DOE/EA-0155

FINAL ENVIRONMENTAL IMPACT ASSESSMENT

of the

PADUCAH GASEOUS DIFFUSION PLANT SITE,
PADUCAH, KENTUCKY

to

UNION CARBIDE CORPORATION
NUCLEAR DIVISION
PADUCAH, KENTUCKY

and

U. S. DEPARTMENT OF ENERGY
OAK RIDGE OPERATIONS
OAK RIDGE, TENNESSEE

August, 1982

CONTENTS

Page

Page

Page

Page

LIST OF FIGURES

LIST OF TABLES

1. SUMMARY

1.1 INTRODUCTION

The Paducah Gaseous Diffusion Plant has been operating since 1955 enriching uranium for national defense and commercial nuclear reactors. Light water nuclear reactors are fueled with uranium containing from 2 to 4% uranium ^{235}U isotope. Since naturally occurring uranium contains only 0.7% ^{235}U, the uranium must be processed to enrich it in the ^{235}U isotope. In the United States that enrichment is gained in the gaseous diffusion process. Three plants in the United States employ that process. In addition to the Paducah plant at Paducah, Kentucky, gaseous diffusion plants are located at Oak Ridge, Tennessee, and Portsmouth, Ohio. The operation of the Paducah plant is the subject of this document.

1.2 BACKGROUND AND DESCRIPTION

1.2.1 Need for uranium enrichment facilities

The predominant need for enriched uranium is for fuels for commercial nuclear power reactors. The reactors currently in operation provide about 11% of the nation's electrical energy. The gaseous diffusion plants, to supply enriched uranium to the growing commercial nuclear industry, have a combined capacity of approximately 27.3 million separative work units (SWU) per year. The Paducah plant alone has a capacity of 9 million SWU/yr and is an integral part of the enrichment system, supplying slightly enriched uranium to the other two plants.

1.2.2 Site location

The Paducah Gaseous Diffusion Plant is located in McCracken County, Kentucky, near the town of Paducah, on a 3425-acre (1385-ha) Federally owned reservation. Four criteria initially were used in site selection: (1) supply of low cost power, (2) water supply, (3) supporting population (4) availability of government-owned land. Additionally, the probabilities of natural disasters at the site are low.

1.2.3 Paducah Gaseous Diffusion Plant (PGDP) Description

The first gaseous diffusion plant was built and operated in Oak Ridge, Tennessee. When plans for another diffusion plant were formulated in 1950 to meet the increased demand for ^{235}U, the Paducah, Kentucky, site was chosen in order to provide some dispersal of the diffusion plants.

The Paducah plant was designed and constructed to operate in conjunction with the Oak Ridge plant. The original design consisted of 880 stages in two process buildings, C-331 and C-333. Because of Atomic Energy Commission projections for the need for more enrichment capacity, plans were made in 1951 for 880 additional stages in two additional buildings, C-335 and C-337, to be operated in a parallel type arrangement and essentially double the capacity of the original plant. Plant construction was completed in 1954. Enrichment capacity was further expanded through the Cascade Improvement and Cascade Uprating Programs (CIP/CUP) which were started in 1971 and 1974, respectively. The plant gross book value was listed as $791 million in January, 1972. The completed CIP/CUP has significantly increased the book value. The Paducah cascade consists of 1760 stages in buildings covering approximately 74 acres (30 ha).

The Paducah cascade enriches uranium to a product ^{235}U concentration of 1 to 2%. The depleted stream is stripped to a tails ^{235}U concentration of from 0.2 to 0.35% depending upon process optimization and DOE requirements. The product of the Paducah cascade is used to feed the Oak Ridge and Portsmouth plants. Although the Paducah cascade could be operated to produce ^{235}U enrichments needed for most civilian nuclear power plants, diffusion plant complex optimization calls for combined operations.

The 1976 labor force was approximately 2300 employees. However, with the completion of the CIP/CUP, the labor force is expected to decline to about 1600 persons needed to maintain and operate the plant in the uprated conditions.

1.2.4 Description of power generating facilities

Electrical power for the PGDP is supplied by the Joppa Steam Electric Plant owned by Electric Energy, Incorporated and by the Tennessee Valley Authority (TVA). The Joppa facility is located directly across the river from the PGDP near Metropolis, Illinois. The Joppa Plant uses Ohio River water for once-through cooling. Coal is delivered by river barge and rail transport.

The Joppa Plant consists of six units rated at 181 MW each. Ash is disposed of in storage ponds with a portion of the flyash being transported to a cement plant for use as raw material or additive. Flue gas is treated in electrostatic precipitators.

The large TVA power network will not be treated in this assessment.

1.3 EXISTING ENVIRONMENT

1.3.1 Paducah Gaseous Diffusion Plant

The Paducah Gaseous Diffusion Plant is located on a 3,425-acre (1385-ha) site in a generally rural area of McCracken County, Kentucky. The climate is characteristic of the humid continental zone where summers are warm and winters are moderately cold. Soils of the site are predominantly silt loams, poorly drained, acidic, with little organic content. The area is low in relief with small, scattered forested areas of upland and riparian hardwoods surrounded by agricultural lands. Much of the plant property is leased by the West Kentucky Wildlife Management Area which employs practices to maintain suitable wildlife habitat and food supply. The area is drained by, and plant discharges flow into, two small tributaries to the Ohio River, Big and Little Bayou Creeks.

1.3.2 Joppa, Illinois, power generating facility

The Joppa Steam Electric Plant is located on a 625-acre (253-ha) site on the north bank of the Ohio River near Joppa, Illinois, approximately 13 mi (21 km) northwest of PGDP. Ecological conditions and land use are very similar to those found at the PGDP site with the exception that the area is not managed for wildlife. The area is drained by the Ohio River and two small unnamed tributaries, which receive plant site runoff.

1.4 ENVIRONMENTAL IMPACTS OF CONTINUING OPERATIONS

1.4.1 Environmental impacts from the Paducah Gaseous Diffusion Plant

Aquatic communities in Big Bayou and Little Bayou Creeks have been adversely impacted by PGDP discharges resulting in alteration of standing crops and number of species of algae, benthic macroinvertebrates, and fish. Levels of residual chlorine in Big Bayou Creek immediately below the sewage treatment outfall frequently exceed concentrations toxic to aquatic life. These impacts will be mitigated by relocation of the outfall. Levels of chromium also occasionally were in excess of recommended criteria in Little Bayou Creek. Much of the chromium problem was eliminated by a new chromate reduction facility. Control of cooling tower losses resulting from windage will further reduce chromium emissions.

Operation of the plant has resulted in accumulations of radioactive nuclides in the creek sediments. Levels of radioactivity in fish tissue are slightly higher in fishes from streams receiving plant discharges than in those from the reference stream. Levels at present are insufficient to cause harm to the organisms and do not exceed limits for human consumption.

There is no anticipated impact on downstream Ohio River water users from PGDP discharges. Thermal alteration caused by cooling tower discharges is minimal; the plant easily complies with existing standards.

Essentially all deposition of cooling tower drift occurs within a 1-mi (1.6-km) radius of the cooling tower. No vegetation damage was observed and no excessive deposition of trace contaminants (i.e., zinc, chromate, sulfate) was observed outside the plant boundary.

Very little off-site fogging and icing have been observed in recent years from operation of the existing PGDP cooling towers. Conservative estimates of fogging and icing are generally below 12.5 and 15 hrs/yr, respectively, at 2400 MW. Aesthetic impacts of the tower plumes are minor because of the low population density of the area immediately surrounding the plant. Current projections indicate that the plant operating power level will not exceed 2400 MW in the foreseeable future.

On various occasions in the past, fluoride concentrations in air samples at the PGDP property boundary exceeded Kentucky standards. These occurrences were infrequent and of such low concentrations as to have caused no visible fluoride damage to vegetation. No sample has exceeded Kentucky standards since UF_6 manufacturing plant ceased operation in 1977. If the plant is restarted mitigating actions will be taken to meet the standards.

No negative impacts associated with noise resulting from plant operations were identified.

1.4.2 Environmental impacts from the Joppa, Illinois, power generating facility

The heated water effluent from the Joppa plant is discharged directly to the Ohio River. Thermal alteration to the river is minimal; the plant easily complies with existing standards. The thermal plume follows the shoreline. There is no blockage or impedence of fish movement. Overall water supply impacts are not anticipated.

Impingement and entrainment investigations report 8.7×10^3 lb (3.9×10^3 kg) of fish entrained on intake screens, and 1.17×10^9 larval fish and eggs entrained in intake water, per year. It is estimated that these removals do not significantly diminish the fish community of this section of the Ohio River.

The plant has completed construction of three 550-ft (168-m) stacks to comply with Illinois statutes. With the completion of the stacks, it is estimated that concentrations of SO_2 and particulates will be well within air quality standards.

A potential, which will be greatly reduced by the new stacks, exists for accumulation of toxic trace elements in biota from deposition, inhalation, or ingestion of toxic trace elements present in the plant plume. The existence and/or extent of these effects is only speculative in the absence of a trace element study of the site.

Fumigation incidents resulting in crop damage have occurred in the past. Implementation of the new stacks should reduce ground level concentrations to less than toxic levels.

1.4.3 Cumulative and long-term impacts

1.4.3.1 Cumulative and long-term impacts of power generation

No significant cumulative effects are anticipated as a result of continued power generating operations at Joppa.

Long-term effects, minor in nature, may result from addition of metal oxides, silicates, and carbonates in ash disposal area runoff and settling pond discharge and leachate to the Ohio River.

1.4.3.2 Cumulative and long-term impacts of continued operation of the Paducah Gaseous Diffusion Plant

Concentrations of salts and trace elements in cooling tower drift deposition have not reached toxic levels to vegetation during 25 years of operation. Impacts, if any, would be restricted to an area inside a 1-mile (1.6-km) radius of the cooling towers.

The discharge of radionuclides in PGDP plant effluents is not expected to produce any cumulative effects. There is sufficient dispersion in the Ohio River at the point of discharge to quickly reduce concentrations in water to background levels. Any cumulative sediment buildup would be spread over a very large area.

No localized effects of radionuclide accumulation in Big and Little Bayou Creeks are anticipated. Net accumulations are decreasing because of improved pollution control measures.

1.5 RELATIONSHIP TO LAND USE PLANS, POLICIES, AND GOALS

The continued operation of the gaseous diffusion plant and the Joppa Steam Electric Station does not conflict with known local, state, or federal land use plans and policies. Compliance with air, water, and solid waste pollution requirements is being met or, where deficient, remedial action is being taken.

1.6 ALTERNATIVES

Several major alternatives to continuing the operation of the Paducah Gaseous Diffusion Plant were considered. Among them were (1) shutdown of the PGDP, (2) use of alternative enrichment processes, (3) relocation, and (4) alternative power systems.

The conclusions reached were as follows: uranium enrichment is essential; replacing the gaseous diffusion process with the gas centrifuge process is not anticipated at this time; replacing the gaseous diffusion process with the laser separation process is not feasible as the latter process is still in the experimental stage; relocation is neither environmentally nor economically advantageous; and similarly, adverse environmental and economic effects of implementing alternative power systems appear to significantly outweigh the advantages of such a change.

2. DESCRIPTION OF PROPOSED ACTION

DOE's Paducah Gaseous Diffusion Plant has been supplying uranium enrichment services for commercial and national defense purposes since 1955. DOE plans to continue to operate in partial fullfillment of DOE's commitment to provide energy choices as well as its commitment to the national defense.

2.1 URANIUM ENRICHMENT

2.1.1 Uranium enrichment and the nuclear fuel cycle

Uranium enrichment is one step in the uranium fuel cycle. This step involves the partial enrichment of the uranium-235 (^{235}U) isotope in naturally occurring uranium to obtain a product with increased fissionable ^{235}U content. The various steps in the nuclear fuel cycle are shown in Fig. 2.1-1. This figure shows uranium enrichment centrally located because it is of central concern in this report; actually, the purpose of the entire fuel cycle is to provide fuel for the nuclear power reactors and to process its waste products. Many of the steps in this cycle require chemical processes to change the characteristics of the uranium fuel. The enrichment step, however, involves only physical separation of isotopes; i.e., the uranium is in the chemical form uranium hexafluoride (UF_6) when it enters the separation equipment and remains UF_6 throughout processing.

As can be seen in Fig. 2.1-1, there are two possible feed streams to the uranium enrichment step. One feed stream is "virgin" in that it comes from uranium ore. The second feed stream has been through the "enrichment-conversion-fuel fabrication-nuclear reactor-fuel reprocessing" chain prior to being returned to the enrichment step. This second feed is termed "recycle." Recycle feed will contain trace amounts of fission products and transuranics that were formed in the nuclear reactor and not completely removed in the fuel reprocessing step. The allowable concentrations of these contaminants, along with other nonradioactive contaminants, are strictly limited by DOE regulation.

The uranium feed to the enrichment step is separated into two components: the "product" which is enriched in ^{235}U, and the "tails," which are depleted in ^{235}U. Tails consist primarily of ^{238}U, which is potentially a nuclear power fuel in the plutonium fuel cycle. Tails are thus stored for possible future use.

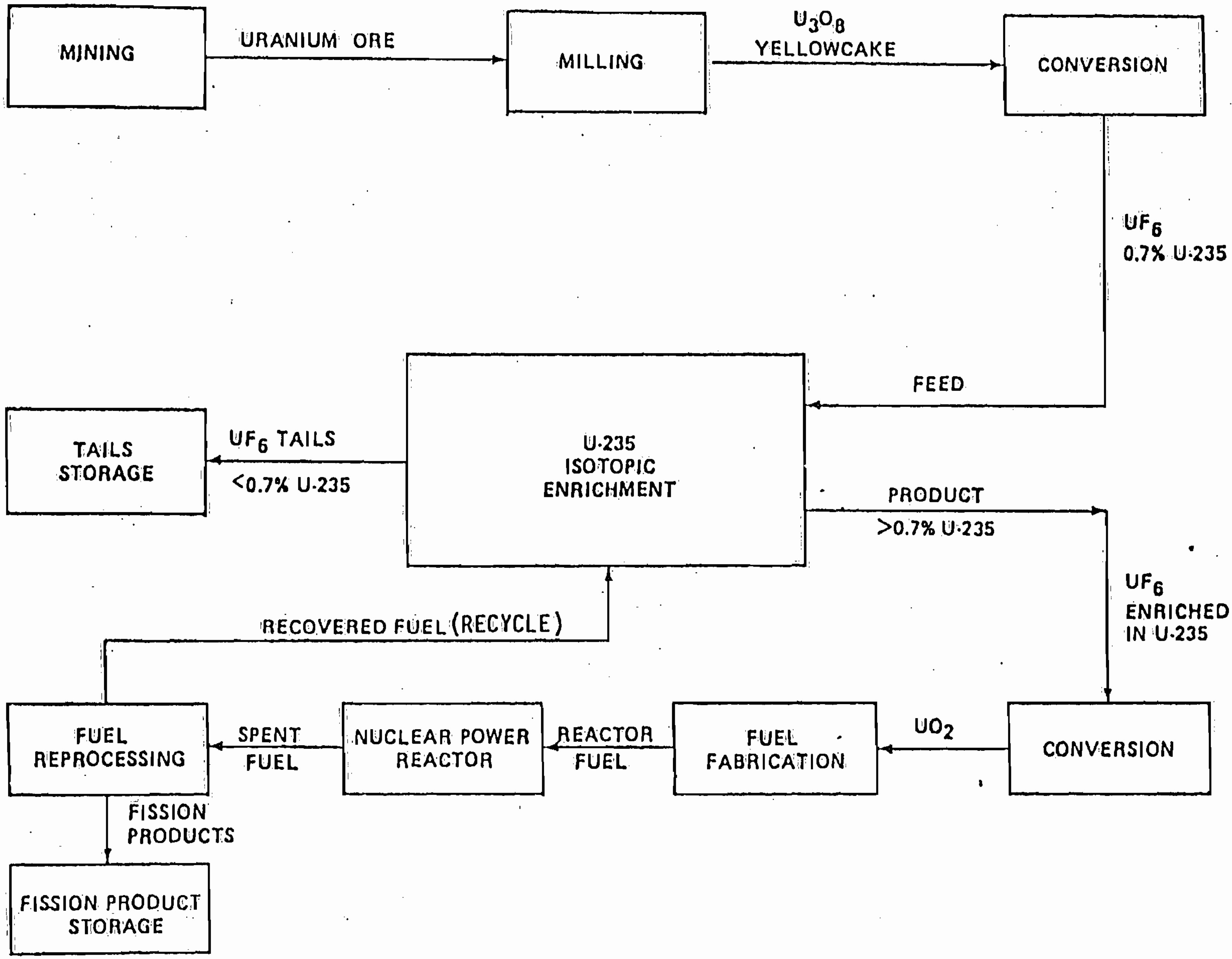


Fig. 2.1-1. Processing scheme for nuclear power reactor fuel.

The majority of the world's current nuclear power reactors use enriched uranium as fuel. The exceptions are, of course, heavy-water reactors fueled with natural uranium. A limited number of these reactors have been built in foreign countries, principally in Canada and India; none exist in the U.S. The worldwide preference for reactors that operate on enriched uranium is projected to continue.

The U.S. plants, located at Oak Ridge, Tennessee, Paducah, Kentucky, and Portsmouth, Ohio, are owned by the U.S. Government and are operated by private industry under contract. Initially, the U.S. plants contributed to the national defense effort by producing highly enriched uranium, but the dominant need for enrichment has shifted almost exclusively to fuels for commercial nuclear power supply systems. Almost all of the enrichment needs of the world's nuclear reactors have been supplied by the three U.S. plants, because only the U.S. provides enrichment services on a large-scale basis to other nations. The amounts of separative work furnished by the AEC from 1959 to 1975 to domestic and foreign reactors in fulfilling enrichment requirements are given in Table 2.1-1.

The assays for nuclear fuels vary with the types of reactors--low assays (2 to 4% ^{235}U) for light-water reactors, and high assays (about 93% ^{235}U) for high-temperature gas reactors.

2.1.2 Need for enriched uranium

Enrichment contracts held by DOE call for deliveries of about 6,875,000 SWU to domestic customers and 3,406,000 SWU to foreign customers (based on 0.2% tails assay) during FY 1980. The U.S. no longer remains the only nation supplying uranium enrichment services to other nations on a large-scale commercial basis; the Soviet Union, France, and the Tripartite Group (Netherlands, United Kingdom, and Federal Republic of Germany) have also supplied enrichment services to the world market.

The April 1980 status of domestic nuclear power reactors is summarized below:(1)*

73	reactors with operating licenses	53,627 MWe
89	reactors with construction permits	97,395 MWe
2	limited work authorizations	2,300 MWe
17	reactors on order	19,874 MWe
181	Total	173,196 MWe

*See subsection 2.5 for Section 2 references.

Table 2.1-1. Separative work production

	Power Reactor Requirements[a] (Thousands of Separative Work Units)	
CY	U.S.	Non-U.S.
1947		
1948		
1949		
1950		
1951		
1952		
1953		
1954		
1955		
1956		
1957	N.A.	
1958	N.A.	
1959	355	19
1960	337	0
1961	331	0
1962	157	140
1963	162	53
1964	355	92
1965	228	390
1966	1062	319
1967	529	630
1968	1341	229
1969	1830	1154
1970	3740	1265
1971	5256	2157
1972	2069	1536
1973	2731	10284[b]
1974	3143	2360
1975	3401	4233
1976	3578	5126
1977	6248	4115
1978	5551	5192
1979	8679	5140

[a]Shipments during 1957 and 1958 to the Shippingport Reactor were not recorded as such. CY-1971 includes 890 MTSW at 0.3% Xw for German Offset; CY-1973 includes 7.975 MTSW at 0.3% Xw for Japanese Advanced Sales.

[b]Increase due to advance sales.

The nuclear power reactors currently in operation provide about 11% of the nation's electrical energy generation. To provide fuel for the nuclear reactors that are being built and operated, U.S. enrichment capacity was expanded from 17.2 million Separative Work Units (SWU)/yr to 27.3 million SWU/yr during the CIP/CUP program.

To ensure an adequate supply of enriched uranium, modifications have been made at the three gaseous diffusion plants which increase enrichment production through a Cascade Improvement Program (CIP) and a Cascade Uprating Program (CUP). The CIP involves (1) the modification of process equipment to incorporate recent advances in gaseous diffusion technology, and (2) the expansion of production support facilities. As a result, separative work production has been increased. The CUP involves the modification and uprating of process utility systems and process equipment so that operating power levels can be raised and the additional electric power can be used more effectively. As a result, separative work levels were increased above the CIP level. The estimate of the fully improved and uprated plant capacity is 27.3 million SWU/yr. This uprated three-plant capacity is fully committed to supply nuclear reactors under long-term contracts. Paducah's up-rated capacity is 9.0 million SWU/yr.

To maintain low tails assay at the DOE gaseous diffusion plants while fulfilling existing contracts and to give DOE the potential to accept new uranium enrichment contracts, DOE is expanding enrichment capacity. This expansion is discussed in the Final Environmental Statement, Portsmouth Gaseous Diffusion Plant Expansion, ERDA-1549. DOE is also developing alternative enrichment technologies that provide more efficient separation, that is, greatly reduced power consumption.

2.2 Historical background

The Paducah Gaseous Diffusion Plant had its conception in July, 1950, when the Department of Defense and the Atomic Energy Commission (AEC) began studies which would lead to a significant increase in fissionable material production capabilities and a determination of the effects of such expansion on the national economy. Those studies analyzed the geographic and economic characteristics of selected strategical portions of the United States.

In August, 1950, the Oak Ridge Operations Office initiated further detailed studies at three sites selected from eight identified in an initial report by the National Security Resources Board. These sites were (1) the Longhorn Ordnance Works, Marshall, Texas; (2) the Louisiana Ordnance Works, Minden, Louisiana; and (3) the Kentucky Ordnance Works, Paducah, Kentucky.

Principal elements evaluated in the site selection process included (1) supply of low cost power, (2) water supply, (3) supporting population and (4) availability and suitability from a strategic standpoint. Based on comparisons of these elements among the three sites, the Kentucky Ordnance Works was found the most suitable. The transfer of these lands [approximately 1,365 acres (552.2 ha)] from the Department of the Army to AEC was effected on January 4, 1951. Additional acreage, largely privately owned land, was subsequently procured by the Corps of Engineers for the AEC, including 1361 acres (551.0 ha) for TVA and 41 acres (16.6 ha) bounding Little Bayou Creek to its confluence with the Ohio River.

In 1959 and 1961, lands in excess of the needs of AEC were leased to the Commonwealth of Kentucky for use by the Kentucky Fish and Wildlife Resources Department.

2.2.1 General description of area

Paducah is located in western Kentucky on the banks of the Ohio River. The surrounding terrain is gently rolling with large areas of open space and farmland. Areas of steeper slope are forested.

The Paducah Gaseous Diffusion Plant is located on a 3,425-acre (1385-ha) site approximately 10 mi west of the city of Paducah, which has a population of approximately 37,500. Major industries are Paducah Marine Ways, the Florsheim Shoe Company, and the Paducah Gaseous Diffusion Plant (Union Carbide Corporation). Distances between the Paducah site and other major population centers are as follows: St. Louis, Mo., 140 mi (226 km); Nashville, Tenn., 112 mi (181 km); Evansville, Ind., 84 mi (135 km); Madisonville, Ky., 72 mi (116 km); Murray, Ky., 50 mi (81 km), Mayfield, Ky., 20 mi (32 km).

The PGDP site is located in the western part of the Ohio River Basin. Surface drainage from the site is to two small tributaries of the Ohio River – Big Bayou Creek on the west and Little Bayou Creek on the east. These two streams join north of the site and discharge to the Ohio River at about River Mile 947 (km 1524), which is approximately 34 mi (55 km) upstream from the confluence of the Ohio and Mississippi rivers.

The existing plant site is largely nonforested, consisting of areas of open grassland. These open areas are managed primarily by the West Kentucky Wildlife Management Area for the maintenance of suitable wildlife habitat and food supply. Patchy wooded areas of mature hardwood (upland and riparian) communities also exist on the site.

2.2.2 Plant production

The first Paducah cell of 10 stages was put on stream in October 1952 and all 1820 stages had been started by the end of 1955. The production peak occurred in the late 1950s and early 1960s after completion of the first cascade improvement program and with cascade power of more than 2100 megawatts (Figure 2.2-2). Production dropped sharply in the mid and late 1960s when all new feed was discontinued, and the annual average power level fell to 1000 megawatts in 1970. Production in million separative work units (SWU) was 3.3 in 1970. It increased annually to 6.1 in fiscal 1977 and decreased to 5.0 million SWU in 1978 because of power reduction. Under uprated conditions at full loading, expected production is 9 million SWU.

Production of UF_6 from UO_3 began in the C-410 feed plant in 1953. Production rates reached 30,000 tons of UF_6 per year in the early 1960s. The plant was shut down in 1964 and was reactivated at a low production level in 1968. Production continued intermittently until April of 1977 when the plant again was deactivated except for four fluorine cells.

2.3 DESCRIPTION OF THE PADUCAH GASEOUS DIFFUSION PLANT (PGDP)

2.3.1 External appearance

The Paducah Gaseous Diffusion Plant is located within an "L" shaped, fenced tract of 750 acres (303 ha) located about four mi (6.4 km) south of the Ohio River. The appearance of the plant is dominated by the four large cascade buildings, each with its cooling tower and large electrical switchyard. The plant area and the surrounding wildlife management area are on relatively flat land draining to two small streams, Big Bayou on the west and Little Bayou on the east side of the plant. Figure 2.3-1 shows the plant layout.

A major support facility outside the main fenced area is the water treatment plant located west of Big Bayou. This facility consists of two large clarifier-type water softeners, other water treatment facilities, settling basins, and sludge settling lagoons.

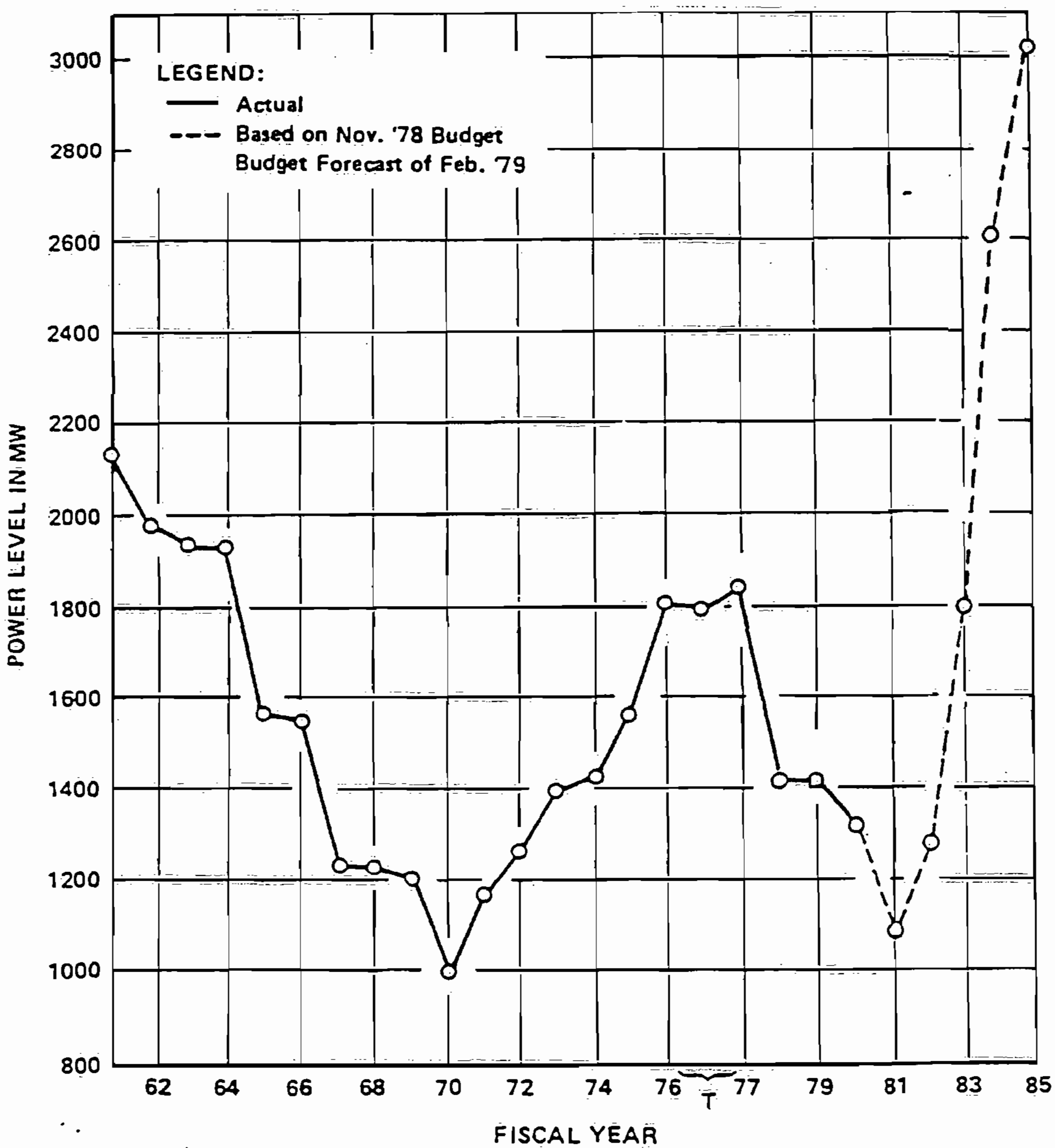


FIGURE 2.2-2. PGDP AVERAGE POWER LEVEL

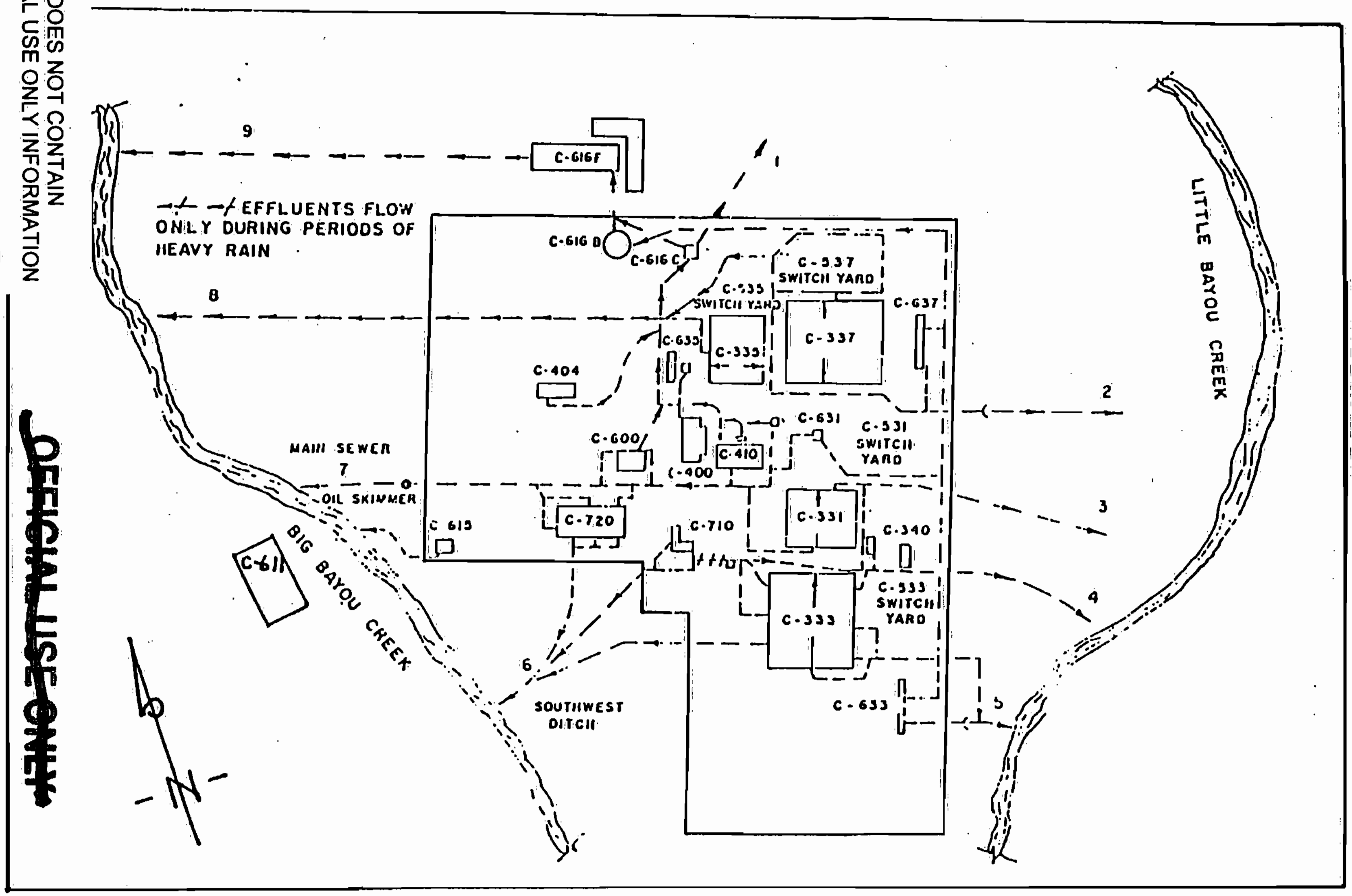


Figure 2.3-1. Paducah Gaseous Diffusion Plant layout.

2.3.2 Processes

PGDP processes are described in detail in Oak Ridge Operations Document ORO-684.[2]

2.3.3 Support facilities

2.3.3.1 C-615 Sewage Treatment Plant

The sewage collection system services all the occupied plant buildings with the exception of the following relatively remote facilities: the C-337A vaporizer, and the C-633 and C-637 Recirculating Cooling Water (RCW) pump houses.

The C-615 Sewage Treatment Plant built in 1952 provides secondary treatment. It consists of a comminutor, primary and secondary settling basins, trickling filter, sludge digester and settling beds, chlorinator, and contact chamber. Sewage is handled by four 400 gpm (25 lps) basin pumps and 75 gpm (5 lps) sludge pumps which provide a basic plant capacity of 800 gpm (50 lps). Normal flow is between 200 and 300 gpm (13 to 19 lps).

2.3.3.2 C-616 Liquid Effluent Treatment Plant

The C-616 Liquid Effluent Treatment Plant began treating RCW blowdown to remove chromium and zinc corrosion inhibiters in June of 1977. All blowdown except that lost through drift and windage is routed from the four RCW systems to the C-616 plant. The pH is adjusted with H_2SO_4 and the Cr^{+6} reduced to Cr^{+3} by $FeSO_4$. The pH is adjusted and the metals are precipitated by the addition of slaked lime. A 105 ft (32 m) diameter clarifier provides a mixing section, sludge blanket, and settling region. The sludge is pumped to a 2.7-acre (1.1-ha) lagoon and the clarified effluent flows by gravity to a 5.2-acre, 12-million-gallon (2.1-ha, 45,600 m^3) polishing lagoon.

2.3.4 Decontamination and recovery facility, C-400

Equipment removed from the cascade after exposure to uranium hexafluoride must be disassembled for decontamination of component parts prior to maintenance or repair work. Decontaminated parts are routinely monitored to assure that all parts meet approved plant allowable limits for surface and "wipe" radioactivity counts. The plant allowable limits for process and shop equipment is 2500 counts per minute per 100 cm^2 surface count and 500 counts per minute per 100 cm^2 "wipe" count. Any part or piece of equipment not meeting these plant allowable limits is retained in C-400 for further processing.

Individual decontamination, recovery, and other processes handled in C-400 are described in the following subsection.

2.3.4.1 Uranium recovery

Uranium is removed from decontamination or other process solutions by acidification followed by precipitation and filtration before the liquid is discharged. (See Appendix A, Fig. A-1). All solutions entering the recovery system contain uranium enriched to less than 1.0 wt % ^{235}U Those solutions containing uranium of between 0.5 and 1.0 wt % are precipitated with sodium hydroxide and filtered through diatomaceous earth on a rotary drum filter. The filter cake is drummed and sent to the Feed Materials Production Center for uranium recovery. Slaked lime is added to the filtrate and to solutions containing uranium of less than 0.5 wt % ^{235}U to precipitate uranium and trace quantities of transuranics. The precipitate is filtered, drummed, and buried in the C-404 low level waste burial area. The filtrate is discharged through the C-616 full flow lagoon to Big Bayou Creek. Prior to burial, the sludge is analyzed for transuranics; drums containing more than 10 picoCuries transuranics per gram are held for retrievable storage. Prior to dischange, the solution is analyzed to assure that it meets discharge criteria.

A typical laboratory analysis of filtrate solutions is shown below:

FILTRATE SOLUTION C-400

U	^{239}Np	^{239}Pu	^{230}Th	^{99}Tc	Fluoride
5 ppm	<1 ppb	<.01 ppb	<.03 ppb	0.8 ppm	4.7 ppm
3.3*	0.6*	0.6*	0.6*	14*	4.7 mg/l

*nanoCuries/liter

2.3.4.2 Spray booth

The spray booth decontamination system is designed for processing large objects, such as compressor and converter parts. It consists of a spray booth with a grated floor drain, solution tanks, pumps, three filters, and associated piping and spraying fixtures.

The solution tanks are used in two sets of three. The first three tanks used for the wash cycle contain a total of 450 gal (1710 l) of ammonium carbonate solution. The three rinse tanks contain 450 gal (1710 l) of water.

Contaminated equipment is first cleaned using the ammonium carbonate solution, then rinsed using water from the recycle rinse tanks. The final rinse (sanitary water) is discharged through the C-616 full flow lagoon. Recycle rinse solutions are utilized to make up the ammonium carbonate decontamination solution. Spent decontamination solutions are processed through the precipitation system (Appendix A, Fig. A-1).

2.3.4.3 Small parts hand tables

Hand tables are used for the decontamination of small parts. Each table contains approximately 50 gal (190 l) of water which has been treated with sodium carbonate. Spent solutions are transferred to one of two 500-gal (1900-l) holding tanks for processing in the precipitation system.

2.3.4.4 Cylinder decontamination facility

This facility is designed for the decontamination, including "heel" removal, of 10- and 14-ton (9- and 13-T) cylinders. The uranium solutions obtained from the decontamination process are stored for eventual processing in the precipitation system. After decontamination, the cylinders are rinsed with water and hydrostatically tested. The water from the final rinse and hydrostating is discharged to a 20 x 20 ft (6.1 x 6.1 m) sump which is periodically pumped to the C-616 full flow lagoon.

2.3.4.5 Laundry facility

The facility contains two 200-lb (91-kg) capacity washer-extractors and four 100-lb (45-kg) capacity dryers. All coveralls, socks, underclothing, towels, lab coats, and other issued clothing worn by employees is laundered daily. Clean clothing is distributed to various locker rooms throughout the plant.

A list of chemicals used is presented below. In addition to these chemicals, the effluent wash solutions may contain minute traces of uranium. The effluent discharges to the C-615 sewage treatment facility via the sanitary sewer system.

LAUNDRY CHEMICALS

Chemical	Usage lb/yr	Usage kg/yr
Sour (ammonium bifluoride)	3,900	1770
Soap	16,000	7260
Alkali (sodium orthosilicate)	3,400	1540
Bleach	3,500	1590

2.3.4.6 Gold dissolver

The recovery of scrap gold is one of the many operations in C-400. The brass in the gold scrap is dissolved in a 64% nitric acid solution. The gold is then separated and smelted into ingots if no other insoluble material is present. If the gold is attached to plastics or other insoluble material, aqua regia is employed to dissolve the gold. The nitric acid in aqua regia is distilled off and the gold is precipitated by using copper strips.

The addition of lime to the residual solution precipitates out most of the heavy metals (Appendix A, Fig. A-2). Lead, zinc, silver, and copper are the major metal ions present. The pH is controlled at 9 to optimize heavy metal removal. The treated effluent is discharged through the C-616 full flow lagoon.

2.3.4.7 Nickel stripper

To facilitate the repair of small parts, nickel plating is stripped off in C-400.

The nickel stripper is prepared using a proprietary solution [McDermid, SCB-A 24 lb (11 kg) and SCB-B 25 gal (95 l)]. Each week, the solution is discarded and a fresh batch mixed in two 50-gal (190-l) tanks. A typical lab analysis of the discarded solution is presented in Appendix A, Table A-1. The spent solution is discharged to the C-616-F full flow lagoon.

2.3.4.8 Vapor degreaser

The vapor degreaser is designed so that large [10 x 15 ft (3.1 x 4.6 m)] pieces of process equipment can be handled. Trichloroethylene is vaporized in the lower portion of the degreaser pit by steam coils.

The vapors diffuse and collect on the cooler metal parts or are condensed by water-cooled condensing coils located on the walls of the degreaser pit. The condensate drains back into the heated portion of the pit from which it may be revaporized.

Trichloroethylene vapors which escape the water-cooled and the upper refrigerated coils and reach the top of the pit are vented through lip-mounted exhausts to the atmosphere. This degreasing facility discharges approximately 714,290 lb (324,000 kg) of trichloroethylene to the atmosphere each year. A motorized cover to close the pit below the vents is being installed to reduce trichloroethylene losses. Residues from the degreasers are drummed and stored for disposal.

2.3.5 Steam plant

The C-600 steam plant is centrally located within the PGDP perimeter. It produces steam used to heat buildings, vaporize UF_6, obtain UF_6 samples, maintain process temperatures, clean equipment, and provide heat for other miscellaneous process operations. It consists of three water wall tube boilers (two coal-fired and one oil- and gas-fired) each capable of producing 100,000 lb (45,400 kg) of steam/hr at 250 psi (1725 k Pa), plus associated equipment. Liquid effluents from steam plant operation originate from three major sources: (1) water treatment, (2) coal and ash handling, and (3) boiler blowdown.

2.3.5.1 Water treatment

Twenty percent of the steam production returns as condensate. Additional boiler feed water comes from the plant sanitary water system. The water, which had received lime-soda softening at the C-611 Water Treatment Plant, passes through one of four sodium zeolite ion exchange water softeners. The softeners remove calcium and magnesium by ion exchange. The softeners are regenerated once every 3 to 5 days, depending on the quantity and quality of the water being softened. Approximately 700 lb (318 kg) of salt (NaCl) are used per generation. The waste stream of $CaCl_2$ is discharged to the building drain pumped to the north-south ditch leading to the C-616 lagoon. After being softened, the feed water is degassed to the building drain and pumped to the drainage path leading to the C-616 full flow lagoon. The combined stream of makeup water and condensate is then treated with sulfite and phosphate and deaerated. Approximately 2400 lb (1090 kg) of sodium sulfite and 1000 lb (454 kg) of phosphate are added to the boiler water feed system each year.

2.3.5.2 Boiler blowdown

Proper concentration of suspended and dissolved solids in the boiler drums are maintained by blowdown from the system. The average blowdown rate is 13,000 gal/day (49,400 l/day). All liquid effluents from C-600 are pumped to the C-616F full flow lagoon.

2.3.5.3 Coal and ash handling

Coal is presently received by rail car and unloaded to a coal crusher. From here, coal may go directly to the coal chute or to the coal storage yard, which has a 20,000 ton (18,140 T) capacity. The steam plant uses approximately 35,000 tons/yr (31,745 T/yr). Runoff water from the coal yard flows to a drainage ditch north of the coal yard and is pumped to the C-616F full flow lagoon. The pH of the water is approximately 2.2 in the drainage ditch. Analyses of the water in this drainage ditch are presented below.

Element	Coal Yard Runoff Water (g/1)
Fe	1.7
SO_4	8.6
Si	0.15
Al	0.05
Ca	0.04
Mg	0.02

The acidic coal pile runoff mixes with other effluents, including the water from the C-616 clarifier. As a result, the pH is raised and most of the dissolved solids are precipitated in the C-616 full flow lagoon.

Pulverized coal feed to the boilers contains from 7 to 11% ash. The ash falls to the bottom ash hoppers or is collected in highly efficient electrostatic precipitators. A steam jet propels the ash to a storage silo where the transferring medium is discharged through a water scrubber. The scrubber solution is transferred, by the same path as coal pile runoff, to the C-616 full flow lagoon for settling and equalization. Ash is stored in a 70-ton (63-T) capacity silo prior to removal to the sanitary landfill.

Purchase specifications for coal are written to result in a maximum of 1.2 lb sulfur/million Btu (0.5 kg/billion J). Coal analyses conducted in 1978 show this limit is usually met.

2.3.6 Maintenance facilities, C-720, C-724, C-750

The C-720 building is located approximately 100 yd (91 m) northwest of the main plant entrance. This facility fabricates and maintains equipment and instrumentation.

Liquid effluents from C-720 flow via the Southwest Ditch and East-West Ditch to Big Bayou Creek. Appendix A, Table A-2, summarizes major wastes generated within C-720. The individual operations contained within C-720 are described briefly as follows.

2.3.6.1 Instrument shop, C-720

Although some of the electronic instrumentation used at the Paducah plant can be purchased through commercial vendors, many of the instruments used are special-purpose and must be designed and fabricated by plant personnel. The instrument shop fabricates and/or performs maintenance on electric, electronic, and pneumatic instrumentation employed at the Paducah plant. Vendor-supplied equipment is tested in the instrument shop prior to its installation.

Effluents and scrap material originating at the instrument shop result primarily from the etching and repair of printed circuit boards.

2.3.6.2 Machine shop, C-720

The machine shop is a general purpose shop which deals in the fabrication and maintenance of all equipment that requires precision machine work. During the CIP/CUP programs the shop worked primarily with cascade equipment components. Wastes include scrap metal, oil, and water soluble oil.

2.3.6.3 Electrical maintenance shop, C-720

The electrical maintenance shop cleans and strips motors before they are repaired or, during the CIP/CUP programs, uprated. A trichloroethylene dip tank is used to dip small parts and motor casings prior to surface finishing or electroplating. Some copper windings, brushes, and other small metal parts are taken to the clean scrap yards for eventual sale.

A few motors are taken to the C-750 garage for steam cleaning. Oil is skimmed prior to discharge to the sanitary sewer.

2.3.6.4 Pump shop, C-720

The pump shop maintains all the pumps used at the Paducah plant. Most of the effluents originating in this shop are in the form of oil and cleaning solvents used on small parts.

2.3.6.5 Sheet metal shop, C-720

The sheet metal shops bends, cuts, and fabricates all types of thin metals, primarily steel, aluminum, stainless steel, monel, and copper. Excess cutting scrap is transferred to the clean scrap yard where it is recovered and sold.

2.3.6.6 Weld shop, C-720

The weld shop deals basically with the fabrication and maintenance of plant equipment. Its primary role presently is the uprating of converter assemblies. Wastes consist primarily of used welding rods and other scrap metal. Oil from turning fixtures, jigs, and other equipment requiring lubrication is collected and sent to the C-750 garage for storage and eventual sale. Welding fumes are discharged through roof vents from both general and local exhaust ventilation.

2.3.6.7 Garage, C-750

The C-750 garage provides the facilities for repair and servicing of automobiles, tow trucks, fork lifts, trucks, and similar equipment. The facilities include gasoline and diesel fuel dispensing, lubrication pit, washing rack, and maintenance bays. As stated above, the garage provides steam cleaning for some electric as well as automobile motors. A buried storage tank is used to collect waste crankcase oil and waste oil from other plant activities. A contract waste oil reclaimer picks up the oil when a sufficient quantity is accumulated.

2.3.6.8 Plant services building, C-724

The Plant Services Building contains a rigging loft, carpenter shop, and paint shop. The rigging loft has no effluents. The sawdust exhausted from power saws is collected by an inertial cyclone separater and is buried in the sanitary landfill. The paint shop uses a water scrubber on the exhaust of the paint spray booth to collect overspray. Paint and thinner residues are collected, poured into 55-gal (209-l) drums and shipped off-site for reclamation.

2.3.7 Laboratory facilities, C-710

Various laboratory facilities within the Technical Services Division are housed in Building C-710. The Technical Services Division is made up of five departments: Classification and Information Services, Analytical Laboratory, Environmenal Control, PTP and Systems Technology, and Process and Materials Technology. Out of these five departments, only two utilize laboratory facilities which make significant contributions to the plant effluents. These are (1) the Analytical Laboratory Department and (2) the Process and Materials Technology Department. The functions of these two departments are described in 2.3.7.1 and 2.3.7.2.

All sanitary effluents from C-710 are discharged to the sanitary sewage system. Effluents from the laboratory facilities are discharged to the southwest ditch which flows into Big Bayou Creek. Appendix A, Table A-3 summarizes the yearly effluents from the laboratory facilities.

2.3.7.1 Analytical Laboratory Department

Routine services of the analytical laboratory include analysis of process gases and environmental samples, metallurgical testing, and radioanalysis. Other services include testing of materials purchased in accordance with established specifications—oils, coolants, chemicals, metals, etc.

The lab is involved in finding solutions to specific plant problems and in providing consultation, theoretical solutions, and experimental work of an original nature. In addition, the lab is involved in the development and improvement of existing lab and plant instrumentation, analytical methods, and techniques. The laboratory wastes are of insignificant quantities, but are given a degree of equalization in a collection pit south of C-710.

2.3.7.2 Process and Materials Technology Department

The Process and Materials Technology Department is made up of three sections: Chemical Technology, Diffusion Technology, and Materials Technology. Each group provides technical support for various process operations.

Chemical Technology conducts research in environmental control methods and designs experiments to reduce effluents from various chemical processes, including the use of monitoring devices in problem areas. Special projects range from testing chemicals on material integrity to developing new cleaning methods for out-of-service coolant condensers.

Diffusion Technology provides technical support for the C-490 and C-720 converter assembly and testing facilities. The group also conducts permeability tests on converters in the test facility and is responsible for determining the separative quality of the barrier in the different cascade stages. A laboratory system is now being constructed to facilitate more extensive barrier testing. There are no continuous or regular liquid wastes. Very small quantities of gaseous fluorides are emitted above the C-710 roof with no measurable effects on ambient fluoride levels.

2.3.8 Nitrogen Plant, C-601

The Nitrogen Plant is located in C-601. The generating equipment consists of a compressor, air dryers, a separation column, storage facilities, and piping. It is designed to produce 150 standard cubic ft (scf) (4.2 m^3) of nitrogen per minute.

Gaseous nitrogen is used at the Paducah Gaseous Diffusion Plant chiefly for purging or inerting various UF_6 processing systems; liquid nitrogen is used as a low temperature refrigerant.

Liquid effluents from the nitrogen facility consist of lubricating oil and condensate. Six pints (2.8 l) of oil are used daily for the lubrication of the compressor cylinders. About half of this is recovered from leaks around the compressor shaft; the other half is discharged to the storm sewer with condensate from the compressor and the entrainment separators. The effluents from the nitrogen facility flow into the oil skimmer ditch and finally into Big Bayou Creek. The oil is first skimmed with a belt-type skimmer in C-600 before going to the storm sewer system served by the oil skimmer at the west perimeter fence. It is skimmed from the ditch before the water is discharged to the creek and is drummed for salvage.

2.3.9 Air Plant Facilities, C-335, C-600, and C-620

The air plant facilities are located in buildings C-335, C-600, and C-620. Buildings C-335 and C-620 contain two electric-powered compressors each. Two steam-powered air compressors are located in C-600. The six compressors are capable of producing a total of 26 x 10^6 scf (7.3 x 10^4 m^3) of clean dry air per day.

The plant air distribution system is used primarily for process systems and instrumentation. The air is dried to less than 50 ppm water and supplied to the plant distribution system at 88 psi (606 k Pa).

A typical air-plant flow diagram is illustrated in Appendix A, Fig. A-3. As dry air is produced, cooling water and condensate are released to Big Bayou and Little Bayou Creeks. Approximately 6 pints of oil are used for lubrication during the daily operation of the two electric compressors in C-620. Oil mixed with cooling water and condensate from compressor-associated equipment flow through an oil recovery system and into the 340 effluent ditch. The 340 effluent ditch exists on the plant's east side and flows into Little Bayou Creek. An oil collection system intercepts floating oil.

The steam engines used to power the air compressors in C-600 require approximately 3 gal (11.4 l) of lubricating oil per day when operated. The compressors themselves require approximately three pints (1.4 l) of lubricating oil daily. C-600 is equipped with an oil skimmer to remove this oil before the condensate and cooling water enter the effluent ditch.

2.3.10 Fluorine Plant, C-410

Fluorine for use in the various process systems is produced at C-410 by an electrolytic process dissociating anhydrous hydrofluoride (HF) in a potassium bifluoride electrolyte. Hydrogen, containing some entrained HF, is vented to the atmosphere through a mist eliminator and a flame arrestor. A maximum of 300 lb (136 kg) of HF is vented to the atmosphere with the hydrogen gas each year. The fluorine plant has the capacity to produce over 10 tons (9 T) of F_2 per day. However, with the UF_6 manufacturing plant shut down, only 500 to 1500 lb (227 to 681 kg) of F_2 are produced per month.

Four fluorine cells, or generators, are presently employed to produce fluorine. The fluorine is then pumped to one of three 1000 ft^3 (28 m^3) storage tanks to be used as needed.

Failed or defective F_2 generators are not repaired but are replaced by one of the spare generators available. The defective generator is stored with the electrolyte in a frozen state within the electrolytic cell.

2.3.11 Anhydrous hydrogen fluoride storage facility, C-410H

The anhydrous HF storage facility consists of seven 10,000 gal (38,000 l) tanks. Only one of these tanks is presently being used.

