluded since the DMSA material has not been characterized.

- Lockheed Martin Utility Services documented these deficiencies in an occurrence report identifying the issue as a potential unreviewed safety question on January 15, 1997 (ORO-LMES-PGDPENVRES-1997-001); however, corrective actions have not been taken in the higher risk DMSAs and current compensatory measures are not adequate.

- Agreements between DOE and USEC to characterize and correct conditions within the DMSAs have not been adhered to, and DOE has not identified or provided alternative funding. The only planned DMSA characterization program was initiated to support seismic upgrades and only addresses a small fraction of the equipment that is suspected of containing fissile material. There is no funding for correcting the deficiencies in all the DMSAs and eliminating the criticality safety hazard.

10. Safety and health procedures are not consistently applied and followed, and in some cases, hazards are not adequately addressed by those procedures.

- Of the occurrence reports submitted to DOE by Bechtel Jacobs since April 1998, a number were attributed to either inadequate procedures or a failure to follow procedures. For example:
  - On July 10, 1998, a subcontractor did not follow a section of an RWP, resulting in a failure to obtain a required baseline bioassay sample.
  - On June 30, 1998, a low-pressure sanitary water line was inadvertently penetrated as a result of an inadequate procedure.
  - On September 3, 1998, two waste containers were found to have been moved in violation of procedures regarding weight limits for a forklift.
  - On December 15, 1998, a pressurized container was discovered during sampling activities. Evaluation of such "neutralized media" had not been included in the Bechtel Jacobs "Scrap Metal Acceptance Criteria and Waste Acceptance Criteria."
  - On May 28, 1999, a small bottle with unknown contents was discovered in a sediment sample. The procedure for this activity was judged to be inadequate and a contributing cause to the occurrence, since the procedure did not address what to do if unexpected items are encountered.
  - On August 25, 1999, a subcontractor violated an Excavation/Penetration Permit by failing to notify the underground utility locator service for the Commonwealth of Kentucky as required by the permit. Consequently, they nearly severed a telecommunications line.

Laboratory personnel did not adhere to the laboratory standard operating procedures or follow guidelines for safe handling of methylene chloride.

- On May 27, 1999, it was determined that laboratory personnel working in a mobile field extraction laboratory had been exposed to methylene chloride above the 15-minute Short-Term Exposure Limit defined by OSHA Regulation 1910.1052. Both root and direct causes of this event were that laboratory personnel did not adhere to the laboratory standard operating procedures or follow guidelines for safe handling of methylene chloride as described in the Material Safety Data Sheet.

- The investigation team observed that some safety and health procedures are not consistently followed. Sections of the sitewide procedure and the subcontractor's Health and Safety Plan for confined space entry were not followed at the L Cylinder Yard. Confined spaces were not evaluated, were not posted in accordance with procedures, and did not have required permits. Sections of Bechtel Jacobs procedures on biological monitoring for industrial chemicals, and workplace air sampling were not followed.

- At the L Cylinder Yard Project, occupational noise is not discussed in the subcontractor's Health and Safety Plan, nor are administrative controls (e.g., hearing protection and hearing conservation program requirements) described in the subcontractor's procedure on noise. Exposure to occupational noise is a safety concern for heavy equipment operators at the L Cylinder Yard. Furthermore, the subcontractor's lack of a documented basis to support the prescribed hearing protection, the absence of sound surveys or noise dosimetry, and the lack of an evaluation to determine whether workers should be enrolled in a hearing conservation program are not in compliance with either OSHA regulations or the Bechtel Jacobs procedure on occupational noise exposure.

- Some subcontractor safety and health procedures have not kept current with changes in OSHA regulations. At the L Cylinder Yard, Bechtel Jacobs approved a subcontractor procedure for confined space entry that differed from the sitewide confined space procedure, resulting in two conflicting procedures being applied. Further, the subcontractor procedure did not reflect current OSHA requirements for confined spaces.

- Bechtel Jacobs does not have a clearly defined or expressed policy on procedure adherence. The Bechtel Jacobs procedure on "Use of Procedures" was deleted and replaced by a procedure on the "Procedure Document Process" that is less stringent in requiring the use of procedures. Bechtel Jacobs' policy statements do not adequately address the importance of following procedures when performing work.

