Executive Summary

EVALUATION:	Office of Oversight Investigation—Phase II
SITE:	Paducah Gaseous Diffusion Plant
DATES:	October-November 1999

Background/Scope

In August 1999, in response to environment, safety, and health (ES&H) allegations and subsequent worker and public concerns, the Secretary of Energy initiated an independent investigation at the Paducah Gaseous Diffusion Plant (PGDP or Plant). These ES&H allegations and concerns included inadequate controls for workers exposed to uranium and transuranic elements, ineffective communication of hazards and radiation exposures to workers, and improper release, dumping, or burial of radioactive and other hazardous materials at unapproved onsite and offsite locations. This investigation was divided into two phases: first, to provide timely information on the status of current operations, and second, to perform a more lengthy investigation of historical operations.

The first phase of the investigation concentrated on the period 1990 to the present and included the current facilities, areas, operations, and activities that are the responsibility of the Department of Energy (DOE) and its current management and integrating contractor. Operations controlled by the United States Enrichment Corporation (USEC) were not evaluated. A report was published in October 1999. Immediate actions were initiated to address issues regarding inadequate posting (i.e., identification) of radiological hazards both on and off DOE property. More detailed, comprehensive, and long-term corrective action plans are currently being developed to address the more complex ES&H program weaknesses identified in the Phase I investigation.

The second phase of this investigation addressed historical conditions and activities from startup of the Plant in 1952 until 1990. In his testimony to Congress prior to the start of this Phase II investigation, Dr. David Michaels, Assistant Secretary for Environment, Safety and Health, stated, "We need to determine how well the workers knew of and understood the hazards they were working with, and how well they were protected from these hazards – even in very small amounts. We will learn much more as our investigation moves ahead and seeks to confirm – in today's regulatory environment – whether the presence of these materials represented a potential health risk at Paducah or any other DOE plant." The Phase II investigation focused on:

- Identifying the concerns and questions of current and former workers and their level of understanding of site hazards and ES&H practices
- Understanding the operations, activities, conditions, and hazards in the workplace
- Identifying the management practices and controls employed and the applicable standards and regulations
- Determining where management practices and controls may not have been effective in protecting workers, the public, or the environment.

A vast amount of information was collected and analyzed to accomplish these objectives. To better understand the various site operations and conditions, the investigation team interviewed hundreds of current and former workers and managers, reviewed thousands of historical records and documents, toured workplaces, and performed limited walk-over surveys of possible disposal sites. The team examined dozens of events, about 40 separate major operations and activities, and related ES&H practices.

The intent of this investigation was to identify and address the overall ES&H concerns and questions of current and former workers and the public, not to determine the validity of specific

allegations. Several ongoing or proposed initiatives of the DOE Office of Environment, Safety and Health should provide greater understanding of certain aspects of these issues:

- The mass balance project will recreate the historical flow of recycled uranium and its contaminants across the DOE complex.
- The medical surveillance project will determine the presence and prevalence of adverse worker health effects from employment at gaseous diffusion plants.
- The exposure assessment project will determine how workers at the gaseous diffusion plants were exposed to radiation, to how much, and from what source.

Determining any long-term effects on employee health from working conditions and management practices at the PGDP will require study that is beyond the scope and resources of this investigation. Similarly, detailed examination of any work that PGDP might have performed for others in relation to weapons systems as well as the effectiveness of any associated ES&H practices was not part of the investigation.

Results

Certain external conditions and influences had a significant effect on the ES&H-related behavior and intentions of both management and workers at the PGDP during the 1952-1990 period. When the PGDP started operation, World War II had recently ended, the country was involved in a major conflict in Korea, and the Cold War was a reality. Many of the workers were military veterans. The work being done was classified, involved high technology, and was important to the national defense. The "need to know" was an ingrained security policy that had a major effect on attitudes toward sensitive operations and materials at the PGDP. The Plant was the biggest employer in the region, paying wages significantly higher than previously available in this rural farming area; people in Paducah and the surrounding area wanted these jobs. Management and the Atomic Energy Commission (AEC) were under pressure to maximize production. Workers in this environment were not inclined to ask many questions. While most of the hundreds of workers interviewed by the team indicated, in response to specific questioning, that they were unafraid to ask questions about safety and they had no fear of reprisals, a few interviewees did express concerns about both. Further, industries in the 1950s, including AEC facilities, were largely self-regulated, and guidance and regulatory requirements were minimal and evolving. Significant industrial and environmental legislation that would focus attention and actions toward greater protection of workers and the environment was not enacted until the 1970s.

During the period 1952 to the early 1980s, oversight by the governing Federal agencies—AEC, the Energy Research and Development Administration (ERDA), and DOE—was primarily directed at cost, schedule, and production, not ES&H. A March 1960 letter revealed that AEC and contractor management, including the PGDP Health Physics and Hygiene Department, were aware of the potential hazards presented by transuranic elements contained in the feed material the Plant received from Hanford reactor tails and the workers' lack of compliance with respiratory protection measures. The document stated that 300 persons at Paducah "should be checked out," but that management was hesitant to study the issue intensively for fear that the labor union would demand hazard pay.