The HF storage tanks are pressurized with nitrogen [maximum 30 psig (206 k·Pa)] to facilitate the transfer of liquid HF to the HF vaporizer in C-410. The transfer header is equipped with flow-limiting orifices. If an excessive pressure differential is detected in the transfer header, the transfer header valves close automatically.

Other safety features are incorporated in the storage facility to minimize the possibility of a significant release. The storage tanks are within a 2 ft (0.6 m) deep concrete pit and HF sensors are placed at various locations in the facility. In the event of an HF release, an alarm will sound. Plant emergency squad personnel may manually activate a fog nozzle system to absorb HF from the air. The water and HF would collect in the concrete pit area and drain to a holding pond where the acid would be diluted and held up for neutralization.

2.3.12 Water treatment facility, C-611

The C-611 water treatment plant supplies all the water requirements for the facility. An average 26 (million gallons per day) [98 million liters per day] is required at the present with a peak of 30 to 32 mgd (114 to 121 mld) expected usage for uprated operations.

The water treatment process is based on conventional water treatment techniques which include softening, coagulation, flocculation, sedimentation, and chlorination. A schematic diagram of the C-611 facility is shown in Appendix A, Fig. A-4.

Raw water is obtained from the Ohio River through an intake station at the TVA Shawnee Power Plant and pumped through water-softening units at the water treatment facility. The water is chlorinated and flocculated in the mixing basin. Approximately 99% of the suspended solids are settled out in four reinforced, concrete-lined settling basins with a total capacity of 12 million gal (45×10^6 l).

After the sedimentation process, approximately 15% of the water is filtered, postchlorinated, and pumped to the sanitary water distribution system (subsection 2.3.14). The remaining water is pumped into the plant water distribution system for use as once-through cooling water or for use in the recirculating cooling water system.

Waste effluents with high solid content are generated at C-611 as a result of the softening process and during sand filter backwashing and sludge removal from the settling basins and mixing basins. This sludge is accumulated at a rate of about 5.5 tons/day (5 T/da) in two lagoons which are connected in series. Typical composition of the sludge is shown in the following tabulation. The sludge is removed from the settling basins several times a year and the filters are backwashed two or three times a day. Sludge is blown down from the softeners several times a day to the two lagoons leading to the NPDES discharge point.

C-611 SLUDGE COMPOSITION

Substances	Wt %
Aluminum hydroxide	2
Calcium carbonate	50
Ferric hydroxide	10
Magnesium hydroxide	4
Manganese	3
Silicon dioxide	6
Silt	26
Titanium	1

The only liquid effluent from the water treatment facility consists of the supernate liquid flowing from the second lagoon. Approximately 0.7 mgd (2.6 mld) are discharged into Big Bayou Creek. Typical supernate data are presented below. This lagoon effluent is permitted under the NPDES system with limits on pH (10) and on suspended solids (50 mg/l).

C-611 LAGOON SUPERNATE LIQUID

COD (chemical oxygen demand)	15 ppm
Flow	0.7 mgd (2.6 mld)
pH	9.0-10.0
Suspended solids	15 ppm
Turbidity	9 ntu

2.3.13 Recirculation water system

An efficient coolant system is an integral part of gaseous diffusion plants. Approximately 90% of the electrical energy consumed on the plant site is converted to heat in the enrichment process when UF_6 is compressed to force it through the stage converter. The recirculation water system removes this heat of compression from the process gas, along with waste heat from a few auxiliary processes, and dissipates this energy to the environment. A flow diagram is presented in Appendix A, Fig. A-5.

The double-loop cooling system employed is designed to reduce the possibility of water contacting the process gas. The primary loop, utilizing freon (R-114) as a heat transfer medium, removes thermal energy from the UF_6. This thermal energy is transferred to the secondary loop, recirculating cooling water, which releases its energy to the atmosphere in mechanical cooling towers. The cooled water is then pumped back to the heat exchangers through the building supply piping systems.

There are 14 cooling towers (six old and eight new), all of which will be needed when the plant reaches its uprated capacity.

Air is both heated and humidified as it is pulled through the towers by fans. The amount of humidification depends on the moisture content of the air; thus, the rate of evaporation of the recycle cooling water varies with weather conditions. As water falls through the towers, it is broken into small droplets, some of which are carried out of the tower with the heated air or blown out the side of the tower by wind.

Evaporation of recirculating water concentrates the dissolved solids that are present in the makeup water, in the corrosion inhibitor, and in sulfuric acid used for pH control. The concentration of solids, especially the carbonate and sulfate ions, must be controlled to prevent fouling of the water-cooled condenser heat transfer surfaces. The control is obtained by continuously removing some of the water. The discarded water, referred to as blowdown, leaves the cool side of the system at the basin temperature (about 95F, 34C).

The total amount of blowdown water depends upon the plant power level, the concentration of dissolved solids in the makeup water, and the number of cycles of concentration allowable. Dissolved solids concentration in the makeup water is minimized by the water-softening process at the C-611 Water Treatment Plant where the calcium and magnesium carbonates are reduced from typically 100 ppm to 30 ppm. However, in addition to the constituents of the makeup water, a chromate-based corrosion inhibitor is added, the pH is maintained at 6 to 6.5 with sulfuric acid, and chlorine is added to control algae. Despite the inhibitor, some corrosion of the steel pipes and copper tubing occurs, adding these dissolved and suspended solids. Leaching of wood preservatives by the water is assumed, but not detectable in the water. Cooling tower cells are taken out of service each year for spraying with Betz F-16 fungicide, which contains about 20% pentachlorophenate. The chemical feeds to the recirculating water are presented in Appendix A, Table A-4.

2.3.14 Sanitary sewage treatment facility, C-615

The C-615 sewage treatment facility processes the sanitary waste water from the Paducah plant prior to discharge into Big Bayou Creek. The facility was designed for a 3,000-person loading and a maximum influent flow of 0.8 mgd (3 mld).

Influent enters a comminutor which grinds up large debris before it enters a 20,000-gal (75,700-l) settling basin (Appendix A, Fig. A-6).

This basin is equipped with a collector and a skimmer to remove floating solids. This settling removes approximately 50 to 65% of the suspended solids and 25 to 40% of the BOD. This is a preliminary step to the biological treatment units. The biological system is a 40 ft (12 m) diameter trickling filter. The secondary effluent guideline is an 85% removal for the biological oxygen demand. Effluent flows through a 17,000 gal (64,300 l) secondary settling basin where more solids are removed. Effluent can be recycled through the trickling filter for additional treatment, if necessary.

Sludges from the primary and secondary settling basins are pumped to a 9000 ft^3 (207 m^3) anaerobic digestor to decompose the waste to methane, water, and CO_2. Small amounts of methane are vented to the atmosphere during the process. The digested sludge, approximately 10 ton/yr (9 T/yr) is then transferred to sludge drying beds for moisture reduction before being disposed of in landfills. Sludge composition is presented below.

C-615 SLUDGE COMPOSITION*

Component	Wt %
Nitrogen	1.5
Phosphorous	0.85
Potassium	0.005
Uranium	0.1
Organic	97

*pH - 5.2

The final treatment is chlorination of the effluent to reduce the fecal coliform bacteria to less than 200 per 100 ml of sample. A typical monthly monitoring report is included in Table 2.3-2.

2.3.15 Storm drainage system

The storm drainage system of sewers, culverts, and ditches collects surface runoff from buildings and grounds and empties this runoff into either Little Bayou Creek, on the east side of the plant, or Big Bayou Creek to the west. This system is also used to conduct the effluent from some of the process facilities, such as cooling water from the dry air and nitrogen plants and final rinse water from the C-400 decontamination facility (Fig. 2.3-1).

Weekly composite samples from two of the drainage ditches existing on the plant site are collected and analyzed. Average flow rates for each of the drainage ditches on the plant site are tabulated in Appendix A, Table A-5. Total effluent is continuously monitored at stations located in Little Bayou and Big Bayou Creeks (subsection 2.3.23).

Table 2.3-2. Monthly monitoring of C-615 sanitary sewage treatment facility

	No. of Samples	Minimum	Maximum	Average	NPDES Requirements
Influent pH	22	6.6	9.6	--	Monitor
Effluent pH	22	5.7	7.3	--	6-9
Effluent total chlorine, ppm	30	1.1	6.2	2.0	Monitor
Influent suspended solids (SS), ppm	5	4	179	71	Monitor
Effluent SS, ppm	5	3	18	9	Monitor
Reduction of SS, percent	--	--	--	87	
Effluent total coliform, per 100 ml	3	2	6	<3	--
Effluent fecal coliform, per 100 ml	1	<2	<2	<2	200
Influent BOD, ppm	5	59	138	86	Monitor
Outfall BOD, ppm	5	6	15	12	15(10)*
Reduction of BOD,	0	0	0	--	0
%	--	--	--	86	--
Effluent uranium, ppm	25	0.012	0.030	0.019	--
Effluent CrO_4, ppm	25	0	0	0	--
Chlorine feed, ppd	--	--	--	11	--
Flow, mgd, metered	--	0.187	0.337	0.319	Monitor
Recycle flow, mgd, metered	--	--	--	1.339	--

*1981 draft NPDES permit limit for BOD is 30 ppm

2.3.16 Full flow lagoon

Effluents from the C-400 decontamination facility and the C-600 steam plant, and leachate from the C-404 radioactive waste burial area, flow into the C-616F detention basin prior to discharging into Big Bayou Creek.

The detention basin was originally designed to serve as a settling basin for the chromium treatment facility in the event of a clarifier malfunction. However, in July 1977, the storm sewers from C-600, C-404, and C-400 were routed through the detention basin to provide settling for fly ash from C-600 and small amounts of low level radioactive contaminants from C-400 and C-404.

2.3.17 Radioactive waste systems

Uranium removed from the process other than in the product or tails streams either goes through the C-400 NaOH precipitation for eventual material recovery or goes to radioactive waste. Impure uranium having assays (^{235}U to total U ratio) of less than 0.5% is considered non-recoverable and therefore in the waste category. Radioactive waste sludges from the C-400 lime precipitation containing this low assay uranium, low concentrations of ^{99}Tc, and traces (less than 10 µCi/gram) of transuranics are buried in the C-404 Radioactive Waste Burial Area. Other materials going to the C-404 facility include contaminated debris from the process areas and vacuum cleanings and impure UF_4 from the C-400 green salt screening and drumming unit.

The C-404 burial area was converted from an existing holding pond. The pond was constructed on a tamped clay bottom and enclosed by a tamped clay-lined dike. It was first used as a burial area in the late 1950s to receive contaminated magnesium fluoride slag from a uranium smelter. It is now filled to the top of the dike; drums are stacked in rows and additional dirt cover is placed on the drums. The final clay cover will be packed and sloped to prevent rainwater absorption and leaching of the burial area.

The C-400 lime precipitation process is considered a radioactive waste treatment system. The system and its typical discharge are described in subsection 2.3.4.1.

The C-310 purge cascade is not considered a radioactive waste system unit. However, the final stages of the purge cascade strips essentially all the UF_6 from the purge gases and permits the light gases to be discharged to the atmosphere.

2.3.18 Biocides

The Paducah plant uses many pesticides. Bulk use of these agents is handled by the plant's Roads and Grounds Department under the supervision of plant personnel who have been certified by the Commonwealth of Kentucky as private applicators. There is no environmental monitoring for these compounds. Application of Betz F-16, a pentachlorophenate-based fungicide, on cooling tower wood is discussed in 2.3.14.

Chlorine is added to the recirculating cooling water (RCW) to inhibit bacteria and algae. It is also used in the water treatment plant and

Table 2.3.3. Continued.

Parameter	Average for 1 month (ppm)	NPDES Requirements	(max)
Chromium (total)	0.16	0.5	(1.0)
Chromium (CR^{+6})	0.005	0.05	(0.1)
Zinc	0.26	0.5	(1.0)
Copper	0.08	0.5	(1.0)
Suspended solids	6.0	30	(45)
Total dissolved solids	1848.0	-	-
Fluoride	1.05	-	-
pH	8.7	6.0-9.0	-
Turbidity	2.0 ntu	-	-
Oil/grease	6.0	10	(15)

2.3.19.2 Waste oil

Approximately 22,500 gal (85,200 l) of various grades of waste oil are generated annually. Approximately 5,500 gal (20,800 l) of the clean waste oil are used in the air intake filters and for sweeping compound; 9,000 gal (34,100 l) are sold to a salvage company.

The remaining 8,000 gal (30,300 l) may be contaminated with radioactive materials and other impurities such as various types of oil, cleaning solutions, solvents, water, etc. Slightly contaminated oil is now being accumulated for eventual incineration in the C-600 boiler.

Uranium emissions from C-600 due to burning of contaminated oil were calculated to be insignificant when compared to the uranium normally found in coal and in the ash resulting from burning coal.

2.3.20 Sanitary landfill

The present sanitary landfill employs a cut-and-fill burial technique. This landfill is circular and covers approximately 3 acres (1.2 ha) outside the southwest plant perimeter fence.

Approximately 13,200 tons (12,000 T) of combustible refuse and 30,800 tons (27,900 T) of steam plant ash are generated each year and disposed of in the sanitary landfill. About 2% of the material comes from the plant cafeteria. The remaining debris is composed of waste paper, cartons, pallets, and similar waste.

Big Bayou Creek flows near the eastern edge of the landfill. Surface runoff and some leachate drain into Big Bayou from the disposal area. Leachate analyses are summarized in Table 2.3-4.

Table 2.3-4. Detectable Trace Elements in Landfill Effluents

Element	Sanitary Landfill Leachate (mg/l)	Big Bayou Creek below Sanitary Landfill (mg/l)
Al	100	4
B	1	0.2
Ca	400	40
Fe	200	8
Hg	0.3	N.D.
Mg	100	8
Mn	100	10
Na	10	8
Si	15	40
Ti	0.3	0.4
Sr	2	0.4

Problems with fugitive dust from ash disposal are experienced during the dry summer months. Fugitive dust is controlled by wetting the dusty areas with water and covering the inactive portion of the landfill with dirt and vegetation. Decomposition gases and odors have not been problems at this site.

The current landfill will be closed out in 1982 when a new landfill to be located on the north side of the plantsite (north of KY Route 386) is operational. The current site will be contoured, and capped with clay and vegetation. The preliminary design and soil survey for the new landfill was submitted to the Kentucky Department of Natural Resources and Environmental Protection for comment. The construction and operation is subject to the Kentucky permit system.

2.3.21 Burial grounds

There is a total of 22 burial sites managed by the Paducah Gaseous Diffusion Plant (20 inside and two outside the perimeter fence). Only four of these sites are active at the present time. The other 18 have been filled and earth capped.

A description of the burial grounds and the types of scrap buried are presented in Table 2.3-5. The location of each site is shown in Appendix A, Figure A-8.

Groundwater samples have been taken monthly from two monitoring wells for several years and have not indicated any leaching of the burial grounds. A series of samples from shallow borings also did not indicate groundwater contamination. All surface water flowing from the plant site is monitored at the water monitoring stations on Big and Little Bayous.

2.3.22 Effluent and environmental monitoring

The environment of the PGDP is continuously monitored by air and water samplers and monitors. Grass sampled at established locations is also used as a monitor for ambient gaseous fluorides. An annual report of the monitoring has been issued each year for 20 or more years. Distribution is made to the DOE and to area news media.

Locations of all PGDP routine monitoring points are presented in Appendix A, Figure A-9.

2.3.22.1 Air monitoring

Ambient monitoring is accomplished by a network of ten continuous monitoring stations. Air filters are changed out weekly, then analyzed for fluorides and counted for gross alpha and gross beta radioactivity. Compliance with the Kentucky ambient fluoride limit (2 ppb HF weekly) is determined by the monitoring data and results are summarized in annual Environmental Monitoring Reports[3].

Stack effluent data are obtained routinely from the C-400 UF_4 pulverizer exhaust and from the C-310 purge vent. Emissions from the C-400 pulverizer exhaust through a bag filter. A sample is withdrawn continuously from the stack and particulates are collected on a thimble filter. This thimble filter is changed out monthly and analyzed for uranium.

Table 2.3-5. Areas used for burial of scrap materials at the Paducah plant through Calendar Year 1978

Description	Location	Size (ft)[a]	Area (ft)[a]	Depth of Hole (ft)[a]	Depth of Earth Cover (ft)[a]	Period of Use	Primary Type of Scrap Buried	Quantity of Scrap Buried[a]	Percent of Area Used
Uranium burial ground	C-749[b]	160 x 200	29,800	7	4	1957-1977	Pyrophoric uranium metal	270 Short Tu; 59,000 gal oil	74
Solid radioactive waste disposal area	C-404[b]	137 x 380	52,000	6[c]	—	1953-1957	Liquid wastes from C-400	2,900 KgU	—
				6[c]	6-8"	1957-Present	Metals plant scrap, reject UF_4, filter cake	3,200 Short TU	33
Classified scrap burial yard	C-746-F	175 x 400	70,000	8	4	1967-Present	Classified Materials not worthy recovery	1,800 tons	35
Trash burial area	Area A	68 x 275	18,700	10-12	4	1962-1967 1967-1979 (closed)	Noncombustible trash Noncombustible trash and contaminated combustible trash		90
C-340 drum and contaminated burial area	Area F	10 x 20	200	6-7	3	1957-1959	Empty contaminated powder drums	50-75 drums	100
		20 x 28	560	6-7	3	1971-1972	Misc. contaminated material & equipment		100
		70 x 110	7,700	6-7	3	1972-1978	Uranium contaminated drums		
Sanitary landfill	C-746-K	400' diameter	125,000	20	1-2	1967-Present	Noncontaminated combustible trash and steam plant ash		65
Subcontractors' discard area (near new sanitary landfill)	Area P	1000 x 1000	1,100,000	None to various	None to various	1951-Present	Construction rubbish Industrial landfill (Permit pending)		—

Table 2.3-5. (Concluded)

Description	Location	Size (ft)[a]	Area (ft)[a]	Depth of Hole (ft)[a]	Depth of Earth Cover (ft)[a]	Period of Use	Primary Type of Scrap Buried	Quantity of Scrap Buried[a]	Percent of Area Used
Contaminated scrap burial area	Area B Area C Area G	60 x 172 60 x 160 27 x 122	23,000	6-7	3	1958-1962	Noncombustible trash; contaminated and noncombustible material & equipment		100
Concrete burial area	Area D Area E	15 x 143 15 x 99	3,650	6-7	3	1960	Concrete pieces from HF reactor tray bases	200 tons	100
Magnesium scrap burial area	Area H	12 x 15	180	6	3	1971	Magnesium scrap	10 full drums	100
Exhaust fan burial area	Area I	8 x 35	280	8	5	1966	Exhaust hood blowers contaminated with perchloric acid	8 blowers	100
Contaminated aluminum burial area	Area J	37 x 100	4,000	6	3	1960-1962	Contaminated aluminum nuts, bolts, plates, etc.	100-150 full drums	100
Magnesium scrap burial area	Area K	12 x 15	180	6	3	1968-1969	Magnesium scrap	20 full drums	100
Modine trap burial area	Area L	20 x 30	600	6	3	1969	Contaminated modine trap	1 trap	100
Hut salvage yard burial area	Area M	15 x 50 50 x 150	8,300	15	2-3	1952-1958	Trash, materials & equipment		100
Chemical waste yard	Area O	80 x 280 x 120 x 280 (d)	28,000			1942-1945	Materials & equipment from old KOW area contaminated with TNT		100

[a] Approximate.

[b] A monitoring well located approximately 850 ft north of these areas is sampled monthly to check the water table for uranium, fluorides, and alpha and beta activity.

[c] The bottom of the discard area is at grade level. The area is surrounded by an earthen dike.

[d] Irregular shape (trapezoidal)

Grab samples are obtained monthly from the C-310 cascade purge vent and are analyzed for uranium, transuranics, and technetium. Fluoride discharges from the cascade are estimated on the basis of chemical usage.

Sulfur dioxide emissions from the C-600 steam plant are based upon coal usage and sulfur analysis of the coal. A continuous SO_2 analyzer was installed on the two coal-fired boilers at C-600.

Particulate emissions have been measured by EPA Method 5 at the C-405 incinerator, C-746 nickel induction smelter, and C-746 aluminum sweating and reverberatory smelters and have been determined to be in compliance with Kentucky particulate emission limits.

2.3.22.2 Effluent liquid monitoring

Environmental and effluent water samples are collected routinely from a number of locations including Little Bayou Creek downstream of plant discharges, Big Bayou Creek and the Ohio River upstream and downstream of plant discharges, and groundwater samples from wells in the area. Monthly grab samples are taken at all locations. Samples are routinely analyzed for hexavalent chromium, uranium, alpha and beta radioactivity, pH, fluoride, and nitrate. The stations on Little Bayou and Big Bayou are continuously monitored for pH, conductivity, flow, temperature, and dissolved oxygen. A composite sampler receiving signals from the flow recorder collects 24-hr composite samples proportional to flow. Samples obtained from these stations are analyzed for total chromium, turbidity, dissolved solids, and oil and grease in addition to the parameters mentioned above.

A Parshall flume is used as a flow channeling device and flows are measured using a bubbler and manometer. The monitoring instruments are housed in a heated vandal-resistant shelter.

In-plant effluent samples are obtained routinely on the South-North Diversion Ditch and on the West-East Ditch exiting the plant near C-340. Continuous 7-day samples are obtained weekly for analysis using a shop-made water sampler. Effluent samples are also collected routinely from the filtrate from the C-400 decontamination solution treatment. Each filtrate batch is analyzed for radionuclides and fluorides. Water collected from the C-404 radioactive waste burial facility is analyzed for uranium, nitrate, and fluorides before being released to the drainage ditch.

2.3.22.3 Vegetation and soil samples

Bimonthly vegetation samples are obtained from 17 locations. Grass is collected, allowed to dry, and then ground in a cutting mill. Samples are analyzed for fluoride.

Soil samples are obtained annually from ten locations. Samples are dried, pulverized. and analyzed for radionuclides. Stream sediment samples are also collected annually and are analyzed for various radioactive and nonradioactive parameters.

2.3.23 Transportation

2.3.23.1 Production materials

Nuclear material is received and shipped by rail and trucks.

All shipments are made in conformance with DOE Manual Chapters 2405 and 5201, the Department of Transportation (DOT) regulations CFR 49, parts 170-189, and the International Atomic Energy Agency (IAEA) Safety Series No. 6. All UF_6 shipping containers must meet American National Standards Institute (ANSI) N14.1-1972 specifications. All enriched UF_6 having an assay greater than 1% of ^{235}U is shipped in steel cylinders enclosed in DOE-DOT approved protective packages.

UF_4 (green salt) is packaged in 55-gal. (208-l) steel drums and is transported within the plant on pallets, on special trailers or trucks, and are handled by forklifts. UF_6 cylinders are handled by special equipment, cylinder carts and overhead cranes. Handling is minimized until the UF_6 in the cylinder is completely solidified. The only equipment used to handle cylinders of liquid UF_6 are the cylinder carts cradling the cylinder while it is being filled and the overhead crane which moves the cylinder from the cart to a nearby cradle for cooling. Handling methods have been subject to both quality assurance and system safety analyses.

Movements of nuclear materials inside the plant are handled by trucks, carts, and other specially designed vehicles. Plant-approved transportation practices control the transportation of production materials.

2.3.23.2 Other materials

Nonnuclear materials are shipped to and from the plant by both highway and railroad. The plant railroad system is served by Illinois Central Gulf Railroad. The plant access road connects directly to U.S. Route 60. All shipping and receiving is handled through Receiving, Purchasing, and Stores in Building C-720.

2.3.23.3 Employees

Most employees live within 30 mi (48 km) of the plant. Personal automobiles are used. Since there is no public transportation available, many of the plant personnel use car-pool arrangements.

2.3.24 Safeguards and security

A comprehensive safeguards and security program is maintained at the Paducah Gaseous Diffusion Plant to meet DOE requirements and to assure adequate protection for the enriched uranium produced, the facilities used for enrichment, and the classified technical information used in the production of enriched uranium.

Acts of sabotage by individuals or groups knowledgeable of plant layouts, external support facilities, and physical security measures could result in the disruption of production and the possible release of hazardous materials to the environment. Safeguards and security measures are designed to make the success of sabotage efforts highly improbable. Plant design is based on the principles of containment to minimize this possibility.

2.3.24.1 Systems

2.3.24.2 Physical protection

The physical protection system for the Paducah plant includes trained armed guards, multiple physical barriers, strict access control to the facility and classified areas, multiple communication systems with local law enforcement authorities, and security control facilities. Protective measures further include the prohibition of personal vehicles within protected areas, backup guard forces, written records of all persons visiting controlled areas, and random search of all packages, briefcases, containers, or vehicles entering or leaving a controlled access area.

A guard force is provided to conduct regular inspections of buildings and grounds to assure that there are no breaches of security. Additional inspections are conducted when facilities are not attended by other personnel.

2.3.24.3 Nuclear materials control

A measurement program is used to establish the quantities of material received, shipped, and in inventory, permitting the timely notice of apparent losses and the localization of possible loss mechanisms. These measurements also serve in process control, criticality control, environmental safety, and inventory management.

The accountability measurement method includes weighing and determining the volume of bulk material and analyses for chemical and isotopic content from representative samples. The measurement of uranium isotopes in the dynamic gas phase in cascade equipment presents a unique challenge in engineering and chemistry principles because item-by-item accountability is impossible.

2.3.24.4 Personnel security

New employees obtain access to the plant only after an investigation by DOE which establishes that access can be permitted without endangering the common defense and security. The extent of the investigation is appropriate to the degree of access required.

Employees of subcontractors requiring access to the plant area and visitors to the plant are also appropriately cleared unless it is practical to control access to classified information by escorts.

An identification system is employed which includes the prominent display of a photographic badge by each individual. Access, even by cleared individuals, is limited to areas and information required in the performance of duties.

2.3.25 Accidents

2.3.25.1 Accidents involving radioactive materials

Criticality accidents

Considering the nature of the material handled at the PGDP, in conjunction with the controls placed on the handling, the probability of an accidental criticality at this facility is exceedingly small. It is impossible to obtain an accidental criticality with uranium enriched to less than 1 wt % ^{235}U when dealing with the uranium compounds encountered at a gaseous diffusion plant. It is also impossible to create a criticality with gaseous uranium hexafluoride. The majority of the operations at the PGDP deal with either gaseous UF_6, or with material at or below 1% enrichment, or a combination of both; such operations are always nuclearly safe.

Other areas possessing potential for criticality have been analyzed. Design parameters and/or administrative controls have been implemented to assure nuclear safety under abnormal operating conditions. Some of the design criteria utilized in maintaining nuclear safety include: geometric sizing of process equipment, limitations on allowable mass accumulations, control of potential moderating substances, protective spacing between uranium solutions, and installation of fixed neutron absorbers. Some of the current administrative controls include: routine audits of all enriched uranium areas by the nuclear safety staff; review of all equipment and procedure modifications, additions, or deletions; and annual criticality safety training of all operating personnel working in enriched uranium areas.

Emergency radiation procedures are maintained and are current. Radiation alarms and evacuation procedures are designed to minimize the exposure from an accidental criticality.

Noncriticality accidents

Uranium hexafluoride releases outside of buildings

The only credible accident scenario resulting in a significant UF_6 release outside of a building would involve the breaching of a cylinder containing liquid UF_6. This cylinder breach could occur if the valve becomes damaged, if the cylinder should be dropped, or if the cylinder itself should be punctured or cracked below the liquid line. It should be noted that in order for UF_6 to be released through the valve damaging sequences, the cylinder would also have to roll to such a position that the valve would be below the liquid level. Procedures are in effect to assure safe handling of all UF_6 cylinders, particularly those in which the UF_6 is still liquid. These procedures include safe handling distances, safe load limits, minimum solidification cooling periods, and guidelines to assure the protection of the cylinder from structural damage.

Cylinders containing liquid UF_6 are moved at three on-site locations (i.e., C-310, C-315, and C-337A; the product withdrawal, tails withdrawal, and product sampling facilities, respectively). Valve protectors are required to be secured over the cylinder valve prior to any movement to guard against accidental damage to the valve. At C-310 and C-315 the cylinders filled with liquid UF_6 are moved away from the withdrawal positions on rail carts. Outside the buildings, they are lifted by overhead crane and placed in cooling positions where they remain until solidified. The total distance travelled by crane is small. At C-337A, an overhead crane is used to transport liquid UF_6 cylinders from the preheat bath to the actual sampling bath and then from the sampling bath to the cooling position where they remain until solidified. This cooling area is located immediately adjacent to the sampling bath, reducing the distance the cylinders must travel with the liquified UF_6. Fixtures or equipment presenting a sharp projection which could puncture a cylinder during transit have been removed or modified.

During 25 years of operation, only three incidents of uranium release greater than 5 kg have occurred in those three areas. The largest of these resulted in a 666 kg release to the environment (0.32 Ci of radioactivity). Using typical meteorological data for PGDP and dispersion modeling, this 666 kg release produced a ground concentration of only 8 nCi/m^3 at the nearest residence. (This conservatively assumed that the entire 666 kg became airborne). The risk of developing a fatal cancer from inhalation is estimated to be approximately 3.34×10^{-8}, or inconsequential(4).

Uranium hexafluoride releases inside buildings

Uranium releases within buildings can be grouped into two basic categories - releases involving liquid UF_6 and releases involving gaseous UF_6. Liquid UF_6 releases may occur at either the tails or product withdrawal stations where liquid UF_6 is drained into cylinders, or at the feed vaporization facilities where UF_6 is liquified in the cylinders in autoclaves. Gaseous UF_6 releases may result from failures of equipment operating above atmospheric pressure or from pigtail breaks at the feeding positions.

In C-315 and C-310, liquid UF_6 is drained into evacuated cylinders. The flexible pigtail used to connect these cylinders to the drain line offers the largest potential for a liquid UF_6 release. If this connection is broken, liquid UF_6 could drain from the accumulator onto the floor. To minimize the size of the release, UF_6 detectors and shut-off valves are designed and installed to close off this liquid drain line. If the cylinder valve is still open, release of gaseous UF_6 is also possible. To date, the largest release due to this type of accident at the PGDP was 414 kg. This release occurred prior to the installation of the shut-off valve. Since this installation the largest release from a broken pigtail has been 63 kg. A conservative estimate of uranium released to the environment from this incident is 25 kg, assuming total vaporization and 40% escape from the building. This constitutes only 0.012 Ci of radioactivity, or a ground concentration of 0.2 nCi/m^2 at the nearest residence, an inconsequential risk from inhalation(4). Only five releases ranging from 5 to 666 kg of uranium of this type have occurred in 25 years.

In the vaporization areas, a hydraulic rupture of a cylinder or a failure of an end plug can release large amounts of liquid UF_6 to the interior of the autoclave. Only one such incident has been recorded at the PGDP. This release occurred in a temporary vaporization facility. The result was a release of 3077 kg of uranium (1.5 Ci) to the building, the drainage system, and the plant environment. There was no detectable surface uranium contamination outside the plant fence. No significant releases have occurred in a permanent vaporization area.

There is also a possibility of sustaining an accidental pigtail break at the vaporization facilities. Such a break would release gaseous UF_6 inside the autoclave. Gaseous UF_6 could also escape into the autoclave via a faulty valve or a leaky pigtail connection. Two accidents of these types have released a total of 25 kg of uranium to the environment in the PGDP operation history.

Any equipment which contains gaseous UF_6 above atmospheric pressure presents, under abnormal operating conditions, a potential for release. PGDP's operating philosophy in case of a release is to first assure personnel safety and then quickly find and stop the UF_6 leak. Buildings, even when not designated to contain UF_6, act as a fairly efficient mechanism to confine the release. It has been estimated that only about 40% of the uranium released may ever migrate to the environment. At Paducah's top assay of 2.0 wt % ^{235}U, a major release would still represent only a minimal environmental exposure. At the present time, very little equipment operates at greater than atmospheric pressure at the PGDP.

2.3.25.2 Nonradioactive releases

Chemical spills

Administrative and engineering controls are used at PGDP to reduce the possibility of chemical spills. These measures include the diking of bulk chemical storage tanks, emergency oil containment dams, routine inspection patrols, and employee spill prevention awareness training.

Ferrous sulfate, nitric acid, sulfuric acid, and trichloroethylene storage tanks, as well as pentachlorophenol stored in drums, are stored in diked areas. Leaks from chromic acid, potassium hydroxide, and sodium bisulfate tanks would flow to a collection sump outside C-400 for recovery, neutralization, or pumping to the C-616 treatment facility. Spills of dry chemicals such as calcium oxide and cupric sulfate are swept up and have little potential for reaching the plant drainage systems. Spills of cupric nitrate, hydrofluoric acid, and sodium hydroxide can be treated at the C-616 facility after collection. Protection against an accidental chlorine release is accomplished primarily by routine inspections. Should a release occur, a water fog would be used on the airborne release to minimize injury to human health.

Oils or PCB

All PCB transformers are diked. Floor drains near these transformers and capacitors located inside buildings are sealed. Oil containment dams located on each major plant ditch serve as backup containment for floating oil. The bulk fuel oil storage tanks and process drain tanks are also diked and visually inspected for structural defects. The dikes are equipped with drains which are closed except to drain rainwater. Damage to piping caused by vehicular traffic is minimized by careful location of pipe lines. Inclined pipe oil retention dams, located on each plant drainage ditch, provide oil separation as well as containment should an oil spill reach the drainage system. The design of these dams permits overflow only during very severe rainstorms. A spill control trailer is available on the plant site for oil spill control and cleanup. Various types of equipment are available in this trailer to deal with spills.

Administrative procedures stress that operators are aware of spill control measures, oil unloading operations are attended, spill reporting and Quality Assurance plans are in effect, routine inspection patrols are conducted twice daily, and drain valves in dikes are kept closed.

Recirculating water (RCW) system accident

Potential exists for a large release of hexavalent chromium from RCW lines or cooling tower basins. The chromium content of this water is 9 ppm. In one incident 300,000 gal (113.4 million l) of RCW were released to Little Bayou Creek when a cooling tower basin was overfilled. This quantity of chromium was below the EPA reporting limit but exceeded the NPDES limit. The total quantity of chromium released was approximately 23 lb (10 kg). Instrumentation is in place to minimize such releases.

2.3.25.3 Fires

Two serious fires have occurred at the Paducah Gaseous Diffusion Plant since it began operation 25 years ago. Both resulted in losses of from 2 to 3 million dollars. Since the first fire, a sprinkler system has been installed throughout the plant. This system helped reduce damage from the second incident by suppressing and localizing the fire.

Should a fire begin to spread to a lubrication oil collection pit, oil can be discharged to the storm drains by manually opening the valve releasing the oil to the plant drainage system where it would be contained by the inclined pipe oil retention dams.

As soon as water begins to flow out of the fire water storage tank, a pump is activated to make up the water loss. This water is pumped out of the C-611 water plant basins. If the flow to fight the fire should rise above 400 gpm, another pump activates to compensate for the increased water usage from the tank. This pump draws from the cooling tower basins which are chromated at 9 ppm. Potential impact exists for releasing chromated water to the environment. Since implementation, no chromated water has been released by this system.

2.3.25.4 Natural disasters

Seismic hazard

Within the 25 years during which the PGDP has been operating, there have been several tremors at the site. There has never been a release as a result of these occurrences.

Should PGDP experience significant ground movement associated with a major earthquake, three areas seem to be most vulnerable. These are the interbuilding tie lines, the flanged pipe joints, and the dislodging of cylinders at the withdrawal positions. Depending upon the number of openings created and the length of time that power is maintained, the potentially released quantity of UF_6 could be large. Estimates approximate this quantity to be 100 tons. Assuming worst case dispersion conditions, evacuation of persons within 5 miles of the plant may be necessary. Procedures have been formulated at the plant to deal with this type of emergency.

Associated with the UF_6 release would be a corresponding release of HF. HF release rates from broken tie lines would be relatively slow. Should an HF storage tank become dislodged or pierced, the liquid (which boils at 69°F) could escape rapidly, with the potential of personal injury.

The effect of an earthquake upon the release of chemicals and their engineered controls has not been quantified.

Tornadoes and high winds

The building walls on all of the Paducah plant process buildings are designed to withstand a force of 20 lb/ft^2. This corresponds to a

90 mph (55.8 km/h) wind speed. The recurrence interval for a 90 mph wind at the Paducah site is once in 200 years. A 90 mph tornado may be experienced once in 5000 years.

The worst credible release which could occur from tornado or high wind damage would stem from a break in an inter-building tie line. The actual quantity of UF_6 released would depend upon the size of the break and the length of time before the line could be isolated. Emergency procedures are in effect which deal with the consequences of such an event, including evacuation of surrounding communities, should it be necessary. A release sustained during high winds or a tornado is subject to extremely turbulent meteorological conditions. This reduces the probabilities of needing to evacuate areas because of the increased dilution of the UF_6 in the atmosphere in conjunction with favorable dispersion characteristics. Airborne and ground level concentrations would be lower because of these conditions.

Chemical storage tanks could be ruptured by airborne objects driven by the high winds. The diking around the majority of these tanks should be sufficient to contain these spills. Inclined pipe dams on all plant effluent ditches would serve as secondary containment for insoluble, floating materials.

Flood hazard

Flooding presents no hazard to operations at the Paducah plant. The largest flood to date in this vicinity was recorded in 1937 at 347 ft above mean sea level. The average elevation of the Paducah plant is 380 ft—33 ft above the highest water mark ever recorded for this area. The usual pool level at the nearest dam is 312 ft. This places PGDP well above all potential flood levels.

2.3.25.5 Transportation accidents

The majority of the radioactive shipments to and from PGDP consist of UF_6 and depleted UF_4 totaling approximately 2200 shipments per year. All radioactive transportation activities are conducted in compliance with regulations established by the U.S. Department of Transportation and the U.S. Nuclear Regulatory Commission.

Throughout the history of gaseous diffusion operations, there has never been a release of radioactive material from a UF_6 cylinder because of a transportation accident. There were two accidents involving radioactive shipments in 1977 which illustrate the survivability of the shipping containers when subjected to an accident environment. One consisted of a derailment of 17 railcars. No cylinders received any appreciable damage. The other accident involved a tractor-trailer unit which ran off of the highway, throwing the radioactive material containers from the trailer. Again there was no rupture of any cylinder and no release of material.

Normal safety precautions in the shipping of UF_6 cylinders include protecting the valve stem by securing a protective cover over it, shipping only solidified UF_6 cylinders, shipping all product cylinders in protective overpacks, phasing out the limited use of thin-walled cylinders for the transportation of normal or depleted UF_6 in favor of thick-walled cylinders, and shipping only cylinders in which the vapor pressure is below atmospheric pressure.

2.4 DESCRIPTION OF POWER GENERATING FACILITIES

Power is supplied to the PGDP by two electric utilities. The larger of the two is the Tennessee Valley Authority (TVA), which contracts with DOE for large power allocations in essentially the same manner as with other industrial customers in the TVA service area. Since the power supplied from the TVA power system is drawn from a network and not from a single plant, the impacts are not quantifiable and will not be addressed in this assessment.

The other supplier is Electric Energy Incorporated, which has contractually dedicated 735 MWe of the 1050 MWe capacity of the Joppa Steam Electric Plant to the PGDP. This power supply is limited to one plant, discussed herein.

2.4.1 Joppa, Illinois, Facility

The Joppa Steam Electric Plant is located on the north bank of the Ohio River at approximately River Mile 952 (km 1535). It is situated in southern Illinois about 1 mi (1.6 km) west of Joppa and about 8 mi (13 km) northwest of Metropolis. The plant site consists of about 624 acres (253 ha) which includes about 92 acres (37 ha) of abandoned ash disposal area, another 55 acres (23 ha) of ash disposal pond presently in service, and another 50 acres (20 ha) of planned ash disposal facility. An easement to the Trunkline Gas Company by former owners carries several high pressure natural gas lines from the underwater river crossing to the pumping station, which lies north of the plant property. The property is bounded by C&EI Railroad right-of-way and tracks on the east, by county road F.A.S. 937 on the north, and by C&EI Railroad property immediately on the west edge, beyond which lies the Missouri Portland Cement Company's Joppa plant.

The plant site is grade elevation 350 ft (107 m), about 60 ft (18 m) above Ohio River pool stage of 290 ft (88 m) elevation, and about 13 to 18 ft (4 to 5 m) above past or expected 100-year flood stages of the Ohio River. The C&EI Railroad, now a part of the Missouri Pacific Railroad, provides rail access for coal and miscellaneous incoming materials. The spur feeds a 5-track "loaded" storage yard, which has access to rotary car dumper and/or shakeout for unloading coal, and then to a 6-track "empty" storage yard, which in turn terminates onto the C&EI main line tracks in the opposite direction of travel. On the bank of the Ohio River are installed the barge unloading facility and the cooling water intake and discharge structures, and more recently a waste water settling lagoon. A coal storage yard, main plant site, and switch-yards are located just north of the river embankment. Three pairs of steel towers carry six 161 KV circuits across the Ohio River to the PGDP.

The generating plant consists of six individual units rated at 181 MW (gross) each consisting of Combustion Engineering reheat tangential fired boilers using pulverized coal. Each boiler supplies 1,200,000 lb/hr (545,000 kg/hr) main steam at 1050 F (566 C) and reheated steam at 1000 F (538 C) to turbo-generators rated at 183,375 KW at 38 psi (207 k Pa) hydrogen. Each unit will consume about 1700 tons (1540 T) of coal per day at fully capacity, or about 10,200 tons (9250 T) per day for the plant. About half of the fuel needed is received from rail suppliers and about half is received by river barge transportation.

Coal is normally unloaded directly from barge or rail car to the bunkers as required, and additional receipts are stored in either "live" storage or "regular" storage piles which are connected. Coal is moved in or out of "live" storage by bulldozers, and in or out of "regular" storage by rubber-tired self-propelled scrapers.

Coal used is pulverized and burned in "dry" bottom boilers where the ash produced either flows with combustion gases to the electrostatic precipitators, or falls to the furnace bottom as "bottom ash." Both ashes are transported hydraulically to the ash disposal ponds as needed.

Each unit had originally installed a mechanical ash separator with a design efficiency of 85% removal of dust which was not more than 26% under 10 micron size. These separators were unable to provide particulate control adequate to meet air quality requirements of the State of Illinois. They were removed after installation of the electrostatic precipitators.

The electrostatic precipitators were installed in 1971-1972 at the direction of the Illinois Air Pollution Control Board, and were purchased to meet the 98.6% removal specifications required by regulations. Each unit's precipitator consists of two isolated sides each containing a 9-ft (2.7-m) inlet section, a 6 ft (1.8 m) center section, and a 6-ft (1.8-m) outlet section. Each unit's inlet, center, and outlet section is powered by its own transformer which is normally used to power both sections in half wave but may be changed to power either section in full wave modes if required.

A significant portion of the flyash is transported dry (in a separate pneumatic transport system) to the nearby cement plant which uses it as a raw material or as an additive to their cement.

Three chimneys, each 250 ft (76 m) high and 24 ft (7 m) top diameter, are installed such that each chimney serves a pair of units located on either side of the chimney. Exit gas is about 315 F(157 C) at 49 ft per second (15 mps) velocity and total volume from each chimney at full load is about 1,346,000 acfm (38,100 acmm). The chimneys are co-linear with a NNE-SSW orientation and are 336 ft (102 m) and 420 ft (128 m) apart.

Cooling water is withdrawn from the Ohio River by eight circulating water pumps of 600 HP each serving Units 1-4, and four pumps of 1000 HP each serving Units 5 and 6 separately. Each pump is designed to pump 42,000 gpm (159,000 lpm). Each unit operates two pumps, and each pair of units is supplied by up to four pumps through one water conduit. Each water conduit supplies cooling water to both condensers of the pair of units. Intake water passes through screen bars, is chlorinated if necessary, passes through revolving screens, is pumped to the condensers, and flows by gravity back to the river through a water conduit for each corresponding pair of units to the discharge structures. One discharge structure serves Units 1-4 and a separate structure serves Units 5 and 6.

Both the intake structure and the discharge structures are located about 200 ft (61 m) north of the normal pool shore line, and are connected with the main river by canals or channels dredged to adequate depths. The intake canal requires infrequent dredging to maintain adequate water volume for proper cooling.

In the transition period between the Air Pollution Control Board and the new Illinois Environmental Protection Act regulations as promulgated by the new Illinois Pollution Control Board, it was necessary to petition for a variance to continue to operate while installing new electrostatic precipitators. The petition was submitted June 29, 1971, to continue operating until July 1, 1972. Because of severe maintenance problems on the Unit 5 turbine, Unit 6 was delayed from coming into compliance until September 1972.

Illinois Pollution Control Board (IPCB) regulation Chapter 2 (Air Pollution) Rule 204(e) limits sulfur dioxide emissions with present chimneys to about 13,890 lb (6310 kg) of SO_2 per hour based on chimney height of 250 ft (76 m). After a comprehensive study had been completed, a petition was submitted to the IPCB to comply using a Supplemental Control System to limit level of SO_2 in ambient atmosphere. A hearing was held in 1975 and evidence presented. Further conferences resulted in a somewhat different compliance program agreeable to the Illinois Environmental Protection Agency, and this program was then submitted to the IPCB as an amendment to the petition before the Board.

The Board approved and ordered the amended program on September 1, 1977. This program consisted of: (1) construction of three new chimneys 550 ft (168 m) tall, (2) installation of an ambient air monitor for SO_2, and (3) limitation of SO_2 emission to 36,875 lb/hr (16740 kg/hr) through use of fuel blending by July 1, 1978. The program has now been completed.

The IPCB adopted various water effluent standards which were published in January 10, 1972, and required compliance by December 31, 1973, for existing sources. A program was formulated to achieve overall compliance with the regulations. The program included: (1) construction of a new ash disposal pond and associated equipment to adjust the pH of the effluent to meet standard requirements; (2) construction of new secondary treatment for plant sewage which included a retention, aeration, and chlorination facility; (3) rerouting of certain plant drains and consolidation of effluents not meeting standards; and (4) construction of a settling lagoon near the river to treat these effluents to the degree required to meet standards. This program was initiated in 1972 and completed in 1974. A subsequent problem with pH of the settling lagoon effluent was solved by rerouting this effluent to the cooling water intake. A problem with effluent from sewage plant required only modification of operating parameters to bring it into compliance.

2.5 REFERENCES FOR SUBSECTIONS 2.1-2.4

1. U. S. Department of Energy. 1980. Nuclear power program information and data. U.S. Department of Energy. March/April.

2. Atomic Energy Commission. January, 1972. Gaseous diffussion plant operations. ORO-684. U.S. Atomic Energy Commission, Washington, D.C.

3. Union Carbide Corporation. 1971-1978. Annual environmental monitoring reports, Paducah Gaseous Diffusion Plant. United States Department of Energy. Union Carbide Corporation, Nuclear Division, Oak Ridge, Tennesse

4. U.S. Environmental Protection Agency. 1979. Radiological impact caused by emissions of radionuclides into air in the United States. Preliminary report. EPA 520/7-79-006. Office of Radiation Programs (ANR-461), U.S. Environmental Protection Agency. Washington D.C.

3. CHARACTERIZATION OF THE EXISTING ENVIRONMENT

3.1 PADUCAH GASEOUS DIFFUSION PLANT

3.1.1 Regional and local geomorphology

The PGDP plant site is located to the south of the Ohio River in an area of low geographic relief. Topographic relief in the vicinity of the plant varies from 290 ft (88.4 m) above sea level at the river to 380 ft (115.8 m) above sea level at the plant site about 3.6 mi (5.8 km) away. The average slope of 23.7 feet/mi (100.5 m/km) is typical of both the immediate site area and the region south of the river as a whole.

The major determinants of surface geomorphology are the streams and rivers whose beds have become incised into the thick deposits of unconsolidated loess, alluvium, sands, and gravels typical of the region. No surface outcroppings of consolidated rock formations are noted within a 25 mi (40 km) radius of the plant site. Topographic features range from rolling terrain in the upland areas to relatively flat flood plain type of relief near the Ohio River.

3.1.2 Geology

The eight-county Jackson Purchase Region is bounded on the east by the Tennessee River (Kentucky Lake), on the north by the Ohio River, on the west by the Mississippi River, and on the south by the Kentucky-Tennessee state line. McCracken County is at the northern end of the Mississippi Embayment, a depositional basin filled with Cretaceous and younger deposits that unconformally overlie Paleozoic rocks. Structurally, the basin is a broad south-plunging syncline, the axis of which coincides roughly with the Mississippi River.[(1)*]

3.1.3 Hydrology

3.1.3.1 Surface water

The Paducah Gaseous Diffusion Plant site is located in the western part of the Ohio River Basin. Surface drainage from the site is to two small tributaries of the Ohio River, Big Bayou Creek on the west and Little Bayou Creek on the east. These two streams join north of the site and discharge to the Ohio River at about river mile 947 (1524 km) which is about 34 miles (55 km) upstream from the confluence of the Ohio and Mississippi Rivers.

---

*See subsection 3.3 for Section 3 references.

Ohio River

Average and extremes of discharge at Metropolis, Illinois are shown below for the period of record which began in January, 1928.

Discharge	Cubic feet/second (cfs)	Cubic meters/second (cms)	Gallons/day (gpd)
Average	265,000	7,500	171×10^9
Maximum (Jan. 1, 1937)	1,780,000	50,380	$1,150 \times 10^9$
Minimum (July 30, 1930)	15,000	430	10×10^9

The maximum gage height recorded (Feb. 2, 1937) at the station is 66.6 ft (20.3 m) above gage datum of 276.27 ft (84.20 m) above mean sea level. Monthly discharge data for the Ohio River at this station are given in Appendix B, Table B-1 for the 1971, 1975, and 1976 water-years (a water-year is from October through September).

Big Bayou Creek

Big Bayou Creek and its tributaries drain an area of 18.6 mi^2 (48.2 km^2), including that of Little Bayou Creek. The basin is about 8.3 mi (13 m) long and has an average length to width ratio of 3.7. Total relief of the basin is about 160 ft (49 m) with elevations ranging from 450 ft (137 m) at the headwaters to 290 ft (88 m), the normal pool elevation of the Ohio River at this location. Stream gradients decrease from about 75 ft/mi (14 m/km) in the extreme upper part of the basin to 10 ft/mi (2 m/km) or less near the Ohio River.

Little Bayou Creek

The area of the Little Bayou Creek basin is 8.5 mi^2 (22 km^2) or a little less than one-half the size of the Big Bayou Creek Basin. The basin is 6 mi (10 km) long and has an average length to width ratio of 4.2. Total relief of the basin is 135 ft (41 m) with elevations ranging from 424 ft (130 m) at the southern upland end of the basin to 290 ft (88 m). Gradients of the stream are 50 ft/mi (9.5 m/km) and 10 ft/mi (2 m/km) or less at the upper and lower end of the basin, respectively.

Estimated mean daily flow rates of Big Bayou and Little Bayou Creeks are given in Appendix B, Table B-2. General characteristics are summarized below:(1)

Basin Characteristics	Basin Values Big Bayou	Little Bayou
Population density (per mi^2)	100	111
Housing density (per mi^2)	36	42
Agriculture (% of basin area)	41	33
Silviculture (% of basin area)	24	22
Urban[a] (% of basin area)	35	45
Hydrologic soil groups[b]	D,C	D,C

[a]Incorporated places, residential, commercial, and industrial areas.

[b]Infiltration of predominant groups in basin; A = high to D = low.

Both basins are predominantly rural in nature. Population and housing densities are essentially equal. Infiltration properties of the soils are similar on the basis of their assigned ratings. Both exhibit rapid rises in stream flow. In the absence of discharge from the plant, Big Bayou and Little Bayou Creeks can be expected to be essentially dry on numerous days from May-June through October-November and, on other occasions during that period, to discharge many millions of gallons per day to the Ohio River. May through November low-flow conditions in Big and Little Bayou Creeks are improved by the discharge from the plant ditches.

3.1.3.2 Groundwater

Examples of specific capacities and yields from two wells in the general environs of the PGDP are given below.(2)

Approximate Location	Specific Capacity[a]	Yield[b]
8 mi (13 km) ESE of PGDP near Cecil, KY	1.5 (18)	120 (154)
14 mi (23 km) SE of PGDP and 5 mi (8 km) S of Paducah, KY	3 (37)	80 (303)

[a]gpm/ft drawdown (lpm/meter).

[b]gpm (lpm).

Groundwater in the Joppa and Heath quadrangles, which include the location of the PGDP, is in abundant supply but the resource is largely undeveloped.[3,4] Depending on thickness, the principal aquifers, gravels, and Eocene sand may yield up to around 1,000 and 500 gpm, respectively (3,785 and 1,893 lpm).

The PGDP is in the pinch-out zone of the Porters Creek Clay. This formation could thus be absent at least under the more northerly part of PGDP property. General direction of shallow groundwater movement at PGDP is toward the Ohio River. The soil of the area is characterized by its extremely slow percolation rate; it is a silty clay almost impenetrable by water. Well-filled farm ponds are plentiful in the area. A geological survey of the area describes the alluvium as follows:

> "Silt, gravel, and sand; mixed with interlensing, nonstratified to poorly stratified. Silt, medium-gray and yellowish-brown, argillaceous, commonly sandy and pebbly; contains varying amounts of carbonized plant material, very sparse mica, and dark-brownish-gray earthy concretions as much as 1/4 inch in diameter which at places occur in layers and pockets. Gravel consists of pebbles of chert and quartz, and boulders of chert and sandstone in a silty sand matrix. Sand, reddish-brown to grayish-yellow, fine to coarse, poorly sorted; commonly contains pebbles; crossbedded at places. Beneath Bayou Creek and West Fork Massac Creek silt is dominant."[5]

The groundwater resources near PGDP are abundant and underutilized at the present.