11. Bechtel Jacobs has not assured that subcontracted medical personnel are sufficiently involved in the identification, evaluation, and integration of workplace hazards to ensure effective worker medical programs.

- Several Office of Environment, Safety and Health reviews and assessments of the PGDP occupational medical program performed during the 1990s identified the need for site medical personnel to be more involved in the identification, evaluation, and integration of workplace hazards to ensure effective worker medical surveillance programs. This deficiency has yet to be resolved.

- The Bechtel Jacobs Work Authorization for ES&H services to be provided by USEC is brief and focuses on the frequency and cost of medical services, rather than on the scope and quality of services.

Animal material in Building 340 poses potential health effects to workers.

- The required interfaces between industrial hygiene and safety, health physics, emergency planning, and subcontractor medical programs are not well documented, and they are not feasible for the USEC Medical Director to accomplish.

- The site's Work Smart Standards have not incorporated DOE Order 440.1A and the subsequent DOE requirements for contractor medical programs.

Neither Bechtel Jacobs nor DOE has performed an assessment of subcontractor medical programs.

- Neither Bechtel Jacobs nor DOE has performed an assessment of subcontractor medical programs.

12. Bechtel Jacobs training programs do not ensure that all workers are knowledgeable of hazards and protection requirements, including those associated with transuranic contamination.

- The Bechtel Jacobs radiation safety training program does not include a process to assure that individuals receive the required training before working in controlled or radiological areas. Although required by procedure, mandatory training is not included in RWPs. The site does not maintain training records for individuals working at the site who are based at other Bechtel Jacobs locations. These individuals are escorted but are not given site-specific training.

None of the current Bechtel Jacobs radiation safety training modules adequately address the presence of transuranic contaminants at the site.

- None of the current Bechtel Jacobs radiation safety training modules adequately address the presence of transuranic contaminants at the site. Training on transuranics was provided once in 1992, and although DOE and Bechtel Jacobs personnel believed that such training was being conducted, in fact the 1992 transuranic-based training was not incorporated into the ongoing radiation worker training program.

- Training for Bechtel Jacobs radiological control technicians does not include monitoring for transuranics, the release criteria to be used, or the use of isotopic analysis information to determine the need for controls.

- Bechtel Jacobs personnel and subcontractors trained to the "Site Access Orientation" level are allowed access to radiological and controlled areas for a period of up to 40 hours per year. This level of training does not meet all 10 CFR 835 training requirements.

- Some workers have not completed required ES&H training. Several subcontractor personnel at the L Cylinder Yard had not met training requirements commensurate with the hazards to which they are exposed (e.g., confined spaces, hazard communication, and noise).

- Although Bechtel Jacobs provides a measure of oversight of subcontractor training programs through quality assurance audits, surveillances, and readiness reviews, this oversight is not consistently applied and is performed at the discretion of the Bechtel Jacobs project manager. There is no threshold or guidance for performing surveillances based on risk or previously identified ES&H deficiencies. At the L Cylinder Yard, for example, no surveillances have been performed to date, although there are a number of hazards, and training deficiencies were previously identified in the project readiness review.

Conclusions

Most occupational and worker exposure hazards have been identified and analyzed, and they are adequately controlled, although criticality safety deficiencies pose an unknown degree of risk and hazard to workers. The failure to address potential criticality safety deficiencies that have been apparent for more than 20 months indicates that DOE management has not placed sufficient priority on this important area of worker safety. Procedures address most occupational hazards; however, improvements are needed in establishing, maintaining, and following procedures, particularly on the part of subcontractors. Pre-job mentoring and review of subcontractor programs by Bechtel Jacobs are evident. However, the rigors of future waste remediation work and the increasing numbers of subcontractors will require more demand for oversight of subcontractors. The lack of training for workers and radiation control technicians regarding the presence of transuranics has exacerbated workers' fear of exposure and contributed to the current mistrust between some workers and line management. The need for medical personnel to be more involved in the identification, evaluation, and integration of workplace hazards was previously identified at the site. Ensuring an effective medical surveillance program is especially important at PGDP in view of the health concerns that have been raised. Overall, increased management attention is needed, particularly in criticality safety risk analysis, oversight of worker training, occupational medicine, and procedure adherence.