Health and safety programs were always in place and functioning at PGDP, with a strong emphasis on industrial safety. Policies, procedures, and training were provided that addressed hazards in the workplace and specified recommended personnel protection and controls. Safety meetings were frequent, and job hazard analyses that described hazards and controls were soon developed for most work activities. The Health Physics and Hygiene Department, although minimally staffed for most of the 38 years covered in this investigation, was active in studying hazards and health effects, analyzing air monitoring results, surveying work areas, and recommending engineering and administrative controls for identified hazards. Fixed and portable ventilation and vacuum systems were installed in some areas to control workers' exposure to radiation and chemicals as well as the spread of contamination. Safety glasses, gloves, and hearing protection were made available to workers, and for certain work activities, the company supplied coveralls, shoes, caps, undergarments, and respiratory protection equipment. By 1960, all personnel exposures to radiation were monitored using film badges and, for targeted workgroups, bioassay techniques, including scheduled and event-driven urinalysis and lung counting. Workers showing high uranium excretion rates were removed from high exposure work. Workers who were excreting uranium over threshold limits were put on a recall urinalysis program until their excretion rates fell to baseline levels, usually within hours or days. Exposures to fluorides were also monitored through the urinalysis program.

Radiological and chemical hazards and exposure risks to personnel were much higher in certain work locations and activities at the Plant than in others. Significant external and internal exposure to concentrated transuranics was possible in handling feed production ash and in uranium, neptunium, and technetium recovery operations. Feed plant operations presented high exposures to airborne UO_3, UF_4, and to HF. Exposure to airborne UF_4, magnesium powder, uranium oxides, and HF was possible in the metals plant. Maintenance and modification activities involved potential airborne and point source exposures to UF_6, HF, UO_2F_2, transuranics, and uranium daughter products in many locations; these activities included bag house filter changeouts, converter modification work, and compressor and seal disassembly repair and replacement. Workers performing decontamination and cleaning operations in Building C-400 had significant exposures to trichloroethene (TCE) in addition to radioactivity.

Although the intent to protect workers from hazards was apparent, the protection programs were not always conservative or consistent. Air emissions, liquid effluents, and solid waste disposal were consistent with practices in general industry and the DOE complex at the time (e.g., dilution, burial, and burning) but resulted in significant adverse impacts on the environment. The following sections summarize the conditions, practices, and consequences in key ES&H areas.

Radiological Protection

The risks and hazards of exposure to uranium and transuranics were neither fully understood nor appreciated. PGDP considered that intakes of uranium were from soluble compounds and would be quickly excreted through the kidneys. This assumption may not have been accurate for all uranium compounds at the Plant, particularly aerosols generated in the feed plant and during maintenance operations such as grinding, buffing, or welding. The comfort level of PGDP technical staff regarding exposure to uranium is reflected in a research experiment, conducted in the late 1950s, where Health Physics and Hygiene staff members voluntarily inhaled and ingested known quantities of uranium compounds to measure excretion rates. In addition, in 1956, test subjects at the Plant, wearing different types of respirators, were exposed to several known concentrations of airborne uranium compounds to determine subsequent excretion rates.

External exposures were monitored using film badges. However, extremity dosimetry was not employed, even though requirements dating from the late 1950s mandated that such monitoring be conducted when the potential exposure could exceed 10 percent of the extremity limit. Over the 38 years of operations, only two exposures over regulatory limits were documented. However, due to high concentrations and variable dose rates in certain areas of the Plant, workers in these areas may have received significant unmonitored exposures to hands and feet during some operations. The concept of keeping exposures as low as reasonably achievable (ALARA) was, in various forms, AEC/ERDA/DOE policy. However, PGDP policies and practices focused on preventing personnel exposures from exceeding Federal Radiation Protection Guidelines, rather than keeping them as low as reasonably achievable.

Contamination controls at Paducah were limited, even into the early 1980s. Eating, drinking, and smoking in contaminated work areas was common practice. Although personnel wearing company clothing typically showered before changing into their personal clothes and leaving the site, the practice was not mandatory, and workers were not required to wash their hands and other exposed skin, or remove contaminated clothing, before entering cafeterias, break areas, and even the main site meeting area in the C-100 "Roxie theatre." Friskers and whole body monitors were not employed until the mid-1980s. As a result, Plant workers probably took radioactive contamination outside site boundaries.

As early as 1957, the site became aware of the presence of transuranic elements (those with atomic numbers higher than uranium) and fission products in feed materials processed from spent reactor fuel at the Hanford and Savannah River Sites. Transuranics and fission products have a much higher specific activity than uranium and resulted in much higher dose to some workers. These materials were a concern where they were concentrated, such as in the "heels" remaining in empty UF_6 cylinders and in the uranium, technetium, and neptunium recovery processes, or where there was airborne exposure such as reactor tails feed material ash in the feed plant, metals production, and maintenance/modification activities. However, the presence of these materials, the increased risks involved, and the rationale for additional controls were not shared with workers. Workers' incomplete awareness of these hazards contributed to and fostered inconsistent compliance with recommended protective measures.