3.1.3.3 Flooding

Flooding is not a problem in the vicinity of the PGDP facility. Flood plain profile maps for the Ohio River have been prepared by the U.S. Army Corps of Engineers.[6] These indicate the flood frequency elevations shown below:

Recurrence Interval	Elevation (MSL) ft	(m)
Historical High Water	341.7	(104.2)
100 yr	333.2	(101.6)
50 yr	331.6	(101.1)
10 yr	326.6	(99.5)

Because the enrichment plant is built on land ranging in elevation from 367 ft (112 m) to 380.6 ft (116 m) above sea level, the possibility of flooding is extremely remote. The 340-ft (104-m) contour extends up Big and Little Bayous to a point near the northern boundary of PGDP property. Thus, flooding, even under the most extreme meteorological conditions observed in the past, has not affected the area within the facility boundaries. Additional information is available in Section 3.1.9.

3.1.4 Climatology and air quality

3.1.4.1 Climatology

The climate of Paducah, Kentucky, is characteristic of the humid continental zone in which it is located. Precipitation is well distributed throughout the year with an average of approximately 47 in. (119 cm). Relative humidity is estimated as approximately 83% at 6 a.m. and 61% at noon. July is the hottest month of the year; January is the coldest. Average monthly temperatures are 78F and 34.7F (25.6C and 1.5C), respectively. The average length of the growing season is 200 days.

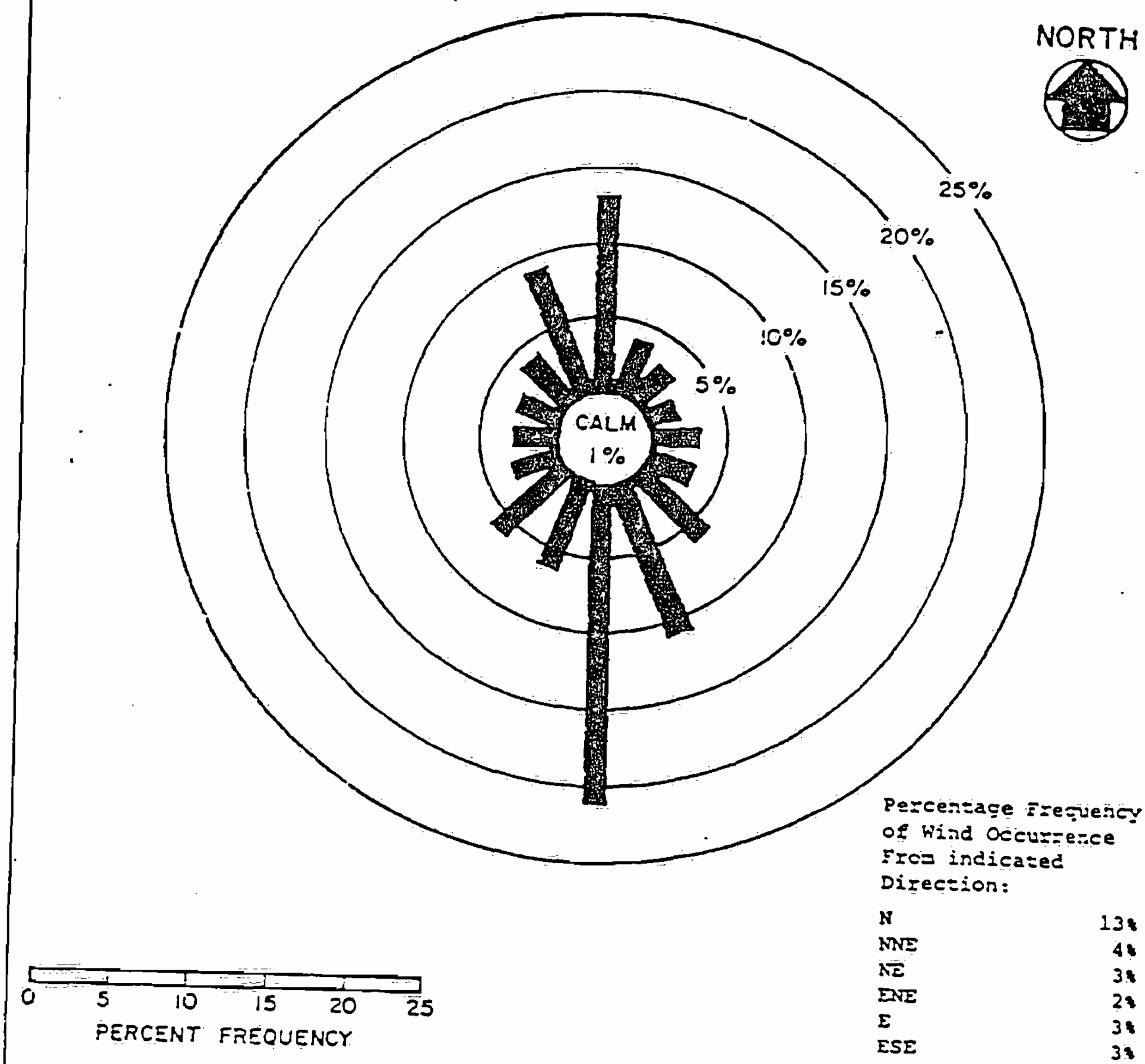
Wind direction and wind speed data were obtained from the Barkley Field Airport, Paducah, Kentucky. These data are presented in a wind rose in Figure 3.1-1. Printed about the circumference of the wind rose are the averages of wind speeds associated with each observed wind direction. The frequency of occurrence of wind direction, expressed as percentages, is printed to the right.

The wind rose data indicate that the prevailing wind direction is south to southwest. Generally, stronger winds are observed where the winds are from the southwest and northwest direction.

A detailed discussion of the climatological and meteorological features of Paducah has been prepared by Battelle's Columbus Laboratories.(1)

3.1.4.2 Ambient air quality

McCracken County is classified a non-attainment area for two pollutants, particulates, and sulfur dioxide. Previous air quality data indicated that ambient air quality for these pollutants exceeded the allowable amounts as specified by the National Ambient Air Quality Standard (NAAQS). The NAAQS are shown in Appendix B, Table B-3(2). However, Kentucky Division of Air Pollution Control samples have not exceeded ambient concentrations in the past three years(3). A petition has been submitted to U.S. EPA requesting that McCracken County be reclassified as an attainment area based on evidence of improved particulate and sulfur dioxide levels.(4)



Percentage Frequency of Wind Occurrence From indicated Direction:

N	13%
NNE	4%
NE	3%
ENE	2%
E	3%
ESE	3%
SE	6%
SSE	11%
S	21%
SSW	6%
SW	6%
WSW	3%
W	3%
WNW	3%
NW	4%
NNW	9%

FIGURE 3.1-1. WIND ROSE SUMMARY FOR BARKLEY FIELD, PADUCAH, KENTUCKY, 1979

Air quality summaries for the eight state-operated air monitoring stations in McCracken County, Kentucky, are presented in Appendix B, Tables B-4 and B-5 for the years 1976-1977.[3, 5] Figure 3.1-2 shows the locations of these monitoring sites. The station closest to the Gaseous Diffusion Plant, located in Heath, Kentucky, commenced operations in 1975 and monitors only sulfur dioxide.

The primary particulate standard was violated in 1976 and 1977 at the Paducah monitoring site on U.S. 45 at Lone Oak. Violations of the secondary annual particulate standard occurred at three of the six monitoring stations in Paducah during the period 1976 through 1977.

The total suspended particulates (TSP) air quality summary does not indicate the second high maximum concentration of the 24-hour concentration but it does show the number of times the concentrations were above the primary and secondary standard. A violation occurs when the standards are exceeded more than once. The secondary TSP 24-hour standard is violated at nearly all the sites in both 1976 and 1977 while the primary standard is not violated in either year.

The sources responsible for the violations of the secondary TSP standard cannot be determined without dispersion analysis of hourly meteorological data and emissions data for the days on which the violations occurred. It is possible that these short-term violations may have been caused by wind-blown fugitive dust.

Of the data available for sulfur dioxide measurements, the Kentucky SO_2 air quality summaries do not show any violations of the annual SO_2 standard. Unlike the data composition for particulates, the SO_2 summaries show the 24-hour second-high concentrations so that a direct comparison can be made with the 24-hour SO_2 standard. The 24-hour and 3-hour standard was not violated at any of the stations which had sufficient data.

Annual and 24-hour air quality summaries from fourteen monitoring sites in the immediate vicinity of the Shawnee Steam Power Plant are presented in Appendix B, Tables B-6 and B-7.[6]

The annual SO_2 concentrations are well within the national standards. So too are the particulate annual concentrations. For short-term averages, violations of the 24-hour and 3-hour sulfur dioxide standards were recorded in 1976 at nine of the TVA Shawnee monitoring stations. In 1977, three of the Shawnee monitoring

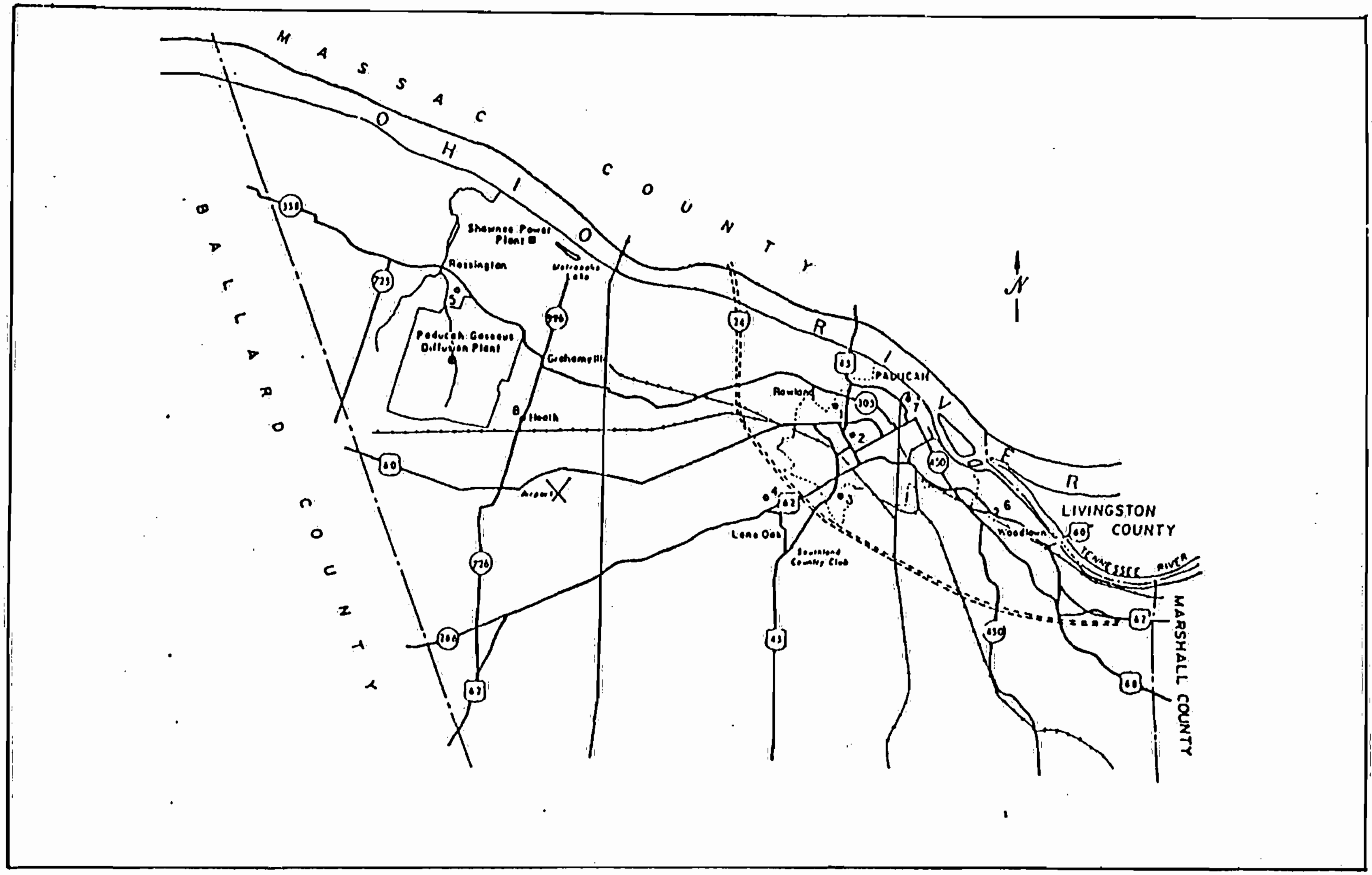


FIGURE 3.1-2. LOCATION OF THE AIR MONITORING SITES IN McCRACKEN COUNTY

stations recorded violations of the short-term SO_2 standards. This seemingly improved SO_2 air quality from 1976 to 1980 may have been a result of overall better dispersion conditions that might have been characteristic of not only the Paducah area but a large portion of the country.

Photochemical oxidants

The State of Kentucky operates two monitoring stations in Paducah that measure photochemical oxidants (O_x) and ozone air quality. The 1976 Kentucky air quality summary showed no violation of the one-hour oxidant standard of 0.08 ppm. The photochemical oxidant standard was violated eight times in 1977 with the second highest one-hour reading being 0.102 ppm. This monitoring data was certainly used by the state to support its classification of McCracken County as a non-attainment area for photochemical oxidants. No violations for this parameter were recorded from 1978 to 1980. (3, 7)

Nitrogen dioxide

NO_2 monitoring data for McCracken County was available for only year 1977. This data is shown in Appendix 3, Table 3-8. The data shows no violation of the nitrogen dioxide annual standard of 100 $\mu g/m^3$.

Carbon monoxide

The State of Kentucky monitors CO concentration at only one site in downtown Paducah. The 8-hour standard of 9 ppm was violated once in 1976 but not in 1977. The one-hour standard was not exceeded in either year.

Air quality summary

In summary, the Kentucky monitoring data presented suggest that the overall air quality in McCracken County has improved from 1976 to 1980. Specifically, annual averages of particulates, SO_2, and photochemical oxidants were reduced to meet the national standards.

For the other regulated pollutants, carbon monoxide air quality levels were not acceptable in 1976 and 1977; nitrogen dioxide concentrations were well within the allowable limits.

The source(s) of these violations cannot be determined without a modeling analysis using meteorological and emissions data for the days on which the violations occurred.

Radioactivity and fluoride data at PGDP

A rather extensive monitoring program was conducted in 1979 to sample air quality for ambient concentrations of radioactive pollutants and fluorides. Sampling data was collected from ten continuously operated stations located in and around the Paducah Gaseous Diffusion Plant. Four of the stations are located on the perimeter fence, one at the DOE property boundary north of the plant, and five approximately 1 mi (1.6 km) from the plant property.

Presented in Appendix B, Tables B-9 through B-12 are data summaries showing pollutant averages in 1979. Ambient airborne radioactivity pollutant levels averaged less than 1% of the applicable Radioactivity Concentration Guide at the offsite sampling locations. Approximately 0.02 Ci of uranium (0.2 to 2% ^{235}U) and 0.06 Ci of ^{99}TC were calculated as being emitted from plant operations in 1979 as airborne radioactive effluents.

Offsite analyses for fluorides in grass met the Kentucky Air Quality Requirements. All onsite and offsite airborne fluoride samples met the Kentucky one-week and one-month standards for gaseous HF shown below (6):

- Maximum 1 week average - 1.0 ppb as HF
- Maximum 1 month average - 0.5 ppb as HF

On January 3, 1978, a chemical explosion occurred in the C-315 tails withdrawal building, damaging a centrifugal compressor. Air samples from the perimeter air monitoring stations showed the concentrations of uranium to be well within acceptable limits.

3.1.5 Ecology

3.1.5.1 Terrestrial ecology

The terrestrial ecosystem at the PGDP site is typical of western Kentucky, although it is subjected, in part, to management practices for wildlife. The three major components of the ecosystem are soils, vegetation, and fauna.

Soils

The Paducah Gaseous Diffusion Plant is established on soils formed in thick deposits of loess (wind-deposited) or alluvium (water-deposited). Topographically, the plant site and immediate vicinity are low in relief and dissected by naturally occurring drainageways. The dominant soils are moderately to poorly drained due to low permeability, causing a seasonally high water table. Low pH and little organic content necessitate the use of lime and fertilizer for crop production.

The majority of the 10 soil series of the site belong to the Calloway-Henry association (Figure 3.1-3). The soils of this association are nearly level, poorly drained, medium textured soils found on uplands.(1) Characteristically, all of the soils series of the site are silt loams, most of which have an impervious fragipan of silty loam at a depth of approximately 26 in. (66 cm). The soils can support cultivated crops and pasture in rotation. Wooded areas are small in size and number. The dominant soil series of the site is Henry silt loam, a very poorly drained soil. Except for small plantings by the West Kentucky Wildlife Management Area, the soils of the PGDP site are not under cultivation. The areas of Vicksburg silt loam are potentailly the most productive; however, it is only found in a small area along Big Bayou.

The woodland capabilities of the site's soils are principally lowland oaks.(1) Forest acreage of the site is typical of this region of Kentucky. Small woodlots of a few acres each are scattered; the only substantial wooded areas are generally along water courses. As was the case for agricultural productivity, the Vicksburg silt loam series also has the highest potential productivity for timber. The most limiting factor for timber production is competition from less desirable tree species. The soils of the site are rated by the Soil Conservation Service as generally good for supporting important wildlife habitat elements and numerous kinds of wildlife.(1) A good rating denotes a soil on which wildlife habitat is easily created, improved, and maintained.

Flora composition

The floristic structure of the PGDP site (Figure 3.1-4) is dominated by two major habitat types -- forested and non-forested. The forest communities are dominated by woody tree species. Non-forested areas, all of which are under management practices, are those dominated by non-woody, herbaceous species, primarily grasses.

Mature hardwood forests dominate the riparian communities on the banks of Little Bayou and Big Bayou Creeks. Forests above the stream banks and over the remainder of the site are dominated by upland communities. Immature hardwood forests are sparsely scattered over the site.

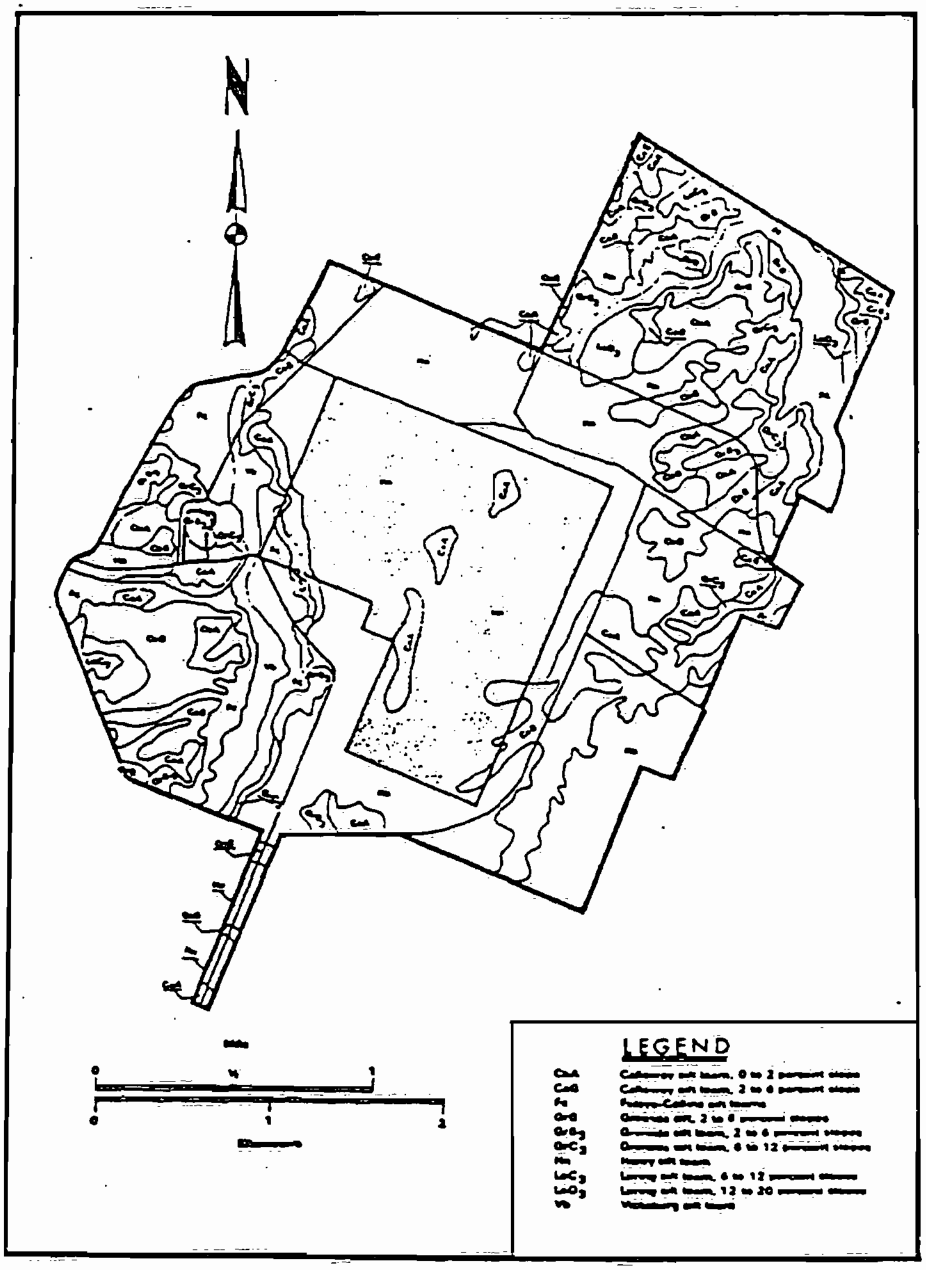


Figure 3.1-3. Soil series of the PGDP site.(1)

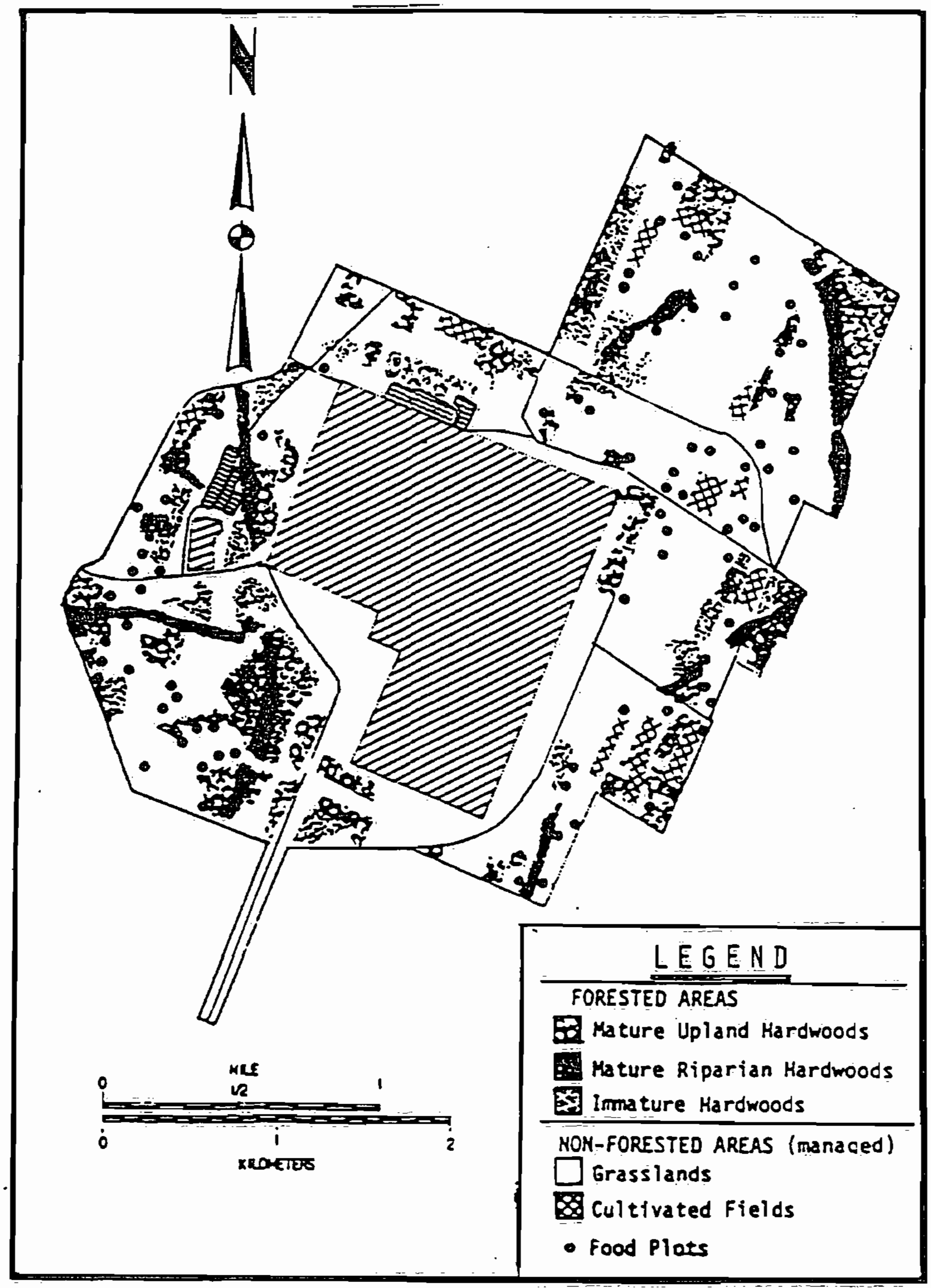


Figure 3.1-4. Vegetation habitats of the PGDP site.[1]

The upland hardwoods are predominately oak-hickory forests with numerous tree species being present. Southern red oak (Quercus falcata), shagbark hickory (Carya ovata), and post oak (Quercus stellata) are the dominant species.(2) There are no extensive areas of upland hardwood forest on the site; instead, numerous small woodlots are common.

Riparian hardwood forests have many species in common with the upland forests; however, they are dominated by different individuals.(2) River birch (Betula nigra), black willow (Salix nigra), and cottonwood (Populus deltoides) significantly dominate over other species in the riparian forests. The riparian forest type forms a continuous, though narrow, band along the entire length of both water courses.

Immature forests are a minor component of the site's floral structure. Due to the game management practices of the facility and the surrounding wildlife area, natural succession has, in general, been prevented. Immature forests are dominated in composition by saplings. Occurrence of this floral type is limited to small areas which were formerly cut over, such as power line rights-of-way and railroad cuts. The remaining areas of this forest type are limited to the edges of mature woodlots, primarily the riparian forest areas along water courses.

Virtually all non-forested areas within the site boundary are managed by personnel from either the PGDP or the West Kentucky Wildlife Management Area for wildlife habitat and food supply. Management practices are primarily limited to mowing, planting, and controlled burning. The mowing technique utilized is an annual mowing of alternating strips, which results in any given strip being mowed every other year. This practice maintains grasses as the dominant vegetation, although numerous other species exist in these areas.(2) Woody species are virtually eliminated from the community structure except in areas where mowing is intentionally omitted. This results in the invasion of either scattered young saplings or small thicket-like stands of herbaceous and woody shrub growth into grass-dominated fields. Woody species, which are the most common invaders, include sassafras (Sassafras albidum), wild black cherry (Prunus serotina), red maple (Acer rubrum), and sumacs (Rhus spp.). Planting activities include the establishment of numerous 0.1 acre wildlife food plots and a few larger cultivated fields.

Productivity

Net primary productivity of the riparian forests has been estimated to be 7,663 pounds per acre per year (8,600 kg/ha/yr); of the upland oak-hickory forests, 6,772 lb/acre/yr (7,600 kg/ha/yr); and of the immature forests, 2,165 lb/acre/yr (2,430 kg/ha/yr)(2). These values are considered to be reasonable estimates of net primary productivity for the forested areas of the site when compared to similar forests.(3)

Standing crop or biomass measurement is a determination of the actual amount of living matter present. As applied to forest vegetation, biomass measurements include all aboveground parts of trees. Riparian forests contained 98 tons per acre (220 metric tons per hectare); oak-hickory forests, 92 T/acre (207 m T/ha).[2]

Another significant contribution of biomass to the system of the PGDP site comes from the extensive areas of grassland. Based on experimental harvest data, grassland areas are capable of producing between 2,000 and 5,000 lb/acre/yr (2200 and 3400 kg/ha/yr).[2] These values are less than forested areas; however, grassland areas comprise a large portion of the overall site and therefore contribute significantly to the system.

The site is thus characterized by forested areas typical of the region and open areas of grasslands and food plots managed for wildlife.

Fauna

Birds

PGDP is on the borderline between the Alluvial Forest Avifaunal Region and the Limestone Plateau Avifaunal Region and, therefore, is characterized by bird species associated with both regions[4]. Birds common to both regions that were regularly seen at PGDP include such species as the red-bellied woodpecker, wood thrush, red-eyed vireo, Kentucky warbler, and rufous-sided towhee.[2]

Roadside bird surveys conducted during the breeding season of 1977 indicated that the following five species were most numerous at the PGDP: bobwhite, cardinal, indigo bunting, common grackel, and rufous-sided towhee.[2]

Surveys conducted along transects in six habitat types on PGDP property provided comparative information on the relative abundance of species and individuals utilizing each habitat during the beginning and middle of the breeding season.[2] Analysis of these numbers resulted in the following arrangement of habitat types from most to least diverse in their avifauna: (1) riparian woods, (2) grass and weed fields with tree groves, (3) game management areas with food strips along tree rows, (4) upland mature oak-hickory woodlots, (5) grass, weed, and shrub fields under powerlines, and (6) grass and weed fields. Of these six habitats, the game management areas were utilized by the greatest number of individual birds (but not number of species).

Surveys during midday at 10 pond sites on PGDP revealed that very little use of these small ponds is made by water birds (waterfowl, shorebirds, wading birds, etc.) during the breeding season[2]. For example, the maximum number of individuals per species recorded on any of the four survey days is as follows: green heron - 6, killdeer - 2, American woodcock - 4, and belted kingfisher - 1.

Diurnal raptors are not numerous on the plant property. Two pairs of red-tailed hawks and four pairs of American kestrels were the only diurnal raptors noted during the field survey[2]. It is likely that many of the land birds and raptors included in the 224 bird species recorded in the area of the Land Between the Lakes[5] also migrate through PGDP property and rest or feed in their preferred habitat types. Waterfowl and marsh birds, however, do not stop at PGDP in any significant numbers due to a lack of appropriate marsh, swamp, and open water habitats within the property boundaries. Most of the ducks and geese migrating in the vicinity of PGDP rest and/or overwinter at the Ballard County Wildlife Management area[6].

The land management practices result in many habitats occupied by birds typical of field and edge habitats at PGDP; birds common to hardwood forest are also present in the woodlots. Marsh birds and waterfowl are sparse due to unsuitable habitats.

Mammals

Mammal populations are characterized by species associated with ecotones and open areas. The most abundant species on the site is the house mouse. It occurs primarily in fields, with particularly high densities in areas where grain-type food plots have been planted for wildlife. Deer and cottontails are common to all parts of the site. Deer use the woodlots for cover and forage in these areas and surrounding fields. Cottontails use primarily the forest edges, borders, and fence rows for cover while feeding mainly in and along the managed grasslands and fields. In recent years, the cottontail population on the site has exhibited marked fluctuations due to unknown causes, but disease (i.e., tularemia) has been suspected[2]. Other species of mammals occur less commonly.

Gray and fox squirrels, white-footed mice, and meadow jumping mice are associated mainly with forested and wooded areas. The white-footed mouse is the most common mammal in the forested areas. The southeastern shrew, a Kentucky endangered species[7], occurs in fields and along fence rows and edges[8]; it has been found on the site[2]. Eastern moles are found in the drier areas with loose soils. Few small herbivorous rodents (e.g., voles) are present on the site. A few beavers are present in both Big and Little Bayous as evidenced by dams and cuttings; the creeks are also used by mink and muskrat. Muskrats are more common in management area ponds adjacent to the PGDP property. Some of the more mobile species, such as foxes and raccoons, use all portions of the site for foraging and denning activities; forests are used mainly for cover while the less wooded areas provide most of the food resources, such as fruits, berries, and small prey. The coyote, an endangered species in Kentucky(7) has reportedly been observed on the site.(6)

The site is typified by diverse mammal populations indigenous to several habitat types (grasslands, fields, riparian and upland forests, and ecotones). Game management practices have resulted in increased abundances of rodents, rabbits and deer.

Amphibians and reptiles

Amphibians occur in most areas of the site. American and Woodhouse's toads are found in essentially all terrestrial portions of the site while frogs, particularly southern leopard and green frogs, are found in and along the streams and ponds. Slimy salamanders occur in most forest situations. Salamanders are sparse or nonexistent in streams on the site and in the surrounding area(2) perhaps due to substrates and the scouring effects in streams during intense storms.

Reptiles are also common to all portions of the site. Their habitats include fields, forests, streams, and ponds. The eastern box turtle is ubiquitous and is the most abundant species. Red-eared turtles and common snapping turtles are found in most water bodies. Snakes are common over the site with several species, both aquatic and terrestrial, being present. The site lies within an area where the ranges of many reptile and amphibian species overlap. As a result, a large number of species may be present with hybrids and integrades occurring. An example of this is the black racer-blue racer integrade, which is one of the most common snakes on the PGDP site.(2)

Important species

Several species of animals occurring at PGDP have particular significance because of their recreational, functional, aesthetic, and legal values. The interrelationships between these and the other components of the local ecosystem are complex and involve the soil, producers (vegetation), consumers (animals), and decomposers (vegetation, animals, and microorganisms). Events affecting any group or population of organisms may dramatically affect other species present. These interrelationships are illustrated in Figure 3.1-5.

Game animals

The two major game bird species occurring at PGDP are the bobwhite and mourning dove, with the bobwhite being the most numerous during the breed-

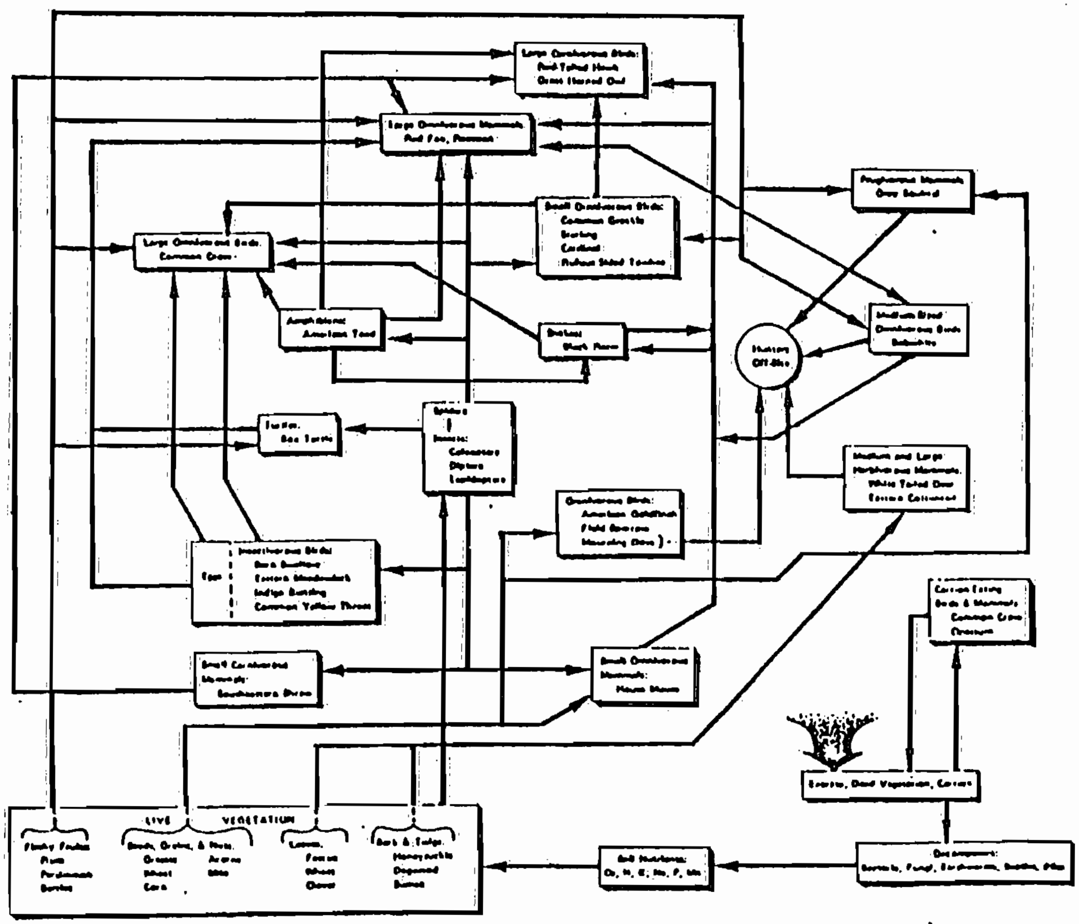


Figure 3.1-5. Simplified food web of summer biota of the Paducah Gaseous Diffusion Plant.

ing season. In addition, a few ducks and woodcock make use of the property.[6] Although hunting is not permitted on PGDP property, portions of the property are leased to the Kentucky Department of Fish and Wildlife Resources and are managed for bobwhite and mourning dove. Some of the birds using the property are probably shot in adjacent hunting areas.

Deer populations in the West Kentucky Wildlife Management Area, which includes part of the PGDP property, are managed for recreational hunting by both firearms and archery. It is estimated that the deer populations on the Management Area consist of 350-400 individuals[6] for a density of approximately 16-18/km^2; approximately 70 of the deer occur on PGDP property outside the perimeter fence. Excellent habitats exist for the deer because of the management programs. A result of hunting activity on the PGDP site and the Management Areas, man has become the principal predator of deer in the area as evidenced by the harvest of 100-150 deer per season in recent years[9].

Eastern cottontail population management is one of the major objectives of the Management Area. The rabbit is a popular game species and is widely hunted in the local region. Populations on the PGDP site have exhibited density fluctuations in recent years as illustrated by harvest data from the Management Area[2].

Gray and fox squirrels are of recreational value on the management site. Neither species is abundant, but the gray squirrel is the more common. Squirrels are not a major game species in the local area, but are in other regions where they are more common.

Threatened or endangered species

No federal or Kentucky threatened or endangered birds were observed during recent breeding bird surveys[2] nor is the habitat at PGDP appropriate as a breeding or wintering area for these birds. However, three species (golden eagle, northern bald eagle, and osprey), considered endangered in Kentucky,[7] have been known to spend part of the winter at the Land Between the Lakes[8] which is about 40 mi (64 km) southeast of PGDP. A few bald eagles and one or two golden eagles also spend part of the winter at the Ballard County Wildlife Management Area which is about 25 mi (41 km) west of PGDP. PGDP is between and within a relatively short flight distance from either of these two raptor wintering areas; these raptors could temporarily stop at PGDP, but would not be expected to remain because of inappropriate habitat.

Two species of mammals listed as rare and endangered by Kentucky have been identified as actually on the PGDP site. These are the coyote and the southeastern (Bachman's) shrew.[2] Coyotes have been observed by plant personnel on several occasions in the vicinity of the main plant entrance in the past few years. The southeastern shrew is considered rare throughout its range. It normally inhabits lowland weedfields, moist woods, and honeysuckle patches[8] and has been found in field habitats on the site[2].

Two species of bats, gray myotis and the Indiana myotis, which are included on the United States endangered species list, may use the PGDP site from time to time. These species are normally associated with caves and are not expected to be found on the site except perhaps during foraging activities. The southeastern myotis is on the state list and probably occurs on the site, at least during foraging activities.[8] It is usually associated with caves but may also be found in culverts, buildings, trees, and under bridges.

Two species of amphibians and six reptiles listed as rare or endangered by Kentucky also have ranges which include the PGDP site. One species of reptile listed on the Kentucky list, the prairie kingsnake, has been found near Massac Creek, about 1 mi (1.5 km) southeast of the PGDP site;[2] this species probably occurs on the site also.

Game management practices at the site are beneficial to at least two species of animals considered rare and endangered by Kentucky and also provide resources for several uncommon species of birds. Other threatened or endangered species may occasionally pass through the site.

Species critical to ecosystem function

Raptors at PGDP, such as the red-tailed hawk, American kestrel, great horned owl, and screech owl regulate populations of prey species (i.e., small mammals). Loss of these predators may result in overpopulation of pest species, which in turn can result in damage to native vegetation or crops and can potentially become a public health problem.[10]

The brown-headed cowbird and common grackle can be a threat to many of the perching birds[11]. The cowbird is a known nest parasite and the grackle robs nests of both eggs and young.

Small mammals, particularly rodents, often play important roles in the structure and functioning of ecosystems. They have major roles in nutrient cycling and are a major food source of predatory animals such as snakes, foxes, hawks, and owls. At the PGDP site, the house mouse is the most abundant rodent with the white-footed mouse being the second most common. House mouse population densities fluctuate dramatically.[8] Densities are usually a reflection of food abundance, both by season and location. White-footed mice occur mainly in woody and shrubby areas. Populations are normally stable with densities of 10-30 per hectare[12].

The site supports at least in part, several populations of animals important to the structure and functioning of the ecosystem. These include the small mammals which are important in recycling nutrients in the plants and soil, raptors and other predators which act to keep the rodent populations in check, and grackles and cowbirds which have negative pressures on desirable perching birds.

3.1.5.2 Aquatic ecology

Fish, benthic macroinvertebrates, and periphyton plankton communities were studied in the three aquatic ecosystems in the vicinity of the Paducah Gaseous Diffusion Plant in 1977 and 1979 in order to describe the existing biological conditions of these streams and to document effects of wastewater diversion in 1978. Data resulting from the studies are presented in Battelle Columbus Laboratories' report to Union Carbide Corporation[2,13].

West Fork of Massac Creek

The West Fork of Massac Creek drains an area similar in size and land use to Big Bayou and Little Bayou Creeks. The biological quality of the sampled area appears to be very good. The stream is used for spawning by several clean-water fish species. In spite of intermittence, the creek maintains a fairly diverse resident fish population. Resident species are comprised of rough and forage fishes as well as several species of game or higher trophic level species. Benthic and algal populations are greatly influenced by natural phenomena—flooding in the spring, low flow in summer.

Little Bayou Creek

Little Bayou Creek is a small headwater stream which is intermittent during summer periods. The portion of the creek upstream from the plant outfall supports a biological community typical of these conditions--low numbers of species; species compositions tolerant of low flows during dry periods. A total of 24 benthic species, including dipteran larvae, fingernail clams, aquatic earthworms, amphipods, crayfish, freshwater naiads, mayflies, and caddisflies were found in collections at the upstream station. Five fish species, including the swamp darter, were also collected.

Most of the flow in Little Bayou Creek can be attributed to the PGDP process water outfalls. The quality of this water did not appear to be suitable for the support of a resident fish or benthic community in 1977. Populations of both fish and invertebrates were sparse or nonexistent in Little Bayou Creek downstream of the PGDP outfall. The algal community also showed signs of environmental stress evidenced by low numbers of species and low species diversities during both surveys. Conditions in 1979 showed signs of recovery, although water quality had improved to a point suitable for fish and algal life, sediments remained inhospitable to colonization by benthic macroinvertebrates downstream from plant outfalls.

Big Bayou Creek

The biological quality of Big Bayou Creek is potentially fairly good. Stations upstream of the PGDP sewage treatment plant outfall support diverse fish and benthic communities. A total of 12 fish species including both forage and sport fishes were found upstream of plant outfalls. Benthic populations, comprised of mayflies, dragonflies, damselflies, and dipteran and caddisfly larvae, were characteristic of clean water streams.

Big Bayou Creek is adversely impacted by the discharge from the PGDP sewage treatment plant resulting in sparse populations of fish and benthos and reduced numbers of species. The algal community below the outfall was dominated by pollution-indicating species characteristic of areas where oxidation of organic load is proceeding. These effects were still noted after the diversion of waste waters from Little Bayou Creek.

All trophic levels investigated showed signs of recovery in Big Bayou Creek above the confluence with Little Bayou Creek. A fairly diverse community of forage and sport fishes had reestablished. Benthic populations characteristic of streams of intermediate quality were found.[2,12] Algal communities indicating milder pollution conditions colonized substrates.

The water quality and available habitat in Big Bayou Creek were found to be suitable for spawning by several species of fishes. There was also evidence of sunfish spawning in the upper portion of Little Bayou Creek.

Ohio River

The Ohio River receives industrial and municipal discharges from several large cities along its course in addition to draining agricultural lands in several states. The biological communities found in the Ohio River in the vicinity of the PGDP are reflective of these conditions. Species compositions of algae were similar upstream and downstream of the confluence of Big and Little Bayou Creeks. Species were characteristic of high inorganic nutrient concentrations and eutrophication, and were cosmopolitan in distribution. No benthic organisms were found in samples upstream and downstream of the Bayou Creek confluence. Substrates encountered were either too firmly compacted or contained too much sand to provide suitable benthic habitat. Results of the surveys of fishes in the Ohio River are inconclusive, but adverse effects from the PGDP are unlikely.

3.1.6 Socioeconomic profile

McCracken County is the geographic scope of this analysis addressing the socioeconomic effects of the PGDP. Although many surrounding areas may be tangentially influenced by the facility, the greatest concentration of PGDP employees occurs within the county. Other delineated boundaries (e.g., 5- and 50-mile radii) are employed where appropriate.

3.1.6.1 Social profile

McCracken County experienced relatively slow population growth from 1960 to 1970, increasing by only 1.7% during the 10-year period (compared with an increase of 5.9% for the state and 13.3% for the U.S. during the same period). However, the county's population increased by 3.2% to an estimated population of 60,200 from 1970 to 1976 (Table 3.1-1). Natural increase (births-deaths) accounted for most of the population gains, with a net migration of 1.5% which added approximately 900 people.[1]

Population projections for the county indicate that population is expected to increase to 61,300 by 1980, a 1.9% increase from 1976.[2] Table 3.1-1 presents population projections for McCracken County through the year 2020; the population is projected to increase at about 5% during each decade.

The county population density of 233 persons per square mile ($90/km^2$) is significantly higher than either the state density of 81 or the U.S. average of 57 persons per square mile (31 and $22/km^2$) (Table 3.1-1). Nearly 61% of McCracken County's population is classified as urban (over 2500 population) compared with the state average of 52% and U.S. average of 74%. Paducah, the county seat, is the largest community in the county, with an estimated population of 30,674 in 1975.[1]

Nearly 11% of the population is non-white, compared with 7.4% for the state and 12.5% for the U.S. The county's black population increased more rapidly than the white population from 1970 to 1975, increasing by 5.8% during that period, compared to a 2.8% increase for white residents.[4]

The 1970 median age of McCracken County population (31.9 years) indicates an older population than that of the state (27.5 years) or the U.S. (28.1 years). The female population has a median age of 34.2 years while the male population's median age is 29.7 years. The median age of the black residents is generally lower than that of white residents (black females, 27.2 years; black males, 23.1 years).[3]

Table 3.1-1. Selected social and demographic characteristics of McCracken County

Population Size	Year
58,281	1970
60,200	1976
61,300	1980
65,200	1990
68,700	2000
71,900	2010
75,800	2020

	McCracken County	Kentucky	U.S.
1970 Population Distribution			
1970 Density (persons/square mile)	233	81	57
1970 Percent Urban Residents	61	52	74
1970 Percent Non-White	11	7.4	12.5
1970 Median Age	31.9	27.5	28.1
1970 Educational Attainment (Years of School Completed)			
Male	11.9	9.9	12.1
Female	11.5		
1970 Median Family Income	12,500	11,200	--
1970 Owner-Occupied Median Home Value	11,774	—	—

Source: References 1-5.

The 1970 educational attainment of McCracken County's population (25 years of age and older) is suggested by data on the number of school years completed. As Table 3.1-1 shows, the median was 11.9 years for males and 11.5 years for females, slightly below the U.S. median of 12.1 years of school but substantially higher than the state median of 9.9 years.(4)

Median family income increased by over 52% from 1970 to 1976 to $12,500; this is higher than the state median of $11,200. In 1975, nearly one-fifth (19.5%) of the residents were classified as falling below the poverty line, compared to one-fourth (24%) for the state.(4)

Of McCracken County's 21,131 housing units, 79.3% are one-unit structures. Over 8% lack some or all plumbing; this share is greater than the U.S. (5.5%) but considerably less than the state average of 18.4%. Over one-half (52.3%) of the structures were built prior to 1950. This median number of rooms for occupied units is 4.9% comparable to the state and U.S. medians.(3) Two-thirds (66%) of the housing units are owner-occupied, with a median value of $11,774. Median contract rent of renter-occupied units is $80.(5) It should be noted that these data are current for 1972.

3.1.6.2 Transient population within 5 miles of the PGDP

The population levels within proximity to nuclear facilities are monitored as a federal policy. Two main categories of population are delineated: residential and transient. The first is defined as those individuals who live within proximity (5 mi or 8 km) to the facility. The transient population, on the other hand, are those people who frequent the area for various activities (working, shopping, church attendance, etc.) but who may not reside in the near vicinity.

The transient population was surveyed employing population nodes within a 5-mi (8-km) radius of the facility. Nodes were defined as land uses which would support a transient population and included institutional uses, educational and recreational facilities, commercial establishments, and employment centers.

Once transient population nodes were established, the estimated number of transient persons who could be associated daily with a given node was obtained by interview.

Appendix C, Figure C-1 illustrates the location of these nodes and their corresponding sector. Appendix C, Table C-1 details specific information regarding each node.

Most of the transient population nodes within two 5-mile (8 km) radii of the PGDP can be categorized as institutional, industrial, or commercial centers. Over half of the facilities in the area are commercial centers. Most of these, however, are not large and therefore do not draw significant numbers of people. Two of the restaurants within 5 mi (8 km) of the plant attract between 380 and 400 people each day. Most of these people probably come from outside the impact area as both restaurants are well known in the county.

Ten of the 39 nodes are institutional facilities and nine of these are churches. Although several churches have a large congregation, most are below 100 people. Since church activities usually occur occasionally during the week, the facilities are not utilized on a continuous basis. It is likely, especially with the smaller churches, that a sizeable portion of the congregation live within the impact area.

Barkley Field, Paducah's commercial airport, is located within 5 mi (8 km) of the PGDP. Although the airport employs only 125 persons, the airport management estimates that approximately 600 passengers arrive or leave through the airport facility each day.

Two large industries are located within a 5 mi (8 km) radius of the PGDP. Essex Group, Inc., employs 178 people and the TVA Shawnee Power Plant has 545 employees.

Heath High School is the only school within the 5 mi (8 km) radius. It draws 700 students and about 50 employees each school day. Although a few students live within the impact area, most are bussed from communities such as West Paducah and Kevil.

3.1.6.3 Projected sector population, 1980-2020

Projections of the sector population sizes and densities for 1980-2020 were derived by the same general methodology employed in an earlier assessment.[6] However, here county population projections were used as the base figures from which to estimate future sector populations. These projections were obtained through the appropriate state agencies and were accepted as the official county projections at the time of this study.[2,6,7,8]

In developing the projected populations for each identified community, the population was assumed to maintain the city-to-county ratio that was prevalent in 1970. Moreover, the same ratios of rural-to-urban population density evident in 1970 were extrapolated using the projections as control totals. This methodology resulted in estimates of residential population and density (1980-2020) for all sectors.

Population and density changes by sector for 5-mile radius, 1980-2020

The forecasts for sector residential population and density levels within 5 mi (8 km) of the PGDP are presented in Appendix C, Figures C-2 through C-6. These projections indicate a consistent absence of residential population within 1 mile of the PGDP. Appendix C, Tables C-1 and C-2 enumerate these projections by sector identification numbers (shown in Appendix C, Figure C-7).

Outside that 1-mi (1.1-km) radius, the sector population levels are expected to increase 5-6% each decade; this reflects the expected overall growth of McCracken County through the same time period.

Population and density changes by sector for 50-mile radius, 1980-2020

The county population projections were used as a basis upon which to estimate the future 50-mile radius (180 km) sector residential population and associated densities. A graphic representation of these sector projections is presented in Appendix C, Figures C-8 through C-17. An enumeration of these sector figures is also recorded in Appendix C, Tables C-3 and C-4.

Appendix C, Figure C-18 shows each sector's location by identification number. The following counties are likely to be the fastest-growing jurisdictions during the projection period:

- Cape Girardeau County, Illinois
- Marshall County, Kentucky
- McCracken County, Kentucky
- Scott County, Missouri
- Williamson County, Illinois.

Therefore, the sectors associated with these counties will probably gain the most population over the next 40 years. Examination of Appendix C, Figures C-8 through C-17 indicates the following significant growth sectors:

- 85-89, 95 [within 10 mi (16 km) of PGDP]
- 102, 103 [within 10-20 mi (16-32 km) of PGDP]
- 118 [within 20-30 mi (32-48 km) of PGDP]
- 135 [within 30-40 mi (48-64 km) of PGDP]
- 145, 157, 158 [within 40-50 mi (64-80 km) of PGDP].

However, even in these growth sectors, the absolute population increase is fairly moderate.

The population projections also suggested expected decreasing populations in some counties. These sectors associated with these jurisdictions are located southwest of the PGDP within 20-50 mi (32-80 km). They include:

- Alexander County, Illinois - 123, 145 [20-30 mi (32-48 km) from PGDP]

- Fulton County, Kentucky - 139, 140 [30-40 mi (48-64 km) from PGDP]
- Mississippi County, Missouri - 154, 155 [40-50 mi (64-80 km) from PGDP].