2.3 Line Oversight

DOE established the Paducah Site Office in 1989 to provide program direction and day-to-day oversight. In the early 1990s, DOE took steps to strengthen the oversight of contractor activities at PGDP. The need for more effective oversight was based on emerging environmental and worker safety issues. Technetium-99 had been discovered in offsite wells in 1988, and numerous sources of contamination at PGDP were being investigated as potential contributors to a plume of contaminated groundwater. A 1990 DOE Tiger Team assessment identified a number of safety problems at the site, problems with contractor activities, and a failure to provide clear direction to the management and

operating contractor. A 1997 Type B accident investigation by OR concluded that "DOE does not adequately perform oversight." In addition, a 1992 OR investigation of a former worker's concern about radiological control practices at PGDP found evidence that workers were intimidated and afraid to raise safety concerns.

The Site Safety Representative Program was completed in 1997 and its two staff members were reassigned to other duties.

Following the Tiger Team assessment, the recently established Paducah Site Office staff was increased from five to 12 staff members to provide more effective line oversight of contractor activities. In 1993, OR assigned two Site Safety Representatives to provide DOE oversight of enrichment activities while line oversight responsibility was being transferred to NRC. The two individuals were selected from the Paducah Site Office staff and reported directly to OR for this assignment. The Site Safety Representative Program was completed in 1997 and the two staff members were reassigned to other duties. With the final transition to NRC regulation of the enrichment facilities in 1997, the scope of DOE activities at PGDP decreased significantly to involving only waste management, environmental assessment, and remediation. Paducah Site Office activities have focused primarily on project management. In April 1998, DOE transitioned from a management and operations contract with Lockheed Martin Energy Services to a management and integration contract with Bechtel Jacobs. The work of the current DOE contractors is focused on maintenance of UF_6 cylinders, maintenance and characterization of packaged waste, assessment of environmental impacts, environmental monitoring, containment of the groundwater plume, and control of surface water runoff.

The current level and effectiveness of line management oversight of ES&H and assurance of compliance with DOE requirements are a matter of concern. Programmatic deficiencies identified through the 1990s either continue or have recurred. Written or verbal direction provided by DOE, primarily OR, regarding implementation of the management and integration contract has significantly reduced the level of oversight conducted by both the Paducah Site Office and Bechtel Jacobs. Consequently, line management has not identified and corrected many of the programmatic problems identified elsewhere in this report.

Issues

13. DOE has not conducted effective oversight of ES&H or ensured that Bechtel Jacobs and its subcontractors effectively implement all DOE and regulatory requirements.

- The improvements in oversight of contractor activities during the early 1990s are no longer apparent. There has been no formal oversight program and few oversight activities since the Site Safety Representative Program was completed in 1997.

- OR has provided little written direction to the Paducah Site Office for oversight of the management and integration contractor, Bechtel Jacobs. Written guidance stated that "the DOE role will center on establishing policies, standards, baselines, and objectives and measuring performance rather than focusing on day-to-day oversight and control." Consequently "day-to-day oversight" has received little attention.

- Without an ongoing program of surveillance and oversight, DOE was unable to provide timely information regarding the status of hazards to workers and the public when allegations regarding worker safety and health were raised in the lawsuit against former operating contractors for PGDP.

Neither OR nor the Paducah Site Office has provided sufficient direction to Bechtel Jacobs to assure adequate oversight of subcontractors.

- Neither OR nor the Paducah Site Office has provided sufficient direction to Bechtel Jacobs to assure adequate oversight of subcontractors, even though subcontractors are performing an increasing amount of work. Written

guidance for administration of the Bechtel Jacobs contract was provided to all OR employees in a memorandum from the OR Manager, dated January 29, 1998, which stated that "the DOE role will center on establishing policies, standards, baselines, and objectives and measuring performance rather than focusing on day-to-day oversight and control."

- The investigation team observed subcontractor ES&H performance that did not meet DOE requirements.

- Performance deficiencies were particularly evident in radiation protection, an area where the Paducah Site Office lacks sufficient expertise to provide effective oversight. The investigation team observed a number of deficiencies in this area that had not been previously identified by the Site Office.

- The Paducah Site Office does not have a formal program or process, including definition of roles and responsibilities, for assessment of Bechtel Jacobs' performance at the activity level, and has performed little assessment of Bechtel Jacobs' activities or conditions.