Initial comprehensive operations training programs, which included radiation theory and control, quickly declined in scope and frequency as resources and attention focused on production. Information concerning workplace radiation and chemical hazards and protective measures was subsequently

communicated primarily through informal on-the-job training, passed from experienced workers to new ones. Although exposure history information was collected from monitoring film badges, bioassays, and lung counts, it was not openly communicated, nor was its meaning explained to workers unless requested.

The Health Physics and Hygiene Department provided monitoring, investigation of elevated intakes and air samples, and recommendations for radiological controls. However, line management had ultimate responsibility for implementing radiation protection measures. In many cases, recommendations for controls or improved protection were the result of high exposures or sample readings, rather than conservative, proactive planning. Workers' compliance with recommended controls (engineering, procedural, and personal protective equipment or PPE) and management's enforcement of compliance were inconsistent. In many areas, individual workers or supervisors decided whether recommended PPE would be used, and early masks and respirators did not fit well, hindering vision in work environments. The inconsistent use of respirators was especially important because they were heavily relied on to minimize workers' inhalation of radioactive materials.

Chemical Hazard Exposure

Acute and chronic exposures to a number of hazardous chemicals used at the Plant were frequent occurrences, and the risks and long-term health effects of such exposures were not fully recognized by the Health Physics and Hygiene Department and consequently, by the workers. Exposures to polychlorinated biphenyls (PCBs), TCE, fungicides used on the cooling towers, and asbestos did not result in apparent, immediate health effects, nor was there recognition of adverse long-term health effects. National standards related to exposure to these materials did not appear until the 1970s or 1980s. An asbestos screening program for asbestos workers was initiated by the Oil, Chemical & Atomic Workers International Union in the mid-1980s. Exposures to caustic HF resulted in frequent burns and respiratory injury. The effects of these exposures were believed to be temporary only, when, in fact, there may be long-term consequences.

Airborne Emissions

Radioactive and fluorine emissions to the atmosphere from stacks, diffuse and fugitive emissions, accidents, and a small number of planned releases have occurred since Plant startup in 1952. Stack emissions were not monitored until the mid-1970s; process knowledge was used to estimate potential releases before then. Published reports estimated that approximately 60,000 kilograms of uranium were released to the atmosphere from 1952 to 1990, 75 percent of it before 1965. There is evidence that past estimates did not include all process gas releases, diffuse emissions, accidental releases, and unauthorized process gas venting. Consequently, the accuracy and conservatism of past public dose estimates are questionable.

Liquid Effluents

Liquid effluents from past operations have had a significant adverse impact on the environmental quality of onsite ditches and streams and groundwater sources in the vicinity of the site. Uranium, thorium, TCE, and small quantities of transuranics and fission products have been released to the environment, primarily from cleaning and decontamination in Building C-400. Significant amounts of chromates and fluorides were released to the environment, as approximately 500,000 gallons of recirculating cooling tower blowdown water were pumped into Little Bayou Creek every day. From the beginning of Plant operations, liquid effluent control was based on dilution, with the objective of ensuring no unacceptable impact on the Ohio River; there was much less concern about onsite and local waterways and groundwater. As a result of increasing regulatory requirements and an increased sensitivity to environmental protection, significant efforts were undertaken in the 1970s that improved the quality of area surface waters.

Waste Disposal

Radioactive and chemically hazardous materials were dumped and buried in numerous locations both inside and outside the site fence. Hazardous and radioactively contaminated materials were often mixed with normal trash and waste materials, and waste disposal was not well monitored, controlled, or documented. Large quantities of radioactive materials, including uranium metals and powders and contaminated waste, were packed in metal barrels and buried. Contaminated empty barrels remain piled in "Drum Mountain." Contaminated concrete rubble and roofing materials were disposed outside the Plant boundaries, some in wildlife areas where public use

and access were authorized and encouraged. Contaminated sludge and floor sweepings were placed in landfills, and the sludge was applied to Plant lawns as fertilizer. Rainfall runoff and leaching have moved contaminants from the disposal sites into the surrounding environment. Federal environmental regulations were enacted in the 1970s, and the Material Terminal Management organization, established in the early 1980s, implemented an integrated waste management program that reduced the amount of radioactive waste disposed of on site and achieved greater control over waste segregation and disposal.

Summary

External conditions significantly affected the policies, practices, and performance of PGDP management (both the Federal owners and the contractors) and workers during the first 38 years of Plant operation. To put PGDP conditions and activities into perspective, it must be considered that almost 50 years ago there was a significantly smaller body of knowledge about radiation, chemical, and other industrial hazards and their effects on humans and the environment. While evidence reviewed indicates that managers were concerned with the safety and health of workers, management decisions and practices were not always conservative. Consequently, worker radiation exposures were higher than necessary, and some workers may have been exposed to hazards that were not adequately monitored or understood. Communication of hazards, the rationale for protective measures, and information about radiation exposure were inadequate. Further, workers were exposed to various chemical hazards for which adverse health effects had not yet been identified. Environmental practices prior to Federal and state legislation in the 1970s and 1980s resulted in many adverse impacts to the environment, both on and off Federal property.