In summary, the sector population growth trends within 50 mi (80 km) are expected to be modest, with no dramatic shifts expected over the next four decades.

3.1.6.4 Economic profile

An economic profile of McCracken County was recently completed.(6) The analysis indicated that in 1974 almost 20,000 people were employed in McCracken County. The labor force from which these workers were drawn was comprised of 74% of the males aged 14 and over plus 37% of the females within that same age bracket.

The most dominant sector in terms of employment was wholesale/retail trade, which accounted for over 6,000 workers. Manufacturing (which encompasses PGDP activities) is the second most important employment generator, followed by business and personal services.(6)

In 1980, the PGDP employed over 1900 individuals, thereby accounting for approximately 10% of the total employment level of the county; 74% of these workers reside in McCracken County. The PGDP is a major economic factor in the area, both in terms of its direct effects (such as PGDP employment) as well as its indirect economic ramifications (such as inducing increased demand for goods and services).(6)

In addition to economic activity in the local private sector, the public sector is also active in the generation of revenue and its expenditure. The primary entities involved included McCracken County, the City of Paducah, the Paducah Independent School District, and the McCracken County School District. A detailed financial profile of these jurisdictions/districts is provided in the earlier study.(6)

3.1.7 Political structure

In order to profile the scope of political activity in McCracken County, it was necessary to (1) identify the entities and (2) discuss the range of public services which are particularly applicable to the assessment of PGDP impact.

3.1.7.1 Political entities

The formal political entities of the area are defined broadly as federal, state, regional, county, and local governments. In turn, each of these can be divided into subelements which achieve the various roles of each governmental level.

The federal government is represented locally by the typical complement of services and offices. However, due to the presence of the gaseous diffusion operation in McCracken County, the U.S. Department of Energy (and general U.S. nuclear policy) is of particular relevance.

McCracken County is the most heavily populated county in western Kentucky and a number of regional state offices are located in the area. Some of the agencies/departments represented locally include:

- Administrative Office of the Courts
- Department of Education
- Department of Highways
- Economic Security Department.

On a regional level, the Paducah Area Development District (ADD) is the most visible quasi-government entity. The area that it serves encompasses the eight westernmost counties in the state. The ADD is governed by a board of directors representing each county. A full-time professional staff serves the District.

Paducah, as the county seat of McCracken County, is the location of many county offices and services. The chief executive officer is the county judge, an elected official. In addition, there are three county commissioners, each serving 4-year terms. The operating fund of the county approximates $1 million.(1)

The incorporated City of Paducah is the predominant municipal entity in the immediate PGDP area. The elected officials of this city include a mayor and four councilpersons. The administration of the city government is the responsibility of a full-time city manager.

In addition to the governmental levels discussed above, there are many local governmental units in McCracken County. Such entities may serve only specified functions and, thus, may or may not be impacted by or related to PGDP activities.

Over and above the formal political entities and related public services outlined, there are also informal political groups which may exert subtle local influence. These include organizations such as:

- Chamber of Commerce
- Civic Clubs
- League of Women Voters.

Although the specified goals of each of these types of organizations may not formally encompass political advocacy, the personalities involved may be influential in formal political circles. Therefore, it is important to note these entities as part of the local political environment.

3.1.7.2 Public services

One of the functions of political entities is to provide a range of public services to local residents. The scope of major services encompasses:

- Education
- Transportation facilities
- Water
- Sewer
- Public safety (fire/police)
- Recreational opportunities.

The following sections discuss the attributes of each of these public services within McCracken County.

Education

Public education within McCracken County is provided by two school districts: the Paducah Independent School District and the McCracken County School District. The Paducah Independent School District has experienced a decine in enrollment of approximately 30% during the 1970's. Enrollment is expected to continue declining, reaching a forecasted plateau of roughly 3,500; this will represent a 45% overall decrease since 1970. The McCracken County School District provides public instruction for all children outside Paducah. Enrollment has been increasing slightly during the 1970's, increasing from 6230 in 1970 to 6609 in 1978.[2]

Transportation

The major elements comprising the transportation system in the Paducah and McCracken County area are highway facilities. Four federal highways (U.S. 45, 60, 62 and 68) and many state highways traverse the area. These are supported by a network of state and county roads. With the completion of Interstate Highway 24, traffic movement within the county and through Paducah has been greatly enhanced.

Water

Six water districts serve the residences, businesses, and industries of McCracken County. Paducah Water Works, the major system that collects, stores, and distributes water for the area, draws its raw water supply from the surface waters of the Ohio River upstream from PGDP. Paducah Municipal Water District serves a population of more than 32,000 and uses approximately 7.4 million gallons per day (28 mld). Four other water districts in the county (Hendron, Lone Oak, West McCracken and Massac) also use Paducah Water Works for their source of treated water. Only one water district, Reidland, presently draws its water from wells. All of the water systems in McCracken County are currently operating at half or less than half capacity; however, the Paducah Water Works plans to begin construction of a new $5 million water treatment facility.(3)

Sewer

Sewage treatment facilities in McCracken County are provided by the City of Paducah and three sanitary districts--Woodlawn, Reidland, and Lone Oak. Union Carbide operates a separate system for the PGDP.

The Paducah system operates a mix of sanitary (40%) and combined (60%) sewers. The current plant began operations in 1957. Secondary treatment facilities went on-line in 1977 with a design capacity of 12 million gallons per day (mgd) (45 mld). Average flow is 3.5 mgd (13 mld) but the peak is reached at times of heavy rain; this problem is accentuated because Paducah is a low river town. When capacity is reached the excess is discharged into the Ohio River.

Reidland and Lone Oak both operate trickling filter plants with capacities of 300,000 and 350,000 gpd (1.1 and 1.3 mld), respectively. Reidland is near capacity while the Lone Oak plant is only 14 years old and still has capacity available. The Woodlawn District operates a 2-cell lagoon treatment facility with a 500,000 gpd (1.9 mld) capacity; it has been plagued with problems such as odor and a frequent dry outflow area. The internal survey conducted by Union Carbide indicated that 72% of the PGDP-related households in McCracken County have sewer; the remaining 28% rely on septic tanks.

The treatment plant at PGDP has both primary and secondary treatment. The plant's design capacity is 800,000 gpd (3 mld) and currently has an average daily flow of 356,000 gallons (1.3 mld). The peak flow was 598,000 gallons (2.3 million liters), necessitating the cutting of some inflows.(3)

Law enforcement

There are four law enforcement agencies that provide service to the City of Paducah and McCracken County—the municipal police force, the county sheriff, the county police force, and the State Highway Patrol. The domain of the Paducah Police Department is almost exclusively limited to enforcement within the city limits. Two law enforcement agencies serve

McCracken County outside of Paducah—the McCracken County Sherrif's Department and the McCracken County Police Department patrol suburban and rural McCracken County. Both county law enforcement agencies also respond to calls in the City of Paducah, if needed. The Kentucky State Police also provide law enforcement support in the county.

The 1978 ratio of full-time law enforcement officers per 1,000 McCracken County residents is 1.66. National standards recommend a ratio of 1.75 - 2.0. Therefore, the county is slightly below that range.[4]

Fire protection

Fire protection in McCracken County is provided by eight fire departments; all areas of the county are served by one of these departments. The largest unit (and the only full-time municipal department for the area) is the Paducah City Fire Department.

Union Carbide provides its own fire protection equipment at the PGDP: three full-size fire trucks and seven mini-trucks are stationed in the process areas. Production personnel are trained to operate the mini-trucks while 17 full-time firemen operate the regular equipment. Union Carbide also operates a fully equipped rescue squad and has a second hearse-style ambulance slated for retirement. Union Carbide and the City of Paducah have an informal assistance arrangement.

The remaining areas of the county are served by five volunteer fire departments. Each district is governed by a seven-member board of trustees and has powers to tax the residents of its district. The districts have cooperative agreements within the limits of state fire regulations. The greatest problem facing the volunteer fire departments is the absence of water mains and hydrants in many areas. This severely limits their ability to protect residents and necessitates the maintenance of tankers to carry water to such areas.[4]

Recreation

The McCracken County area possesses good surface water resources which form a basis for outdoor water-related recreation, hunting (especially goose and duck), and fishing. There are two major lakes (Kentucky Lake and Barkley Lake) with rugged shorelines totaling 3,000 miles (4830 km). Just east of Kentucky Lake lies the "Land Between the Lakes," a 170,000-acre (68,850-ha) federally owned and managed recreational preserve area devoid of private development; it annually attracts more than 1.7 million visitors. There are also three state parks within 53 mi (85 km) of Paducah—Kentucky Dam Village State Resort Park, Kenlake State Park, and Lake Barkley State Park. The City of Paducah has nine city parks totaling 300 acres (121 ha), the largest of which is Noble Park; one municipal and two private golf courses; and a fully programmed City/

County Recreational Department with ball diamonds, tennis courts, and other equipment for all sports and activities. Two public swimming pools are available--one is operated by Paducah in Noble Park and the other is operated at Broadway United Methodist Church which is open to the public. Several private pools are also available at other locations.(1)

3.1.8 Land use analysis

Land use patterns

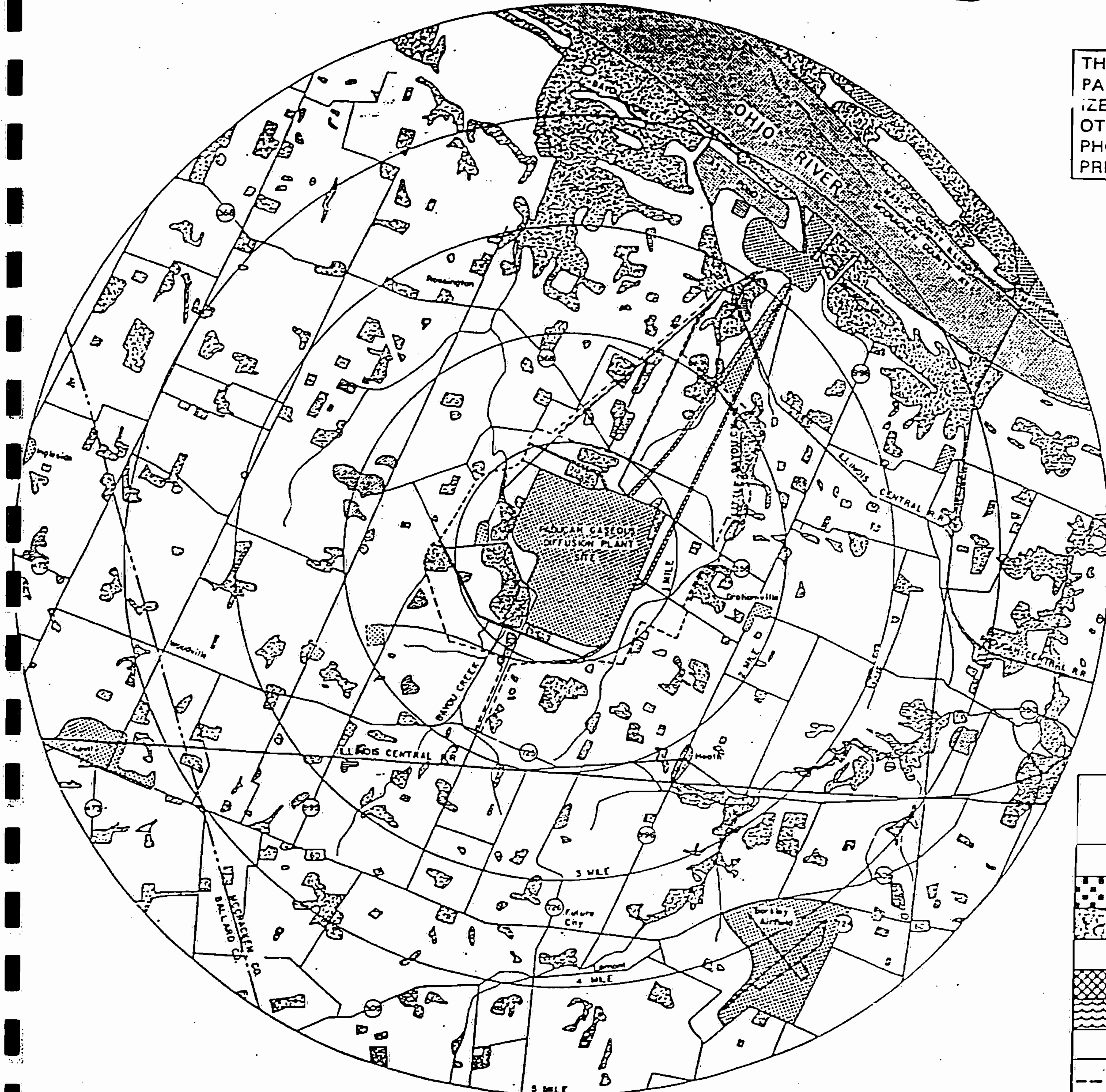
The Paducah Gaseous Diffusion Plant is located on a 3,425-acre (1387 ha) site in a generally rural area of McCracken County approximately 10 miles west of the City of Paducah. The site was previously part of the Kentucky Ordinance Works Area. An additional 2,780 acres (1126 ha) of land owned by the U.S. Department of Energy is presently leased to the Kentucky Department for Natural Resources and Environmental Protection for wildlife conservation purposes. General land use patterns of the Paducah, Kentucky, region and specific land use patterns within a 5 mi (8 ha) radius of the facility are illustrated in Figures 3.1-6 and 3.1-7, respectively.(1)

The minimum mapping unit for all land use/land cover categories is 40 acres (16 ha) except for urban and built-up water, agricultural and mining areas which are mapped at a minimum unit of 10 acres (4 ha). As shown in Figure 3.1-6, agricultural and forested lands comprise the predominant land use patterns in the Paducah region.

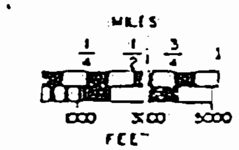
Figure 3.1-7 provides a map of the generalized existing land use patterns of areas lying within a 5 mi (8 km) radius of the Paducah Gaseous Diffusion Plant (PGDP). This land use map is a composite of several multidate land use maps of the area.

The area within the 5 mi (8 km) radius of the PGDP is predominantly agricultural and open space land, totaling approximately 75% of the area. Forested areas account for approximately 15%; urban/built-up areas comprise approximately 4%. The small clusters of residential areas forming small communities in the study area and their approximately straightline distance from the Paducah Gaseous Diffusion Plant are as follows:

Grahamville	(1.5 mi, 2.4 km)	Lamont	(3.7 mi, 6.0 km)
Heath	(2.2 mi, 3.5 km)	Kevil	(4.7 mi, 7.6 km)
Rossington	(2.7 mi, 4.3 km)	Ingleside	(5.0 mi, 8.0 km)
Future City	(3.3 mi, 5.3 km)		
Woodville	(3.5 mi, 5.6 km)		



THIS LAND USE MAP OF AREAS WITHIN A FIVE MILE RADIUS OF THE PADUCAH GASEOUS DIFFUSION PLANT ILLUSTRATES ONLY GENERALIZED EXISTING LAND USE PATTERNS. THIS MAP WAS PREPARED FROM OTHER MAPS PUBLISHED IN SEVERAL DOCUMENTS WITH AERIAL PHOTOGRAPHS UTILIZED AS A SUPPLEMENTARY DATA BASE. MAP PREPARED JUNE 1977.



EXISTING GENERALIZED LAND USE

LAND USE CLASSIFICATION	AREA	
	ACRES	PERCENT
URBAN/BUILT-UP AREAS	2,150	4.28
WOODED AREAS	7,750	15.43
AGRICULTURE/OPEN SPACE AREAS	37,540	74.72
GRAVEL PITS (ABANDONED)	175	.35
WATER BODIES	2,625	5.22
TOTAL	50,240	100.00
---- PROPERTY BOUNDARY OF THE ERDA PADUCAH FACILITY	3,425	6.82

Figure 3.1-7. Generalized existing land use patterns within a 5-mile radius of the Paducah Gaseous Diffusion Plant

Metropolis, Paducah, and La Center are larger communities located near the facility. Other urban/built-up areas within the 5-mile (8-km) radius include Barkley Airfield and the Tennessee Valley Authority's Shawnee Steam Power Facility. The major highways crossing the study area are Interstate 24, U.S. Route 60 and Kentucky Routes 305, 358, 725, 726, and 996. The Illinois Central and Paducah Central railroads also traverse the area.

The Ohio River, Metropolis Lake, Bayou Creek, and other smaller water impoundments constitute approximately 5% of the study area. A portion of the study area lies within the flood plain of the Ohio River. Except for the TVA Shawnee Power Plant, little development has occurred on the alluvial plains within this flood hazard area.

A number of small abandoned gravel pits total less than 0.5% of the total area within the study area; no mining activities are presently being conducted.

Land capability and productivity

A breakdown of land use for Ballard, McCracken, and Massac counties by U.S. Soil Conservation Service land capability classes from the 1970 Soil and Water Conservation Needs Inventory(2,3) was recently compiled.(1) This inventory included 91% of the total land area of these three counties. The best land, Class I, accounts for 6% of the total area while 11.5% of the area was categorized as Class V-VIII lands. Erosion, excessive water, and soil limitations in the root zone are the dominant soil and water conservation problems of 52%, 40%, and 2%, respectively. The 1967 inventory also revealed 24.4% of the land in the three-county area was forest land, 49.2% was cropland, 22.0% was range and pasture land, and 4.4% was in other land-use categories.

The existing land-use patterns in the Ballard, McCracken, and Massac counties are predominantly comprised of agricultural and open space lands. Data compiled from the 1974 census of agriculture (preliminary reports) provide a further breakdown of the use of land in the three-county area and other selected agricultural statistics.(4) Comparison of the 1969 and 1974 data reveals a 15% decline in the number of farms, a 14-acre (5.7 ha) increase in the average size of farms, and a 5% decline in the number of acres of land in farms over that 5-year period.

Principal crops grown in the three-county area include corn, sorghum, wheat, soybeans, hay, and tobacco. Agricultural productivity in terms of approximate average annual yields of these six crops as derived from the 1974 census of agriculture, the 1976 soil survey of Ballard and McCracken Counties, annual Kentucky agricultural statistics, and other reports are as follows:(1)

Corn	70 bushels/acre (6.0 m^3/ha)
Sorghum	55 bushels/acre (4.7 m^3/ha)
Wheat	32 bushels/acre (2.8 m^3/ha)
Soybeans	25 bushels/acre (2.2 m^3/ha)
Hay	2 tons/acre (4.4 T/ha)
Tobacco	2,050 lb/acre (2300 kg/ha)

On a county basis, 26% of the total land area of Ballard County and 24% of McCracken County are designated as commercial forest lands.(5,6) Volume data for Ballard and McCracken counties were 46.5 million and 92.5 million board feet (109,662 and 218,145 m^3) of sawtimber, respectively.

3.1.9 Water supply

3.1.9.1 Water use

Water use in the area of PGDP includes the following potential sources:

- Ohio River
- Big and Little Bayous
- Groundwater

The U.S. Army Corps of Engineers has made estimates of the quantity of Ohio River water presently used for municipal and industrial purposes.(1) Their regional area includes the portion of the river between Uniontown Lock and Dam and the juncture with the Mississippi River. Projected 1980 municipal uses are approximately 15 million gallons per day (0.5 m^3/sec; 24 cfs). Compared to the historical minimum river flow of 9,700 million gallons per day (425 m^3/sec; 15,000 cfs), the projected use indicates the low level of urbanization within the area of the PGDP.

Current industrial usage is also a very small percentage of the available water supply. Major withdrawals for industrial use, excluding power generation, were projected to reach 6 million gallons per day (0.1 m^3/sec; 3.9 cfs) by 1980. The Tennessee Valley Authority's Shawnee Power Plant, which is approximately 4 mi (6 km) north of the PGDP on the Ohio River, withdraws about 1.4 billion gallons per day (2,166 cfs, 61 m^3/sec). Greater than 98% of this flow returns to the river. The Ohio River is also the source of water for the PGDP via the TVA intake structure. Water withdrawals by PGDP strongly depend on electric power consumption levels. Power levels in turn are related to production levels. During the first seven months of 1979, water withdrawals ranged from 11 to 17.1 mgd (0.5-0.8 m^3/sec; 16.9-27.3 cfs). At maximum power consumption levels of 3040 MW the corresponding water withdrawals are estimated at 26.1 mgd (1.2 m^3/sec; 40.2 cfs). Slightly more water is used in the winter season because the colder weather temperatures make the softening process less efficient. At the other extreme, water withdrawals for zero power comsumption correspond to sanitary usage of about 2.8 mgd (10 mld). About 4 mgd (15 mld), on average, is returned to the Ohio River via Big and Little Bayous. The remaining large industrial user of water in this stretch of the river is the Joppa Steam Electric Plant owned by Electric Energy, Inc. Water use at the facility will be discussed in Section 3.2.6. For discussion purposes, average withdrawals are about 830 cfs (17 m^3/sec) of which about 98% is returned to the river. Table 3.1-2 summarizes projected 1980 demands compared to the 100-year low flow supply.

Table 3.1-2. Regional water use from the Ohio River near Paducah Gasous Diffusion Plant

Usage		MGD	cfs	m^3/sec	Percent of River Flow
Municipal	Withdrawal	15	24	0.5	<0.1
	Consumption	0.2	0.2	0.05	<0.1
Non-energy Industries	Withdrawal	6	9.2	0.2	<0.1
	Consumption	0.06	0.9	0.02	<0.1
Energy Industries	Withdrawal	1,945	2,996.0	64.8	15.3
	Consumption	38.9	59.9	1.3	0.3
Supply (Low-Flow)		9,700	15,000	425	—

Current consumption of river water does not exceed 1% of the flow.

No domestic, commercial or industrial withdrawals of water directly from Big and Little Bayou Creeks have been identified. These streams cannot be relied upon for a non-interruptable source of water supply. Local groundwater withdrawals were estimated on the basis of the population densities given previously. Two estimates of per capita usage were located. One study conducted near Paducah found usages of 5 to 43 gpcd (19-163 lpcd) while another estimate for the entire McCracken County cited a value of 89 gpcd (337 lpcd).[2,3] This latter estimate probably includes some municipalities for which per capita usage is much greater than in rural areas.

Annual groundwater withdrawals for domestic use by residents of Big Bayou and Little Bayou basins lie between 5 and 85 million gallons. One estimate arrived at a value of annual recharge between 85-125 million gallons per square mile or 1.9 - 2.8 billion gallons for the two basins combined.[4] Current estimated usage is therefore only a very small fraction of recharge, even if the majority of the annual recharge is lost to deep storage. No large-scale use of groundwater by commercial or industrial facilities was found.

3.1.9.2 Water quality

Existing water quality in the area of the PGDP is determined by the following factors:

- Dominant land use and soil types
- Specific industrial activities/discharges
- Municipal waste water discharges.

Numerous studies have cited a relationship between watershed land uses and water quality.[5,6] Land use in the area of the PGDP is almost exclusively rural. Only 90,000 persons in communities along the Ohio River or its tributaries between Uniontown and Cairo were served by municipal water systems in 1960. Of this total, 56% resided in McCracken County, Kentucky.

Although there are patches of forest in the vicinity, the primary rural land use type is agricultural. Agriculture results in a number of pollutants being contributed to rivers and streams, particularly sediment. No estimates of quantitative losses have been made for the area, but the heavy clay soils and lack of topographic relief probably indicate a lower value than 4,800 tons/mi^2/yr (1600 T/km^2/yr) commonly cited as an average for cropland.[7] Along with sediment, fertilizer and pesticide runoff is the most persistent problem associated with agriculture. Phosphorus, ammonia, and nitrate are the principal contaminants.

In addition to suspended material, storm runoff from urban areas contributes significantly to the amount of heavy metals and oxygen-depleting materials found in rivers and streams.

In addition to these contributions, specific industrial activities may introduce unique sets of contaminants. For the PGDP, these contaminants include radionuclides, principally uranium and technetium; fluoride and nitrate from supporting activities; residual chlorine from cooling tower blowdown; and chromium and zinc from cooling tower drift. Trace amounts of oil and grease as well as other metals and chemicals may also be found occasionally. Impacts of these discharges on receiving water bodies are discussed in Section 4.1.

A summary of existing water quality in the Ohio River is shown in Table 3.1-3. These values may be compared to background values to determine the extent of man's influence. Most values at Lock and Dam 53 are above the background concentrations as defined by analyses at U.S. Geological Survey benchmark stations, particularly for parameters such as suspended solids and plant nutrients which are related to agriculture. Heavy metal concentrations, especially those associated with particulates, show evidence of upstream municipal or industrial discharges.

Table 3.1-3. Existing water quality in the Ohio River at Lock and Dam 53 near Grand Chain, Illinois,[a] and near PGDP as compared to background concentrations

Location	pH (Range) Units	T °C	Alkalinity as $CaCO_3$ mg/l	Hardness (Ca,Mg) mg/l	Suspended Solids mg/l	Dissolved Solids @ 180°C mg/l	Dissolved F^- mg/l	Total NO_2+NO_3 mg/l	Total N mg/l	Total P mg/l	Metals µg/l Cr D[b]	Cr T	Cu D	Cu T	Zn D	Zn T	Fe D	Fe T
Lock and Dam 53	6.1-8.3	4-30	55-104	81-180	6-376	120-302	0.1-0.6	0.24-3.40	71-3.3	0.03-1.0	0-3	0-30	3-8	3-48	0-50	10-120	0-70	240-13000
Near PGDP[c]	8.1-8.7	14.5-21	38-83	74-106	30-77	112-312	<0.1-0.3	0.3-3.1	<0.2-0.6	0.17-0.31	-	<10-10	-	<10-10	-	10-30	-	340-2300
Background[d]	8.0	-	125	150	20	150	0.1[f]	0.2	0.03	0-19	0-19	10-30	2-10	2-10	0-30	10-30	-	-

(a) USGS Station 03612500 at R.M. 962.2. Water Resources Data for Kentucky, issued annually by the U.S. Geological Survey. Data are from 1973 to 1977 inclusive.

(b) D = Dissolved, T = Total.

(c) Sampling stations located both upstream and downstream of TVA Shawnee, and discharge point of Big and Little Bayou Creeks.

(d) Source: Reference(5)

(e) From nearest hydrologic benchmark station of U.S.G.S.

Values for water quality sampling stations near PGDP do not show specific trends that might be indicative of plant contributions. Due to the small flows discharged from the plant and based on a dispersion model which is discussed in Section 4.1.2.1, only fluoride and possible chromium or nitrate concentrations in the river will be influenced by PGDP discharges and even then only to a minor degree.

Radionuclide concentrations have been measured above and below PGDP in both short-term grab sampling and long-term monitoring and may be compared to background values (Figure 3.1-8). Results show that for both alpha and beta radiation, the levels are significantly above the estimated background water concentrations for this section of the United States. However, the graph also clearly shows a negligible difference between radiation levels above or below PGDP. These findings and other data on aqueous radiation levels near PGDP will be treated in more detail in Section 4.1.2.2 following the description of the applicable standards.

In general, water quality in the Ohio River is the result of many ongoing activities within the basin. Of those which take place in the local area of the plant, agriculture probably provides the most significant influences, followed by energy-related industrial activity. Energy related activities include those at PGDP. Urban areas do not comprise a significant land use and therefore constitute a relatively minor influence on water quality.

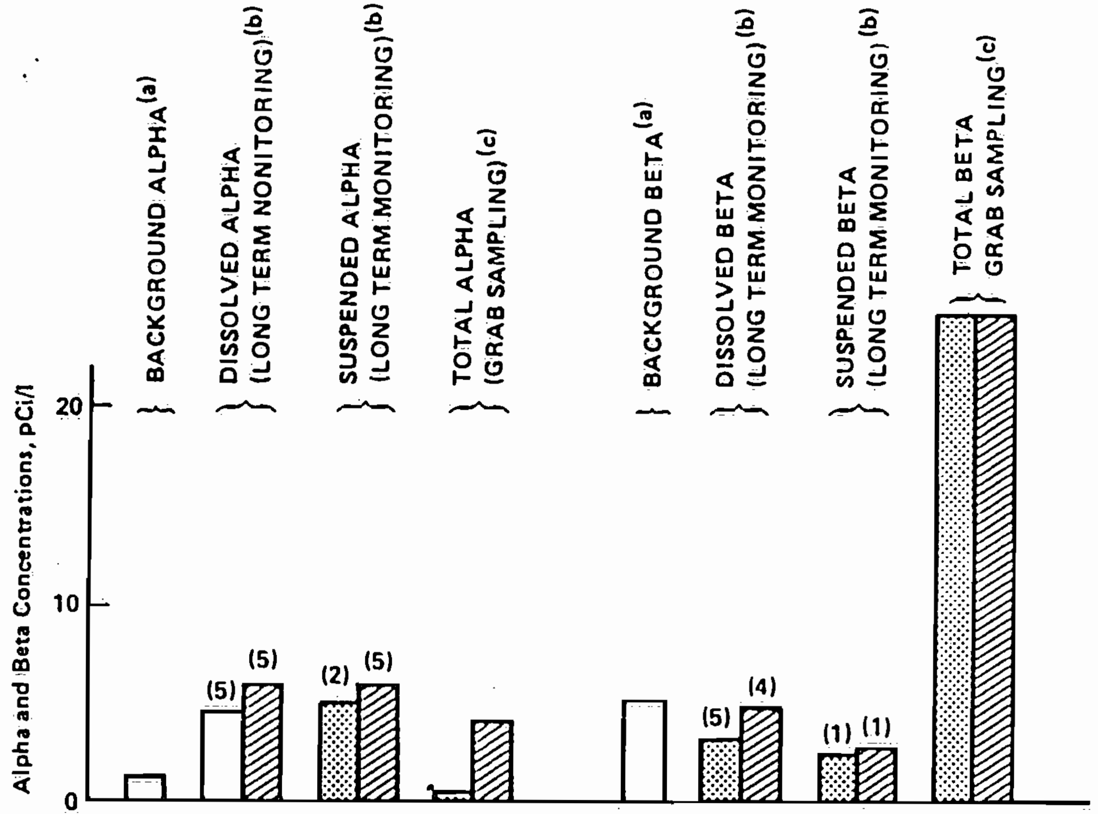
Water quality in Big and Little Bayous can be characterized by comparison to Massac Creek water quality. Massac Creek is a small watershed to the east of PGDP which has no known major sources of pollutants and should therefore be background representative of conditions in Big and Little Bayou Creeks without the PGDP and without other point sources. Based on data gathered during 1977-78 environmental sampling and monitoring (Figure 3.1-9), the following conclusions can be drawn concerning existing water quality in Big and Little Bayou Creeks as compared to Massac Creek:[8]

Massac Creek—

- Massac Creek is currently free from industrial pollution and is representative of desirable water quality for small rural watershed conditions.

- During hot weather, flow in the West Fork of Massac Creek is so low as to cause asphyxiation of fish due to low dissolved oxygen.

- The iron and manganese content of Massac Creek sediments together with the high native clay mineral content should effectively remove any naturally-occurring heavy metals from the water. The very low sediment concentrations of zinc, nickel, mercury, lead, and cop-



(a) Source: MRI.
(b) Covers the Period 1976-78.
(c) Two dates in April and June, 1977.

LEGEND:
UPSTREAM STATION
DOWNSTREAM STATION
STANDARD DEVIATION
(Average Values Shown)(5)

FIGURE 3.1-8. EXISTING RADIOLOGICAL QUALITY OF OHIO RIVER WATER BETWEEN RIVER MILES 948 AND 948.4

per make it reasonable to believe that the creek has historically not been the receptor of these metals.

- The only known discharger to Massac Creek is a small municipality. This, and the agricultural nature of the basin, probably accounts for the observed ammonia, nitrate, Kjeldahl nitrogen, and phosphate values.
- The temperature of Massac Creek water was below the applicable standards of 21.1 and 30.6 C for April and June, respectively.

Little Bayou Creek—

- Significant increases in chromium and zinc were noted in the sediments downstream of PGDP discharge.
- Heavy metal concentrations were higher below PGDP, particularly for zinc and chromium, which are added to the cooling tower makeup. Since June 1977 a chromate removal system (which is also effective for zinc) has reduced the concentrations and shifted the discharge to Big Bayou Creek. However, windage from the towers into Little Bayou Creek is still being addressed, as monitoring data for the latter part of 1977 and 1978 showed relatively elevated concentrations.
- Discharge of cooling tower blowdown historically increased the concentration of dissolved solids in Little Bayou Creek by as much as an order of magnitude. Routing the blowdown to the chromate facility in 1977 shifted the effect to Big Bayou Creek. During 1977 elevated concentrations of dissolved solids in Little Bayou Creek were probably due to the windage problem with the cooling towers; monitoring data for 1978 showed 100 percent compliance with NPDES permit conditions.
- Residual chlorine from biocide addition was in a toxic concentration range downstream from PGDP, but rerouting blowdown through the chromate system should show considerable reductions. Any remaining effects have been shifted to Big Bayou Creek. Effects from excessive levels of residual chlorine will be mitigated by downstream relocation of the outfall.
- UF_6 and UF_4 manufacturing/reduction operations were discontinued in May 1977. Fluoride concentrations have dropped but are not yet to background levels.
- The temperature of Little Bayou Creek was below the applicable ambient standards (see Massac Creek) for both sampling dates in 1977 and met NPDES limits 99% of the time in 1978.

Big Bayou—

- Upstream of the PGDP discharge, ammonia concentrations may occasionally reach toxic levels. The source of the ammonia is believed to be either sanitary waste from a small school or industrial solid waste leachate from the old ordnance works.

- Low flow augmentation of Big Bayou by PGDP discharge has beneficial effects on dissolved oxygen levels.

- Dissolved solids levels during 1978 have remained at or have been slightly reduced from those found in 1977, i.e., no significant effects of the rerouting of cooling tower blowdown have been noted thus far.

- Aqueous concentrations of hexavalent chromium increased significantly between stations upstream and downstream of PGDP and as compared with Massac Creek. As with Little Bayou, the chromate reduction facility will decrease discharges substantially. As is shown in Figure 3.1-9, some reduction can be noted already.

- The temperature of the water was below the applicable standards for both sampling dates in 1977 and met NPDES limits 99 percent of the time in 1978.

Uranium and radioactivity levels in the waters of Big and Little Bayou Creeks were also monitored during 1977. Selected results of analysis of these samples are depicted in Figure 3.1-10. Levels of all three analyses are generally between one and two orders of magnitude higher at stations downstream of PGDP compared to upstream stations.

3.1.10 Historical radiological characteristics of the site

Radiological levels monitored on and near the Paducah Gaseous Diffusion Facility for the period 1971 through 1977 have been below levels which would be expected to present significant impact on the environment. Analysis of radioactivity levels in air during this period determined concentrations at off-site sampling locations to be generally less than 1% of the applicable radioactivity concentration guide. (1,2,3)

With one exception, levels of uranium in soil from the perimeter of the plant property did not significantly vary from the established 1-2 ppm background concentration for this area. Uranium levels at the PGDP perimeter fence in 1971 were found to be 3.6 - 24.0 ppm in soil samples. Although these levels exceeded background concentrations, no significant

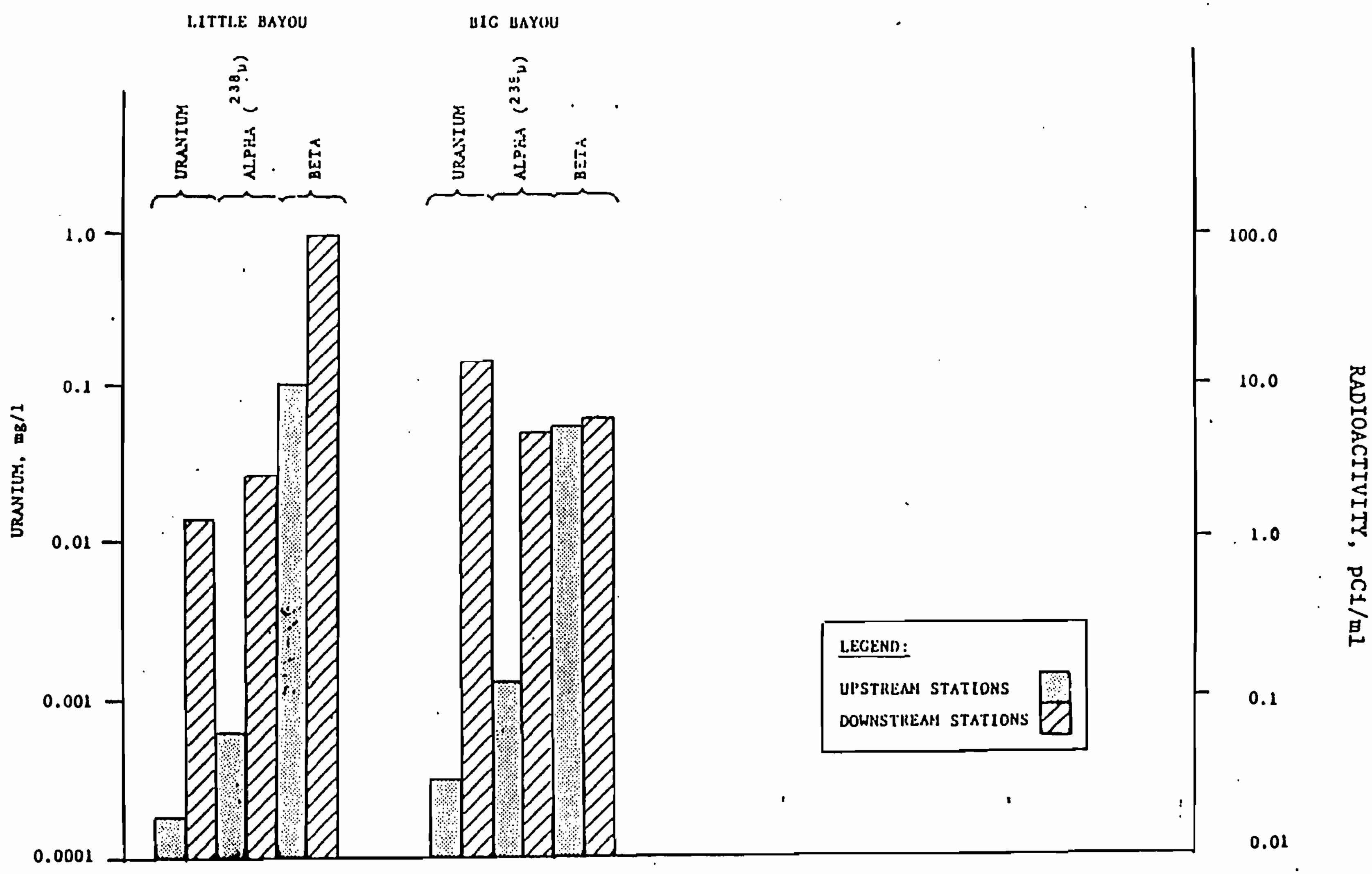


Figure 3.1-10. Uranium and radioactivity in Big and Little Bayou creeks' water.

impact on the environment was expected.[1] Difficulty was encountered in the evaluation of uranium levels in soil because there were no comparable standards.

No significant changes in the radioactive characteristics of the Ohio River or groundwater have been attributed to PGDP during this period.

3.1.11 Regional historic, scenic, cultural, ~~and~~ natural landmarks

3.1.11.1 Historic

The study area encompasses an area within a 10-mile (16-km) radius of the plant, involving McCracken and Ballard counties in Kentucky and Massac County in Illinois. A few important historic sites and natural areas short distances beyond this radius are included.

State

Thirteen houses, barns, and churches located in the Bandana, Heath, and Lovelaceville quadrangles are worthy of consideration for the National Register of Historic Places (Figure 3.1-11). More structures may be added in the future. Historic sites in Massac County, Illinois (Joppa excluded) include eight memorials or buildings in Metropolis and Brookport. Eight centennial homes, Upper Salem Church, and twenty-four other structures lie in the vicinity.

National

The National Register of Historic Places includes a description of the Market House (named in 1976); the Alben W. Barkley Museum; the Irvin S. Cobb Hotel (1978);"Angles", the Barkley home in Paducah, Kentucky; and the Fort Massac site in Fort Massac State Park in Illinois.[1] Also being considered are the Iron Horse Memorial, the last steam locomotive in the area, the Paducah City Hall, and the Anderson-Smith house in Paducah (Figure 3.1-11).

3.1.11.2 Archaeological

Exploration indicates that the Ohio River corridor is an archaeologically intensive area. Sites have been located primarily on the terraces along the river in the Kentucky counties, McCracken and Ballard, and Massac County, Illinois. No systematic survey has been conducted but local authorities have found extensive evidence of pre-Indian cultures in these counties.[2,3] Nine mounds, villages, or camps have been located in the Bandana Quadrangle,

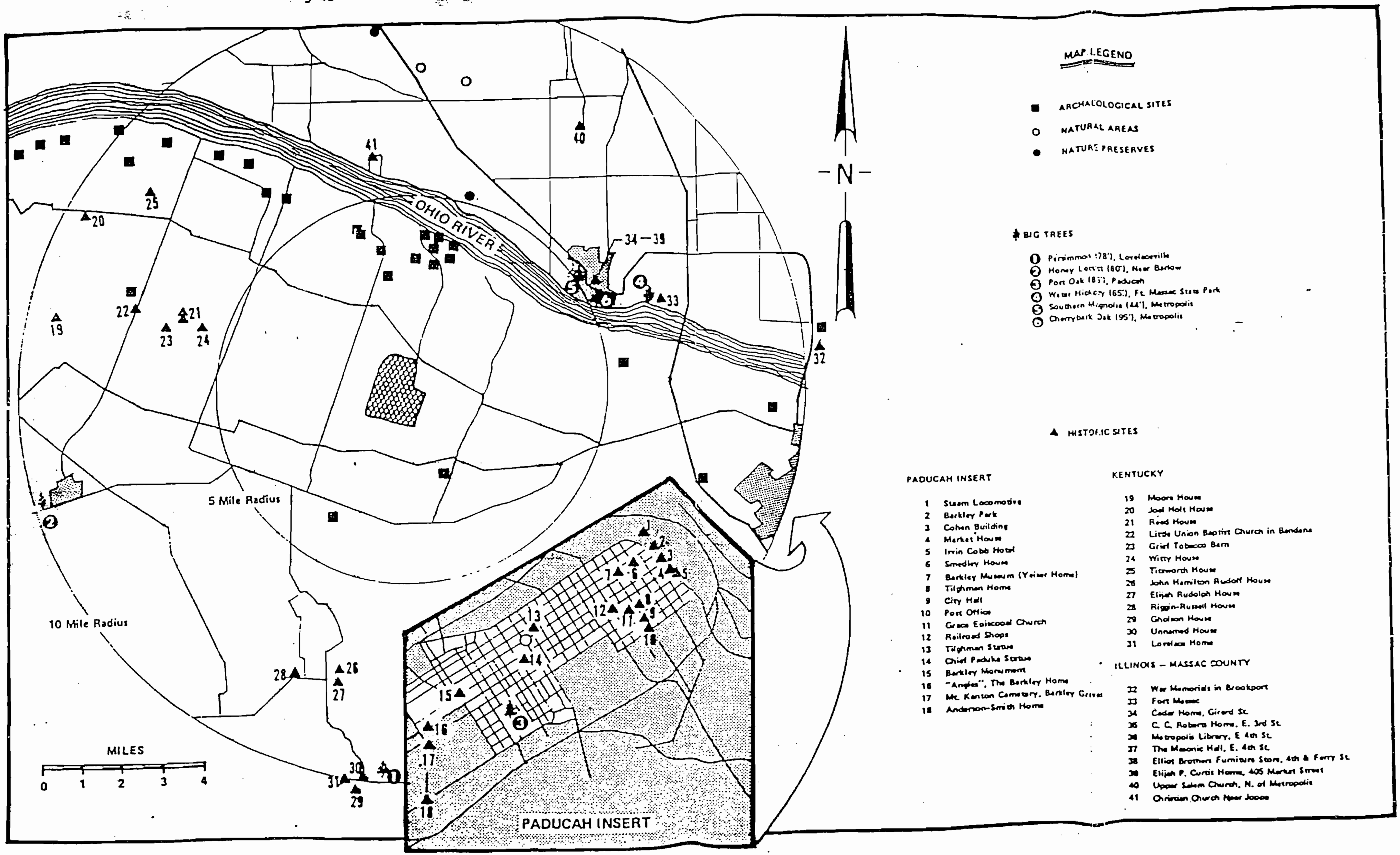


Figure 3.1-11. Historic, natural, and archaeological features in a 10-mile radius of the Paducah Gaseous Diffusion Plant

two in the Heath Quadrangle, and three in the West Paducah Quadrangle (Figure 3.1-11). It is estimated that numerous sites have been erased by the development of the City of Paducah.

In accordance with the National Preservation Act of 1966 and the Federal Code of Regulations (CFR 800) describing procedures for the protection of historic and cultural properties(1), no further disturbance should occur until a competent archaeologist conducts such a survey. Reference is made also to the Antiquities Act of 1906, 16 USC Section 431; the Historic Sites Acts of 1935, 16 USC 461; the National Environmental Policy Act of 1969; the Executive Order (11593) Protection and Enhancement of the Cultural Environments, May, 1971; and the Archaeological and Historic Preservation Act of 1974 which extended the coverage "...to include all federal, federally-assisted or federally licensed construction projects."(4)

3.1.11.3 Scenic

Local and state

Because the study area is unglaciated, underlain by young Pleistocene sediments including loessial deposits and alluvium, the topography is generally gently rolling. The exception is the ravine topography cut by intermittent streams on the Massac County side of the Ohio River. This means that except for a view of the Ohio River from the highest point on the Irvin Cobb or Highway 24 bridges, there is little scenic advantage to the area. However, the area is an extension of the Coastal Plain and Cretaceous Hills Province with numerous sloughs providing cypress swamp habitat. Beyond the study area on the Ohio River between the Ballard County Wildlife Management Area and Cairo and south on the Mississippi River, the bluffs provide scenic views of the river and the countryside.

3.1.11.4 Natural areas

State

Kentucky has only recently formed a Natural Areas Commission and begun a state inventory locating significant natural areas.

Although no known natural areas lie within the 10-mi (16-km) radius study area, the survey may uncover areas not yet discovered. One such area may be the 100 acres (40 ha) in Tract Six within the Western Kentucky Wildlife Management Area adjacent to the PGDP. This slough contains scattered cypress, water tupelo, some large timber, thickets with snakes, and numerous birds which could be of special interest. Other slough areas between the plant and the Ohio River may provide similar habitats worthy of protection. The Ballard County Wildlife Management Area is potentially a part of the Nature Preserve system.

Although no state or national forests lie within the study area, the Kentucky Division of Forestry describes several notable speciments in the study area[5] (Figure 3.1-11). None are on the PGDP site.

Illinois was one of the first states to establish a nature preserve system. The Massac County inventory includes two established nature preserves (Section 3.2.7) and eleven determined natural areas. These areas are described as relatively undisturbed communities (unique plots or with rare or endangered species).[6] Fort Massac State Park is included in the state inventory as a site worthy of preservation for its natural features. It is also listed in the Register of Historic Places (Figure 3.1-10).

The federal laws applying to the historic sites and archaéology relate also to the natural heritage of the study area and require investigation and protection when changes in the environment are anticipated. No changes relating to the PGDP are projected at this time.

3.1.11.5 Cultural

Local

The cultural pattern of the study area has historically been dominated by the physical environment. The loessial and alluvial soils were conducive to settlement for farming. The Ohio and Tennessee rivers have been significant in the development of trade, commerce, and industry. The availability of great quantities of water has been responsible for industrial growth.

The settlement of the area was influenced by five general cultural patterns. The early homes reflect the fact that the pioneers did not represent the wealthy segments of the communities from which they came, nor did they attain wealth in those first decades. The pattern of slavery in the home states from which they came is reflected in early population figures in the Kentucky Purchase (393 slaves in 1822).[7] After the Civil War, blacks remained in the area with a concentration in the vicinity of Paducah.

The influence of the Civil War is reflected in the war memorials, the statues, and the preserved homes of generals and other officials.

Interest in education is reflected in the number of schools in the area, the history of former places of higher education, and the development of present facilities. Within Paducah, there is a large and innovative high school, a community college, a vocational educational center, and the Western Kentucky State Vocational-Technical School. Murray State University in Calloway County, only 48 mi (77 km) from Paducah, has an enrollment of 8,000 and offers advanced degree programs.

Large recreational areas have been developed in the Kentucky and Barkley Lake region 20 mi (32 km) east of Paducah. Facilities are available for camping, hunting and fishing, water sports, hiking, wildlife conservation, and nature study. Paducah provides a supervised public recreation program in 13 parks. The Ohio and Tennessee Rivers offer opportunities for water sports, fishing, and boating. Associated with recreation are cultural events including summer festival, public lectures, concerts, art guild activities, and a Christian Arts Festival. Hunting and fishing are permitted in the Ballard County Wildlife Management Area. It is an exceptional site for bird-watchers as it is located on the Mississippi Flyway and also contains a cypress swamp habitat. There is controlled hunting in the Western Kentucky Wildlife Management Area adjacent to the DOE plant and seasonal duck hunting at the Mermet Lake State Conservation Area in Massac County, Illinois.

The two major manufacturing firms in the area are the Paducah Marine Ways (makers of river barges and towboats) and the Florsheim Shoe Company. The Illinois Central Railroad Shops has the largest local labor force. The advent of the gaseous diffusion plant and, in 1951, the TVA Shawnee Power Plant, built because of the huge electric power requirements, contribute to the economy of the area. The TVA dams have provided not only tremendous recreational facilities but also flood protection, increased navigation, and electric power. A new Port Authority is now in operation at Paducah; the airport has been enlarged; a large distilled spirits bottling plant was recently completed; and a convention complex is planned. These suggest the possibility that the study area may become an even more significant industrial complex.(8)

3.1.12 Noise

Measurements of background noise levels in the vicinity of the PGDP were made during 1977(1). The noise levels measured were typical of rural situations with some noise from small scale agricultural operations, traffic on secondary roads, infrequent commercial air traffic, and natural sounds, i.e., birds, animals, insects, and the wind in the trees. Some of the noise measurement locations used in the survey were chosen to represent the nonplant noise environment. Although these locations were 2 mi (3.2 km) or less from the plant boundary, noise levels were relatively low and there was no noticeable influence of the plant on the noise values obtained. At the 2-mi (3.2-km) distance, the ambient was found to be as low as 26 dBA at the time of the survey; and in a wooded area adjacent to the plant, the hourly equivalent noise level was found to be 40 dBA.

In Grahamville, the nearest community, most of the noise comes from traffic. It was observed that the peak noise levels come from vehicles which stop at the intersection of State Route 305 and State Route 996, then accelerate rapidly. It is this source which accounts for the maximum measured noise level of 69 dBA. At the Grahamville measurement site, a jet departing from Barkley Airfield produced a momentary maximum level of 61 dBA.

3.2 JOPPA STEAM ELECTRIC PLANT

3.2.1 Geology and geography

The unconsolidated materials forming the present-day land surface in Massac County range in thickness from about 5 ft (1.5 m) in the upland areas to about 130 ft (40 m) in the Cache River Valley. In the upland areas, wind-blown silt (loess) and residual soils 5-25 ft (1.5-7.6 m) thick are present and yield little or no water. In the bottomlands along the Cache and Ohio River valleys, permeable sand and gravel deposits up to 50 ft (15 m) in thickness are capable of yielding small to moderate municipal and industrial groundwater supplies.

Semi-consolidated deposits (Cretaceous) of sand and silt are present in the southern two-thirds of the county and are potential sources for moderate to large municipal and industrial supplies, particularly in the southern portions of the county. These materials range in thickness from a feather-edge along the northern boundary to 250 ft in the southern parts of the county. Locally, a chert gravel or limestone rubble is often present at the consolidated bedrock surface and can be a significant source of water for larger groundwater developments.

The consolidated bedrock units underlying Massac County are of Mississippian age and consist of shales, limestones, and sandstones of the Chester series in the northeastern part and the Valmeyeran limestones in the southwestern part of the county. Northeast trending faults have produced moderate vertical displacements of these units throughout the county. In the southern portions of the county, the Valmeyeran limestones are potential sources of municipal and industrial water supplies (Appendix B, Figure B-1).[1]

Significant geographic and geologic features of the region are shown in Figure 3.2-1.