- OR has not maintained a DOE Facility Representative at PGDP since the regulation of enrichment was transferred to NRC.

- There is little oversight of training programs by DOE, and there are no mechanisms to ensure that the training that is provided is adequate.

- The Paducah Site Office did not identify the appropriate DOE requirements for unrestricted release of potentially contaminated property before approving the sale of fluorine cells.

14. Bechtel Jacobs has not conducted fully effective oversight of ES&H performance or ensured that its subcontractors effectively implement all DOE and regulatory requirements and are held accountable.

- Numerous weaknesses were identified in procedure adherence, safe work practices, occupational medicine, and worker training. These weaknesses resulted in a stop-work action for one subcontractor during the investigation period.

- Bechtel Jacobs' subcontractors do not consistently follow safety and health procedures.

- Subcontractors are screened by Bechtel Jacobs before starting work, but these screenings are not adequate to ensure that the subcontractors have working programs in place that meet DOE requirements for industrial safety, industrial hygiene, and medical surveillance.

- Some recent subcontractor work activities have resulted in unsafe work practices.

Building 410 corroded ash receiver

- Although Bechtel Jacobs provides a measure of oversight of subcontractor training programs through quality assurance audits, surveillances, and readiness reviews, the oversight is not consistently applied and is performed only at the discretion of the Bechtel Jacobs project manager.

Planned reductions in staff will further reduce Bechtel Jacobs' technical capability to conduct oversight and surveillance of subcontractor activities.

- Planned reductions in staff within Bechtel Jacobs will further reduce Bechtel Jacobs' technical capability to conduct oversight and surveillance of subcontractor activities. Planned staffing changes include a reduction in Safety Advocates from four (one Safety Advocate and three Safety Engineers who perform the Safety Advocate function) to one and elimination of the training coordinator position. In addition, there are significant shortages in key safety disciplines, such as industrial hygiene.

Conclusions

DOE and Bechtel Jacobs line management practices and processes have not assured compliance with ES&H requirements. Previously-identified problems that had been corrected after the Tiger Team assessment have resurfaced. With the shift to a management and integration contract, expanding reliance on subcontractors for the cleanup and waste management activities will require significantly more surveillance and oversight by both Bechtel Jacobs and DOE personnel who are knowledgeable of DOE requirements. In some cases, these requirements may be more stringent than the subcontractors' normally accepted practices. It has been demonstrated throughout the DOE complex that more active oversight and surveillance at the activity level is necessary to raise the threshold of acceptability for safe work practices and environmental conditions. If DOE is successful in obtaining funding to accelerate cleanup activities at PGDP, significantly more effort must be expended on surveillance and oversight to achieve and maintain the requisite standards for protecting the environment, the public, and especially the workers.

APPENDIX A
ISSUES FOR CORRECTIVE ACTION AND FOLLOW-UP

Line management is responsible for correcting deficiencies and addressing weaknesses identified in Office of Oversight reviews. Following each review, line management prepares a corrective action plan. The Office of Oversight follows up on significant issues as part of a multifaceted program that involves follow-up reviews, site profile updates, and tracking of individual issues.

This appendix summarizes the significant issues identified in this report of the Phase I investigation of PGDP. The issues identified in Table A-1 will be formally tracked in accordance with the DOE plan developed in response to DNFSB Recommendation 98-1, which addressed follow-up of independent oversight findings. OR, the Paducah Site Office, and Bechtel Jacobs need to specifically address these issues in the corrective action plan.

During an investigation, the Office of Oversight team may identify isolated weaknesses and/or minor deficiencies in otherwise effective programs. Although the site needs to correct such weaknesses and deficiencies, the Office of Oversight does not include every identified weakness in the formal tracking system. However, all weaknesses and deficiencies are considered as part of the Office of Oversight follow-up program when evaluating performance and planning future Oversight evaluation and follow-up activities.