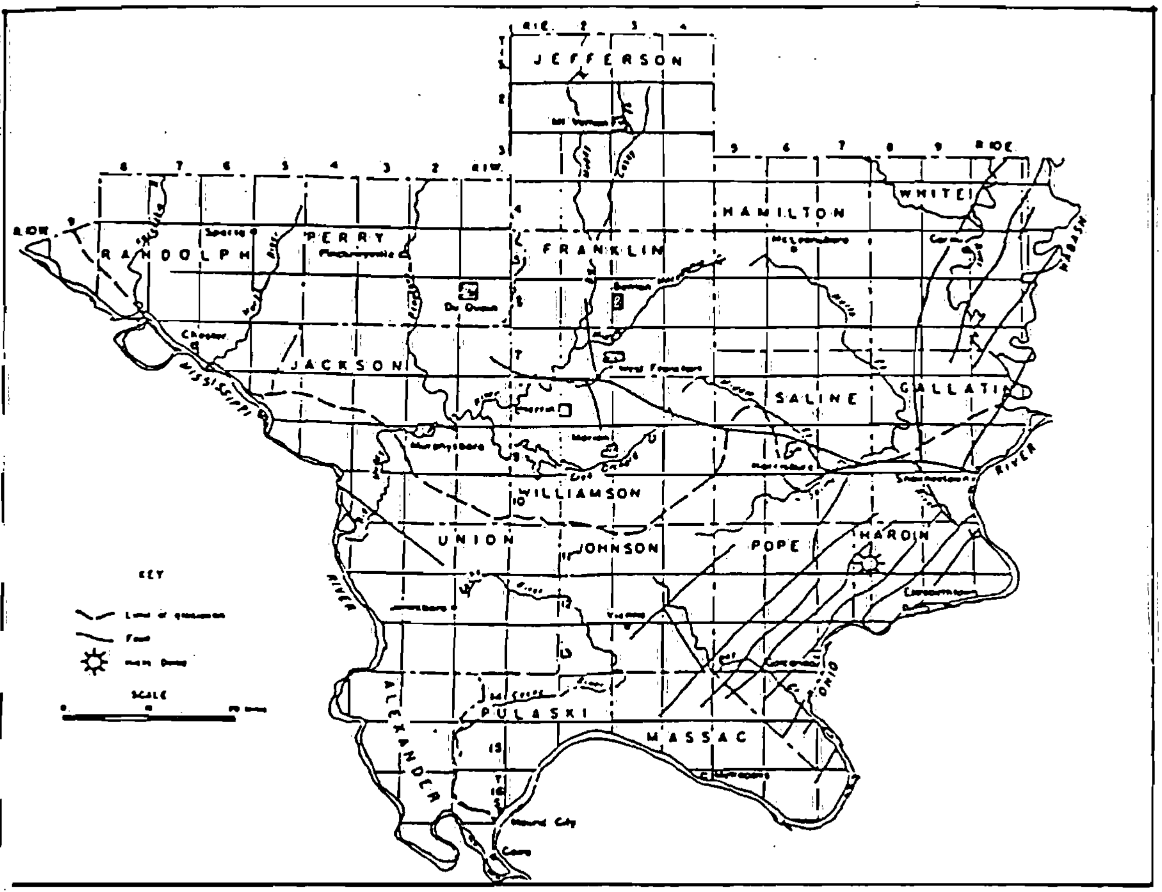


Figure 3.2-1. Pertinent geographic and geologic features of the southern Illinois region near Massac County.(1)

3.2.2 Hydrology

3.2.2.1 Groundwater

Groundwater in Massac County is used as a source of municipal water supply at Brookport, Joppa, Metropolis, and the Millstone Public Water District. In addition, industrial water supplies for the Joppa Steam Plant and several small manufacturing facilities are furnished by groundwater. Alluvial plains along the Mississippi, Ohio, and Wabash Rivers from Randolph to White County inclusive, are locations for wells of high capacity. The yields range from 75 to 1,500 gpm (284-5680 lpm) with specific capabities of 15-90 gpm per ft (186-1117 lpm) of drawdown. The estimated daily pumpage is 4 million gal (15 million l) in an area with an urban population of about 15,000.

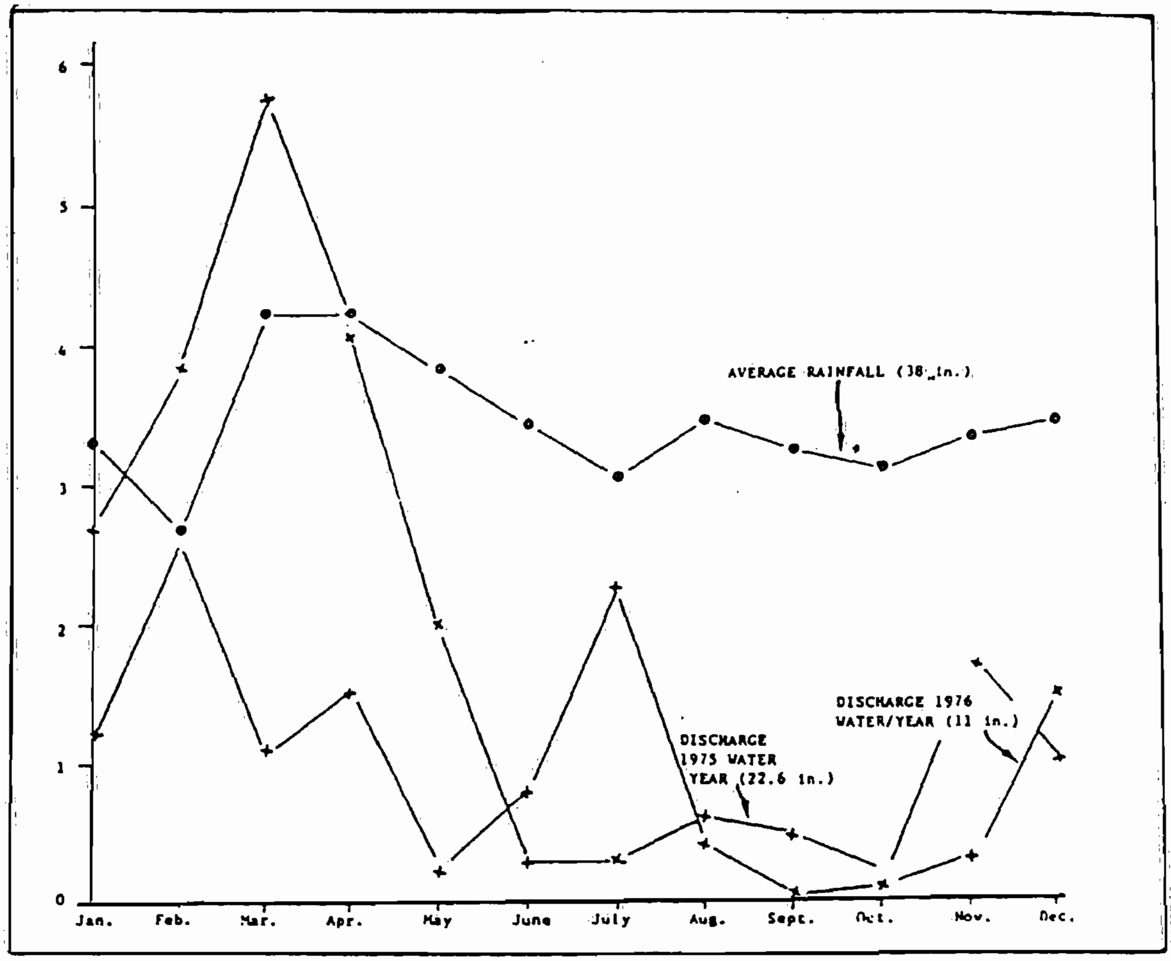


Figure 3.2-2. Surface water hydrology for small catchments near Electric Energy, Inc., Joppa steam-electric Plant.

Seepage of water through the ash pond to the river is not a major concern due to the highly impermeable nature of the subsoils. Engineering evaluation of the permeability coefficient indicates values of between 10^{-4}-10^{-7} cm/sec, with most of the individual sample determinations falling toward the low end of this range(2).

3.2.2.3 Flooding

Recurrence intervals and flood elevations for the Joppa facility are similar to those cited in Section 3.1.3.3. All plant components, including the generators and coal storage and ash disposal areas, are well above the 100-year flood elevation. Some local flooding of fields adjacent to the ash disposal area may occur due to backwater from the river; however, this will affect only a few hundred acres.

The settling pond located along the river has a top elevation of 336 ft (102 m) above the sea level datum so that direct inundation of the pond would require a very unusual magnitude flood, but erosion of the sides of the retaining wall due to flood flow velocities is a possibility.

3.2.3 Climatology and air quality

The climatological and meteorological features of the area encompassing the Joppa Steam Electric Plant are essentially identical to those described for Paducah, Kentucky (Section 3.1.4). That discussion pertains to the entire area of western Kentucky and southern Illinois.

The air quality presentation in the previous section includes all of the data available in the entire area. There are no monitoring stations situated in the immediate vicinity of the Joppa facility.

3.2.3.1. Changes in Joppa stack heights, emissions

With chimney heights of 250 ft (76 m), the Illinois Pollution Control Board (IPCB) limited sulfur dioxide emissions to about 13,890 lb (6306 kg) of SO_2/hr. Subsequent to a comprehensive study conducted by a consulting engineer, a petition was submitted to the IPCB to comply using a Supplemental Control System to limit the level of SO_2 in the ambient atmosphere. An amended program was approved by IPCB on September 1, 1977. This program consists of: (1) construction of three new chimneys 550 ft (168 m) tall which will be in operation by November 1, 1978; (2) installation of an ambient air monitor for SO_2 by November 1, 1978; and (3) limitation of SO_2 emission to 36,875 lb/hr (16,741 kg/hr) through use of fuel blending by July 1, 1978.

The construction of the 550-ft (168-m) stacks was on schedule and are operational. The old chimneys were roofed, closed, and abandoned in place. The ambient monitor was received and installed. Sargent and Lundy Engineers provided the modeling for ambient air concentrations of SO_2. These results are presented in Section 4.2.3.2 with the results of additional dispersion modeling. As a result of controlled SO_2 emissions the monitoring requirement was removed from the 1981 state air permit for the plant.[1]

3.2.4 Ecology

3.2.4.1 Terrestrial ecology

Soils

The soils of Joppa Steam Electric Plant belong to the Hosmer-Stoy soil association. These soils vary from nearly level uplands to some areas of moderately steep slopes dissected by natural drainage patterns. Figure 3.2-3 delineates the distribution of the individual soil series found on the Joppa plant site which comprise this association.[1] The most abundant series found in the undisturbed areas of the site is the Hosmer series, a silt loam changing to silty clay loam with depth, underlain with a fragipan that restricts permeability which can hamper productivity. This series, located predominantly in the more upland areas of the site, is susceptible to a seasonal high water table and commonly has a pH of 4.0-6.0. Small areas of the Stoy series, which typically have similar characteristics to Hosmer soils, are found interspersed with the Hosmer series in the uplands. The only other naturally occurring soils are found in the drainage patterns. These soils belong to the Belknap series which are deep soils found in the sediments along streams. These silt loam soils are similar to the Hosmer and Stoy series in permeability and are generally considered to be poorly drained, often having a high water table. The Belknap series is somewhat acidic, ranging in pH from 4.5-5.5.

The natural soil patterns of this area were disrupted by the establishment of the Joppa plant, resulting in the reclassification of the soils underlying the plant facilities as cut and fill land.

The characteristics of poor drainage, acid soils, slow permeability, and presence of fragipan and erosion hazards, create management problems for the agricultural usage of these soils. Under proper management, reasonable yields can be expected, such as 60-90 bushels (5.2-7.8 m^3/ha) of corn, 25-30 bushels (2.2-2.6 m^3/ha) of soybeans, 25-40 bushels (2.2-3.5 m^3/ha) of wheat, or 2-3 tons of hay on a per-acre (4.5-6.7 T/ha) basis.[1] These soils are also capable of supporting a natural community dominated by upland oaks at a productivity of 350-450 board ft/ac/yr (2.0-2.6 m^3/ha/yr). Additionally, these soils are well suited to open land wildlife.

Flora

The area in which the Joppa Steam Electric Plant is located is characterized by small immature woodlots, open grassland areas, and numerous thicket-like areas of young trees, brush and weeds (Figure 3.2-4). With the exception of a few large individual trees, primarily found along water courses, the overall vegetative community can be described as relatively young. Extensive timber harvesting by early pioneers reduced the native forests substantially. Additional cutting and the development of the Joppa area in general precluded regeneration of the forest community to its former productivity. The development of the Joppa plant removed some acreage from production and has necessitated the maintenance of small areas in a non-climax successional state. The most substantial acreage of the Joppa plant site is devoted to the steam generating facility and accompanying coal pile and ash disposal ponds. The remaining acreage within the property boundaries of the plant is almost equally proportioned in grassland, scrub, and woodlot areas. Acreage is

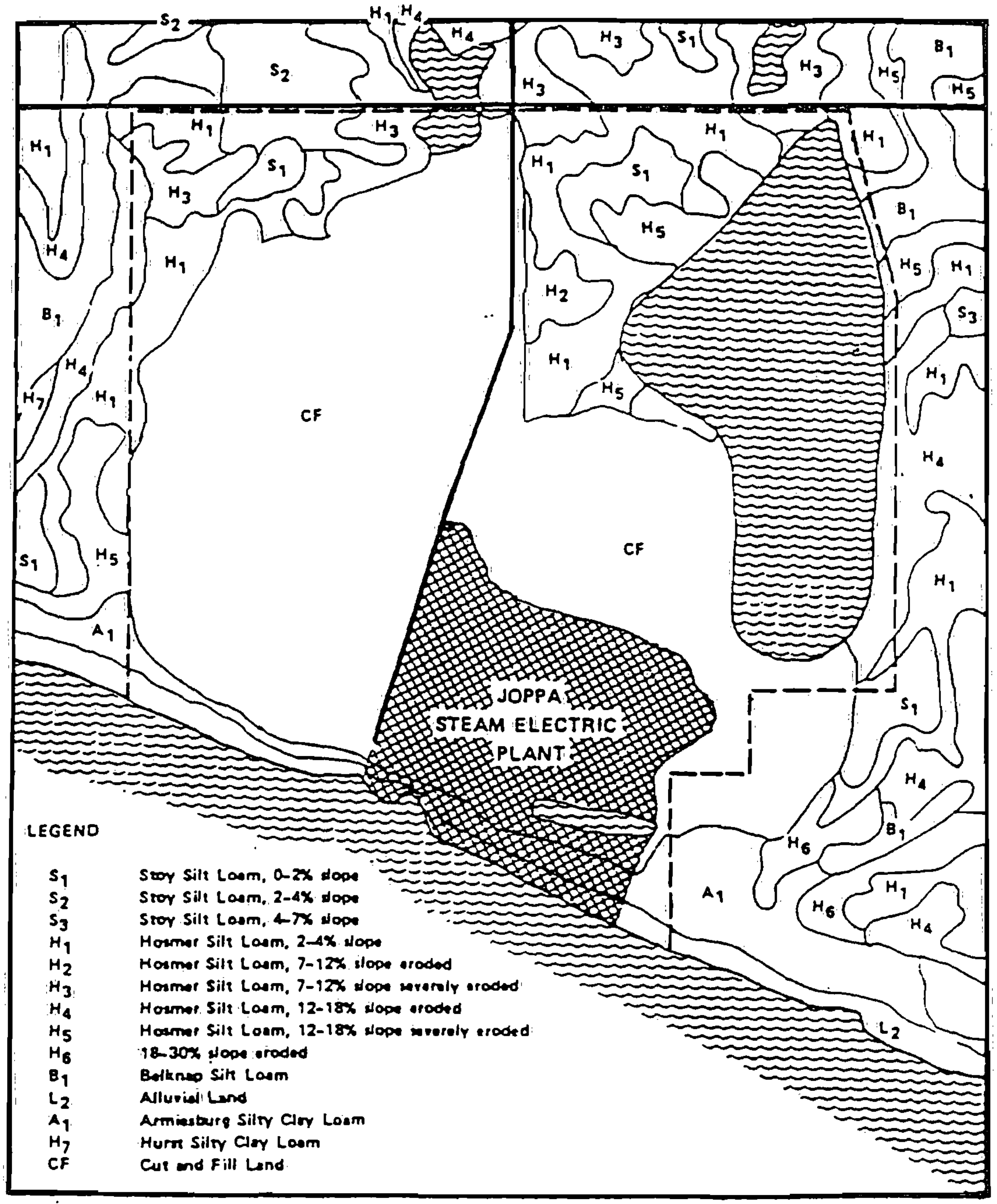


Figure 3.2-3. Soils Map of the Joppa Steam Electric Plant.

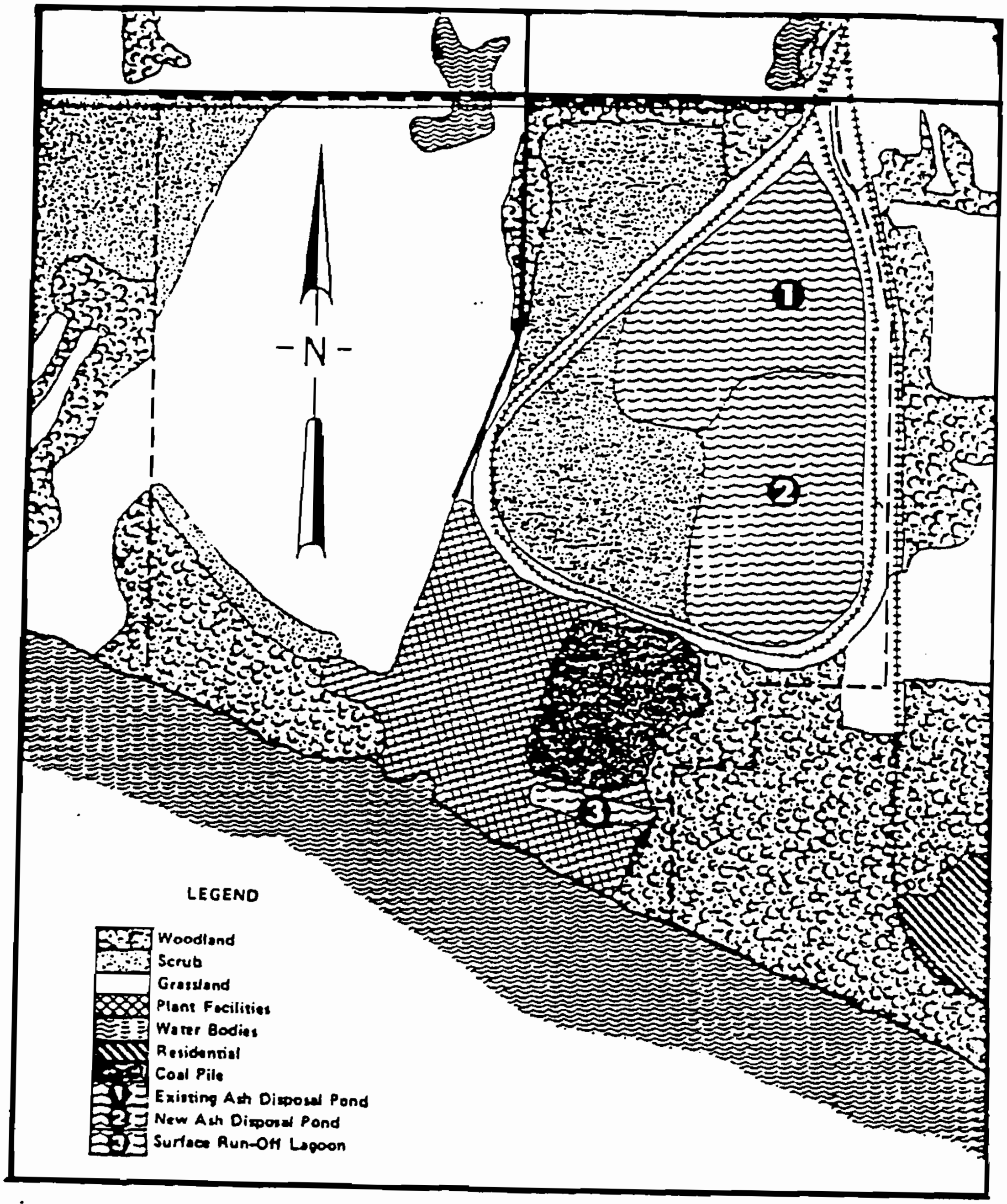


Figure 3.2-4. Vegetation map of the Joppa steam electric plant.

typically agricultural, either pastured or cultivated, with scattered woodlots. The upland woodlots are dominated by a few large oaks and hickories; however, a large portion of these woodlots is dominated by abundant young growth of maples, black locust, ash, and boxelder. Riparian forest communities in the natural drainage patterns and along the Ohio River are dominated by numerous large individual trees of sycamore, cottonwood, and willows. As is the case in upland communities, numerous other species contribute to the diversity of the community.

Scrub growth areas of the site contain densely growing mixtures of grasses, weeds, shrubs, and young trees, dominated by young maples, sassafras, sumac, locust, and elm tree species.

The grassland communities of the site are comprised of various grass species, numerous weed species, and sparse shrub and tree growth. These communities commonly exist in areas resulting from previous activities of plant operation. The most noteworthy grassland community exists at the former ash disposal pond site.

In general, the extent and diversity of communities within the site are suitable habitat for wildlife, providing both cover and food sources.

Fauna

Much of the land area of the site has been dedicated to uses associated with the generation of electrical energy; consequently, the numbers of both species and individuals occurring on this property are greatly reduced. The animals that are present are common to the southern Illinois-western Kentucky region.

Birds

Due to the similarity of habitat types, bird species, especially land birds and raptors, occurring on the Joppa Steam Electric Plant property are very likely similar to those reported for the PGDP property[2] (Section 3.1.5.1). However, since no game management is practiced on the Joppa property, the number of individual birds per acre is probably less than at PGDP.

Wetland habitat suitable for waterfowl and shorebirds is available on Joppa property in the form of ash ponds and the Ohio River shoreline. Thus, many of the common waterfowl, shorebirds, and wading bird species recorded at the Crab Orchard National Wildlife Refuge[3,4], Horseshoe Lake Conservation Area[5], and Land between the Lakes[6] probably stop to rest on the Joppa plant wetland areas. Because marshy habitat at Joppa is limited to a narrow band along the Ohio River, it is doubtful that very many waterfowl remain to breed in the area.

Mammals

Mammals at the plant site generally are those associated with wooded areas and ecotones and occur primarily along the southeastern, northern, and western boundaries. The wooded area in the southeastern portion of the site is particularly used by mammals. Species known to occur include whitetail deer, red and gray foxes, striped skunk, raccoon, opossum, eastern cottontail, gray squirrel, muskrat, Norway rat, and small rodents. A deer herd varying in size from 3-12 individuals frequents the site; muskrats occasionally establish dens in the dikes of the settling basins.[7] Mammal species present or expected to occur at the PGDP (Section 3.1.5.1) could also be expected to occur at the Joppa site.

Reptiles and amphibians

Only a few species have been positively identified on the property; but those present or expected ot occur at the PGDP site (Section 3.1.5.1) could also be expected to occur at the Joppa site. Species known to occur include the copperhead, box turtle, rat snake ("chicken snake"), "kingsnake", and "snapping turtle". Snapping turtles are occasionally found in the settling ponds.[7]

Important species

Several species of animals may occur at the Joppa plant that have particular significance due to their recreational, aesthetic, or legal values. The interrelationships between these and other species that may be present are exemplified in Section 3.1.5.1.

Game animals

The Joppa power plant is located in a portion of the Mississippi Flyway that is used by large numbers of ducks and geese.[3,8] Small numbers of these waterfowl use the two older ash settling ponds on Joppa power plant property and the adjacent segment of the Ohio River as migratory stop-over and overwintering areas. The mallard is probably the most abundant waterfowl species on the ash ponds during the winter.[7] Other species of waterfowl utilizing the ash ponds and river during migration or as an overwintering area probably include the following species commonly seen at the Crab Orchard National Wildlife Refuge during migration: Canada goose, snow goose, black duck, pintail, green-winged teal, American wigeon, northern shoveler, ring-necked duck, common goldeneye, bufflehead, ruddy duck, hooded merganser, and common merganser.[3]

The wood duck is likely to nest in any large cavity-bearing trees on the Joppa plant property, especially the trees adjacent to the Ohio River and in the southeast corner of the property.

Upland game birds observed on the Joppa plant property include the bobwhite and mourning dove.[7] Game mammals that use the site are deer, cottontail, raccoon, and foxes. Although hunting is not permitted on the site, it is allowed in surrounding areas and the site provides some food and cover for animals hunted in the vicinity.

Threatened or endangered species

No federal or Illinois threatened or endangered birds have been identified on the Joppa plant property. However, the geographic location of the property and the presence of woodlands, brushy fields, ash ponds, and the Ohio River make it possible for several threatened or endangered birds to utilize the Joppa plant property for brief periods of time. Twenty-four bird species observed at the Crab Orchard National Wildlife Refuge are on the federal and/or Illinois threatened or endangered species lists.[9,10] Of these 24 bird species, only the following 19 are likely to stop during migration at the Joppa plant property:

Endangered Birds of Illinois

Great egret	Osprey
Little blue heron	Marsh hawk
American bittern	Upland sandpiper
Black-crowned night heron	Black tern
Cooper's hawk	Short-eared owl
Red-shouldered hawk	Brown creeper
Bald eagle	Bachman's sparrow

Threatened Birds of Illinois

Common gallinule	Loggerhead shrike
Bewick's wren	Swainson's warbler
Veery	

The northern subspecies of the bald eagle is likely to spend some time in the trees along the Ohio River border of the Joppa plant property because bald eagles overwinter in the area and are known to eat both live and dead fish.[3] Approximately 350,000 fish are impinged on the power plant intake water screens per year and are flushed back into the river;[11] these fish would be a good source of food for bald eagles. The northern subspecies of the bald eagle was recently placed on the list of federally endangered species.[12] This is the only federally endangered or threatened bird species likely to utilize the Joppa plant property.

No federal or state endangered or threatened species of mammals, reptiles, or amphibians is known to be present on the site but several state-listed species[10] have ranges which may include the area. The mammals are: golden mouse, rice rat, eastern woodrat, gray bat, and Indiana bat. The reptiles and amphibians are: slider, broadbanded watersnake, eastern ribbon snake, western hognose snake, dusky salamander, and Illinois chorus frog. The gray bat and Indiana bat are also included on the federal threatened and endangered species lists[13].

3.2.4.2 Aquatic ecology

The Joppa Steam Electric Plant is located on River Mile 952 of the Ohio River. Detailed surveys have been conducted on this area of the river in connection with the thermal discharge from the plant.[11]

Diatoms were the most abundant phytoplankton encountered. Cyclotella-Stephanodiscus and Melosira were the dominant genera. No statistical differences were noted between samples taken upstream and downstream of the plant discharge.

Zooplankters were common midwestern riverine types. Numbers of organisms per liter were reduced at the point of discharge and downstream of the outfall.

Macroinvertebrate communities colonized artificial substrates with no significant differences noted between upstream and downstream populations. Species diversity indices were similar and characteristic of streams of intermediate biological quality.[14] Collections were comprised predominantly of mayflies, caddisflies, and dipteran larvae. Water quality appears to be suitable for the support of a normal benthic community. However, suitable natural substrates for colonization are not abundant in this area of the Ohio River.[11]

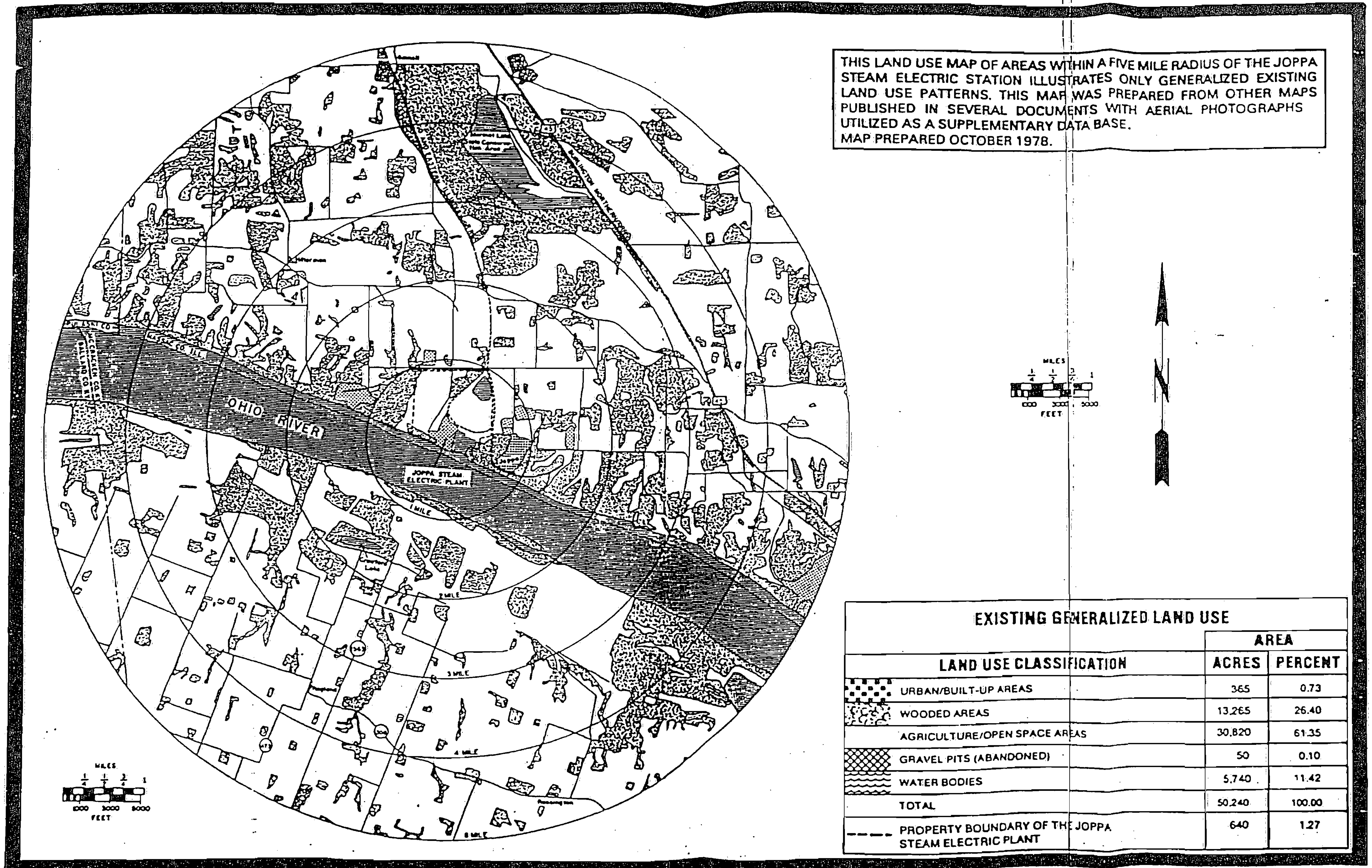
Twenty-four species of fish were collected from this section of the Ohio River in 1974.[11] The most common species encountered were gizzard shad, goldeye, and skipjack herring, comprising approximately 80% of the total fish taken. Sportfish encountered included smallmouth bass, crappie, sauger, channel catfish, and several species of sunfish.

There were no apparent, significant differences in fish populations upstream and downstream of the Joppa facility. However, fish were found to congregate in the thermal plume during November sampling.

The two unnamed tributaries to the Ohio River on either side of the Joppa facility are intermittent most of the year. Such conditions are not conducive to the maintenance of a balanced aquatic community. The tributary to the east of the plant has been channelized and serves as a drainage ditch, receiving ash pond overflow and coal pile runoff from the Joppa plant. The combination of these factors exerts stress on any existing aquatic community.

3.2.5 Land use

The following paragraphs provide a description of the land-use patterns within a 5-mi (8-km) radius of the Joppa Steam Electric Plant. Portions of four counties lie within a 5-mi (8-km) radius of the station--Massac and Pulaski counties, Illinois, and Ballard and McCracken counties, Kentucky. Descriptions of regional land-use patterns and land capability and productivity data for Massac, Ballard, and McCracken counties were previously presented in the land-use description of the Paducah Gaseous Diffusion Facility (Section 3.1.8).



EXISTING GENERALIZED LAND USE

LAND USE CLASSIFICATION	AREA ACRES	AREA PERCENT
URBAN/BUILT-UP AREAS	365	0.73
WOODED AREAS	13,265	26.40
AGRICULTURE/OPEN SPACE AREAS	30,820	61.35
GRAVEL PITS (ABANDONED)	50	0.10
WATER BODIES	5,740	11.42
TOTAL	50,240	100.00
PROPERTY BOUNDARY OF THE JOPPA STEAM ELECTRIC PLANT	640	1.27

Figure 3.2-5. Generalized existing land use patterns within a 5-mile radius of the Joppa Steam Electric Station

H-82

3.2.6 Water use/water quality

Water use at Joppa consists of withdrawals for condenser cooling and miscellaneous station uses. Condenser cooling discharges have recently averaged 790 cfs (22 cms) with a maximum of 1120 cfs (32 cms) and a minimum of 230 cfs (6.5 cms). This average is about 5% of the low flow discharge and a very small percentage of the mean annual flow. Other station water uses total about 25 cfs (0.7 cms) with a maximum of 55 cfs (1.6 cms) and a minimum of about 11 (0.3). Greater than 90% of these uses are satisfied by withdrawals of surface water from the river while the remaining demand represents groundwater withdrawals.

Water quality of Joppa discharges is shown in Table 3.2-1.[1] For those parameters where downstream values have been obtained, the general effluent quality even before dilution does not represent a signficant deterioration of Ohio River quality. Specific instances of impacts are often the result of mechanical failure. For example, high pH values in the ash pond overflow have been caused by a freeze-up of the sulfuric acid dosing equipment. Trace metals have been analyzed in several samples and have not been detected. The potential localized impacts of these discharges are evaluated in greater detail in Section 4.2.2.

3.2.7 Regional historic, cultural, archaeological, and natural landmarks

3.2.7.1 Historic

The village of Joppa, population 572, was incorporated in 1902. Settlement prior to that date included the construction of the Christian Church in downtown Joppa. This structure (1894) is listed in the Illinois Historic Sites and Landmarks Survey for preservation[1] along with a Southern Baptist church, a Methodist church, and a Church of the Latter Day Saints. The Christian Church still functions. A service station, one store, and two taverns constitute the present business enterprises.

At one time, the major industry in Joppa was a railroad tie yard, reputed to be the largest in the world. It was operated by the Republican Creosote Company; it burned in 1943 and was never rebuilt.

By 1954 the power plant was established, which expanded the rail lines of the Chicago and Eastern Illinois Railway and brought prosperity back to the town. The construction of a portland cement company, the addition of the Trunkline Gas Plant of Houston, and the Commercial Trucking Company for transporting the portland cement increased still more the importance of the town.

Table 3.2-1. Joppa power station - chemical quaity of effluents

Location/Parameter	pH, Units	SS, mg/l	TDS, mg/l	Temperature, °F	Oil and Grease, mg/l	Chlorine, mg/l	Fecal Coliform, MPN/100ml	BOD_5, mg/l
Ash Pond Overflow	7.0-11.0	8 ± 4.7	409 ± 55	-	2.3 ± 2.1	-	-	-
Travelling Screen Wash	-	-	-	-	-	-	-	-
Condenser Discharge	7.3-8.3	-	-	82.7 ± 15	-	0.04 ± .05	-	-
Sanitary System	7.1-8.6	18.7 ± 4.3	-	-	-	-	3.9 ± 12.8	16.2 ± 4.8
Flume	7.9-8.4	-	-	74.1 ± 13	-	-	-	-
Settling Pond	2.6-7.2	12.3 ± 4.1	-	-	2.4 ± 2.3	-	-	-
Ohio River at Grand Chain, IL (1973-77)(2)	6.1-8.3	6-378 (median=85)	102-320	61.6-87.6	-	-	35-430	-

3.2.7.2 Cultural

The labor force for the industries close to the village and two more operations east of Joppa, Allied Chemical and Cook's Coal Terminal, has been drawn from neighboring towns such as Metropolis (population 7500) and Paducah.

The disproportionate amount of industry provides a tremendous tax benefit for the Joppa high school and grade school. Both are new, well equipped, and have a teacher-pupil ratio of 1:7. Students receive free meals, books and equipment. Senior citizens may participate in a prepared food program.

3.2.7.3 Archaeological

The Joppa Quadrangle has a concentration of archaeological sites along both sides of the Ohio River corridor. A local anthropologist estimates there are 200 sites in southern Illinois.(2) No sites have been designated in the Joppa area. The presence of potential locations intensifies the concern for an archaeological survey before any further alteration of the environment takes place.

3.2.7.4 Natural areas

The Mermet Lake Conservation Area, owned and protected by the Illinois Department of Conservation, lies north of Joppa. It is a forest and swamp habitat of the Bottomlands Section and Forest of the Cretaceous Hills Section of the Coastal Plain Natural Division. The 43-acre (17-ha) Mermet Swamp Nature Preserve lies in the southeast corner of the conservation area. The vegetation includes sweet gum, second-growth cypress, pin oak, swamp cottonwood, pumpkin ash, and second-growth white and red oak on slopes. Some unusual plants are styrax (Styrax americana), arrow arum (Peltandra virginica), white basswood, and red iris. Tree speciments of notable size are found in the conservation area (see Figure 3.1-11).

The 14.7-acre (6.0 ha) Halesis Nature Preserve, located along the Ohio River 3 miles (5 km) southeast of Joppa, is owned by American Electric Power Company. Its natural features are characterized by forest on dissected river terraces. Several rare plants and the type locality for a sedge (Carex socialis) are found on this preserve. The property is fenced and permission for visitation is required by the owner.

The Illinois State Natural Areas Inventory includes a number of sites in the vicinity of Joppa designated as natural areas which may be dedicated as nature preserves in the future.

3.2.8 Noise

Except for the power plant and a cement plant, Joppa has no major industry. Except for the motor vehicles, the noise level expected for such a community would normally be low. On the basis of limited data, the 32-34 dBA background level measured approximately 1 mi (1.6 km) east of Joppa has been assumed to be representative of the minimum potential noise level in the Joppa area.(1) Sources of noise, other than the power plant, consist of autos and light trucks, infrequent local freight trains, and towboats. Motor vehicle noise is present throughout most of the daytime and evening hours and is the loudest of any of the sources. The magnitude of the noise is dependent mostly on the mechanical condition and the manner in which the vehicles are operated.

Under certain conditions of wind direction and cloud cover, noise from the gas pipeline compressor station northeast of the town would be audible but not disturbing.

Lacking extensive data for the community, estimates of 42-45 dBA for Equivalent Noise Level, L_{eq}, and 46-49 dBA for day-night noise levels, L_{dn}, were obtained, based on a number of assumptions about the noise time-history of the community.

Residences in the vicinity of the rail classification yard in the southwest quadrant are the most likely to be disturbed by operation of infrequent switch engines. The classification yard is used primarily for storage of boxcars since the coal transfer terminal was abandoned.

Overall, the community is relatively free of noise of any consequence.

3.3 REFERENCES FOR SECTION 3

References for Section 3.1.2

1. Davis, R. W., T. W. Lambert, and A. J. Hansen, Jr. 1973. Surface geology and ground water resources of the Jackson Purchase Region, Kentucky. USGS Water-Supply Paper No. 1987.

References for Section 3.1.3

1. The river basin water quality management plan for Kentucky: Ohio River (no date and issuing agency).

2. Reference 1, Section 3.1.2.

3. Lambert, T. W. 1966. Availability of ground water in the Heath quadrangle, Jackson Purchase Region, Kentucky. USGS Hydrological Investigations Atlas HA-168.

4. Hansen, A. J., Jr. 1966. Availability of ground water in Kentucky parts of the Joppa and Metroplis quadrangles, Jackson Purchase Region, Kentucky. USGS Hydrological Investigations Atlas HA-171.

5. Union Carbide, Nuclear Division. 1978. Environmental monitoring report. Draft. Paducah Gaseous Diffusion Plant. Oak Ridge, Tennessee.

6. U.S. Army Corps of Engineers. September, 1967. Ohio River flood plain profile, Mound City pool reach. OMC-16/65. U.S. Army Corps of Engineers. 175 sheets.

References for Section 3.1.4

1. Eischen, M. A., W. T. Lawhon, T. L. Anderson, N. A. Frazier, D. K. Landstrom, R. W. Melvin, S. E. Pomeroy, C. W. Rodman, H. E. Smail, P. R. Sticksel, D. A. Tolle, and B. W. Vigon. 1978. Environmental studies at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky. Final report to Union Carbide Corporation. Battelle's Columbus Laboratories, Columbus, Ohio. Various paging.

2. Federal Register. National ambient air quality standards, states attainment status, March 3, 1978. pp 8962, 8996-8997.

3. Kentucky Department of Natural Resources and Environmental Protection. Kentucky ambient air quality, 1976-1980 annual reports. Division of Air Pollution. Technical Branch, Kentucky Department of Natural Resources and Environmental Protection, Frankfort, Kentucky.

4. Letter from Jackie Swigart, Kentucky Department of Natural Resources and Environmental Protection to Charles Geter, Administrator, Region IV, U.S. EPA, Petition to reclassify McCracken County as an attainment area, February 16, 1982.

5. Illinois Environmental Protection Agency. 1976. 1976 annual air quality report. Division of Air Pollution Control, Ambient Air Monitoring Section, Springfield, Illinois.

6. Tennessee Valley Authority. 1976 and 1977. Air quality data summary, Shawnee Steam Plant.

7. Kentucky Department of Natural Resources and Environmental Protection. Kentucky Air Pollution Control Regulations. Bureau of Environmental Quality, Frankfort, Kentucky 40601.

References for Section 3.1.5

1. Humphrey, M. E. 1976. Soil survey of Ballard and McCracken Counties, Kentucky. USDA, Soil Conservation Service. 81 p.

2. Reference 1, Section 3.1.4.

3. Monk, C. G., G. I. Child, and S. A. Nicholson. 1970. Biomass, litter and leaf surface area estimates of an oak-hickory forest. OIKOS 21:138-141.

4. Mengel, R. M. 1965. The birds of Kentucky. The American Ornithologists' Union, Ornithol. Monogr. No. 3. The Allen Press, Lawrence, Kansas. 581 p.

5. Tennessee Valley Authority. 1967. A checklist of birds of Land between the Lakes. Tennessee Valley Authority, Golden Pond, Kentucky. 4 p.

6. Young, T. 1977. Area Manager, West Kentucky Wildlife Management Area, Kevil, Kentucky. Personal communication to Steven Pomeroy.

7. Kentucky Code. 1975. 301 KAR 3:60 endangered fish and wildlife species. Kentucky Department of Fish and Wildlife Resources, Frankfort. 2 p.

8. Barbour, R. W., and W. H. Davis. 1974. Mammals of Kentucky. The University Press of Kentucky, Lexington. 322 p.

9. Young, T. 1977. Wildlife management area surveys. Project No. W-45-7, Job No. 1 VIII-A(2a). Kentucky Department of Fish and Wildlife Resources, Frankfort. 9 p.

10. Craighead, J. J., and F. C. Craighead, Jr. 1966. Raptors. p. 200-217. In: A. Stefferud, ed. Birds in our lives. U.S. Government Printing Office, Washington, D.C.

11. Bent, A. C. 1965. Life histories of North American blackbirds, orioles, tanagers, and allies. Dover Publications, Inc., New York. 549 p.

12. Burt, W. H., and R. P. Grossenheider. 1976. A field guide to the mammals. Third edition. Houghton Mifflon Company. Boston, Massachusetts. 289 p.

13. Eischen, M. A. 1979. Further aquatic field studies at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky. Draft final report to Union Carbide Corporation. Battelle Columbus Laboratories, Columbus, Ohio. 36 p.

14. Wilhm, J. 1970. Range of diversity index in benthic macroinvertebrate populations. J. Water Poll. Control Fed. 42:221-223.

References for Section 3.1.6

1. U.S. Department of Commerce, Bureau of the Census, Population estimates, Series P-26.

2. University of Louisville, Urban Studies Center. 1977. Kentucky county population projections.

3. U.S. Department of Commerce, Bureau of the Census, 1970 Census of population.

4. Kentucky Department of Commerce. 1977. Kentucky deskbook of economic statistics. 77 pages.

5. U.S. Department of Commerce, Bureau of the Census. 1972. City and county data book.

6. Battelle's Columbus Laboratories. 1978. Socioeconomic assessment of the Paducah Gaseous Diffusion Plant. Final report submitted to Union Carbide at the Paducah gaseous diffusion plant. 58 pages.

7. State of Illinois. 1976. Bureau of Budget, Illinois population projections.

8. State of Missouri. 1977. Division of Budget and Planning, Estimates and projections of population in Missouri - 1970 to 1990.

References for Section 3.1.7

1. Kentucky Department of Commerce. 1976. Industrial resources - Paducah, Kentucky.

2. Reference 6, Section 3.1.6.

3. Purchase Area Development District. 1973. A comprehensive plan for water and sewer development - purchase area development district.

4. Unpublished data gathered by Union Carbide. 1977.

References for Section 3.1.8

1. Reference 1, Section 3.1.4.

2. U.S. Department of Agriculture. 1970. Kentucky soil and water conservation needs inventory 1970. Soil Conservation Service, Lexington, Kentucky.

3. Cooperative Extension Service. 1970. Illinois soil and water conservation needs inventory 1970. University of Illinois at Urbana - Champaign.

4. U.S. Department of Commerce. September 1976. 1974 census of agriculture (preliminary reports for McCracken and Ballard counties, Kentucky, and Massac County, Illinois). Bureau of Census.

5. Barnard, J. E., and T. M. Bowers. 1977. A review of Kentucky's forest resource. USDA Forest Service Research Note NE-234. Northeastern Forest Experiment Station. Upper Darby, Pennsylvania.

6. Bones, J. T., and C. J. Lohr. 1977. The timber industries of Kentucky. Northeastern Forest Experiment Station, Upper Darby, Pennsylvania. 26 pp.

References for Section 3.1.9

1. U.S. Army, Corps of Engineers. 1965. Ohio River basin comprehensive survey. Volume XI., Various paging.

2. Reference 6, Section 3.1.3.

3. Reference 5, Section 3.1.3.

4. Reference 1, Section 3.1.1.

5. Omerink, J. M. 1977. Non point source - stream nutrient level relationships: a nationwide study. EPA-600/3-77-105.

6. Donigan, A. S., Jr. and Crawford, N. H. 1976. Modeling non-point pollution from the land surface. EPA-600/3-76-083.

7. U.S. Environmental Protection Agency. 1973. Methods for identifying and evaluating the nature and extent of non-point sources of pollutants. EPA-430/9-73-014.

8. Reference 1, Section 3.1.4.

9. McElroy, A. D., S. Y. Chiu, J. W. Mebgen, A. Aleti, and F. W. Bennett. 1976. Loading functions for assessment of water pollution from non-point sources. EPA-600/2-76-151.

References for Section 3.1.10

1. Union Carbide Corporation. 1971, 1972, and 1973. Environmental monitoring report, United States Atomic Energy Commission, Paducah Gaseous Diffusion Plant. UCC-ND-222, -245 and -279. Union Carbide Corporation, Nuclear Division, Office of Safety and Environmental Protection, Oak Ridge, Tennessee.

2. Union Carbide Corporation. 1974 and 1976. Environmental monitoring report, United States Energy Research and Development Administration. Paducah Gaseous Diffusion Plant. UCC-ND-303 and Y/UB-7. Union Carbide Corporation, Nuclear Division, Office of Safety and Environmental Protection, Oak Ridge, Tennessee.

3. Union Carbide Corporation. 1977. Environmental monitoring report, United States Department of Energy, Paducah Gaseous Diffusion Plant. Y/UB-9. Union Carbide Corporation, Nuclear Division, Office of Safety and Environmental Protection, Oak Ridge, Tennessee.

References for Section 3.1.11

1. U.S. Department of the Interior. 1969, 1972 and 1974. National register of historic places. Procedures for compliance by the National Park Service, Advisory Council on Historic Preservation.

2. Muller, Dr. John, Department of Anthropology, Southern Illinois University, Carbondale, Illinois. Personal communication to Mrs. Ruth Melvin, 1977.

3. Clay, Dr. Berle, State Archaeologist of Kentucky. Personal communication to Mrs. Ruth Melvin, 1977.

4. McGimsey, C. R., and H. A. Davis (ed.). 1977. The Airlie House report, the management of archaeological resources. Special publication of the Society for American Archaeology.

5. Kentucky Division of Forestry. No date. Kentucky's big trees. Department of Natural Resources and Environmental Protection, Frankfort.

6. Illinois Nature Reserves Commission. 1975-1976. Preserving Illinois' natural heritage, biennial report. Illinois Natural Reserves Commission, Rockford. pp. 34,40.

7. Kentucky Population Projections -- 1975. Population composition by race--1970 census. Paducah Chamber of Commerce, 2020 Vol. 1.

8. Kentucky Department of Commerce. 1976. Industrial resources, Paducah, Kentucky. Prepared in cooperation with the Paducah Area Chamber of Commerce.

References for Section 3.1.12

1. Reference 1, Section 3.1.4.

References for Section 3.2.1

1. Illinois State Water Survey. 1962. Potential water resources of southern Illinois, report of investigation 31. Second printing.

References for Section 3.2.2

1. Woller, D. M. 1972. Public groundwater supplies in Massac County, State of Illinois, Department of Registration and Education, Bull. ISWS/BUL-60(14)/75(1975).

2. So-Bi-Co Soils Engineers. No date. Report to WAPORA, Inc. concerning the permeability conditions near the Joppa Steam Electric Facility.

References for Section 3.2.3

1. Jacobs, J. Environmental coordinator, Electric Energy, Inc. Joppa, Illinois. Personal communication to M.A. Eischen. Battelle Columbus Laboratories, February 27, 1981.

References for Section 3.2.4

1. Parks, Walter D. 1975. Soil Survey of Pope, Hardin, and Massac Counties, Illinois. USDA, Soil Conservation Services. 230 pp.

2. Reference 1, Section 3.1.4.

3. Pettingill, O. S., Jr. 1977. A guide to bird finding east of the Mississippi. Second Edition. Oxford University Press, New York. 659 p.

4. Kitching, J. Birdwatcher's guide to wildlife sanctuaries. Arco Publishing Company, Inc., New York, New York. 233 p.

5. Robbins, C. S., and W. T. Van Velzen. 1969. The breeding bird survey, 1967 and 1968. U.S. Fish and Wildlife Service, Spec. Sci. Rept. -- Wildl. No. 124. U.S. Government Printing Office, Washington, D.C. 107 p.

6. Tennessee Valley Authority. 1967. A checklist of birds of Land between the Lakes. Tennessee Valley Authority, Golden Pond, Kentucky, 4 p.

7. Bowman, J. Supervisor of Accounting and Regulatory Reports, Electric Energy, Inc. Personal communication to Duane Tolle, 1978.

8. U.S. Army Engineer Division. Ohio River basin comprehensive survey, appendix G, fish and wildlife resources. Prepared by U.S. Fish and Wildlife Service, U.S. Army Engineer Division, Ohio River, Cincinnati, Ohio. 74 p.

9. Booker Associates, Inc. No date. Crab Orchard National Wildlife Refuge -- Draft Environmental Assessment. Prepared for the U.S. Fish and Wildlife Service, Twin Cities, Minnesota. 105 p.

10. Illinois Department of Conservation. 1978. Administrative Order: Article 138 -- Illinois list of endangered and threatened vertebrate species issued in accordance with provisions of Section 337 of the Illinois Endangered Species Protection Act. Illinois Department of Conservation, Springfield, Illinois. 3 p.

11. Electric Energy, Inc. 1976. Demonstration regarding evidence of absence of prior appreciable harm from thermal discharges into the Ohio River. Electric Energy, Inc., Joppa, Illinois.

12. U.S. Fish and Wildlife Service. 1978. Bald eagle's status listed for 48 states. Endangered species Technical Bulletin 3(3): 1 and 9.

13. U.S. Department of the Interior. 1977. Endangered and threatened wildlife and plants. Federal register 42:36419-36431.

14. Wilhm, J. 1970. Range of diversity index in benthic macroinvertebrate populations. J. Water Poll. Control Fed. 42:221-223.

References for Section 3.2.6

1. Joppa Steam Electric Generating Station. Compliance reports for national pollutant discharge elimination system permit (1977-78).

2. U.S. Geological Survey. 1973-1977. Water resources data for Kentucky.

References for Section 3.2.7

1. Illinois historic landmarks survey. 19--. Benton, Illinois. In: Illinois historic structure survey. Chicago, Illinois. Preliminary report.

2. Muller, Dr. John, Department of Anthropology, Southern Illinois University, Carbondale, Illinois. Personal communication to Mrs. Ruth Melvin, 1978.

References for Section 3.2.8

1. Unpublished data. Battelle's Columbus Laboratories, Columbus, Ohio. August 21-22, 1978.

4. POTENTIAL ENVIRONMENTAL IMPACTS

4.1 PADUCAH GASEOUS DIFFUSION PLANT

4.1.1 Impacts on land use

4.1.1.1 Radioactive Waste Burial

The burial of low level solid radioactive waste has been limited primarily to two adjacent areas covering approximately 2 acres (0.9 ha) within the plant fence. About 35 percent of this area was utilized during the period 1957 to 1974 for burial of uranium metal scrap. The remaining area (65 percent) was originally constructed in 1953 as a clay-lined holding pond, and was later covered and sloped for use as a burial area for drummed uranium-containing waste. This site is still in use for burial of low-level, low specific activity radioactive waste. Both of these sites are underlain with low permeability clay soils which lower the potential for migration of contaminants.

4.1.1.2 Use of biocides

Utilization of biocides such as herbicides and pesticides at the PGDP should not significantly alter current or future land use. These activities generally have only a localized effect in the area of application and therefore should not affect land use beyond the plant boundaries. Biocidal use in cooling tower maintenance has not had any apparent effect upon terrestrial ecology in general (Section 4.1.6), and is not expected to affect current land use.

4.1.1.3 Chemical discharges

Chemical discharges from the PGDP include emissions from boilers and process sources, airborne substances from cooling towers and exhaust vents, and liquid discharges from various sources. Potentially toxic substances in these discharges have not been found to occur in dangerous levels in the terrestrial environment, or in the vicinity of the PGDP property. However, discharges to Little Bayou Creek during previous operations have impacted the creek (Section 4.1.7) and therefore affected land use with respect to utilization of the stream as a water source for plants and animals. However, this impact is predominantly limited to acreage within the PGDP property boundaries and therefore it should have little effect on off-site land use.

4.1.1.4 Noise and aesthetic impacts

Noise criteria

Appendix D, Table D-1, summarizes the tentative regulatory levels for the State of Kentucky noise control act.[(1)*] The Class I land use includes residential and forest preserve areas. Appendix D, Table D-2, summarizes the EPA recommendations for yearly equivalent sound levels and day-night sound levels.

The EPA criteria which are applicable are:

- Residential (with outside space) and farm space
- Industrial (plant site only)
- Recreational areas
- Farm land and general unpopulated land

The most stringent outdoor limit imposed on levels by the recommended criteria for these land areas is the L_{dn} (24 hours) of 55 dBA for residential areas. The industrial limit of 70 dBA for L_{eg} (24 hours) applies inside the plant property.

In the immediate area of the plant, the dominant sound is that of the plant itself. The noise emissions are at a sufficiently low level that natural sounds, i.e., bird song, wind, and insects, are clearly audible. When evaluated according to applicable criteria for environmental noise, the plant noise emissions are considered acceptable.

The highest noise level found at the perimeter fence (adjacent to the cooling tower) line was 50 dBA. This is well within the U.S. EPA guidelines and the state limit for off-site noise.

The nearest residence is on McCaw Road, east of the plant approximately 1 mi (1.6 km). Although no measurements were made at the residence, other measurements, made closer to the plant, permit an evaluation of the potential noise impact at the residence. Measurements show that the contribution of the plant to the L_{eq} at the nearest residence would be on the order of 40 dBA;[(2)] the L_{dn} would be on the order of 55 dBA, the value recommended by U.S. EPA. Vehicular traffic on the road is the principal contributor to the noise environment of the residence.

Traffic-generated noise is a significant feature of the PGDP. The greatest concentration of vehicles occurs during the half-hour immediately following the end of the day shift, with the half-hour periods preceding the day shift and the evening shift being next in traffic density.

---

*See subsection 4.4 for Section 4 references.

The L_{10} (level exceeded 10% of the time) at a point 200 ft (61 m) west of the intersection of Entrance Highway and Dyke Road during the afternoon shift (the point of greatest traffic noise) does not exceed the value of 70 dBA established for design level peak traffic hour.(3) It is not expected that any residential receptors along commuter routes will be impacted.(2) Schools and churches in the area are not expected to be affected by plant-related traffic noise because normal hours of session do not coincide with shift change times.

In summary, the impact of noise, either from the plant or from sources related to it, is minimal, with measured noise levels falling well below values considered to be acceptable limits.

Occupational noise

Within the plant boundary, noise exposure of employees is the subject of regulations established by the federal Occupational Safety and Health Act (OSHA). The management of the PGDP maintains a program designed to assure compliance with the requirements of OSHA; noise considerations are a part of this program.

Aesthetic impacts

Aesthetic impacts are associated primarily with the visible plumes from the cooling towers. The physical presence and appearance of the cooling tower per se are of little importance in comparison with other plant facilities. Some visible plume is most likely present during any given period of operation. However, except for instances of ground level contact (fogging), the presence of a visible plume at most contributes to the industrial appearance of the overall site. Because the area immediately surrounding the plant site has a low population density and the local land-use policy includes the existence of an operating gaseous diffusion plant, such visual considerations due to the plume are minor.

4.1.2 Impacts on water quality and water use

4.1.2.1 Water quality criteria and standards

Water quality criteria and standards have been developed for many potential contaminants on the basis of both ecological and human health considerations. Those most applicable to PGDP may be divided into categories depending on whether the standards or criteria are to apply to the effluent itself or to the receiving water body at some point downstream after the wastes have had the opportunity to mix with the diluting water. A second categorization may be made based on the agency promulgating the criterion or standard.

Effluent regulations

- National Pollutant Discharge Elimination System (NPDES), U.S. EPA
- Guidelines for Discharge of Radionuclides to Unrestricted Areas, U.S. Department of Energy/U.S. Nuclear Regulatory Commission

Ambient Regulations/Criteria

- Kentucky Water Quality Standards
- Quality Criteria for Water, U.S. EPA
- Primary/Secondary Drinking Water Standards, U.S. EPA/ Kentucky Department of Natural Resources (DNR)

Presently enforceable values for each of these sets of regulations and the particular point at which thev are to be applied are listed in Appendix D, Tables D-3, D-4, and D-5.[1,2]

In addition, it is DOE practice to discuss the highest aqueous concentration of each radionuclide in an unrestricted area averaged over a period of one year in water at points of use downstream from the point of release of the effluent.[3] To evaluate these concentrations, a chemical dispersion model was used (Appendix D, page D-7).[4]

4.1.2.2 Surface water

Use of surface water in Big and Little Bayous is presently restricted to aquatic life propagation. This situation is likely to continue into the foreseeable future. Analysis of available data with respect to the continued operation of PGDP leads to the following conclusions:[5]

- Upstream water quality in Little Bayou meets applicable water quality standards except for polychlorinated biphenyls for which the existing aqueous concentrations were measured to be about twice the Kentucky aquatic life standard. Allowable concentrations were calculated from toxicity data for indigenous fish species. The source of these pollutants is not apparent and the data are too limited to generalize about any environmental damages that may be caused by their presence. The concentrations at the downstream stations may reflect low concentrations in the PGDP effluent or may be the result of release PCBs previously attached to particulates.

- Upstream water quality in Big Bayou will probably continue to be affected by sporadic discharges of leachate from the Kentucky ordnance works disposal areas. Ammonia, nitrates, BOD, and selected heavy metals are the parameters that are likely to exhibit the most noticeable trends.

- Continued operation of PGDP should maintain the desirable increases in stream dissolved oxygen levels that have been observed in the past.

- Heavy metals, particularly chromium, have exceeded standards on several occasions in the past. Though these occurrences do not persist long, they create long-term adverse conditions by increasing sediment concentrations. Most of the problems have been solved by the construction and operation of the chromate reduction facility in 1979. Control of the cooling tower drift problem will further reduce chromium emissions. The elevated levels in the sediments will probably never return to control levels; however, careful attention to maintaining the pH above 6 will permit as full a use of the Big and Little Bayou Creeks as is possible.

- Similarly, fluoride concentrations have occasionally exceeded standards and criteria. This situation has not been totally solved; however, discontinuation of fluoride processing activities should result in a reduction in levels over time. No floride violations of NPDES permit conditions have occurred since 1977. Fluoride concentrations below 10 mg/l do not appear to be acutely toxic to the types of fish likely to be found in the creeks and the NPDES limit of 3-4 mg/l will protect these uses.(6)

- Long-term operation of the plant has resulted in accumulations of radionuclides in the creek sediments. During periods when water concentrations are low, the sediments may release these constituents to the water.

In general, water concentrations have been well below suggested guidelines. Very limited data have been reported in the literature concerning the effects of ionizing radiation on fish or other aquatic organisms. The conclusion reached by one study was that by far the most serious effect of exposure to radiation was the accumulation of nuclides to the point of being a hazard to man. At levels lower than this, the ionizing radiation was insufficient to cause damages to organisms.(6) The impacts on aquatic biota are discussed in section 4.1.5.2.

No changes in surface water radiological quality are foreseen with regard to continued operations under current safety regulations and barring an unforeseen catastrophe.

Potential water quality effects on downstream users of the Ohio River water are shown in Table 4.1-1. These data confirm that even for the highest discharge levels monitored, the area of influence of the chemical and radiological plume is indeed limited. Accumulation in the sediments will not present any problems because transport processes move the particles downstream and dilute them over time. There are no water intakes for more than 20 mi (33 km) downstream of PGDP, at which point the radioactivity will be essentially at background levels.

TABLE 4.1-1. Potential impacts on water use downstream of PGDP for selected components

Contaminant	Emission Rate kg/sec	Initial Concentration kg/m^3	Critical Concentration kg/m^3	Critical Volume M^3	Downstream Distance to Critical Conc.[e] M
Uranium	1.05×10^{-3}	6×10^{-3} [c]	1.7×10^{-4} [a]	300	30
Alpha	2.8×10^{-4} [b]	1.6×10^{-3} [c]	1.5×10^{-6} [a][b]	280,800	300
Beta	1.1×10^{-3} [b]	6.3×10^{-3} [c]	7.4×10^{-6} [a][b]	178,000	260
Fluoride	1.1×10^{-2}	60×10^{-3} [c]	0.1×10^{-3}	97,500	210
Nitrate	1.2×10^{-2}	67×10^{-3} [c]	10×10^{-3}	10 (minimum)[d]	10
Chromium	7.4×10^{-4}	4.2×10^{-3} [c]	0.05×10^{-3}	1,770	60

(a) 1 percent of value determined by conversion of NRC uranium guidelines from radiological units to gravimetric units.

(b) Using specific activity of nat. U as conversion factor.

(c) Maximum measured during 1976-77.

(d) Depends on ambient NO_3 concentration.

(e) Rectangular mixing Volume (W D 0.1L).

4.1.2.3 Groundwater

Information on groundwater suggests that potential impacts are practically non-existent because local groundwater demand is very low and is expected to remain low through the year 2000.

Extensive contamination is also unlikely because PGDP does not use groundwater for process purposes and because the permeability of the native geologic materials is not conducive to rapid migration of contaminants to water supplies (see Section 3.1.3.2).

Occasionally, anomalous water quality values have been noted in the past.[7] If a trend develops, the isolated nature of the PGDP indicates that sufficient time will be available to solve any problems that may arise.

4.1.3 Physical effects of heat dissipation

4.1.3.1 Introduction

The mechanical-draft cooling towers associated with the Paducah Gaseous Diffusion Plant constitute a potential impact on local land use and terrestrial ecology. Possible effects include (1) thermal alteration of streams and rivers by the discharge of blowdown from the cooling towers and other plant effluents, (2) salt deposition (drift), (3) ground level plume contact (fogging), and (4) cold water icing.

The amount of water that recirculates through the heat dissipation system is dependent on the heat load of the process; for the Paducah plant at peak operating power, the heat load is approximately 2300 MW[1] and the circulating flow rate would be about 5×10^8 gpd (1.9×10^9 lpd). Because the diffusion process is characteristically stable, the heat load and water flow should remain relatively constant. More than 90% of the heat is released to the atmosphere in the cooling tower (typically 1.8×10^7 gpd or 7.0×10^7 lpd). A small percentage of the heat is released to the atmosphere through the building ventilation systems and only a small fraction (less than 0.5%) of the total energy is released through the blowdown stream and into the discharge creeks.

4.1.3.2 Thermal alteration of streams and rivers

Thermal standards

At present, guidelines and standards specifically applicable to a uranium enrichment plant source category have not been issued by the U.S. Environmental Protection Agency. Most states have promulgated thermal standards under the state participatory provisions of EPA's National Pollutant Discharge Elimination System (NPDES).[2] The

Kentucky Department for Natural Resources and Environmental Protection has promulgated thermal water quality standards [3] which are directly applicable to the existing uranium enrichment facility (Appendix D, Table D-6).

Thermal effluents from cooling towers

The plant cooling towers at full power will require approximately 2.0×10^7 gpd (7.6×10^7 lpd) of makeup water. Of this amount, the cooling towers will discharge to the atmosphere a maximum of about 1.8×10^7 gpd (6.8×10^7 lpd) through evaporation and approximately 5×10^5 gpd (1.9×10^6 lpd) as drift. Approximately 1.0×10^6 gpd (3.8×10^6 lpd) of heated blowdown water is discharged to the chromate removal system, discharge creeks, and ultimately to the Ohio River. Smaller sources of discharge are steam plant boiler blowdown and laundry effluent discharged to the sewage treatment facility. A conservative estimate is that heated thermal effluent will not exceed 1.5×10^6 gpd (5.7×10^6 lpd). Water temperature of blowdown is estimated to be a maximum of 95F (35C). There is some dilution and some cooling in the plant before the water reaches the C-616 full flow lagoon which was heat-load calculated and sized to provide adequate cooling prior to discharge.

Most of the water in Big and Little Bayou results from plant operation. If there were no upstream flow to mix with the plant effluent or if the flow was very small with respect to the plant total, the thermal standards would, by definition, be violated, i.e., "stream maximum temperature of 89F (31.7C): and "the maximum temperature rise at any time or place above natural temperatures shall not exceed 5F (2.8C)."[3]

Only limited data are available concerning upstream flow in the discharge creeks. During extremely dry weather, there may be no flow, and temperature rise cannot be computed. For these reasons, it is assumed that the point of discharge to meet thermal standards is at the Ohio River.

The impacts of effluents having elevated temperatures depend primarily on the temperature and volume of the receiving water, the extent of the thermal mixing zone, and the nature of the water uses. For a very conservative evaluation, the following assumptions are offered: (1) the thermal effluents from the existing gaseous diffusion plant are discharged directly to the receiving body (Ohio River) with no prior dilution or holdup; (2) the receiving body flow is at a temperature of 4C (39.2F)[5] which is the low temperature recorded for the period 1973-1976 at River Mile 962.2; and an approximately, 10-year low-flow discharge for the Ohio River at Smithland Dam is 19,500 cfs (546 cm).[4]

Under these worst-case conditions, the fully mixed receiving water thermal increment would be less than 0.007C (.013F). At average blowdown flow and average Ohio River flow of 265,000 cfs (7420 cms), the temperature rise would be much less. The cooling tower blowdown and the steam plant boiler blowdown are discharged into holding ponds where some of the heat will be dissipated to the atmosphere prior to release. Therefore, downstream thermal increments would be virtually impossible to detect and would be within the realm of statistical uncertainty.

Although the extent of the mixing zone is not precisely defined, it would be small even under worst-case flow in the Ohio River of 19,500 cfs (546 cms). For these conditions with the existing plant operating at maximum load, the heated thermal effluent would amount to about 0.012% of the total flow. It is apparent that the thermal alteration of the Ohio River due to the Paducah Gaseous Diffusion Plant cooling towers is minimal and that the existing plant will easily comply with all local, state, and federal thermal standards.

4.1.3.3 Cooling tower drift

The existing environment includes a gaseous diffusion plant that utilizes mechanical draft cooling towers for heat dissipation. The drift from these towers is estimated to be 0.05%, which is typical of older mechanical draft towers.(5) Modern cooling water technology reports much lower drift figures.

Using existing cooling tower data as supplied by Paducah Gaseous Diffusion Plant,(5) the Oak Ridge Fog and Drift code (ORFAD)(6,7) was used to calculate the cooling tower drift and the salt concentration in air as a function of distance from the cooling towers.(8) As is typical with mechanical drift towers, essentially all deposition occurs within a 1-mi (1.6-km) radius of the cooling tower.

Based on these calculations, effects on terrestrial ecology due to impaction of drift salts (as contrasted with impaction of drift chemicals) will be restricted to the near vicinity (i.e., about 1000-ft radius or 305 m) of the tower installation, affecting only a limited area. With a yearly average precipitation of approximately 46 in. (117 cm),(9) the drift deposits will be diluted and dispersed to the surrounding watershed and extensive buildup of salts will not occur. A plot of the salt concentration in air ($\mu g/m^3$) at a height of 26 ft (8 m) as a function of distance from the cooling towers shows that the salt concentrations drop off rapidly with distance.(8) Beyond a 0.5 mi (0.8 km) radius they are well below the 10 $\mu g/m^3$ levels known to affect the general vigor and distribution of plants.(10)

Although other salts may be present, ORFAD assumes that the salt is primarily NaCl. Other salts such as chromate, $CaSO_4$, other sulfates, and zinc will be present and deposition is probably similar to that calculated for NaCl. An experimental study of chromate deposition at PGDP(11), prepared using measurements obtained along the prevailing wind direction from the C-637 cooling tower, confirms that the chromate concentrations in grass and soil essentially reach background concentrations within a 0.6 mi (1000 m) radius of the tower installation. Any vegetation damage or excessive deposition of trace contaminants (e.g., chromate, zinc) likely to be incurred will be confined within this radius.[10] No damage or excessive level has been detected as a result of the present operations and any future impacts from continued operations are expected to be insignificant.

4.1.3.4 Fogging and icing

Ground-level plume contact (fogging and cold weather icing) is associated with operation of mechanical draft cooling towers. These localized phenomena can affect nearby commercial, industrial, residential, agricultural, and recreational land use. The frequency of occurrence and the duration of these potential effects will depend on the local topography and weather conditions.

For mechanical draft cooling towers, the primary atmospheric effects are associated with the discharge of water vapor and the formation of a visible (water droplet) plume due to the condensation of water vapor as it mixes with cooler ambient air. The length and other dimensions of the plume depend principally on existing weather conditions.

When ambient temperatures are sufficiently low, cooling tower plumes can cause icing. Observations of ice deposited from freezing plumes or fog indicate that such ice is similar to that deposited by naturally freezing fog and is very light and friable.

No precise records are available concerning fogging and icing that result from operation of the existing Paducah cooling towers. Very little fogging or icing has been observed in recent years because of reduced power levels.

The hours per year of induced fog as a function of distance from the existing cooling towers as calculated using ORFAD[8] show that the induced fog drops off rapidly with distance. Beyond 4 mi (6.4 km) from the towers, it is generally below 12.5 hr/yr, which is in the realm of uncertainty with regard to natural fog versus induced fog. The heaviest concentration of induced fog is directly to the northeast of the cooling towers (100 hr/yr) and extends almost 1 mi (1.6 km). This is a conservative calculation because when all towers are considered ORFAD will treat them as being closely grouped together. This increases fogging estimates because the towers interact.

A plot of hours per year of induced icing as a function of distance from the cooling towers shows the icing as generally below 15 hr/yr.[8] The exception is a small area southeast of the towers where up to 30 hr/yr is predicted. These figures are also within the realm of uncertainty with regard to natural icing versus induced icing; however, some icing can certainly be expected within 1-2 mi (1.6-3.2 km) of the towers.

The visible plumes generated by the evaporation of cooling water would be expected to extend for no more than 2500 ft (762 m) from the tower, with the average plume length reaching about 750 ft (229 m). Normally, the plume height would be expected to rise to about 750 ft (229 m).[9]

Possible effects from fogging and icing do not seriously impact on public highways due to the distance of the towers from major roadways.

4.1.4 Impacts on air quality

The Paducah Gaseous Diffusion Plant is located in McCracken County, Kentucky, about 4 mi (6 km) south of the Ohio River and 20 mi (32 km) east of the confluence of the Ohio and Mississippi Rivers. In terms of total separative work capacity and power utilization, it is the largest of the three government-owned (DOE) diffusion plants.

As specified in the Kentucky Air Pollution Control Regulation, the sulfur dioxide emission regulation for the coal-fired boilers is 1.2 lb/MMBtu (0.5 kg/10^9 J). Low sulfur coal (i.e., <1.0 percent sulfur) is burned to comply with this emission regulation.

At maximum operating levels for the coal-fired boilers (i.e., <100% capacity) the total SO_2 emission tonnage on an annual basis is about 1200 tons (1088 T).[1] Since this amount is within the SO_2 emission limitation enforced by the State of Kentucky, it follows that downwind SO_2 concentrations, for a complying facility such as the PGDP, should be within the ambient national standards. In 1978, the average sulfur dioxide emission was 0.47 kg/10^9J (1.20 lbs/10^6 Btu), which complies with the state regulations.

For particulates, the emission regulation promulgated on the coal-fired boilers limits particulate emissions to 0.24 lb/MMBtu (0.1 kg/10^9 J). In terms of an emission per unit time, this converts to a maximum allowable emission rate of approximately 56 lb/hr (25 kg/hr) or 248 tons/yr (225 T/yr).

An Agreed Order was negotiated with EPA and the State of Kentucky in which timetables were established for bringing the steam plant, smelters, and UF_6 manufacturing plant into compliance with Kentucky's air pollution regulations. Stack emission tests determined that the smelters were in compliance.

New electrostatic precipitators (ESP) were installed on the two coal-fired boilers at the steam plant in October 1978 and are operational. They are designed to meet EPA and Kentucky new source performance standards of 0.1 lb/MMBtu (0.04 kg/10^9 J). Low sulfur coal is burned in the steam plant to meet Kentucky SO_2 emission limits.

Listed below is a summary of the characteristics of the two stacks: both stacks are identical.

Stack Height	:	33.55 m
Stack Diameter	:	1.83 m
Exit Velocity	:	8.61 m/sec
Stack Effluent Temp	:	439°K

Two EPA dispersion models, PTMAX and CDM, were utilized in assessing expected downwind SO_2 and TSP concentrations. PTMAX was used to estimate short-term concentrations, while the Climatological Dispersion Model (CDM) was employed to estimate long-term or annual concentrations. PTMAX estimated the 3-hour maximum SO_2 concentration to be approximately 360 $\mu g/m^3$; the 24-hour SO_2 concentration would be significantly lower. The 24-hour SO_2 standard is 365 $\mu g/m^3$. The estimated 3-hour maximum particulate concentration was also within national standards.

The contribution to annual SO_2 and TSP concentrations as predicted by CDM were less than 5 $\mu g/m^3$. This amount is well below the National Air Quality Standards.

Fluorides and other regulated pollutants were not included in the analysis because of the lack of input data and the inadequacy of the government models to analyze highly reactive pollutants such as photo-chemical oxidants.

4.1.5 Radiological impacts on biota other than man

4.1.5.1 Terrestrial biota

Operation of the PGDP facility has resulted in no significant accumulation of radionuclides in the local terrestrial environment. No detectable radiation induced effects have been observed. Continued operation of the facility is not expected to result in any detectable radiological impacts to the terrestrial biota.

4.1.5.2 Aquatic biota

Radioisotopes ^{235}U and ^{238}U were found to increase by an order of magnitude in tissue from upstream and downstream of PGDP discharges in Little Bayou Creek.(1) These levels, particularly ^{238}U, are directly attributable to plant activity, because concentrations in tissue from streams receiving plant discharges were all higher than in tissue from the reference stream. However, all samples were well within published standards.(2)

4.1.6 Impacts on terrestrial ecology

4.1.6.1 Plant emissions

Past plant operations have not resulted in any observable injury to vegetation or animals from emissions of fluorides or other chemicals. Continued operations are not expected to have any observable effects on the terrestrial ecosystem.

4.1.6.2 Cooling tower operation

Operation of the PGDP cooling towers does result in the release of various salts and metals. However, analysis of soil and vegetation samples both on and off the PGDP site determined the levels of these substances to generally be within naturally occurring ranges.[1] Determinations of the physical nature of dispersion from the cooling towers (Section 4.1.3.2) indicate that the affected area is limited to about a 1000 ft radius (305 m). The concentrations of salts, primarily NaCl, beyond 0.5 mi (0.8 km) were determined to be well below levels known to affect plant vigor and distribution,[1] and are not expected to accumulate sufficiently in the future to affect vegetation.

In general, the chemical characterization studies did not detect any levels determined to be either high by "normal" levels or potentially toxic in soils, vegetation, or small mammals. Comparison of on-site samples with off-site samples detected no significant differences.[1]

Blowdown discharge to Little Bayou Creek has eliminated this stream as a food source for fish-eating birds, such as the green heron or belted kingfisher. Although the creek did not support a resident fish population at the time this study was conducted,[1] the diversion of recirculating water blowdown to C616 and the control of cooling tower windage should result in improvements in water quality. Chromate reduction, settling, and dilution prior to discharge to Big Bayou Creek resulted in minimal additional impact to that system[3].

4.1.7 Impacts on aquatic ecology

Potential impacts on aquatic ecology resulting from operation of the Paducah Gaseous Diffusion Plant involve liquid thermal discharge and releases of biocides, sanitary sewage, and other chemicals to Little Bayou Creek, Big Bayou Creek, and ultimately, to the Ohio River.

4.1.7.1 Thermal discharge

Concerning the impacts to Big and Little Bayou Creeks immediately below the thermal discharge points, it is doubtful that the conditions noted (reduction or elimination of species and standing crops of fish, benthos, and algae) were due to thermal alteration. Field measurements taken at the time of sampling were well within standards. Similarly, since there is estimated to be little or no thermal alteration to the Ohio River from PGDP outfalls, no impacts are expected.

4.1.7.2 Biocides

The major biocidal release from the Paducah facility is chlorine in the cooling tower blowdown and sewage treatment wastewater. In addition, a fungicide, Betz F-16, containing 20% sodium pentachlorophenate, is applied to the cooling tower wood as a preservative. Other pesticides used intermittently on the plant site enter local surface waters in runoff.

Residual chlorine levels in the water of Little Bayou Creek were found in a range toxic to aquatic life(1,2) below the PGDP outfall in 1977. Extensive sampling of plant outfalls to Little Bayou in 1981 indicated residual chlorine in the Bayou to 0.1 ppm. During low flow periods, levels of residual chlorine in Big Bayou Creek also approached toxic levels for freshwater organisms.

Sodium pentachlorophenate is toxic to aquatic organisms at concentrations as low as 0.31 ppm.(3) Depending on the application techniques employed, and the amount of recirculating water in the cooling towers, these concentrations could be approached in the cooling tower blowdown. However, the highest concentration of effluents found in any outfall was less than 1/2 this threshold level.

Other pesticides used intermittently for plant grounds maintenance purposes could potentially reach surface waters by means of runoff. Depending on the persistence of the pesticide, even small releases may accumulate in the biota.

4.1.7.3 Sanitary sewage wastewaters

Sanitary sewage wastewaters from the Paducah facility are treated at the C-615 sewage treatment facility and discharged to Big Bayou Creek.

Residual chlorine levels during low flow periods may reach levels that are toxic, particularly to benthic or attached organisms. Fish species, being motile, may avoid the area of the discharge.

The PGDP discharge augments low flow conditions in Big Bayou Creek, resulting in beneficial effects on dissolved oxygen levels.

None of the other measured parameters associated with sewage outfalls (i.e., metals, ammonia, nitrates, phosphate, COD, alkalinity, dissolved and suspended solids) appears in Big Bayou Creek at levels sufficient to cause adverse effects.

4.1.7.4 Other chemical wastes

Chemical discharges to Big Bayou Creek include: effluents from the maintenance facilities, laboratory facility, chrome reduction facility, nitrogen facility, water treatment plant, and detention basin (holding pond for wastes from the decontamination facility, steam plant, and leachate from the radioactive waste burial ground); storm water runoff; and the effluent from the sewage treatment plant. Little Bayou Creek receives cooling-tower blowdown, storm water run-off, and air plant facility effluent via the 340 effluent ditch. Chromium exceeded recommended criteria for aquatic life in Little Bayou Creek below the PGDP outfall in 1977. Concentrations of chromium can cause direct mortality to non-motile organisms, thereby removing a food supply for predator species. Low concentrations can be detected by other organisms, causing them to avoid the area. With the installation of the chromate reduction facility, chromate levels have been reduced and future impacts will be insignificant.

4.1.8 Socioeconomic impacts

4.1.8.1 Social impacts

Since the location of the PGDP in McCracken County in the 1950s, the County has changed from a primarily rural character to one where over 60% of the county is classified as urban. Not all of the social change may be attributable directly to the plant. However, social impacts of the PGDP's location in McCracken County include effects related to:

- Work force
- Civic involvement
- Public services and institutions.

Sixty-one percent of PGDP's employees reside in McCracken County, accounting for approximately 12% of the county's overall employment.

Participation of PGDP employees in local civic activities is relatively high. A list of elective governmental and appointive positions held by Union Carbide PGDP employees, 1972-1976, compiled by Union Carbide, indicates that a wide range of such positions have been filled by PGDP employees--including, for example, positions with the McCracken County Board of Education, the McCracken County Red Cross Board of Directors, the McCracken County Fire and Rescue Squad, and the Paducah City Commissioner's Office.

With regard to public service impacts, results of a PGDP in-plant survey indicate that employee households heavily utilize the Paducah Public Library, local hospitals, McCracken County Health Department, and police.

Employees also indicated that they, and their families, utilize the fire departments, nursing homes, welfare services, mental health center, and other public services provided in the county[1].

Impacts on McCracken County institutions also include the effect of the PGDP on local schools and general educational attainment.

The overall educational level of McCracken County's residents has increased as a direct and indirect result of the employment and skill requirements of the PGDP.

In addition, the PGDP in-plant survey indicated that 861 children of PGDP employees attend Paducah public and McCracken County schools. Another 207 attend parochial or special educational institutions. Children of PGDP employees account for approximately 8% of total school enrollment in the county.

The survey also suggests that PGDP employees and their families utilize Paducah Community College, the Paducah Area Vocational Educational Center, and other educational institutions relatively frequently.

4.1.8.2 Economic impacts

The economic ramifications of the PGDP's presence in McCracken County has been previously analyzed in detail.[2] Data on PGDP's local material purchases and employment levels were examined, as well as information on overall economic activity in the county. The analysis indicated that the PGDP directly or indirectly accounts for:

- 33% of the county total economic output
- 27% ($119.8 million) of the county value added
- Over 12% of the county employment.

The economic sectors that are most dramatically influenced by PDGP include:

- Electrical power
- Wholesale and retail trade
- Food and kindred products
- Education services and non-profit organizations
- Finance and insurance.

The PGDP is not only an important entity in the private economic sector, but in the area of public finance as well. The recent analysis indicated the county, as well as the Paducah Independent and McCracken County School Districts, currently experience net revenue inflows as a result of PGDP.[2] However, the City of Paducah realizes a net outflow of such magnitude that the aggregate effect of PGDP on all jurisdictions is negative. However, this may be somewhat mitigated by consideration of the indirect public finance benefits attributable to the PGDP.

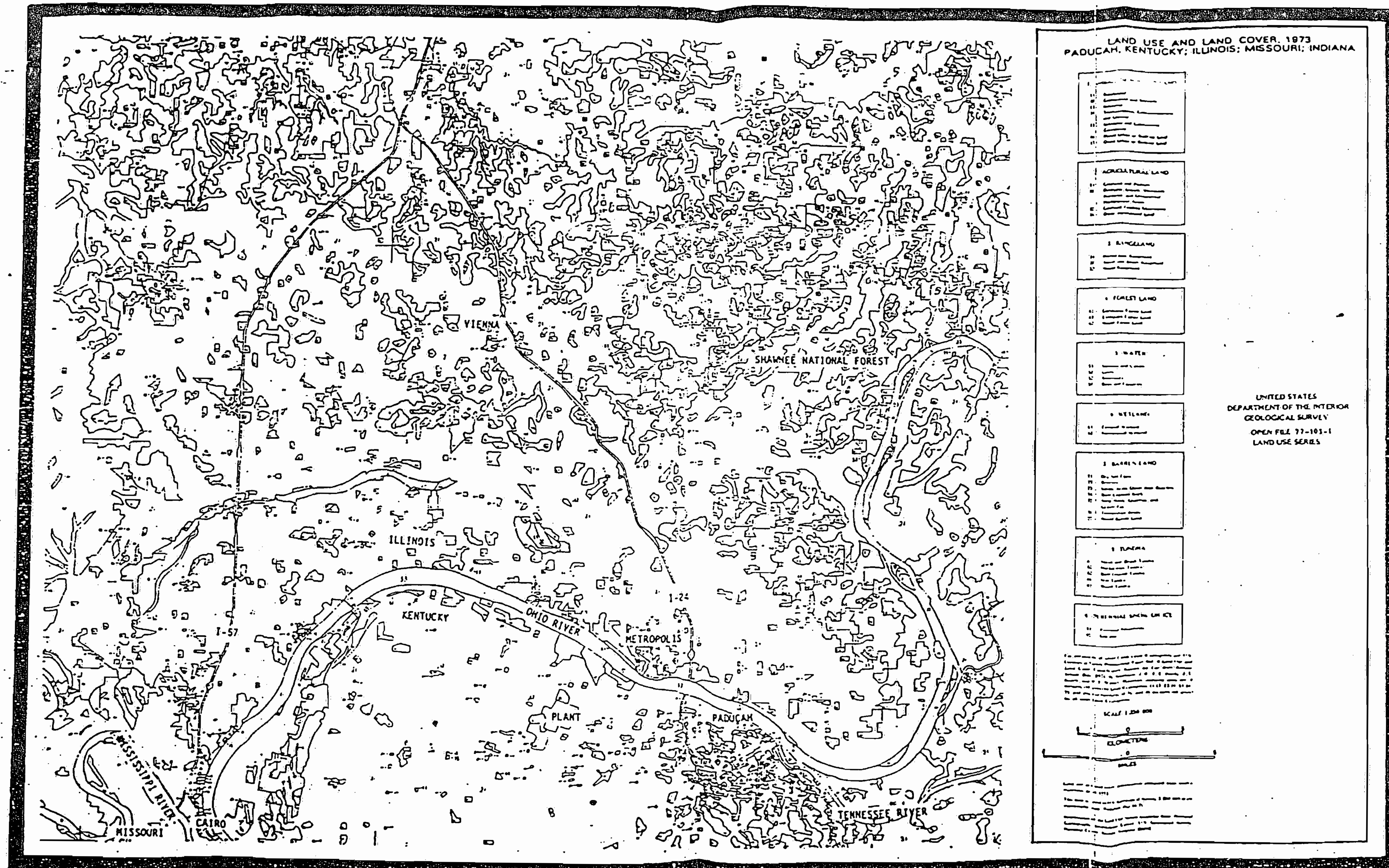


Figure 3.1-6. Portion of the 1973 U.S. Geological Survey land use and land cover map for the Paducah, Kentucky vicinity

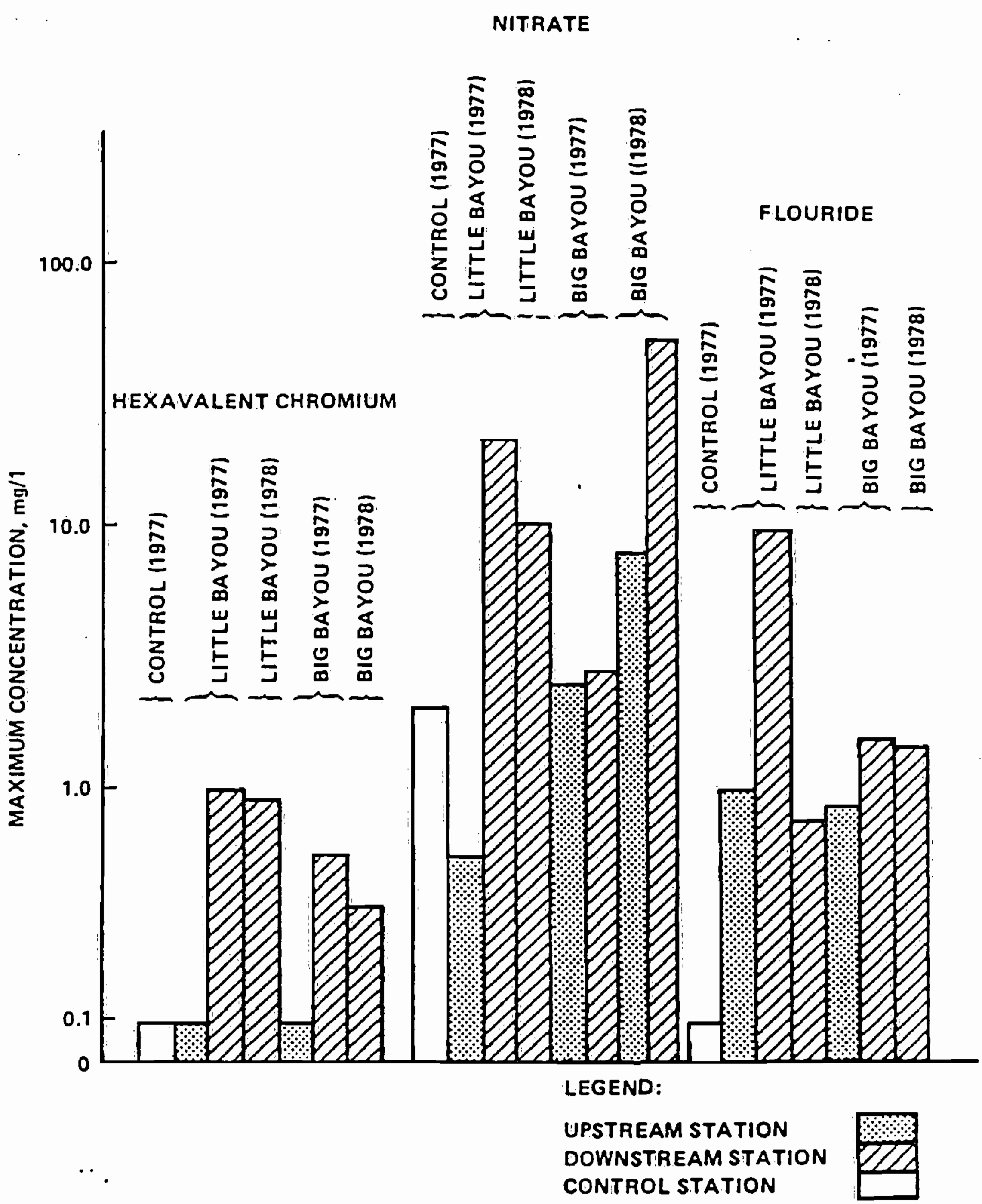


FIGURE 3.1-9. CONCENTRATIONS OF SELECTED WATER QUALITY PARAMETERS IN BIG AND LITTLE BAYOU CREEKS COMPARED TO MASSAC CREEK CONTROLS

The available groundwater resources in this area appear to be virtually undeveloped. Yields of the State Game Refuge wells in Union County and the municipal wells at Metropolis are reported to be 1000-1500 gpm (3785-5677 lpm). The Missouri Pacific Railroad wells at Gorham, the well of Anna State Hospital near Wolf Lake in Union County, and the Texas Company wells at New Haven have reported yields of 500 gpm (1892 lpm). These wells are constructed in sand and gravel at depths of less than 100 ft (30 m) and have specific capacities estimated from 30-90 gpm/ft (372-1117 lpm/m) of drawdown.(1)

Most of the water is returned to the Ohio River after usage. Appendix B, Table B-13 summarizes data on groundwater availability in Massac County wells drilled into both consolidated and unconsolidated aquifers. Several wells are used sporadically and average daily pumpage has not been specified.

Groundwater recharge in this area is probably similar to that near PGDP due to the similar infiltration capacities of the soils. Current usage is therefore a small percentage of the available supply. Actual supply varies considerably from one area to another.

3.2.2.2 Surface water

The land area around the Joppa power station drains into two small unnamed tributaries to the Ohio River and to the river itself. The tributary to the west has a total drainage area of 1424 acres (2.2 mi^2; 576 ha, 5.7 km^2) while the tributary to the east drains an area of 1066 acres (1.7 mi^2; 431 ha, 4.3 km^2). These tributaries have not been gaged but an order of magnitude estimate of the flows may be obtained by examining the data in Figure 3.2-2. These discharge values have been derived from measurements made on the Cache River Basin slightly to the northwest.

The data are given for two water-years. The 1975 water-year was unusually wet, particularly during the spring, while 1976 was very dry. Average conditions have resulted in 16.7 in. (42.4 cm) of runoff which is intermediate to the extremes shown. For the western basin, maximum monthly, minimum monthly, and average annual flows are 11.5, 0.1, and 2.6 cfs (326, 3, and 74 l/sec), respectively. This drainage receives no additional flows due to wastewater discharges from the generating facility. For the eastern basin the respective values are 8.6, 0.07, and 2.0 cfs (244, 2, and 57 l/sec). Discharges from this basin to the Ohio River also include overflow from the ash settling basin. During the 18-month period from January 1977 to June 1978, these flows averaged about 14.1 cfs (399 l/sec).

Hydrologic conditions for the Ohio River are similar to those discussed for the PGDP in Section 3.1.3.2. All other plant discharges, excluding condenser cooling water, amount to about 8.6 cfs (244 l/sec) and consist primarily of river water augmented with small amounts of groundwater.

The Joppa plant is located on approximately 624 acres (253 ha) of land in Massac County, Illinois, on the northern bank of the Ohio River approximately 1 mi (1.6 km) west of Joppa and about 8 mi (13 km) northwest of Metropolis. The plant is located on a coastal plain bottomland physiographic province at an elevation of 350 ft (107 m) above sea level, about 60 ft (18 m) above the normal Ohio River pool stage. A barge unloading facility and the cooling water intake and discharge structures are located on the bank of the Ohio River. In addition to the main plant facility and a coal storage yard, the site includes a 55-acre (22 ha) ash disposal pond, a 92-acre (37 ha) abandoned ash disposal area, and a planned 50-acre (20 ha) ash disposal facility.

Figure 3.2-5 provides a map of generalized existing land-use patterns of areas lying within a 5-mile (8 km) radius of the facility compiled from several multi-date land-use maps of the area.

As illustrated by the land-use map and accompanying statistical summary table provided in Figure 3.2-5, the area within a 5-mi (8 km) radius of the Joppa plant is predominantly rural in nature, with agricultural (crop and pasture lands) and open space land totaling approximately 61% of the area.

Forested areas adjacent to the Ohio River, the 2,091-acre (847-ha) Mermet Lake State Conservation Area and Swamp Nature Preserve, and numerous small dispersed wooded areas throughout the study area total approximately 26.5% of the study area. Also included within the forest area is the 15-acre (6-ha) Halesia Nature Preserve established by the American Electric Power Company which lies adjacent to the southeastern boundary of the plant property and the Ohio River. The Ohio River, Mermet Lake, and other smaller water impoundments constitute approximately 11.5% of the study area.

U.S. Route 45 is the major highway in the area, with many secondary roads providing access. The other major transportation corridors include the Ohio River (barge and riverboat traffic), the Chicago and Eastern Illinois and the Burlington Northern railroads, and the Central and Eastern Illinois Railroad, now part of the Missouri Pacific Railroad system, which provides rail access for coal and miscellaneous incoming materials to the plant.

The city of Joppa is the major center of population located within a 5-mi (8-km) radius of the facility. Other very small communities and their approximate straight-line distance from the Joppa plant include: Hillerman, Illinois (2.8 mi, 4.5 km); Choaf, Illinois (3.25 mi, 5.2 km); Ragland, Kentucky (3.4 mi, 5.5 km); and Rossington, Kentucky (4.5 mi, 7.2 km). These communities and other industrial developments along the banks of the Ohio River form a total urban built-up area of approximately 0.75% of the study area. Also, two very small gravel pits are found in the vicinity of Joppa Steam Electric Plant which constitute approximately 50 acres (20 ha) (0.1%) of the study area.

4.1.8.3 Impacts on political entities

The initiation of PGDP activities in the Paducah/McCracken County area in the 1950s raised issues and aroused local concern. Prior to this project, the area had essentially a rural character and most construction undertakings had been small. However, the massiveness of this effort required tremendous manpower and material levels.

The scope of local issues/concerns arising from these demands included:

- Land use
- Transportation
- Law enforcement
- Tax base
- Housing
- Education.

These issues/concerns reflect major areas in which local political entities may have experienced strain in fulfilling their functions. Over time, these entities were able to better accommodate the impact of PGDP; systems and resources developed the capability of meeting the higher demand levels. Currently, the PGDP operations are a component of the local environment in which political entities function. The presence of the facility no longer raises distinguishable and overwhelming issues and concerns in itself. Dramatic changes (especially decreases) in PGDP's current work force level or scope of operations could induce uncertainty and uneasiness. This general anxiety could arouse local issues/concerns which in turn would influence the functioning of local political entities.

4.2 Joppa, Illinois, facility

4.2.1 Impacts on land use

Initial impacts on land use occurred with removal from production and the commitment of 625 acres (253 ha) for the construction of the Joppa Steam Electric Plant. Additional acreage has been necessary for the expansion of the ash disposal pond. Current operations are not significantly effecting further changes in land use.

Given the life expectancy of the plant and continued successful pollution control activities, no additional acreage requirements or other land use impacts are anticipated.

4.2.2. Impacts on water quality and use

The Joppa generating facility has been operating under the State of Illinois standards and Federal/State NPDES permit conditions indicated in Table 4.2-1. A problem area remains before full compliance will be acheived.

TABLE 4.2-1 Current standards in effect at Joppa Electric Station

	pH, units	Suspended Solids, mg/l	Dissolved Solids, mg/l	Temperature F	Oil and Grease, mg/l	Chlorine Residual, mg/l	Fecal Coliform, MPN/100 ml	BOD_5
Effluent Standard (NPDES)	6-9	15 (max)[a] 30 (avg)[b] 45 (max)[b]	750 (max)	Sec. 316[a] Permit	10 (avg) 15 (max)	0.2 (max)	200 (avg) 400 (max)	30 (avg) 45 (max)
Ill. Effluent Stds.[c]	5-10	37[b] 15[a]	bkgd + 750	--	15.0	--	--	30
Ambient Standard[d] or Criterion	615-9	--	1,000	50-89	--	--	200 (avg) 400 (max)	--

(a) Applicable to discharges from ash pond and settling lagoon.

(b) Applicable to discharges from sewage treatment plant.

(c) Source: Reference (4)

(d) Source: Reference (4,5)

The problem is a short-circuiting phenomenon which has been noted in the settling pond. This has caused poor solids removal and inadequate neutralization of coal pile runoff at times. Consequently, localized adverse effects on the Ohio River have occurred. This problem has been partially solved by controlling and rerouting the drainage from the coal pile. Although some short-circuiting from an inactive area still occurs, the amount of drainage reaching the Ohio River has been reduced by approximately 75 percent since 1977 [1]. The water quality in the river appears to have sufficient alkalinity to prevent any long-term deterioration.

The Joppa facility is near the end of its useful life and may be retired before PGDP. If that happens, then power will need to be supplied from another facility. It is likely that the new facility will have to comply with similar standards and that potential impacts will be similar to those of the current facility.

Overall water supply impacts at either Joppa or PGDP are not anticipated. The Corps of Engineers has forecast ample supplies out beyond the end of the century and the Illinois State Water Survey has suggested exporting some of the bountiful groundwater near Joppa.[2, 3]

Heat pollution and other waste water problems were likewise dismissed as inconsequential for this portion of the main stem of the Ohio River.

4.2.3 Impacts on air quality

The generating plant consists of six individual boilers, each which consume about 1,800 tons (1633 T) of coal per day at full capacity. The total design capacity of six boilers is 9,948 MMBtu/hr.

4.2.3.1 Emissions and regulations

The Illinois emission regulations for the Joppa Steam Power Plant limits SO_2 emissions to 36,875 lb/hr (16,741 kg/hr) and particulate emissions to 1,591.7 lb/hr (722.6 kg/hr). The SO_2 emission regulation was attained in July, 1978, through the use of fuel blending. Electrostatic precipitators (removal efficiency, 98.6%) were installed in 1971-1972 to comply with the particulate emission regulation. Construction of three 500-ft (168-m) stacks was required.

Shown below are the parameters and dimensions of the old versus new stacks.

	Old 250 ft (76 m) Stacks	New 550 ft (168 m)
Stack Diameter:	7.32 m	5.49 m
Effluent Exit Velocity:	2.05 m/sec	27.43 m/sec
Exit Gas Temperature:	429°K	430°K

It appears that compliance to the Illinois emission regulations will soon be attained and that the resulting impact on air quality should be acceptable and cleaner than the National Air Quality Standards.

4.2.3.2 Air quality impact

A dispersion modeling study of sulfur dioxide emissions has been conducted for the Joppa Steam Electric Plant.(1) The principal objective of the study was to determine whether the existing SO_2 emissions and stack height were in compliance with the Illinois environmental regulations.

The study concluded that the existing station was in compliance with the State of Illinois emission standard of 6.0 lb SO_2/MMBtu (2.6 kg/10^9 J), but was not in compliance with Illinois Statute 204(e) which dictates the requirements for chimney height. The modeling demonstrated that for any of the proposed alternative stack heights, (of which the 550' (168 m) stack was one alternative) no violations of the SO_2 short-term air quality standards would occur.

The impact of particulate emissions from the Joppa facility were assessed using EPA's PTMAX dispersion model. The results of PTMAX estimates showed that the resulting short-term concentrations were well below any short-term standard (3-hour and 24-hour) and even below the annual standard of 75 ug/m^3. Again as was the case for SO_2 emissions, the air quality impact from TSP emissions, is estimated to be well within acceptable limits.

Annual concentrations were estimated using the CDM model. As expected, CDM estimated the maximum sulfur dioxide and particulate concentrations to be well within the air quality standards.

4.2.4 Physical effect of heat dissipation

The Joppa Steam Electric Plant constitutes a potential impact due to heat dissipation in the Ohio River.

The Joppa plant produces a maximum of 1050 MW (approximately one-half of the maximum Paducah plant requirements) with six coal-fired generating units. An average of 832 cfs (24 cms) of Ohio River water is used to cool the steam condensers releasing an average of 4.4 x 10^9 Btu/hr (4.6 x 10^{12} Joules/hr). The heated water is discharged into the Ohio River near the surface on shore approximately 100 yards downstream from the plant.

The Joppa plant releases and approximated maximum of 5 x 10^9 Btu/hr (5.3 x 10^{12} Joules/hr) of heat to the Ohio River. The volume of water discharged (830 - 900 cfs, of 23-25 cms) is small in comparison to the 10 year low-flow for the Ohio River of 19,500 cfs meters (546 cms).(1) The design of the discharge structure insures that the thermal plume will follow the shoreline and not impede passage of fish or other organisms in the Ohio River. Experimental measurements[2] indicate that the maximum plume width for a ΔT of 5° above normal river water temperature will not exceed 160-200 ft (48.8-61 meters) from the shoreline. Since the Ohio River is approximately 3400 ft (1,036 meters) wide at Joppa, only about 5% of the river is affected. Theoretical calculations using a simple diffusion model confirm these results (Appendix D, page D-9).

Although the extent of the mixing zone is not precisely defined, it would be small even at minimum flow in the Ohio River. Calculations based on the simple diffusion model indicate that a maximum area in the Ohio River of approximately 0.6 acre(0.2 hectare) out of 352 acres (143 hectares) will experience a ΔT of 5°F or more above the normal river temperature under worst case assumptions. It is apparent that the thermal alteration of the Ohio River due to the Joppa Power Plant is minimal and that the existing plant will comply with local, state, and Federal standards.

4.2.5 Impacts on terrestrial ecology

Continued operation of the Joppa power plant will have some negative impacts on the biota in the immediate vicinity. If additional land is needed for new settling ponds, coal storage piles, or other facilities, the land will no longer support vegetation and consequently wildlife habitat and usage will be reduced.

Existing and new ash settling ponds will continue to attract migratory waterfowl, wading birds, and shorebird. These birds may be killed by collision with any transmission lines in the area. In addition, waterfowl are known to ingest slag from the bottom of ash ponds which may contain potentially toxic trace elements.[1]

Adverse effects of gaseous pollutants in the power plant plume on terrestrial plants and animals[1] should be greatly reduced by the recent construction of tall stacks (168 m). These tall stacks should prevent recurrence of fumigation incidents, but will pose a threat to night-migrating songbirds. Songbirds may be killed by flying into the three power plant stacks during the migratory seasons.[2]

Particulate emissions (fly ash) from the power plant stacks as well as particulate emissions from open coal storage piles (fugitive dust) contain potentially toxic trace elements that can have adverse effects on terrestrial plants and animals. Although no obvious adverse effects have been noted from casual observations, subtle changes such as reduction in numbers of sensitive species may be occurring.[1] Soil contamination by toxic trace elements in particulate deposition can result in the loss of essential nutrients and the accumulation of toxic elements in plant tissue.[1,3,4,5] Animals may also pick up trace elements added to the environment through particulate deposition by ingesting contaminated water or plants or by direct inhalation of respirable-size particles.[1]

4.2.6 Impacts on aquatic ecology

A thorough investigation of the impact of the Joppa Steam Electric Plant was completed in 1976.[1] Results of that study showed no significant impact on the total biota (plankton, invertebrates, and fishes) of the Ohio River. One case of diatom mortality in the plant outfall was not measurable further downstream.

Impingement investigations conducted during the 1976 study reported an estimated loss due to impingement of 8.7×10^3 lb (3.9×10^3 kg) of fish comprised of 3.5×10^5 specimen. The most common and abundant species impinged were gizzard shad and freshwater drum.

Entrainment studies reported an estimated $1.17 \pm 0.006 \times 10^9$ larval fish and eggs entrained in plant intake waters during the year. An estimated $1.49 \pm 0.007 \times 10^9$ would be the maximum entrained for a year at full plant intake capacity. Again the most common and abundant larval and egg types were of the family clupeidae (shad) and freshwater drum.

No apparent difference between rates of impingement during day and night operations were detected. Higher impingement rates were recorded during chlorination when fish may have been stunned or displayed an avoidance response making them more susceptible to impingement. It was suggested that these rates may be reduced if chlorination occurs after intake water passes the screens. Survival may further be increased if fish washed from the screens are not deposited directly into the discharge canal where they are subject to physical damage and thermal stress.[1]

The Joppa plant has been in operation for 25 years. Although the river fishery cannot be quantitively evaluated due to the lack of information regarding the size, composition, and distribution of the fish population, it is not likely that the community has been significantly diminished by plant operations, based on the number and diversity of fish impinged.

There are no data on the biological communities of the two tributary streams to the Ohio River on either side of the Joppa plant. It is likely that stressed conditions exist in the channelized streams to the east of the facility. Habitats have been altered or destroyed; the creek is intermittent; overflow from the plant's ash disposal pond and runoff from its coal pile comprise much of the flow. The combination of these factors likely result in conditions unsuitable for the maintenance of a balanced aquatic community.

4.2.7 Impacts by noise

In addition to the noise control goals of EPA discussed in Section 4.1.1.3, criteria for avoidance of environmental degradation by noise and protection against physiological effects are the basis of regulations established by the Illinois Pollution Control Board.[1] The regulations limit daytime noise emissions to redisential land use to 61 dBA and nighttime emissions to 51 dBA.