Table A-1. Issues Identified in the Phase I Investigation at PGDP

IDENTIFIER	ISSUE STATEMENT	REFER TO PAGES
PGDP-INV-99-01	There has been limited progress in remediating and characterizing environmental contamination, low-level wastes, and stored hazardous materials that were produced by past industrial activities, and major cleanup milestones under the Federal Facility Agreement are jeopardized by funding constraints.	18-21
PGDP-INV-99-02	There are continuing weaknesses in the radiation protection management of known environmental contamination areas by both Bechtel Jacobs and DOE.	21-23
PGDP-INV-99-03	Radiological exposure pathways for DOE operations have not been fully assessed or documented.	23-24
PGDP-INV-99-04	Groundwater contamination has not been adequately characterized in some areas.	24-26
PGDP-INV-99-05	Unclear assignment of responsibilities and weaknesses in the integration and interpretation of environmental information have adversely impacted the understanding of environmental conditions.	26-27
PGDP-INV-99-06	Information to the public has sometimes been delayed and is in forms not clearly understood by the general public and other stakeholder groups, contributing to a perception that DOE and the contractor are withholding information from the public.	27-28
PGDP-INV-99-07	Incomplete radiological characterization of the workplace adversely affects the ability of the radiological control organization to identify hazards and institute controls as necessary to ensure consistent and appropriate radiological protection for workers.	35
PGDP-INV-99-08	There is a lack of rigor, formality, and discipline in the development, maintenance, and implementation of the Bechtel Jacobs radiation protection program.	35-40
PGDP-INV-99-09	Criticality safety deficiencies in DMSAs have not been resolved by DOE in a timely manner, posing an unnecessary hazard to workers in surrounding areas.	41-43
PGDP-INV-99-10	Safety and health procedures are not consistently applied and followed, and in some cases, hazards are not adequately addressed by those procedures.	43-44
PGDP-INV-99-11	Bechtel Jacobs has not assured that subcontracted medical personnel are sufficiently involved in the identification, evaluation, and integration of workplace hazards to ensure effective worker medical programs.	44
PGDP-INV-99-12	Bechtel Jacobs training programs do not ensure that all workers are knowledgeable of hazards and protection requirements, including those associated with transuranic contamination.	44-45
PGDP-INV-99-13	DOE has not conducted effective oversight of ES&H or ensured that Bechtel Jacobs and its subcontractors effectively implement all DOE and regulatory requirements.	46-47
PGDP-INV-99-14	Bechtel Jacobs has not conducted fully effective oversight of ES&H performance or ensured that its subcontractors effectively implement all DOE and regulatory requirements and are held accountable.	47-48

APPENDIX B
CHARACTERIZATION OF SELECTED SOLID WASTE MANAGEMENT UNITS

Table B-1 provides a characterization of selected SWMUs at PGDP as they were understood in the early 1990s. Information in the table was obtained from "Results of the Site Investigation, Phase II at the Paducah Gaseous Diffusion Plant," KY/ER-4, Volume 2 of 6, April 1992. SWMUs presented in the table are those units for which quantitative sampling information on either radioactive or hazardous materials was provided in the reference document.

Table B-1. Characterization of Selected PDGP Solid Waste Management Units from 1990[1]