No data are available for noise emissions from the Joppa plant, however, noise data from Joppa and surrounding areas have been examined (2) and provide some indication of the noise emission.

The power plant contribution to the noise level in Joppa appears to be 50 dBA, or less. However, since there is a substantial amount of wooded land between the power plant and the town, excess absorption (i.e., sound reduction in addition to attenuation due to distance and normal absorption by air) amounting to 5 dB could be expected, reducing the power plant contribution to 45 dbA . In terms of the Illinois Noise Control law, the plant would be in compliance at this level since 51 dB is the limit for nighttime noise emission. Adding the 45 dBA plant contribution has little influence on daytime noise levels but accounts for the nighttime noise level in the community. The values for L_{eq} and L_{dn}, with the plant contribution, are in the ranges of 48 to 50 dbA and 53 to 55 dbA , respectively. These values represent increases of five or six decibels in the equivalent noise level or six or seven decibels increase in the day-night noise level.

The power plant management has not had any complaints concerning noise from the plant. This would indicate that noise from the plant is at a level which is consistent with the estimates made here.

The Joppa facility normally receives one unit train of coal each day, Monday through Friday. The coal is dumped by rotary dumpers sometime between 7 AM and 8 PM; normally no coal is dumped at night. Depending on the time of arrival of the train, noise from the locomotive and from the car wheels squeeling on the curved portion of the tracks has a potential for producing sleep disturbance, however, the absence of complaints indicates this is not a problem.

Approximately 180 employees work any given weekday at the Joppa plant; 125 are on the regular day shift, 40 are on the evening shift, and 20 are on the third shift (midnight to 8 AM). Of these, approximately 50% live in or drive through or around Joppa while commuting. Most of the remainder drive north on the Grand Chain Road, or west from the plant entrance. Since no shift changes occur between midnight and 7 AM, there is relatively little impact from plant traffic-caused noise during the nighttime hours. Overall, traffic generated by the power plant is estimated to represent 8 to 10% of the total vehicular traffic in Joppa.

In summary, there is no reason to expect that operation of the Joppa plant causes any substantial noise impact on the community of Joppa or the surrounding area.

4.3 Cumulative and long-term effects

4.3.1 Cumulative and long-term impacts of power generation

There are no significant cumulative effects anticipated as a result of continued power generating operations at Joppa, if "cumulative" is defined to mean an increasing effect over ti[illegible]

sarily cumulative, effects may be noted as a result of the unavoida
need to dispose of the vast quantity of flyash and bottom ash gener
by the plant. The present practice of sluicing the ash to a settli
pond where the excess water is neutralized and discharged to the Oh
River is expected to continue for the remaining useful life of the
station.

This settling process still permits some fine particulates containi
oxides, silicates, and carbonates of metals to find their way into
river. The large dilution ratio of the waste discharge to the rive
flow and the moderately efficient mixing in the river ensure that a
long-term effects will be minor in nature. Also, since there is so
slight permeability to the soils beneath the ash disposal areas, ov
a long time period minor amounts of leachate may reach the river.

Power generation at Joppa has resulted in the removal of land from
production of vegetation and the elimination of food and resources
wildlife. No further commitment of resources is anticipated at thi
site. A potential exists for some long-term accumulation of toxic
elements and chemicals in the environment as a result of coal handl
and combustion. Without a trace element study on the plant propert
the extent of effects can only be speculated. However, considerin
length of time the plant has been in operation, effects would proba
be minor.

4.3.2 Cumulative and long-term effects of continued operation of th
Paducah Gaseous Diffusion Plant

Management of the PGDP property for wildlife has been beneficial to
biota and will continue to be as long as the management programs ar
active. A slight potential exists for vegetation damage from fluor
but is not a significant concern. Salts and metals from cooling to
drift may accumulate in the immediate vicinity of the towers. In th
long term, concentrations might reach levels toxic to vegetation, bu
effects would likely be minor. Metals may also accumulate in soils
wildlife, but levels are not expected to reach toxic concentrations.

The principal cumulative water effect of uranium enrichment activiti
will be the annual discharge of radionuclides in effluents. Historically, these have been almost exclusively uranium and technetium. The amounts have varied over the past few years, but have generally been less than 20 curies of each nuclide. Since the half-lives of these elements (and of many of the daughter species) are long, discharges are cumulative.

From the standpoint of cumulative environmental impacts, a more impo
tant parameter is the nuclide concentration in the aqueous or sediment phase. Based on the analysis presented in Section 4.1.2.3, there is sufficient dispersion in the Ohio River at the point of dis

charge to reduce the discharge concentrations to near background levels very quickly. Sediment measurements, supported by studies which indicate soluble uranium carbonates may predominate in high alkalinity water, suggest that cumulative sediment buildup, if any, will be spread over a large area.(1) Localized concentration effects on Big and Little Bayou Creeks are likely to be more pronounced than in the Ohio River. However, since a large safety margin for aquatic organism exposure currently exists, it may be presumed that the slow buildup of radioactivy is inconsequential. Occasional severe storms will serve to scour out some of the accumulation and probably represent, together with chemical solubility/absorption, a mechanism for limiting upper bound radioactivity levels.

4.4 REFERENCES FOR SECTION 4

References for Section 4.1.1

1. Kentucky State Noise Control Act, KRS Chapter 224, House Bill 121, 1974 General Assembly.

2. Eischen, M. A., W. T. Lawhon, T. L. Anderson, N. A. Frazier, D. K. Landstrom, R. W. Melvin, S. E. Pomeroy, C. W. Rodman, H. E. Smail, P. R. Sticksel, D. A. Tolle, and B. W. Vigon. 1978. Environmental studies at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky. Final report to Union Carbide Corporation. Battelle's Columbus Laboratories, Columbus, Ohio. Various paging.

3. Federal Register, Vol. 41, No. 80, 23. Part 772 -- Procedures for abatement of highway traffic noise and construction noise, Chapter 1, subchapter 4. U.S. Department of Transportation, Washington, D.C.

References for Section 4.1.2

1. Water quality standards for the State of Kentucky. 1974.

2. U.S. Environmental Protection Agency. 1976. Quality criteria for water. EPA 440/9-76-023, Washington, D.C. 501 pp.

3. Nuclear Regulatory Commission, 1976. Code of Federal Regulations, title 10, chapter 1, part 20, standards for protection against radiation, p. 138-164.

4. Srinivasan, S., T. Thomas, A. Gezen, A. Coyle, C. Kimm. February, 1975. Influence of environmental factors on selected amelioration techniques for discharges of hazardous chemicals. Report to Department of Transportation, Battelle's Columbus Laboratories, Columbus, Ohio. 109 pages and appendices.

5. Union Carbide Nuclear Division. 1971-1976. Environmental monitoring report, Paducah gaseous diffusion plant. U.S. Energy Research and Development Administration.

6. McKee, J. E., and H. W. Wolf. 1963. Water quality criteria. 2nd edition. The Resources Agency of California, State Water Quality Control Board. 548 pp.

7. Reference 2, Section 4.1.1.

References for Section 4.1.3

1. Baker, Richard, Environmental Section, Union Carbide Corporation, Paducah, Kentucky. Personal communication to Karl Landstrom, Battelle, Columbus Laboratories, 1977.

2. Federal Water Pollution Control Act. 1972. PL 92-500.

3. Kentucky Department for National Resources and Environmental Protection Division of Water Quality. 1975. Kentucky water quality standards. 401 KAR 5:025. Section 6 adopted June 5, 1975, effective July 2, 1975.

4. Water resources data for Kentucky. 1972-1976. U.S. Geological Survey and Kentucky.

5. Laverne, Mel. Union Carbide Corporation, Oak Ridge National Laboratory. Personal communication to K.D. Landstrom, Battelle, Columbus Laboratories, January 1977.

6. Wilson, J.V. 1975. A computer program to estimate fog and drift from wet cooling towers. Report ORNL-TM4568. Oak Ridge National Laboratory, Oak Ridge, Tenn.

7. LaVerne, M.E. 1977. The Oak Ridge fog and drift code (ORFAD) user's manual. Report ORNL/TM-5201. Oak Ridge National Laboratory, Oak Ridge, Tenn.

8. Reference 2, Section 4.1.1.

9. Hill, J.D. 1976. Climate of Kentucky. Kentucky Agricultural Experiment Station. Progress Report 221. Lexington, Kentucky.

10. U.S. Energy Research and Development Administration. 1975. Draft environmental statement, expansion of U.S. uranium enrichment capacity. ERDA-1543. pp. 3.2-8.

11. Taylor, G.F. 1978. Cooling tower drift studies at the Paducah Gaseous Diffusion Plant. ORNL/TM-6131 (to be published). Oak Ridge National Laboratory, Oak Ridge, Tenn.

References for Section 4.1.4

1. Baker, Richard, Environmental Section, Union Carbide Corporation, Paducah, Kentucky. Personal communication to Karl Landstrom, Battelle, Columbus Laboratories, 1977.

References for Sections 4.1.5 & 4.1.6

1. Reference 2, Section 4.1.1.

2. U.S. Energy Research and Development Administration. 1977. ERDA manual, vol. 0000, general administration, chapter 0524, standards for radiation protection, annex A. U.S. ERDA, Washington, D.C.

3. Eischen, M. 1979. Further aquatic field studies at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky. Draft final report. Battelle, Columbus Laboratories, Columbus, Ohio

References for Section 4.1.7

1. Reference 6, Section 4.1.2.

2. Reference 2, Section 4.1.2.

3. U.S. Environmental Protection Agency. September 1973. Water quality criteria data book, Vol. 5, effects of chemicals on aquatic life. Water Pollution Control Research Series, 18050HLA 09/73. Office of Research and Development, U.S. EPA, Washington, D.C. Various paging.

References for Section 4.1.8

1. Union Carbide Corporation. 1977. Paducah Gaseous Diffusion Plant, internal socioeconomic profile questionnaire; study coordinated by Robert Langston.

2. Ramlet, E., M. Duchi, A. Buhr, and G. Watkins. February 10, 1978. Socioeconomic assessment of Paducah Gaseous Diffusion Plant. Final report to Union Carbide Corporation. Battelle's Columbus Laboratories, Columbus, Ohio.

References for Section 4.2.2

1. Jacobs, J. Environmental coordinator, Electric Energy, Inc. Joppa, Illinois. Personal communication to M.A. Eischen, Battelle, Columbus Laboratories, February 27, 1981.

2. U.S. Army Corps of Engineers. 1965. Ohio River basin comprehensive survey. Volume XI. Various paging.

3. Woller, D. M. 1975. Public groundwater supplies in Massac County. Bull ISWS/BUL-60/14/75. State of Illinois, Department of Registration and Education.

4. Illinois Environmental Protection Act, Chapter 766, as amended through January, 1978.

5. Reference 4, Section 4.1.2.

References for Section 4.2.3

1. Sargent and Lundy Engineers. January 29, 1975. Sulfur dioxide atmospheric modeling study. Joppa Steam Electric Station.

References for Section 4.2.4

1. Reference 3, Section 4.1.1.

2. Electric Energy, Inc. February 1976. Demonstration regarding evidence of absence of prior appreciable harm from thermal discharges into the Ohio River. Electric Energy, Inc., Joppa, Illinois. 357 p.

References for Section 4.2.5

1. Dvorak, A. J., B. G. Lewis, P. C. Chee, E. H. Dettmann, R. F. Freeman III, R. M. Goldstein, R. R. Hinchman, J. D. Jastrow, F. C. Kornegay, D. L. Mabes, P. A. Merry, E. D. Pentecost, J. C. Prioleau, L. F. Soholt, W. S. Vinikour, E. W. Walbridge. 1978. Impacts of coal-fired power palnts on fish, wildlife, and their habitats. FWS/OBS-78/29. Prepared for U.S. Department of the Interior, Fish and Wildlife Service, Office of Biological Services, National Power Plant Team, Ann Arbor, Michigan. 261 p.

2. Weir, R. D. 1977. Bird kills at the Lennox generating station, spring and autumn 1977. Blue Bill 24(4):40-42.

3. Furr, A. K., T. F. Parkinson, R. A. Hinrichs, D. R. Van Campen, C. A. Bache, W. H. Gutenmann, L. E. St. John, Jr. I. S. Pakkala, and D. J. Lisk. 1977. National survey of elements and radioactivity in fly ashes: absorption of elements by cabbage grown in fly ash-soil mixtures. Environmental Science and Technology, 11(13):1194-1201.

4. Jackson, D. R., and A. P. Watson. 1977. Disruption of nutrient pools and transport of heavy metals in a forested watershed near a lead smelter. Journal of Environmental Quality 6(4):331-338.

5. Kerin, Z. 1975. Relationship between lead content in the soil and in the plants contaminated by industrial emissions of lead aerosols. Pages 487-502. In: T. C. Hutchinson (Chief Ed.), International conference on heavy metals in the environment. Vol. II, Part 2. Symposium was held in Toronto, Ontario, Canada. October 27-31, 1975.

References for Section 4.2.6

1. Reference 2, Section 4.2.4.

References for Section 4.2.7

1. Illinois Pollution Control Board Rules and Regulations. Chapter 8. Noise regulations. Adopted July 26, 1973; effective August 9, 1973; revised September 4, 1975; amended May 12, 1977; Rule 301 amended July 7, 1977, Part III.

2. Unpublished data. Battelle's Columbus Laboratories, Columbus, Ohio. August 21-22, 1978.

References for Section 4.3

1. Garrels, R. M., and C. L. Christ. 1965. Solutions, minerals, and equilibria. Harper and Row, New York, New York.

5. RELATIONSHIP TO LAND USE PLANS, POLICIES, AND GOALS

5.1 LOCAL LAND USE PLANS, POLICIES, AND GOALS

Within a 5-mile radius of either the Paducah Gaseous Diffusion Plant or the Joppa Steam Electric Plant, no city, township, or county governmental agency has set up any effective up-to-date local land use plans, policies, or controls. In fact, most local residents and public officials do not favor establishing land use plans. Specific inherent reasons for such attitudes and the lack of land use planning in the region include the following interrelated factors:(1)*

- High unemployment and relatively low income exist in the region and there is a strong sentiment to encourage development; land use plans and controls are viewed as devices which inhibit development.

- The rural, predominantly agricultural setting, with a strong prevailing private land ownership ethic, provides an atmosphere not favorable to land use planning and controls.

- The need for land use planning and controls has not been clearly demonstrated since the population of the area is small and sparsely distributed; the land use conflicts that arise with larger, denser populations have not occurred.

- Because the area has a low potential for generating tax revenue and because the region needs adequate public services and facilities, neither citizens nor officials feel that the formulation or implementation of land use plans has high priority.

In Ballard and McCracken counties, Kentucky, Planning Commissions exist primarily to advise courts on subdivision regulations; there are no rural zoning ordinances. In Massac County, Illinois, there presently is no planning commission or zoning and subdivision regulations. A building code has recently been adopted in Massac County and building codes were required to be adopted by January 1, 1979, in Ballard and McCracken Counties under provisions of recent state legislation. Also, a Comprehensive Plan for Ballard County was completed in 1972; an existing Land-Use Map and Analysis, and a Land-Use Plan for McCracken County were completed in 1968.(2-5) However, these plans were never implemented and the land use data and projections contained within these documents are now out of date.

Most of the existing land use programs were established to satisfy a particular need at a given point in time as funds were available. However, this method of planning will not be able to serve the purpose in the future as it has in the past. With assistance from the regional

*See subsection 5.5 for Section 5 references.

planning agencies as discussed below, local units of government are becoming aware of the predicted location, type, intensity, and timing of growth in order to effectively plan for future growth. Efforts are now under way by communities to solicit grants for initiating new or updating existing comprehensive plans, zoning ordinances, subdivision regulations, etc.

Although almost no land use plans, policies, and controls exist at the local or county level in the study area, the two regional (multi-county) planning and A-95 review agencies for the three-county area have been responsible for establishing comprehensive land use planning programs in the study area. Specifically, the Purchase Area Development District, located in Mayfield, Kentucky, is the regional planning agency for Ballard, McCracken, and six other western Kentucky counties. Similarly, the Southern Five Regional Planning District and Development Commission, located in Anna, Illinois, is the regional planning agency for Massac and four other southern Illinois counties.

The Purchase Area Development District completed a land use policies study in August, 1977, to guide the local units of government and the regional planning agency in the preparation and development of planning programs to promote orderly land use development in the region.(6) A land use mapping inventory was subsequently completed in July, 1978, which provides graphic representation of the policies presented in the land use policies manual. This mapping inventory includes both existing proposed land uses in nine major categories: transportation, water resources, industrial development, flood plains, agriculture, silviculture, soils, urban centralization, and recreation.(7) In June, 1977, the Southern Five Regional Commission prepared a regional land use plan which summarizes natural features, area of environmental concern, physical restraints on development, land use, and socio-economic and other pertinent information for the region. The regional land use plan also establishes land use goals, objectives, policies, and plans of the agency.(1) Generally, these regional planning agencies seem to be providing leadership to the local government agencies to formulate land use policies and controls and conduct land use surveys. However, the authority of these two regional commissions is limited to recommending, but not implementing, land use plans, policies, and controls.

The general consensus of the existing land use plans and projections for the three-county area is that a slow-to-modest rate of economic and population growth will occur through 2000 with minor changes in existing land use plans.(1-11) In the study area some open space/agricultural lands will be developed; residential developments are also likely to occur along the major highways that traverse the area as people seek the amenities of living in a rural environment, especially if county subdivision and rural zoning ordinances and land use policies are not enacted and enforced. A 1973 Comprehensive Water and Sewer Plan includes the proposed construction of a rural sewerage system for an area within the study area just north of U.S. Route 60 near the Paducah Gaseous Diffusion Plant.(12) Additionally, some land may be set aside as park land and developed to provide additional recreational facilities. Nevertheless, agriculture, open space, and forest land most likely will continue as the dominant land-use patterns in the study area through the year 2000.(1,6,13)

5.2 STATE LAND USE PLANS, POLICIES, AND GOALS

The two major state agencies affecting land use plans and control in the three-county area are the Kentucky Department for Local Government and the Illinois Department of Local Government Affairs. These state agencies are responsible for administering most of the land use-related legislation passed by the General Assemblies of their respective states and are sources of planning grants to the regional and local agencies.

Several other Kentucky and Illinois state agencies which affect land use planning within the three-county study area are the Departments of Agriculture (county extension agents), Transportation (highways) and Natural Resources, and Environmental Protection and Conservation (fish and wildlife habitat, parks, conservation areas, 208 water quality planning, air and water quality management, etc.). Specifically, the Kentucky Department of Natural Resources and Environmental Protection leases 2,780 acres (1134 ha) of land located adjacent to the Paducah Gaseous Diffusion Plant from the U.S. Department of Energy for wildlife conservation purposes. The State of Illinois controls 2,091 acres (847 ha) in the Mermet Lake Conservation Area and Swamp Nature Preserve located about 3 miles (5 km) north of the Joppa Steam Electric plant. Also, Murray State University is establishing mechanisms and procedures for utilizing repetitive data obtained from the NASA Landsat program to provide physiographic land use data which can be incorporated into the Purchase Area Development District land use mapping and inventorying program.

5.3 FEDERAL LAND USE PLANS, POLICIES, AND GOALS

The primary locally administered federal agencies whose programs and activities influence land use programs in the study area are the Soil Conservation Service and the Agricultural Stabilization and Conservation Service. Additionally, the U.S. Department of Energy and the Tennessee Valley Authority are responsible for the Paducah Gaseous Diffusion Plant and the TVA Shawnee Power Plant properties, respectively.

The major federal programs conducted on a nationwide basis which are related to regional and local government land use plans, policies, and controls include the U.S. Environmental Protection Agency's 201 Waste Water Treatment Construction Grant Program, the 208 Area-wide Waste Management Planning Program and the 303e River Basin Planning Program, and the U.S. Department of Housing and Urban Development's 701 Comprehensive Planning Program. These federal programs provide funds for studies conducted on a local or regional basis. Other federal regulatory programs effect land use and development in flood plains and near airports

Other area-specific federal programs which may influence land use patterns in the vicinity of Paducah, Kentucky, include the completion of I-24 and Tennessee-Tombigbee projects and Tennessee Valley Authority corridor easements. The Tennessee-Tombigbee Waterway scheduled for completion in 1985 will provide a waterway from the Ohio River to the Gulf of Mexico at Mobile, Alabama. This Corps of Engineers project will most likely stimulate employment, population growth, and development in the Paducah vicinity and along the Tennessee and Ohio Rivers. Likewise, I-24, which is currently under construction, includes a new bridge across the Ohio River just west of Paducah and provides direct connection via a four-lane highway to Nashville, Tennessee; St. Louis, Missouri; and other midwestern cities. Also, the TVA is presently considering the Shawnee Steam Plant as one of the three possible sites for construction of a 200 MW fluidized bed combustion facility. If implemented, no additional land is likely to be required for the facility; however, regional growth would be stimulated.

5.4 PRIME AND UNIQUE FARMLANDS

During the last few years increasing attention has been given to the retention of important farmland, forestland, rangeland, and wetlands and the preservation of flood plain areas. Federal agencies, especially in the U.S. Department of Agriculture, have enacted policies designed to limit adverse environmental impacts of development and to find alternatives to the conversion of prime agricultural land.

Farmland is considered "prime" if it has "the best combination of physical and chemical characteristics" for producing crops. "Unique farmland" is land "used for the production of specific high-value food and fiber crops." USDA policies also provide for "additional farmland of statewide importance" to be defined based on criteria developed by state agencies. In some cases, localities may designate similar "farmland of local importance" even though the land may not be of national or state importance.(14)

Agriculture is the primary industry of the Paducah area. Agricultural policies seek to help guide development patterns in a manner consistent with important agricultural lands. To be effective, state and local governmental land use controls will be required. One such control already enacted is a 1974 provision to the Kentucky Revised Statutes (No. 132.45) which permits a lower tax assessment rate for property taxes of agricultural lands to aid in the protection of those lands from urban infringement.(11,13)

There is no unique farmland in McCracken County; however, there are 29,808 ha (73,600 acres) which have been classified as prime farmland(15). Some prime farmland which is based on soil type, occurs on the plant site and immediately to the east and west of the property. The soils classed as prime farmland include Calloway silt loam - CaA and CaB, Falaya - Collins silt loam - Fc, Grenada silt - GrB, and Vicksburg silt loam - Vb(16). The distributions

5.5 REFERENCES FOR SECTION 5

1. Southern Five Regional Planning District and Development Commission. June 1977. Regional land use plan. Anna, Illinois.

2. Purchase Area Development District. May 1977. Purchase area housing assistance plan. Mayfield, Kentucky.

3. Commonwealth of Kentucky. 1968. Existing land-use analysis, Paducah-McCracken County, Kentucky. Department of Commerce.

4. McCracken County Planning Commission. March 1969. McCracken county land-use plan. Paducah, Kentucky.

5. McCracken County, Kentucky Subdivision Regulations. 1967.

6. Purchase Area Development District. August 1966. Purchase area land use policies manual. Mayfield, Kentucky.

7. Purchase Area Development District. July 1978. Purchase area land use mapping inventory. Mayfield, Kentucky.

8. Commonwealth of Kentucky. 1976. The river basin water quality management plan for Kentucky (Ohio River and lower Cumberland River). Department for Natural Resources and Environmental Protection.

9. Bartholomew, H., and Associates. August 1973. Paducah urban area transportation study. Memphis, Tennessee.

10. Purchase Area Development District. June 1976. Purchase areawide land-use planning report. Mayfield, Kentucky.

11. Purchase Area Development District. June 1977. Purchase area integrated program design. Mayfield, Kentucky.

12. Community Programs Consultants. April 1973. A comprehensive plan for water and sewer development of the purchase area development district. Paducah, Kentucky.

13. Legislative Research Commission. December 1975. Final report on the Kentucky environmental and economic development policy project. Information Bulletin No. 111. Frankfort, Kentucky.

14. U.S. Department of Agriculture. 1976. Perspective on prime lands. Washington, D.C.

15. U. S. Department of Agriculture. 1978. Important farmlands, McCracken County Kentucky. Soil Conservation Service map.

16. Burkeen, J. O. 1981. U. S. Department of Agriculture, Soil Conservation Service, Paducah, Kentucky. Personal communication to Steve Pomeroy, Battelle, Columbus Laboratories, Columbus, Ohio, February 27, 1981.

6. ALTERNATIVES

Several major alternatives to continuing the operation of the Paducah Gaseous Diffusion Plant are given limited consideration below. A detailed analysis of alternatives is beyond the scope of this assessment. In addition, alternative power supply subsystems are briefly discussed.

6.1 SHUTDOWN OF PADUCAH GASEOUS DIFFUSION PLANT

The Paducah Gaseous Diffusion Plant provides fuel enriching services important to the operation of nuclear power reactors in the United States and abroad. If the Paducah Plant were to be shut down, it is doubtful the Department of Energy could fulfill its existing contractual agreements with corporations in the private sector or otherwise supply enrichment services to meet current demands. Some spare capacity exists or is under construction outside the U.S.; however, it is doubtful that the enrichment capacity of foreign entities would ever be commercially available in sufficient quantities to replace the capacity of the Paducah Plant.

6.2 USE OF ALTERNATIVE ENRICHMENT PROCESSES

A variation of the Gaseous Diffusion Plant shutdown alternative is the consideration of the major substitution of another enrichment technology. The two most likely alternative technologies are the gas centrifuge and the laser separation processes. The relative non-site-specific impacts of the diffusion versus the centrifuge process have been considered in detail in the Final Environmental statement, Expansion of U.S. Uranium Enrichment Capacity, ERDA-1543.(1)* The replacement of a portion of the existing diffusion enrichment capacity with centrifuge technology, possibly involving phase-out of older equipment or reduced power levels at Paducah, is a distinct possibility in view of DOE's Gas Centrifuge Enrichment Project currently under construction. However, based on current construction schedules and future enrichment services demand projections, no significant substitution of centrifuge capacity for active diffusion capacity is anticipated.

Laser isotope separation processes are still in experimental stages and the environmental issues that might be associated with a major production facility of this type cannot be defined at this time. Since a significant amount of research and development would have to precede any large-scale application of this technology, it cannot be reasonably considered as an alternative to the continued operation of the Paducah Gaseous Diffusion Plant.

---

* See subsection 6.5 for Section 6 references.

6.3 RELOCATION

The replacement of the Paducah enrichment capacity with additional gaseous diffusion capacity at another location, or the actual relocation of the existing plant and redirection of the necessary electrical power, would necessitate the development of a new enrichment site with the associated environmental and socioeconomic impacts. Depending on the location, new power production facilities might also be required (see Section 6.4). From the practical standpoint, there are very few conceivable environmental advantages to this alternative. It is completely impractical from the economic standpoint.

6.4 ALTERNATIVE SUBSYSTEMS

Alternative power supplies are given consideration relative to the Paducah Gaseous Diffusion Plant operations in the following subsections. Alternative waste heat dissipation and utilization systems, chemical treatment of RCW systems, biocidal treatment methods, and polychlorinated biphenyl alternative systems are evaluated relative to DOE's Portsmouth Gaseous Diffusion Plant in ERDA-1555, the Final Environmental Statement for that facility.(1) The evaluation and conclusions reached are also applicable to the Paducah site and will not be covered in this assessment. ERDA-1555 also gives consideration to several alternative waste handling and treatment subsystems relative to the Portsmouth operations that, although not directly applicable to Paducah's situation, are of similar concern. These topics include water supply, radioactive waste handling, dissolved solids in cooling water blowdown, and chemical waste disposal. DOE-ORO must continuously consider and periodically implement alternative subsystems to reduce or eliminate the adverse environmental impacts related to these and other operations at the Paducah Plant. These considerations relate to the broad spectrum of regulations in effect or being developed by U.S. EPA or the Commonwealth of Kentucky relative to the current environmental statutes including, but not limited to the following:

- Clean Air Act
- Clean Water Act
- Resource Conservation and Recovery Act
- Toxic Substances Control Act
- Federal Insecticide, Fungicide and Rodenticide Act
- Atomic Energy Act
- Kentucky Environmental Protection Law

A detailed discussion of a large number of alternative environmental control subsystems exceeds the scope of this environmental assessment. However, any evaluation of alternative subsystems would be covered by appropriate NEPA documentation.

6.4.1 Power alternatives

In this section, it is assumed the Paducah Gaseous Diffusion Plant will continue to operate, but sources of electric power other than those now used are considered. Power is presently supplied to Paducah from two sources. The larger of the two suppliers is the Tennessee Valley Authority, which contracts with DOE for large power allocations in essentially the same manner as with other industrial customers in the TVA service area. The other supplier is Electric Energy Incorporated (EEInc.), which has contractually dedicated 735 MWe of the 1050 MWe capacity of the Joppa Steam Electric Plant to the Paducah Gaseous Diffusion Plant. The balance of the Paducah Plant power load, which at full power will be 2305 MWe, is provided by TVA.

6.4.1.1 Power from a new dedicated plant

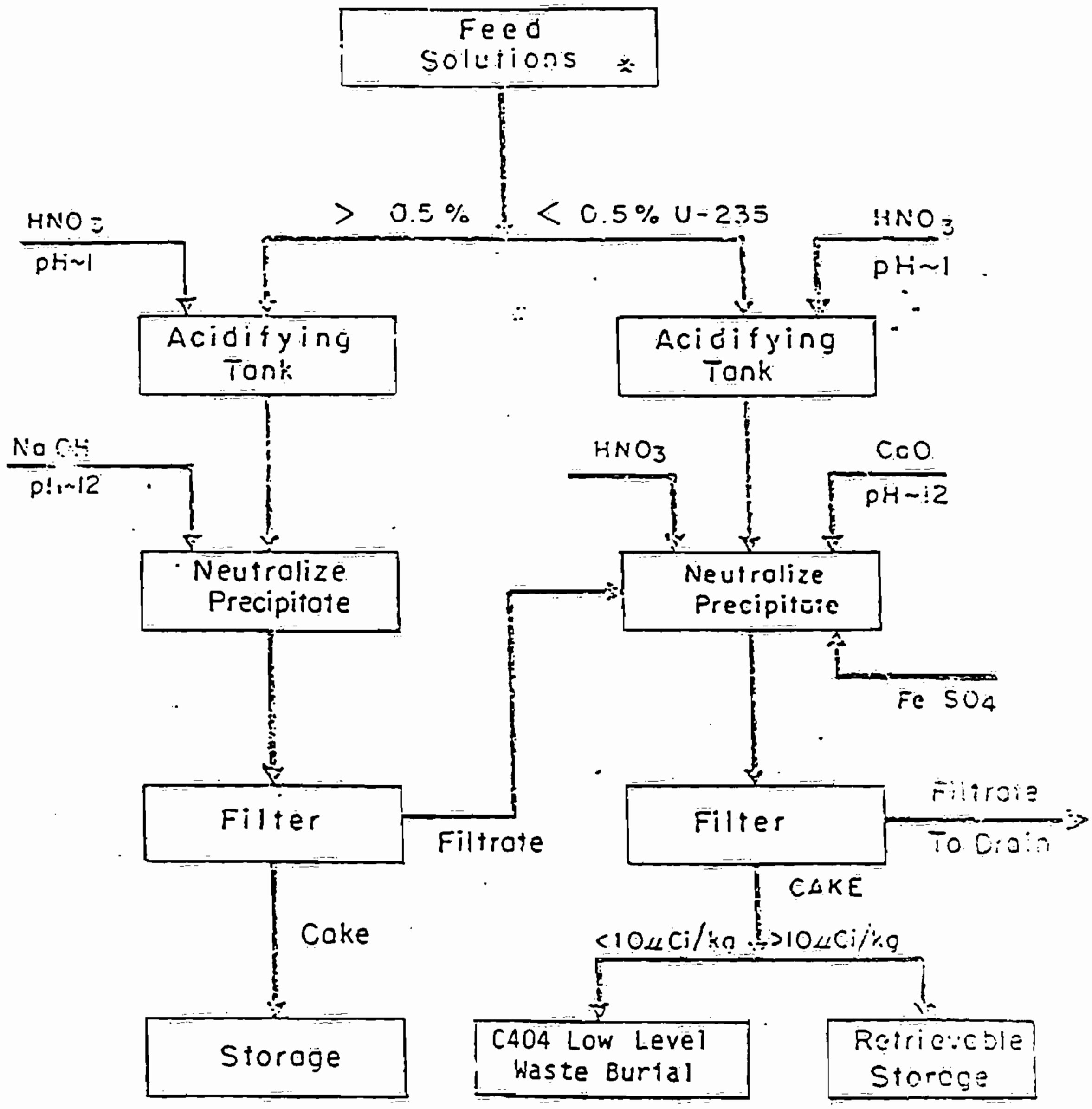
Assuming that the new dedicated facility would be located somewhere near the Paducah Plant, this alternative would involve all the environmental and socioeconomic impacts that might normally be associated with such a large power installation in the Ohio River Valley. New coal-fired steam electric generating capacity similar to that of the Joppa Station, extensively described in this assessment, would be expected to have similar environmental effects.

A dedicated plant would have to be large enough to have a reserve capacity of approximately 35% of the peak Paducah plant demand, or a total capacity of about 4104 MWe. For purposes of operational stability, it would probably still be necessary to interconnect this power supply with either the TVA or the EEInc. system (or both) so that (1) power could be reliably obtained externally in an emergency, and (2) excess power, when available, could be transferred to the utility distribution systems.

Since TVA's Shawnee Power Plant (1700 MWe) is located just north of the Paducah Plant and the Joppa Plant is in the immediate vicinity of the plant on the opposite side of the river (1050 MWe), the consideration of this power alternative is essentially analogous to the existing power supply situation. A new, dedicated power plant in the vicinity of the Paducah Gaseous Diffusion Plant would adversely affect the balance and efficiency of the existing systems and the duplication of facilities would create a situation of less than optimum utilization of the power production and transmission facilities that have already been provided for the demand of the Paducah facility.

APPENDIX A

PGDP SYSTEMS FLOW DIAGRAMS AND WASTE MATERIALS INFORMATION



*Feed Solution

1. Decontamination Solutions - Cascade & Feed Plant Equipment
2. Hand Table Solutions
3. Cylinder Washings

Figure A-1. C-400 decontamination solution-precipitation flow diagram.

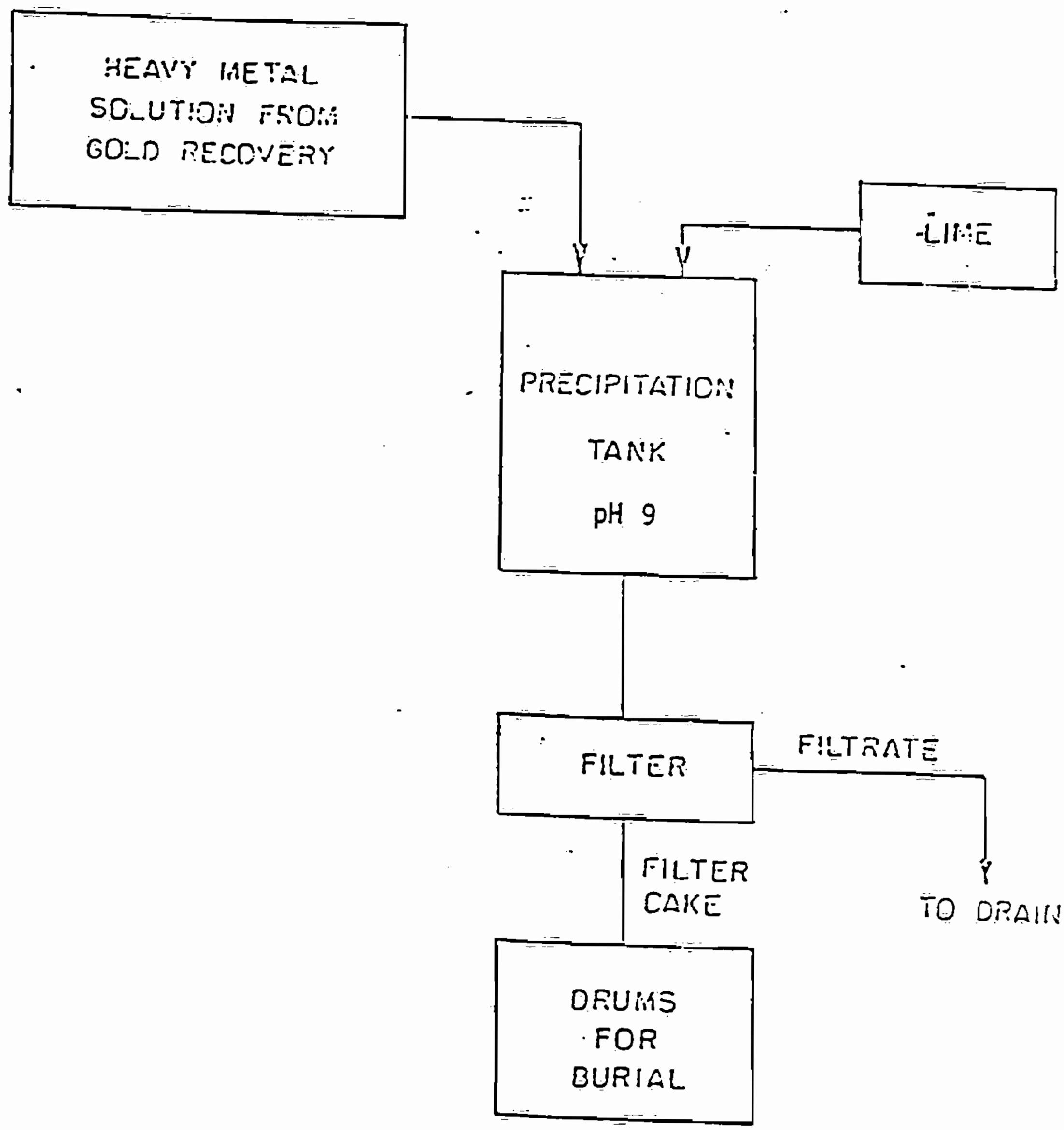


Figure A-2. Heavy metal removal from gold recovery operations.

Table A-1. Lab analysis of spent nickel stripper solution

Element	mg/l
Ag	15
Al	30
Cu	100
Fe	15
Mg	60
Na	600
Ni	2,000
P	60
Pb	200
Si	50
Sn	30
U	100
Zn	200

Table A-2. Major wastes generated by maintenance facilities, C-720

TYPE OF OPERATION		QUANTITY	PERMANENT DISPOSAL SITE
Instrument Shop	Oil	200 l/yr	Garage for transfer
Instrument Shop	Trichloroethane	200 l/yr	Oil disposal plot
Instrument Shop	Chromic Acid	12 l/yr	Drain
Instrument Shop	Isopropyl Alcohol	20 l/yr	Drain
Instrument Shop	Acetone	20 l/yr	Drain
Instrument Shop	Scrap Metal	600 kg/yr	Scrap Yard
Instrument Shop	Mercury	20 kg/yr	Oak Ridge for reprocessing
Machine Shop	Soluble Machine Oil	27070 l/yr	Oil disposal plot
Machine Shop	Machine oil	2500 l/yr	Garage for transfer
Machine Shop	Solvent, Trichloroethane	200 l/yr	Oil disposal plot
Machine Shop	Steel Shavings	98450 kg/yr	Burial Hole A
Electrical Shop	Bearing Oil	600 l/yr	Garage for transfer
Electrical Shop	Trichloroethylene Sludge	800 l/yr	Oil disposal plot
Electrical Shop	Copper	250 l/yr	Scrap Yard
Electrical Shop	Metals	10 Dumpsters/yr	Scrap Yard
Pump Shop	Trichloroethane	2500 l/yr	Oil disposal plot
Sheet Metal Shop	Metal	12000 kg/yr	Clean Scrap Yard
Weld Shop	Converter Shells		Contaminated Scrap Yard
Weld Shop	Lube Oil	2500 l/yr	Garage for transfer

Table A-3. Laboratory effluents from C-710

Chemical	Quantity Discharged Per Year (liters)
Various Acids	270
Strong Bases	500
Alcohols	9
Toluene	5
Freon	200
Acetone	200
Methanol	3
Hexane	3
Lube Oil (Dissolved in Toluene-Isopropyl alcohol mixture)	5
Silver Nitrate	990
Barium Chloride	296
Nickel (In nitric acid)	990
Copper (In nitric acid)	49
Potassium Permanganate	49
Potassium Carbonate (kg)	10
Aluminum Nitrate	10,000
Sodium Nitrate	15,000
Sodium Acetate	39,500
Sodium Chloride	25,000
Sodium Fluoride	990
UO_2F_2, HF(1% HF, U(4000 ppm))*	2000

*Taken to C-400 for recovery.

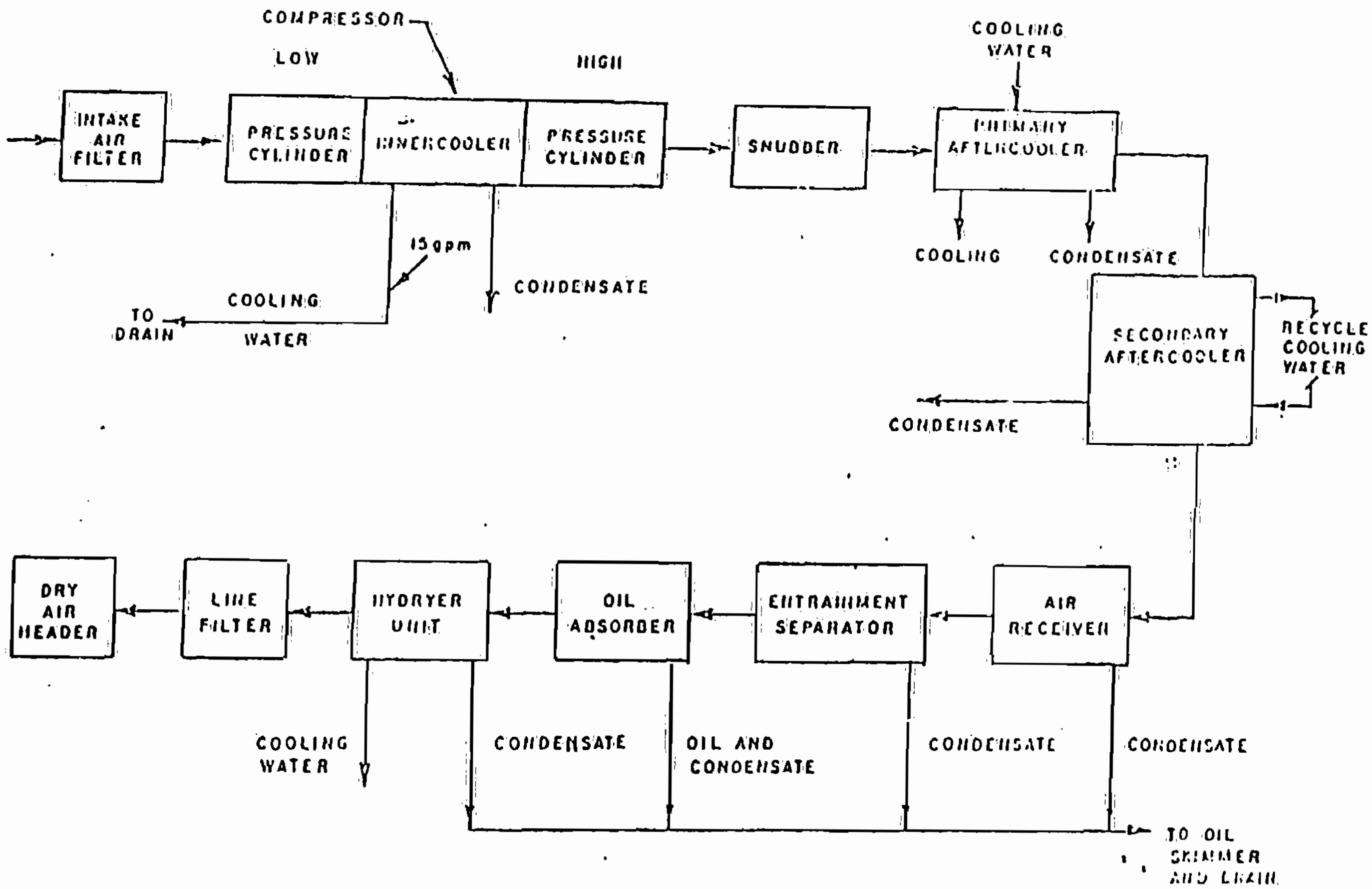


Figure A-3. Typical air plant flow diagram.

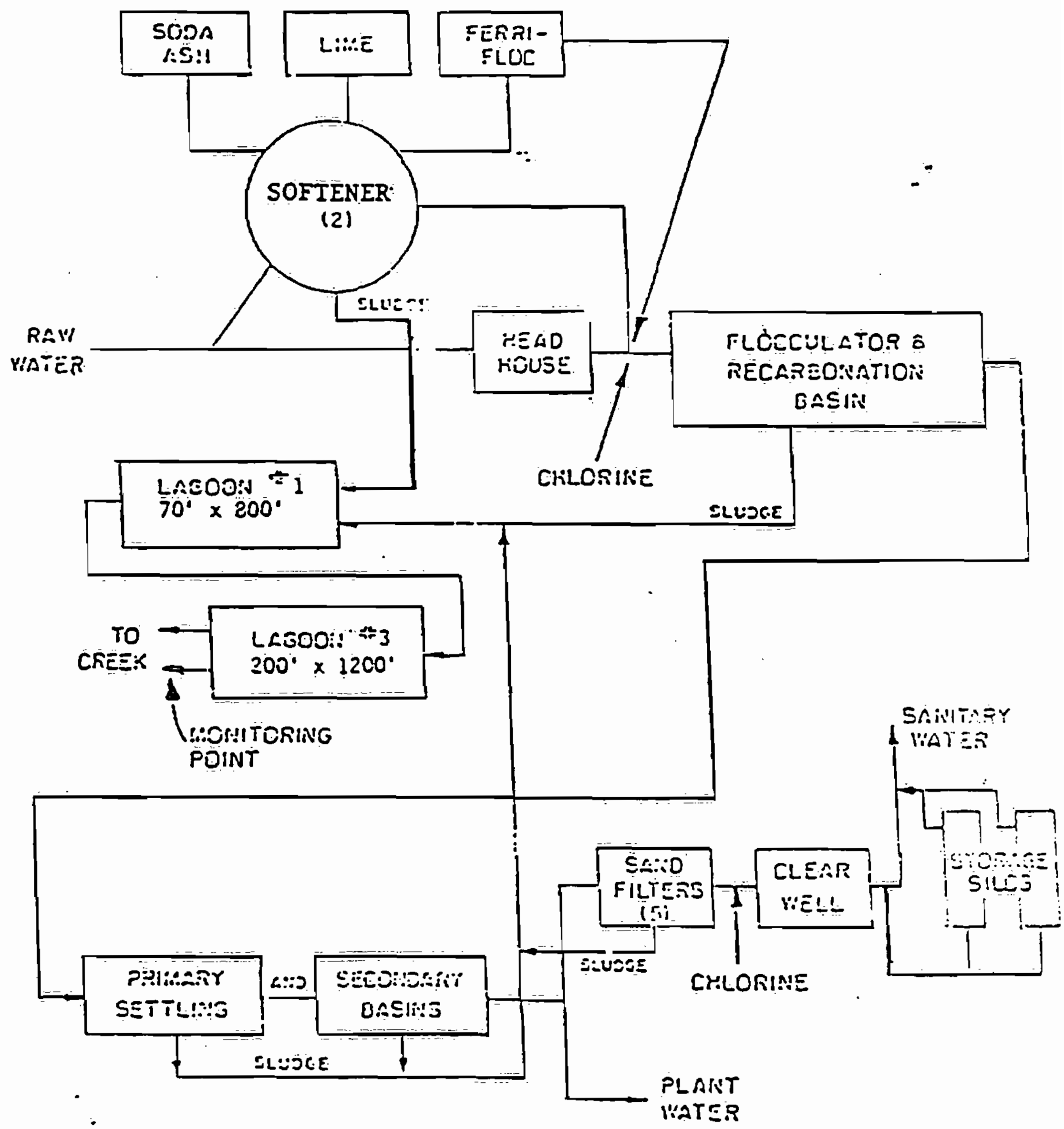


Figure A-4. C-611 water treatment plant.

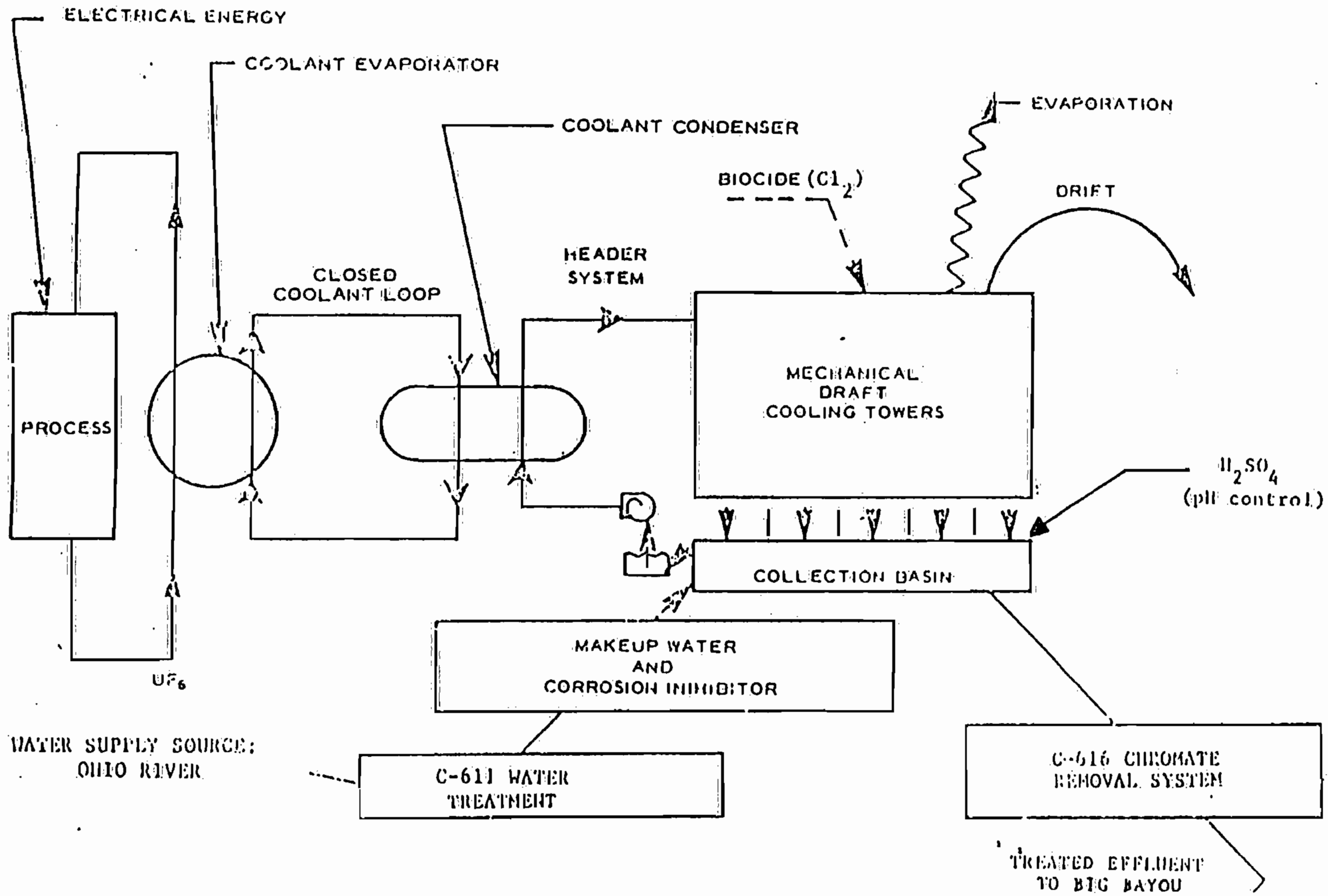


Figure A-5. Waste heat removal system.

Table A-4. Recirculating water chemical feeds.

Chemical Feeds		Total (per month)	Average (per/day)
OROCOL-GDP	(lbs)	7,100	229
Sulfuric acid	(gals)	1,197	39
Chlorine	(lbs)	16,000	516
Betz F-16[(a)]	(gals)	430	14

(a) Not a chemical feed.

Wood is treated during summer months only; F-16 is not added to water.