Number & Location	Areal Extent	Period of Operation	Sampling Data	Comments
SWMU 1: C-747C Oil Landfarm	96,300 ft^2	1975-1979	Phase I: TCE – 190 μg/kg Aroclor 1242 and 1254 – 1,400 μg/kg Semivolatile organics – 1,800 μg/kg PCBs – range from 25-10,000 ppm Tc-99 – 2.36J ± 8.7 pCi/g U-234, U-238 – 15.7J ±1.28 pCi/g	At least 5,000 gallons of waste oil were applied to the landfarm. Periodically, lime and fertilizer were applied to the area, and the surface was replowed.
SWMU 2: C-749 Uranium Burial Ground	32,000 ft^2	1951-1977	270 tons of uranium 59,000 gallons of oils 450 gallons of TCE Phase I well data near Burial Ground: Tc-99 – 747J pCi/g U-234 – 1,860J pCi/g U-238 – 3,333J pCi/g	Burial ground included pyrophoric forms of U metal. Only 4 of 15 (30-gallon) drums with TCE were recovered.
SWMU 3: C-404 Low-Level Waste Radioactive Waste Burial Ground	53,200 ft^2	1951-1986	Phase I: Tc-99 – 2,175 pCi/g TCE – 210 μg/L	Most Tc-99 was released from the C-400 facility to the C-404 facility. The upper tier of waste includes 450 drums with Cd, Se, and Pb.
SWMU 5: C-746F Classified Burial Yard	168,000 ft^2	1965 – present	Phase I: Benzene – 980J μg/kg TCE – 9 μg/kg	
SWMU 7: C-747A Burial Ground	7 areas ranging from 1,500 ft^2 to 19,250 ft^2 , with an overall total of 53,650 ft^2	1957-1979	Phase I: TCE – 6,100 and 5,300 μg/L Tc-99 – 3,195 and 2,830 pCi/L Phase I Deep Borings: Tc-99 – 72.7 pCi/g Aroclor 1254 – 730 μg/kg Aroclor 1260 – 26μg/kg	No record of TCE disposal, although Well 66 has the highest concentrations of any onsite or offsite wells. Burial ground contains uranium-contaminated material from C-410 Feed Plant and uranium powder scrap from C-340 facility.
SWMU 9: C-746S Residential Landfill	6 cells occupying 700,000 ft^2	1982 – present	Phase I: TCE – 21 μg/L Tc-99 – 83 pCi/L	Landfill is a potential offsite contamination source.
SWMU 11: C-400 Trichloroethene Leak Site	4,200 ft^2	Storm sewer received TCE from early 1950s to June 1986 from C-400 Cleaning Building	1986 samples from excavation: TCE – 7,000 mg/kg Phase I: TCE – 33 μg/L Tc-99 – 177J pCi/g Phase I Deep Boring: TCE – 220 μg/kg	In 1986, 310 ft^3 of contaminated soil was removed containing 150 pounds of TCE. Some contaminated soil was left in and around C-400 Cleaning Building for structural reasons. Deep boring identified detectable concentrations to the base of the Regional Gravel Aquifer.

[1] Information obtained from "Results of the Site Investigation, Phase II at the Paducah Gaseous Diffusion Plant," KY/ER-4, Volume 2 of 6, April 1992. SWMUs presented in the table are those for which quantitative sampling information on either radioactive or hazardous materials was provided in the reference document. The symbol "J" indicates an estimated, measured value.

Number & Location	Areal Extent	Period of Operation	Sampling Data	Comments
SWMU 17: C-616E Sludge Lagoon	Impoundment of 215,000 ft²	1979 – present	Phase I: Tc-99 – 4.9 pCi/L Phase I Deep Borings: TCE, chloroform, and chloromethane – 1.0J to 34 μg/L Gross beta, Tc-99, U-238, Pu-239 – 0.05 ± 0.05 to 16 ± 1.7 pCi/g	The lagoon is located north of Plant security fence. The lagoon sludge also contains chromium.
SWMU 18: C-616F Full Flow Lagoon	N/A	1977 – present	Phase I: TCE – 22 μg/L Tc-99 – 76 pCi/L Phase I Deep Borings: Toluene, TCE, chloroform, and chloromethane – 1.0J to 34 ug/l Gross beta, Tc-99, U-238, Pu-239 – 0.05 ± 0.05 to 16 ± 1.7 pCi/g	The lagoon is located north of the Plant security fence. The lagoon receives much of the Tc-99 discharged from the Plant. The lagoon overflows to Big Bayou Creek through Outfall 001.
SWMU 20: Emergency Holding Pond	Below grade impoundment of 600 ft²	1950s – present	Phase I samples from sludge: Tc-99 – 56 pCi/g Total Uranium – 381.8 pCi/g Np-237 – 1.2 pCi/g Nickel – 201,600 μg/L, TCLP extract PCBs – 3,000 μg/kg	It is reported that the unit never received TCE, Tc-99, or PCBs.
SWMU 30: C-747A Burn Area	128,000 ft²	1951-1970	Phase I – from Well 66: TCE – 5,300 μg/L Tc-99 – 2,830 pCi/g Phase I Deep Boring: Aroclors 1254 – 120 μg/kg Aroclors 1260 – 26 μg/kg	Ash and burned material were buried when the incinerator was closed. Much lower concentrations of TCE and Tc-99 were obtained during Phase I sampling from Wells 63, 64, and 65 that are all located west of the unit.
SWMU 33: C-727 Motor Cleaning Facility	N/A	1957 – present	Phase I Shallow Borings: PCBs – 66,000 μg/kg Dioxins/furans – 3.29J μg/kg VOCs (e.g., benzene, ethylbenzene, and xylenes) – 210 μg/kg	Process for cleaning changed in 1975 from dipping in mineral spirits to steam cleaning.
SWMU 40: C-403 Neutralization Tank	N/A	1950s – present	Approximately 3,200 Ci of Tc-99 were discharged at a controlled rate from the Plant to surface waters, primarily from C-400 effluents and, therefore, potentially through C-403.	C-403 receives effluents from C-400 Cleaning Building and discharges to North/South Diversion Ditch, where it is directed to the C-616-F Full Flow Lagoon. C-616 discharges to Big Bayou Creek through Outfall 001.
SWMU 47: C-400 Technetium Storage Tank Area	4,000 gallons	1960s – 1986 when the tank was removed	1986 samples in and around tank: Tc-99 – 0.5 ppm in soil, 0.08 ppm in concrete Chromium – 10.1 ppm in soil, 17.2 ppm in concrete Uranium – 165 ppm in soil, in concrete	No spills of Tc-99 were 28 ppm were documented.
SWMUs 58-69: Effluent Ditches and Little and Big Bayou Creeks	The two creeks follow along the western and eastern sides of the Plant, respectively, and empty into the Ohio River.	N/A	Phase I; Evidence of transuranic, Tc-99, PCB, and organic compound contamination in sediments and surface water. Subsequent assessment indicated risk from exposure to creek sediments.	Reaches with contaminated soils and sediments include: the North/South Diversion Ditch from the Plant to Little Bayou Creek (10,000 ft), Little Bayou Creek from Plant Outfall 011 to the North/South Diversion Ditch (16,000 ft), and Big Bayou Creek from Plant Outfall 009 to New Water Line Road (3,000 ft).

Number & Location	Areal Extent	Period of Operation	Sampling Data	Comments
SWMU 74: PCB Spill Site	N/A	Spills occurred from 1950s to early 1970s	Phase I: Aroclor 1260 – 2,974.8 μg/kg Dioxins – 16 μg/kg Gross beta – 38.5 ± 2.1 pCi/g	Exact release dates are unknown.
SWMU 75: PCB Spill Site	N/A	Spills occurred from 1950s to early 1970s	Phase I: Aroclor 1254 and 1260 – 770 μg/kg Dioxins/furans – 230 μg/kg	Exact release dates are unknown.
SWMU 79: PCB Spill Site	N/A	Spills occurred from 1950s to early 1970s	Phase I: Aroclor 1260 – 12,000 μg/kg Dioxin (OCDD) – 8.69J μg/kg Organics – 80J μg/kg Tc-99 – 1.0J pCi/g Pu-239 – 0.36 ± 0.17 pCi/g	Exact release dates are unknown.
SWMU 80: PCB Spill Site	N/A	Spills occurred from 1950s to early 1970s	Phase I: Aroclor 1260 – 150,000 μg/kg Dioxins – 37.2 μg/kg OCDD – 8.3 ug/kg Tc-99 – 1.9J ± 0.2 pCi/g	Exact release dates are unknown.
SWMU 81: PCB Spill Site	N/A	Spills occurred from 1950s to early 1970s	Phase I: Aroclor 1260 – 17,417 μg/kg Dioxins – 12.63J μg/kg OCDD – 170 μg/kg	Exact release dates are unknown.
SWMU 82: Electrical Switchyard	N/A	1951 – present	Phase I: Aroclor 1260 < 112.9 μg/kg OCDD < 7.51 μg/kg Gross beta – 21.7 ± 1.9 pCi/g	Pre-RCRA, TCE was dumped on the ground when cleaning operations were finished. Several hundred gallons were used annually. PCB contamination also found.
SWMU 83: Electrical Switchyard	N/A	1951 – present	Phase I: Aroclor 1260 < 570 μg/kg	Pre-RCRA, TCE was dumped on the ground when cleaning operations were finished. Several hundred gallons were used annually. PCB contamination was found.
SWMU 84: Electrical Switchyard	N/A	1953 – present	Phase I: Aroclor 1260 < 63 μg/kg	Pre-RCRA, TCE was dumped on the ground when cleaning operations were finished. Several hundred gallons were used annually.
SWMU 85: Electrical Switchyard	N/A	1951 – present	Phase I Chloromethane – 480J μg/kg Total xylenes – 250J μg/kg	Pre-RCRA, TCE was dumped on the ground when cleaning operations were finished. Several hundred gallons were used annually.
SWMU 91: UF_6 Cylinder Drop Test Area	N/A	1979	Phase I Deep Boring: TCE – present to 24 feet bls in concentrations up to 260 μg/kg	TCE was typically left in pit for days prior to pumping.
SWMUs 94 and 95: Old Kentucky Ordnance Works	N/A	1942 – 1946	1988 leach field samples, SWMU 94: PAH – 131 to 1,040 μg/kg	
SWMU 138: C-100 South Side Lawn	N/A	See comments	No samples identified as having been taken for SWMU 138; however, historic analyses of the SWMU 38 sludge (one of two sources of the sludge) reported the presence of PCBs and uranium.	Receives sludge from the C-611 Water Treatment Plant and the C-615 Sewage Disposal Plant (SWMU 38). Sludge applied directly to lawn as fertilizer. C-615 sludge contained PCBs and uranium.

APPENDIX C
TEAM COMPOSITION

To reflect the investigation team's overall mission of assessing the impact of current DOE activities on worker safety, public safety, and environmental protection, the investigation activities of the team are organized into three groups – management and worker safety, environmental management, and radiation protection. Each group is composed of a group leader and individual members with relevant expertise. Each group developed lines of inquiry that guided the evaluation scope of interest for that group. The specific activities of the investigation team are discussed in Section 1.4.

The team composition and areas of responsibility are shown below.

Senior Manager

S. David Stadler, Ph.D.

Team Leader

Patricia Worthington, Ph.D.

Management and Worker Safety Group

Brad Davy - Group Leader
Marvin Mielke, RN
Bob Freeman
Regina Griego
Bill McArthur, Ph.D., CIH
Jerry McKamy, Ph.D.
Al Gibson**
Jim Lockridge, PE, CIH, CSP**
Mark Good**

Environmental Management Group

Bill Eckroade, REM – Group Leader
Vic Crawford, PE, REM
Arlene Weiner, REM**
Thomas Naymik, Ph.D., CPG, RG**
Chris Perry, CPG**
Mario Vigliani, CHP**

Radiation Protection Group

Ed Blackwood – Group Leader
Robert Loesch, RRPT
Bill Cooper, CSP
Pete O'Connell, CHP

Communications and Support

Mary Anne Sirk
Barbara Harshman
Bob McCallum
Marcia Taylor
Kathy Moore

Quality Review Board

S. David Stadler
Raymond Hardwick
Thomas Staker
Tom Davis

RN	Registered Nurse
CIH	Certified Industrial Hygienist
CSP	Certified Safety Professional
REM	Registered Environmental Manager
PE	Professional Engineer
CPG	Certified Professional Geologist
RG	Registered Geologist
CHP	Certified Health Physicist
RRPT	Registered Radiation Protection Technologist

** Technical Advisor

Abbreviations Used in This Report

ALARA	**As Low As Reasonably Achievable**
CERCLA	**Comprehensive Environmental Response, Compensation, and Liability Act**
CFR	**Code of Federal Regulations**
DCG	**Derived Concentration Guidelines**
DHHS	**U.S. Department of Health and Human Services**
DMSA	**DOE Material Storage Area**
DNFSB	**Defense Nuclear Facilities Safety Board**
DOE	**U.S. Department of Energy**
EPA	**Environmental Protection Agency**
ES&H	**Environment, Safety, and Health**
MCL	**Maximum Contaminant Level**
MMES	**Martin Marietta Energy Systems**
NRC	**Nuclear Regulatory Commission**
OR	**Oak Ridge Operations Office**
ORNL	**Oak Ridge National Laboratory**
OSHA	**Occupational Safety and Health Administration**
PACE	**Paper, Allied-Industrial, Chemical, and Energy (Workers)**
PCB	**Polychlorinated Biphenyl**
PGDP	**Paducah Gaseous Diffusion Plant**
ppb	**Parts Per Billion**
RCRA	**Resource Conservation and Recovery Act**
RWP	**Radiological Work Permit**
SSAB	**Site Specific Advisory Board**
SWMU	**Solid Waste Management Unit**
TCE	**Trichloroethene**
TVA	**Tennessee Valley Authority**
USEC	**United States Enrichment Corporation**