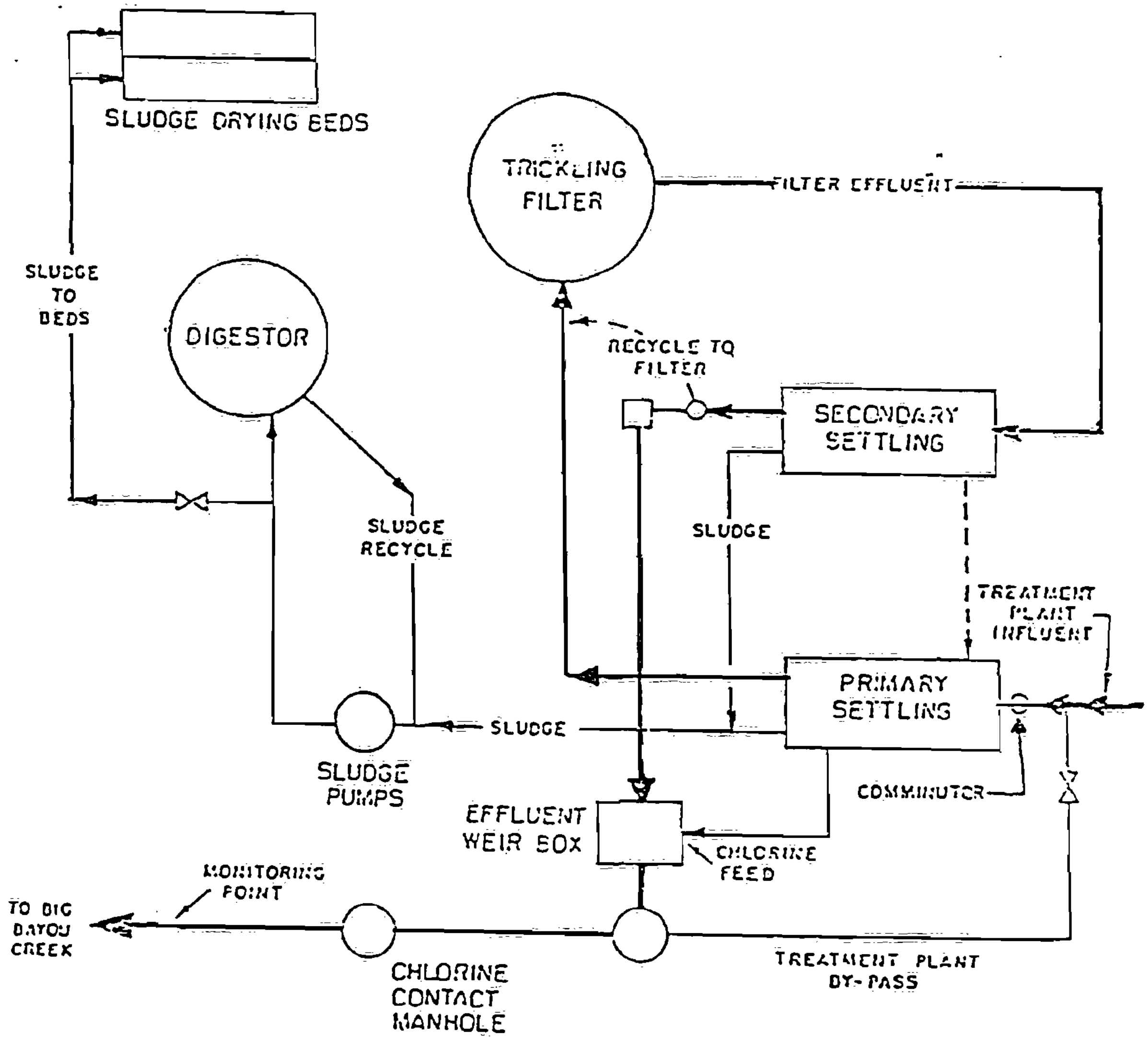


Figure A-6. Flow diagram of C-615 sewage treatment plant.

Table A-5. Effluent ditch average flow rates

Ditch	Flow(mgd)	Ditch	Flow(mgd)
2	0.1	6	0.1
3	0.1	7	1.0
4	0.1	8	1.0
5	0.1	9	1.5
		C-615	0.5

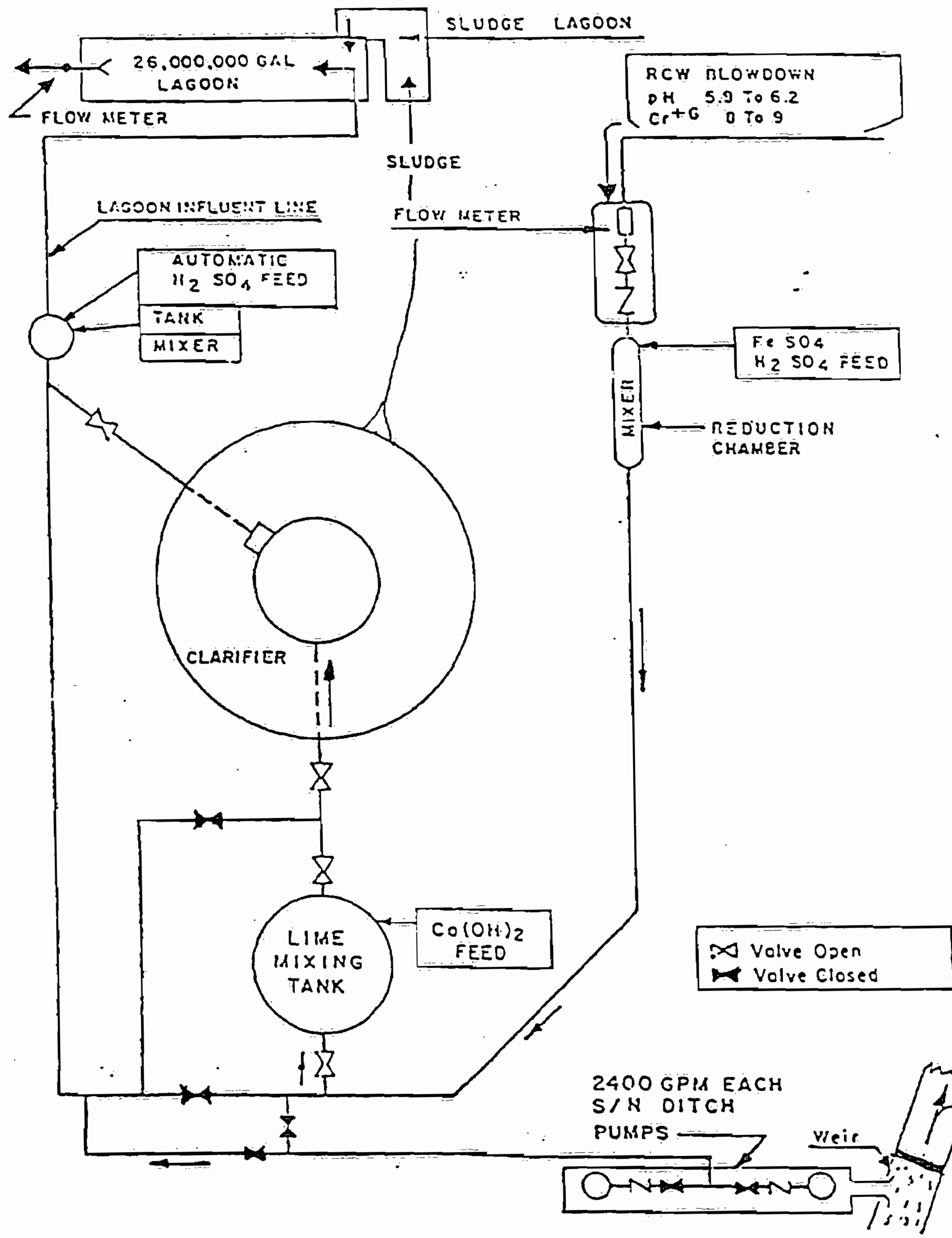


Figure A-7. Flow diagram of C-616 recirculating water system.

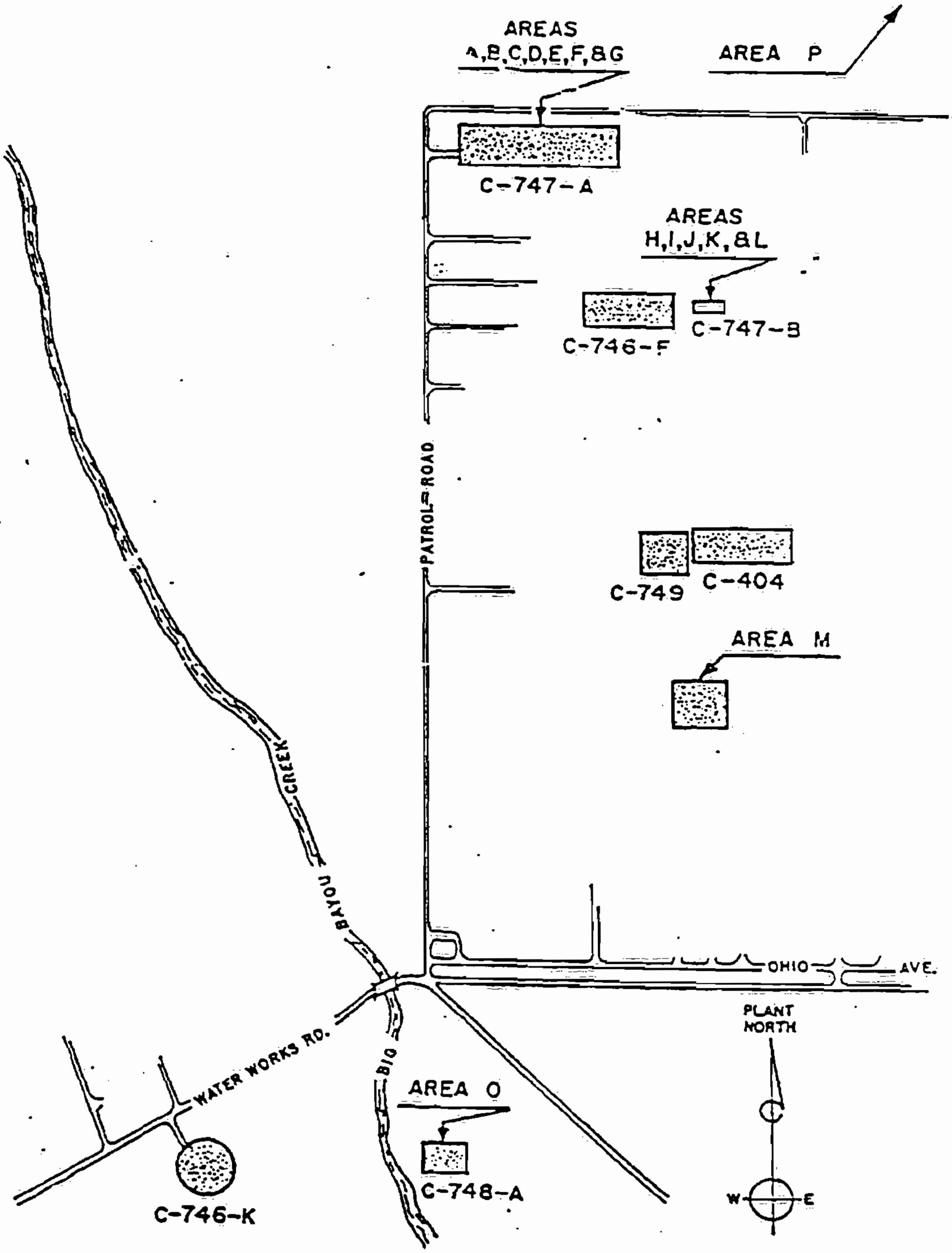


Figure A-8. Locations of PGDP waste burial sites.

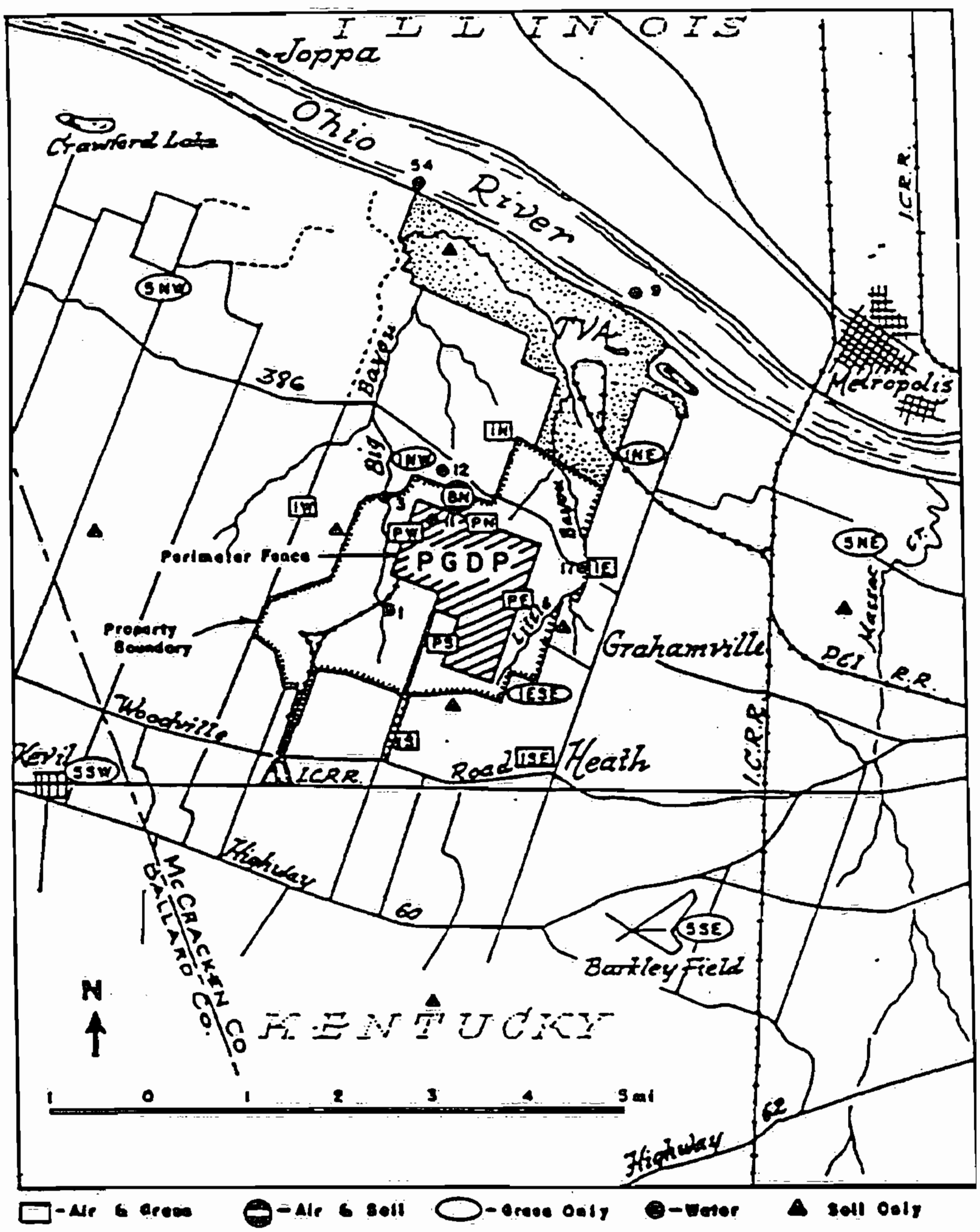


Figure A-9. Locations of sampling points.

APPENDIX B

SUPPORTIVE DATA FOR THE CHARACTERIZATION OF EXISTING ENVIRONMENTS AT THE PADUCAH GASEOUS DIFFUSION PLANT AND JOPPA STEAM ELECTRIC PLANT

Table B-1. Stream discharge data from the Ohio River at Metropolis, Illinois[a]

(Drainage Area 203,000 sq. mi.)

	WY 1971[b] (1000 cfs)[c]			WY 1975[b] (1000 cfs)[c]			WY 1976[b] (1000 cfs)[c]		
	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min
Oct.	116.4	173	63.2	138	195	94.1	278	524	121
Nov.	209.8	250	149	206	301	111	214.4	367	134
Dec.	266.7	523	129	364	508	264	310.2	464	226
Jan.	351.9	489	285	596	739	506	532.1	756	287
Feb.	514.1	794	233	665	759	526	520.6	800	267
Mar.	549.5	795	289	929	1160	625	434.5	757	290
Apr.	185.1	281	99.5	710	1180	291	250.3	517	98.3
May	321	577	134	461	711	240	126.4	204	77.7
June	154	201	96.6	231	287	134	192.3	274	94.5
July	133.9	199	77.9	134	177	91.2	191.9	239	136
Aug.	162.6	267	87.3	120	179	81.2	122.5	177	72.5
Sept.	148.4	231	89	176	355	110	87.95	168	61.7
WY[b]	258.3	795	63.2	393	1180	81.2	271.3	800	61.7

(a) Water Resources Data for Kentucky, issued annually by U.S. Geological Survey Station No. 03611500 at river mile 944.1.

(b) WY = water year.

(c) cfs = cubic feet/second; 1 cubic foot = 7.48 gallons = 0.02832 cubic meters.

Table B-2. Estimated mean daily discharge of Big and Little Bayou creeks for each month of water-years 1972 through 1976[a]

	Units	Big Bayou Creek Water Year 1972	1973	1974	1975	1976	Mean	Little Bayou Creek Water Year 1972	1973	1974	1975	1976	Mean
Oct.	cfs[d]	.4	16	.6	1	2	4	.2	7	.3	.7	1	2
Nov.	cfs	.6	42	46	3	23	23	.3	19	21	1	11	11
Dec.	cfs	11	77	55	12	43	39	5	35	25	5	20	18
Jan.	cfs	23	45	61	24	28	36	10	21	28	11	13	17
Feb.	cfs	69	28	18	73	67	51	32	13	8	33	31	23
Mar.	cfs	43	69	21	131	39	61	20	32	10	60	18	28
Apr.	cfs	35	154	31	31	4	55	25	70	14	14	2	25
May	cfs	6	64	3	12	6	18	3	29	1	6	3	8
June	cfs	.4	2	8	43	31	17	.2	.9	4	20	14	8
July	cfs	41	.9	.6	35	34	22	19	.4	.3	16	16	10
Aug.	cfs	5	.6	4	3	.6	3	2	.3	2	2	.3	1
Sept.	cfs	5	.4	1	4	.4	2	2	.2	.5	2	.2	1
Mean	cfs	21	42	21	31	23	28	10	19	9	14	11	14
Discharge	inches	15.7	30.4	15.8	22.6	16.9	20.1	Same as Big Bayou Creek					
Precipitation[b]	inches	63	54.2	56.4	49.3	---	55.7[c]	Same as Big Bayou Creek					
Discharge	% of Precip.	25	56	28	46	---	38[c]	Same as Big Bayou Creek					

(a) Discharge computed from data on Middle Fork of Massac Creek, U.S. Geological Survey station 03611260, Water Resources Data for Kentucky, issued annually by the U.S. Geological Survey.

(b) Precipitation data from Climatological Data, annual summaries for Kentucky issued by U.S. Department of Commerce, National Oceanic and Atmospheric Administration.

(c) Water years 1972 through 1975.

(d) cfs = cubic feet/second; 1 cubic foot = 7.48 gallons = 0.02832 cubic meters.

TABLE B-3. NATIONAL AMBIENT AIR QUALITY STANDARD (NAAQS)
(Concentrations in μg/m³)

POLLUTANT	DURATION	RESTRICTION	U.S. EPA AIR QUALITY STANDARDS Primary	Secondary
Suspended Particulates	Annual Mean (G)	Not to be exceeded	75	60
"	24-hour concentration	Not to be exceeded more than once per year	260	150
Sulfur Dioxide	Annual Mean (A)	Not to be exceeded	80 (.03)	--
"	24-hour concentration	Not to be exceeded more than once per year	365 (.14)	--
"	3-hour concentration	"	--	1,300 (.50)
Carbon	8-hour mean (A) concentration	Not to be exceeded more than 1 eight hour period per year	10* (9.0)	10* (9.0)
"	1-hour mean (A) concentration	Not to be exceeded more than once per year	40* (35.0)	40* (35.0)
Photochemical Oxidants	1-hour mean (A) concentration	Not to be exceeded	160* (.08)	160 (.08)
"	4-hour mean (A) concentration	Not to be exceeded more than 1 consecutive 4-hour period per year	--	--
"	24-hour mean (A) concentration	Not to be exceeded more than 1 day per year	--	--
Non-methane Hydrocarbons	3-hour mean (A) concentration	Not to be exceeded between 6 AM and 9 AM	160 (.24)	160 (.24)
"	24-hour mean (A) concentration	Not to be exceeded more than 1 day per year	--	--
Nitrogen Dioxide	Annual mean (A)	Not to be exceeded	100 (.05)	100 (.05)

(A) Arithmetic (G) Geometric
* Only standard expressed in milligrams per cubic meter
** Values in parentheses are equivalent values in parts per million

Primary Standard - For Protection of Public Health
Secondary Standard - For Protection of Public Welfare

TABLE B-4. TOTAL SUSPENDED PARTICULATES DATA SUMMARY McCRACKEN COUNTY 1976-1977

Monitoring Site and Address	Measurement Method	No. Observations 1976	No. Observations 1977	Times >260/Times >150 1976	Times >260/Times >150 1977	Annual Geometric Mean (ug/m^3) 1976	Annual Geometric Mean (ug/m^3) 1977
1. Paducah (1400 Thompson)	Hi-Vol Sampler	59	51	1/1	0.3	53	58
2. Paducah (2400 Washington)	Hi-Vol Sampler	62	52	0/2	0/0	*69	*63
3. Paducah (U.S. 45 at Lone Oak)	Hi-Vol Sampler	59	51	0/2	0/2	*78	*80
4. Paducah (U.S. 62 at Community College)	Hi-Vol Sampler	60	49	0/3	0/2	46	48
5. McCracken County (Wildlife Game Reserve)	Hi-Vol Sampler	56	51	0/1	0/2	57	49
6. Paducah (1609 Ky Ave)	Hi-Vol Sampler	60	52	0/0	0/0	*61	*68
7. Paducah (1350 S. 6th St.)	Hi-Vol Sampler	59	55	0/0	0/2	55	57
8. McCracken County (Graham Rd. at Heath)	Hi-Vol Sampler	61	57	0/2	0/1	50	52

*Represents a violation of the annual primary or secondary particulate standards.

Table B-5. Sulfur dioxide data summary, McCracken County, 1976-1977

Monitoring Site and Address	Measurement Method	No. Observations 1976	No. Observations 1977	24-Hour 2nd-High Maximum 1976	24-Hour 2nd-High Maximum 1977	3-Hour 2nd-High Maximum 1976	3-Hour 2nd-High Maximum 1977	Annual Mean (ug/m^3) 1976	Annual Mean (ug/m^3) 1977
1. Paducah (1400 Thompson)	24-Hour Bubbler	57	48	187.6	72.5	--	--	29.2	15.3
2. Paducah (2400 Washington)	24-Hour Bubbler	59	54	78.6	81.9	--	--	14.3	13.5
3. Paducah (U.S. 45 at Lone Oak)	24-Hour Bubbler	56	50	107.0	89.6	--	--	20.2	15.4
4. Paducah (U.S. 62 at Community College)	24-Hour Bubbler	59	47	144.7	85.0	--	--	31.2	15.4
5. McCracken County (Wildlife Game Reserve)	Continuous	2,670	6,831	248.9	290.8	856.7	1,129.2	43.2	29.7
	24-Hour Bubbler	58	--	212.6	--	--	--	49.3	--
6. Paducah (1609 Ky Ave)	Continuous	7,716	7,950	191.3	146.7	437.5	560.7	32.7	38.3
	24-Hour Bubbler	59	--	160.1	--	--	--	28.6	--
7. Paducah (1350 S. 6th St)	3-Hour Bubbler	380	449	220.1	62.9	851.5	264.6	30.3	12.9
	24-Hour Bubbler	56	--	135.1	--	--	--	26.1	--
8. McCracken County (Graham Rd. at Heath)	Continuous	7,225	6,048	335.4	332.7	885.6	851.5	39.7	28.4

Table B-6. Annual averages of SO_2 and TSP

(TVA monitoring sites-Shawnee Power Plant)

Year	1975		1976		1977	
Site No.	SO_2 (ppm)	TSP ($\mu g/m^3$)	SO_2 (ppm)	TSP ($\mu g/m^3$)	SO_2 (ppm)	TSP ($\mu g/m^3$)
1	.013		.016		.007	
2	.012		.011		.006	
3	.013	48	.015	49	.010	49
4	.009	44	.012	49	.007	51
5	.019	47	.024	49	.010	51
6	.009	54	.011	60	.009	60
7	.007		.008		.005	
8	.009		.012		.006	
9	.009		.012		.006	
10	.012		.013		.008	
11	.012		.011		.009	
12			.013		.007	
13			.014		.009	
14			.024		.010	

Table B-7. Maximum 2nd-high, 24-hour and 3-hour SO_2 concentrations

(TVA monitoring sites-Shawnee Power Plant)

Year / Site No.	1976 24-Hour (ppm)	1976 3-Hour (ppm)	1977 24-Hour (ppm)	1977 3-Hour (ppm)
1	0.18*	0.60*	0.08	0.27
2	0.13	0.65*	0.08	0.34
3	0.22*	0.64*	0.12	0.61*
4	0.15*	0.45	0.08	0.43
5	0.37*	0.87*	0.20*	0.61*
6	0.11	0.52*	0.11	0.48
7	0.08	0.45	0.09	0.44
8	0.17*	0.57*	0.10	0.35
9	0.14	0.45	0.09	0.29
10	0.11	0.57*	0.09	0.47
11	0.11	0.44	0.09	0.47
12	0.10	0.38	0.06	0.35
13	0.11	0.47	0.12	0.51*
14	0.26*	0.64*	0.11	0.50

*Represents a violation of a SO_2 National Ambient Air Quality Standards.

TABLE B-8. Kentucky NO_2 monitoring data for McCracken County (1977)

Monitoring Site	No. of Observations	Arithmetic Mean
Paducah-1400 Thompson	46	30.4
Paducah-2400 Washington	56	41.2
Paducah-U.S. 45 & Lone Oak	52	47.7
Paducah-1350 S. 6th St.	53	30.8
Paducah-U.S. 62 Community College	49	22.4
McCracken County Wildlife Game Reserve	49	11.8
Paducah-609 Kentucky Ave.	50	45.3

TABLE B-9. Discharges of radioactivity to the atmosphere (1979)

RADIONUCLIDE	CURIES DISCHARGED
URANIUM[a]	0.02
^{99}Tc	0.06

[a] Uranium discharges had an average isotopic composition of 0.003% ^{234}U, 0.49% ^{235}U, and 99.5% ^{238}U.

TABLE B-10. ENVIRONMENTAL AIR SAMPLING - ALPHA RADIOACTIVITY (1979)

SAMPLE POINT[a]	NUMBER OF SAMPLES	CONCENTRATION (10^{-14} μCi/ml)				%
		MINIMUM	MAXIMUM	AVERAGE	STD.[b]	STD.
PN	52	0.14	66	<2.7 ± 2.5	c	
PE	52	<0.14	19	<1.4 ± 0.8	c	
PS	51	<0.14	3	<0.4 ± 0.2	c	
PW	51	<0.14	3	<0.5 ± 0.2	c	
BN	52	<0.14	8	<0.9 ± 0.4	400	<0.2
BE	48	<0.14	13	<0.9 ± 0.6	400	<0.2
IN	52	<0.14	6	<0.4 ± 0.3	400	<0.1
IE	49	<0.14	9	<0.4 ± 0.4	400	<0.1
ISE	51	<0.14	5	<0.4 ± 0.3	400	<0.1
IS	50	<0.14	11	<0.4 ± 0.4	400	<0.1
IW	46	<0.18	10	<0.9 ± 0.4	400	<0.2
GR	51	<0.14	8	<0.4 ± 0.3	400	<0.1

[a]See Figure A-9.
[b]DOE Concentration Guide (4 x 10^{-12} μCi/ml for a mixture of uranium isotopes).
[c]Sampling locations are on Government property inside the plant perimeter fence. For comparison, the DOE weighted average occupational concentration guide is 3 x 10^{-10} μCi/ml for a mixture of uranium isotopes.
NOTE: Lower limit of detection is 0.3 dpm or 1.4 x 10^{-15} μCi/ml for an 86 cubic meter sample.

TABLE B-11. ENVIRONMENTAL AIR SAMPLING - BETA RADIOACTIVITY (1979)

SAMPLE POINT[a]	NUMBER OF SAMPLES	CONCENTRATION (10^{-13} μCi/ml)				% STD.
		MINIMUM	MAXIMUM	AVERAGE	STD.[b]	
PN	52	<0.05	10	<1.9 ± 0.5	c	
PE	52	<0.05	4	<1.5 ± 0.3	c	
PS	51	<0.05	5	<1.5 ± 0.3	c	
PW	51	<0.05	3	<1.5 ± 0.3	c	
BN	52	<0.05	4	<1.6 ± 0.3	10,000	<0.02
BE	40	<0.05	9	<1.5 ± 0.4	10,000	<0.02
FN	52	<0.05	4	<1.4 ± 0.3	10,000	<0.01
FE	49	<0.05	4	<1.4 ± 0.3	10,000	<0.01
FSE	51	<0.05	5	<1.6 ± 0.3	10,000	<0.02
FS	50	<0.05	4	<1.5 ± 0.3	10,000	<0.02
FW	46	<0.05	4	<1.5 ± 0.3	10,000	<0.02
GR	51	<0.05	70	<3.5 ± 2.7	10,000	<0.04

[a]See Figure A-9.
[b]As ^{234}Th (DOE Manual Appendix 0524 Annex A, Table 2).
[c]Sampling locations are on Government property inside plant perimeter fence. For comparison, the DOE occupational concentration guide is 3×10^{-8} μCi/ml.
NOTE: Lower limit of detection is 1 dpm per sample or 5×10^{-15} μCi/ml.

TABLE B-13. ENVIRONMENTAL AIR SAMPLING - FLUORIDES (1979)

SAMPLE POINT[a]	NUMBER OF SAMPLES	CONCENTRATION (ppb, HF)				% STD.
		MINIMUM	MAXIMUM	AVERAGE	STD.[b]	
PN	52	0.1	1.1	0.3 ± 0.04	c	
PE	52	<0.08	0.7	<0.3 ± 0.04	c	
PS	51	<0.07	0.2	<0.2 ± 0.01	c	
PW	51	<0.08	0.5	<0.2 ± 0.02	c	
DN	52	<0.07	0.3	<0.2 ± 0.02	0.6	<33
DE	48	<0.06	0.6	<0.2 ± 0.02	0.6	<33
IN	52	<0.07	0.3	<0.2 ± 0.01	0.6	<33
IE	49	<0.07	0.4	<0.1 ± 0.01	0.6	<17
ISE	51	<0.07	0.2	<0.1 ± 0.01	0.6	<17
IS	50	<0.08	0.2	<0.2 ± 0.01	0.6	<33
IW	46	<0.08	0.2	<0.2 ± 0.04	0.6	<33
GR	51	<0.07	0.5	<0.2 ± 0.02	0.6	<33

[a] See Figure A-9.
[b] Kentucky Secondary Ambient Air Quality Standards (401 KAR 53:010): Maximum one week average 1.0 ppb as HF; monthly average 0.5 ppb as HF. Primary ambient standard (annual average) is 500 ppb as HF.
[c] Sampling locations are on Government property inside the plant perimeter fence. For comparisons, the 40-hour occupational threshold limit value (TLV) for HF is 3000 ppb.
NOTE: Lower limit of detection is 5.0 μg HF per sample.

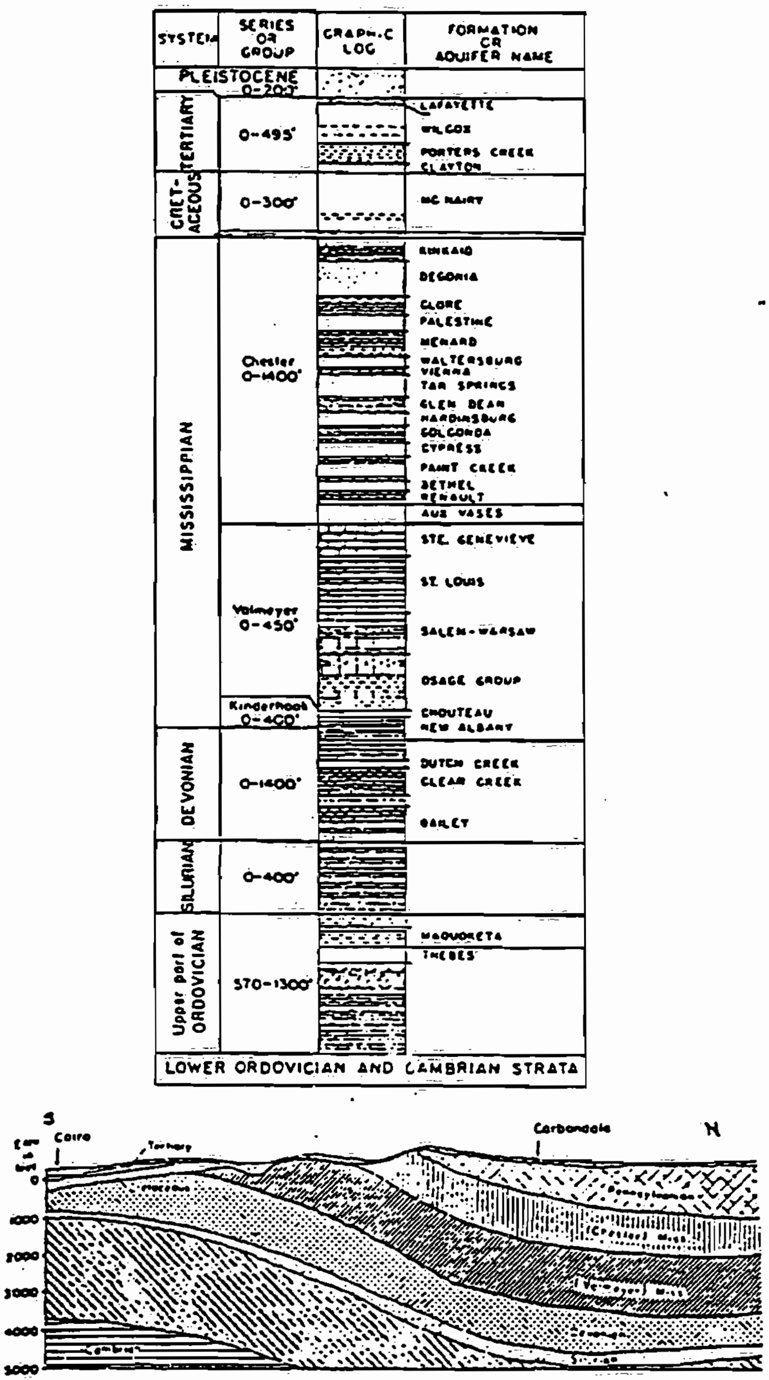


Figure B-1. Geologic strata underlying Massac County.

Table B-13. Groundwater supply, Massac County, Illinois

Location	Type of Aquifer (a)	Total Depth Feet	Yield gpm	Specific Capacity, gpm/ft drawdown	Average Daily Pumpage, 1000 gal
Electric Energy Inc. Pl. No. 3	R	403	320	107	300
Electric Energy Inc. Pl. No. 1	R	235	305	102	300
C. & E. I. School	U	95	4	1	1
Indiana Tie Co.	R	465	160	160	
Joppa	R	448	90	2	50
West Ind. Gravel Co.	U	420	1000		
Metropolis No. 4	R	400	293	5	500
Metropolis No. 1	U	270	600	30	500
Metropolis No. 2	U	420	1500		
Metropolis No. 3	U	286			
Brookport (west)	U	208	100		129
Brookport (east)	U	207	50		

(a) R = rock, U = unconsolidated

APPENDIX C

POPULATION AND DENSITY CHANGES BY SECTOR FOR 5-MILE AND 50-MILE RADII, 1980-2020

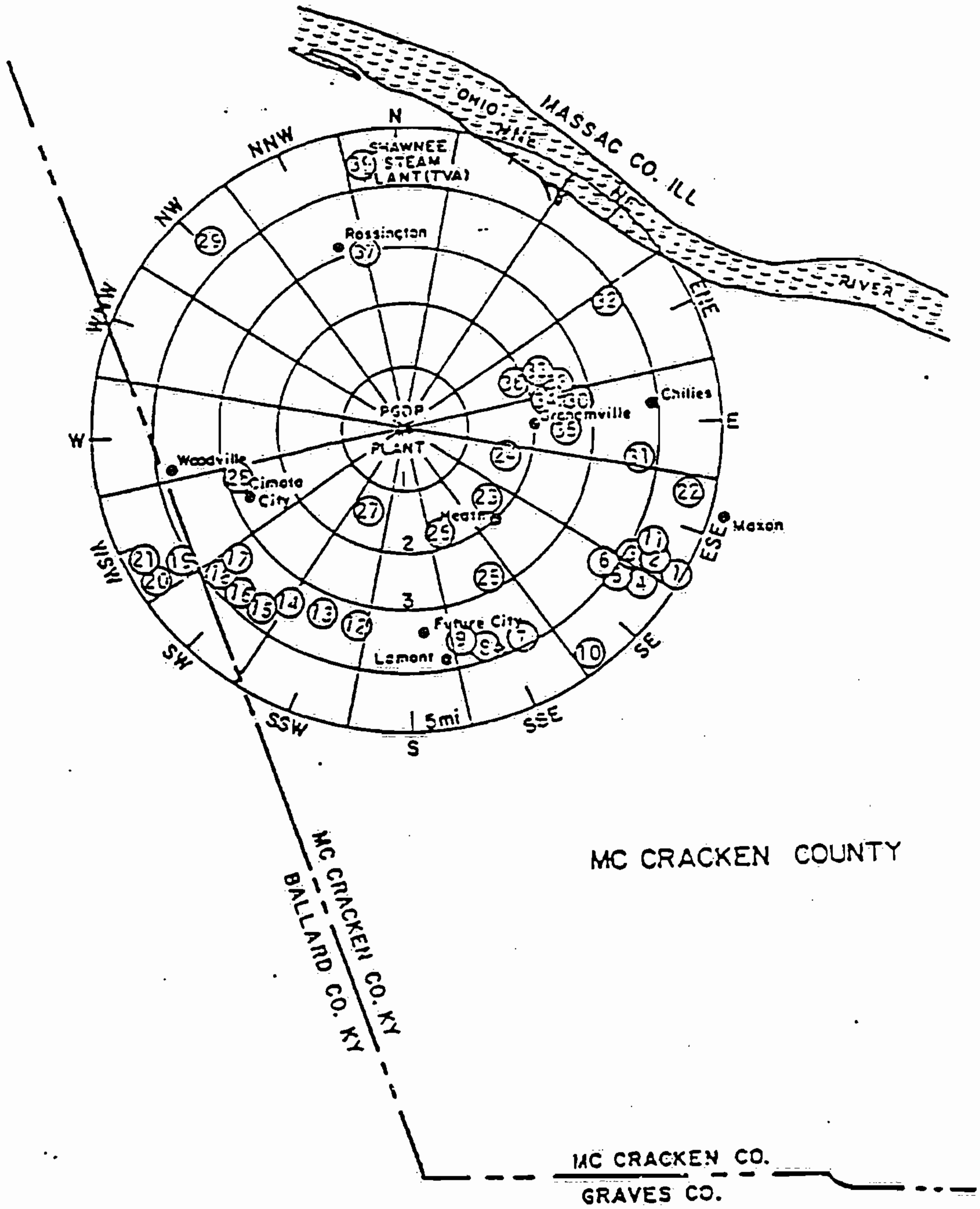


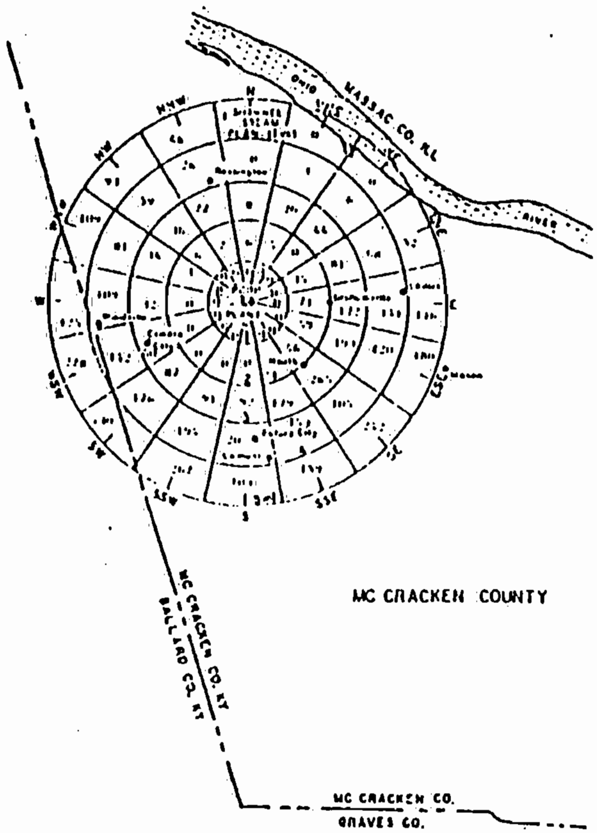
Figure C-1. Transient population nodes within 5 miles of PGDP.

APPENDIX D

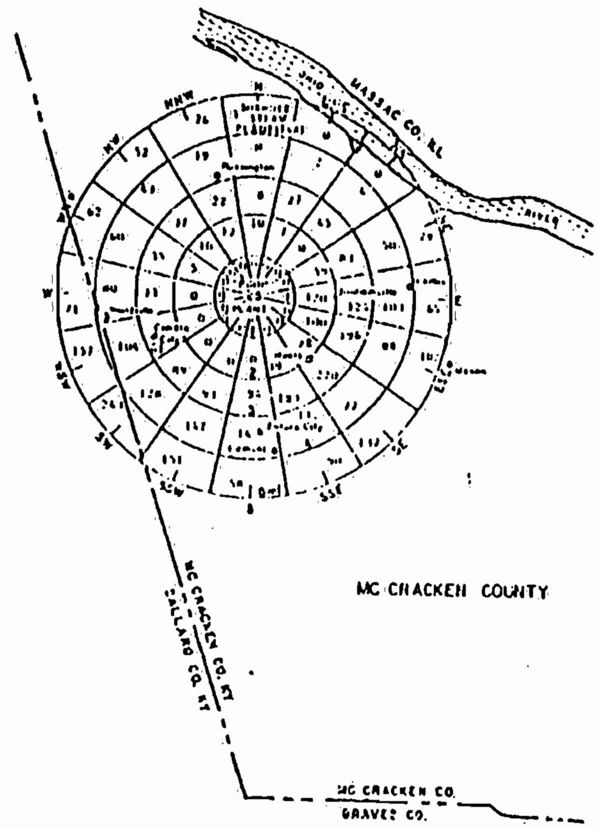
REGULATIONS, STANDARDS AND MODELS USED FOR DETERMINING ENVIRONMENTAL IMPACTS AT THE PADUCAH GASEOUS DIFFUSION PLANT AND JOPPA STEAM ELECTRIC PLANT

Table C-1. Transient population nodes within 5 miles of the Atomic Energy Commission plant—Paducah, Kentucky

Nodes	Activity	Sector	Transient Population
1	Industry	70	10
2	Commercial	70	54
3	Commercial	70	52
4	Commercial	71	12
5	Commercial	71	13
6	Commercial	55	102
7	Commercial	56	-
8	Commercial	56	79
9	Commercial	56	380
10	Institutional	71	725
11	Institutional	70	47
12	Commercial	58	3
13	Commercial	58	7
14	Commercial	59	21
15	Commercial	59	17
16	Commercial	59	9
17	Commercial	59	2
18	Industry	59	14
19	Commercial	76	127
20	Commercial	76	254
21	Commercial	76	406
22	Institutional	70	14
23	Commercial	23	52
24	Commercial	22	99
25	School	40	750
26	Institutional	24	30
27	Institutional	26	43
28	Institutional	44	32
29	Institutional	79	14
30	Institutional	37	750
31	Institutional	53	254
32	Industry	52	200
33	Commercial	37	35
34	Commercial	36	20
35	Commercial	36	20
36	Institutional	20	50
37	Commercial	64	20
38	Commercial	37	25
39	Industry	65	545

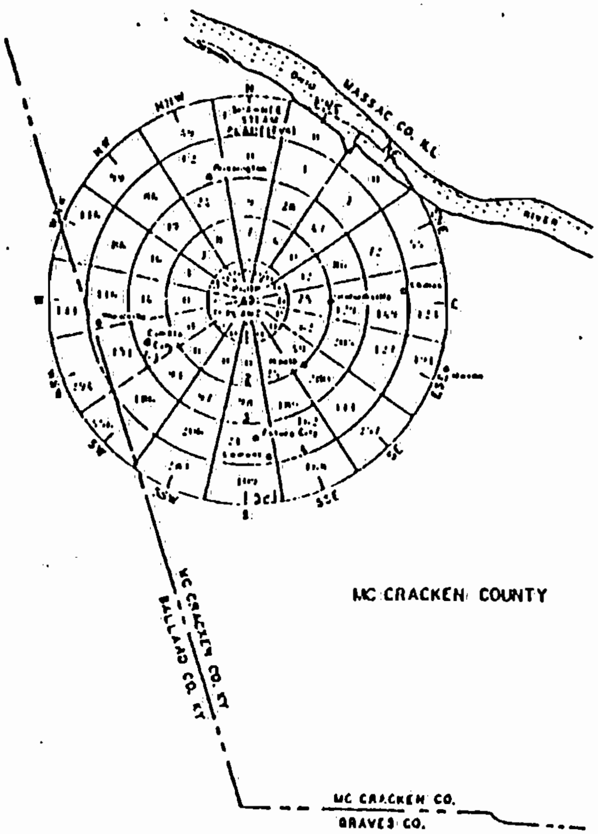


POPULATION (IN NUMBER OF PERSONS)

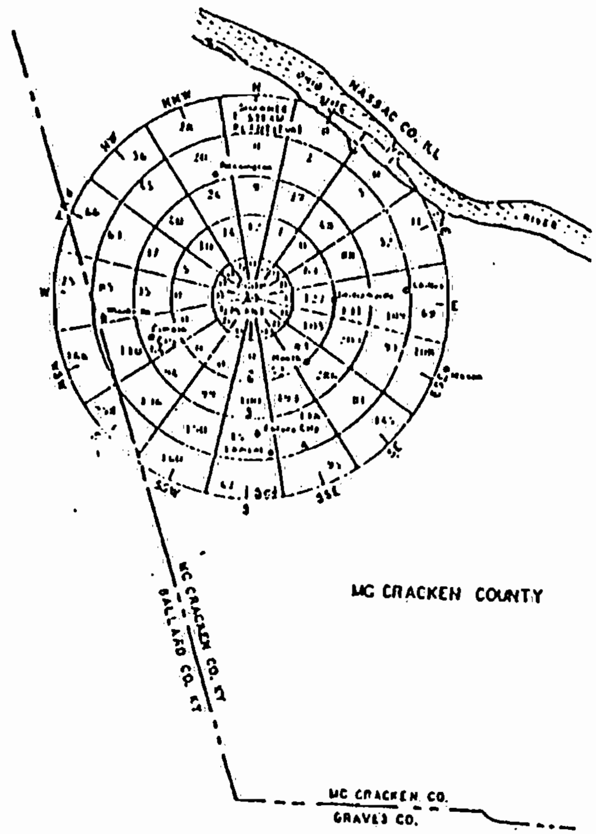


DENSITY (IN PERSONS PER SQUARE MILE)

Figure C-2. Projected demographics, 1980, for sectors within 5 miles of the PGDP.

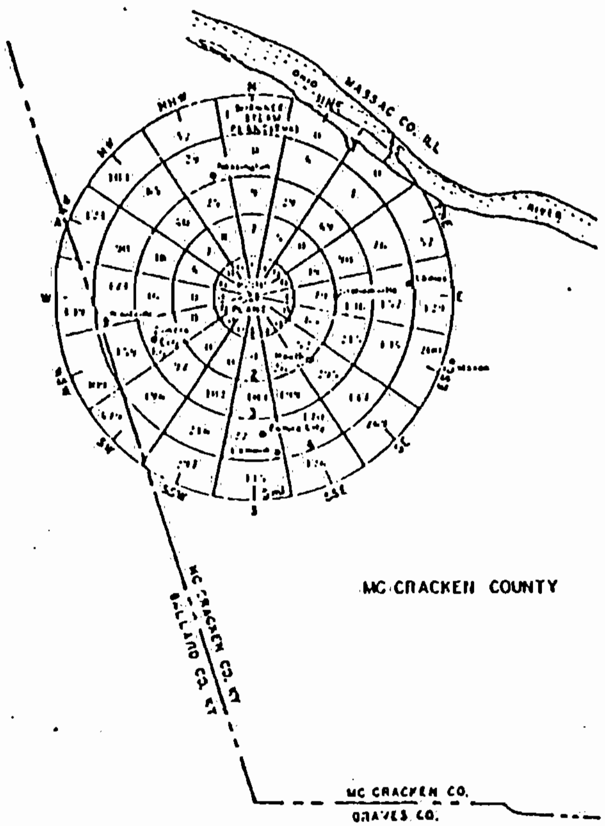


POPULATION (IN NUMBER OF PERSONS)

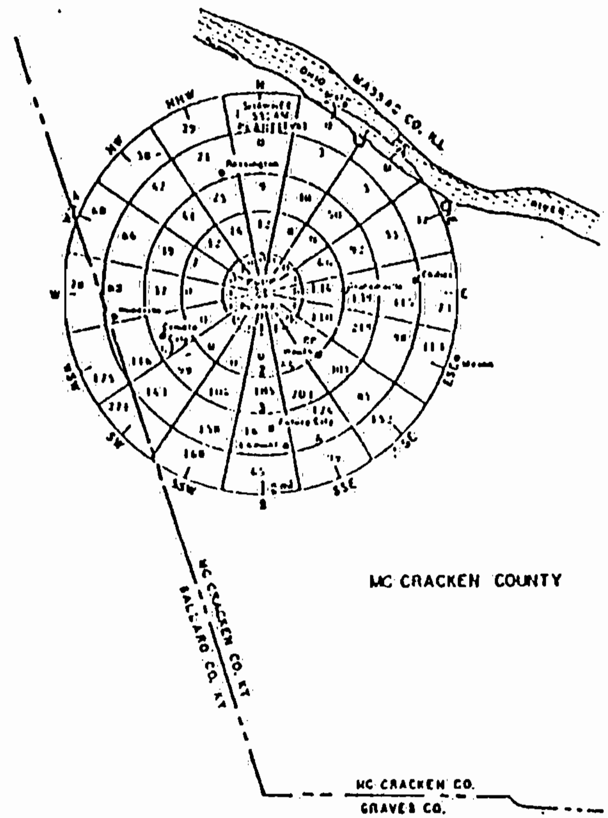


DENSITY (IN PERSONS PER SQUARE MILE)

Figure C-3. Projected demographics, 1990, for sectors within 5 miles of the PGDP.

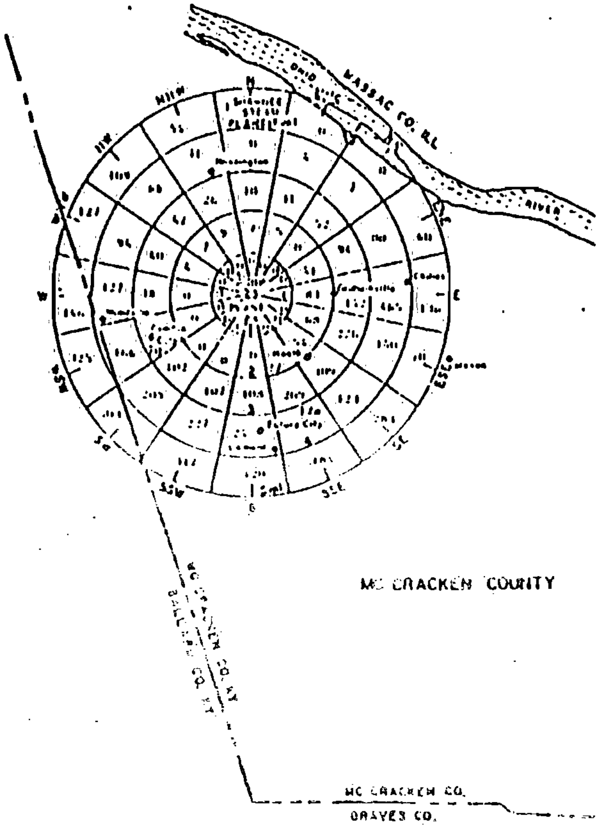


POPULATION (IN NUMBER OF PERSONS)

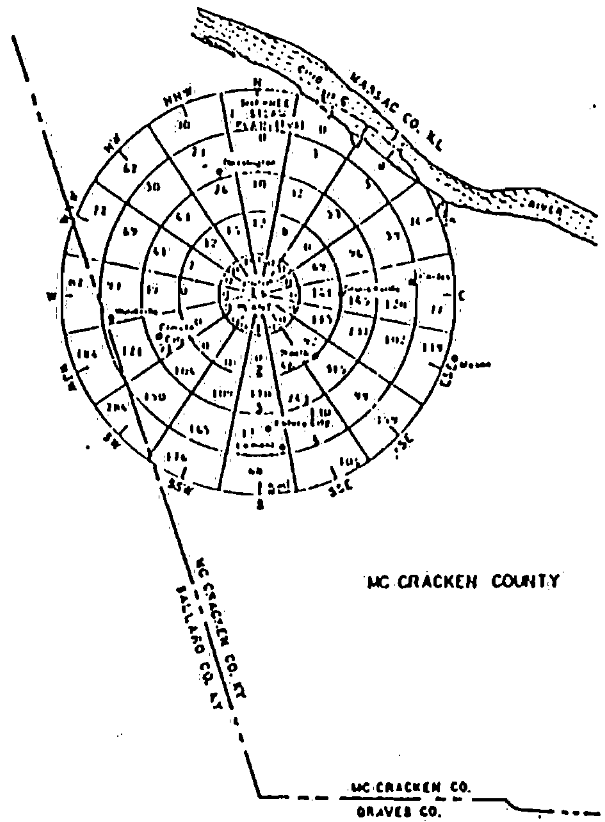


DENSITY (IN PERSONS PER SQUARE MILE)

Figure C-4. Projected demographics, 2000, for sectors within 5 miles of the PGDP.

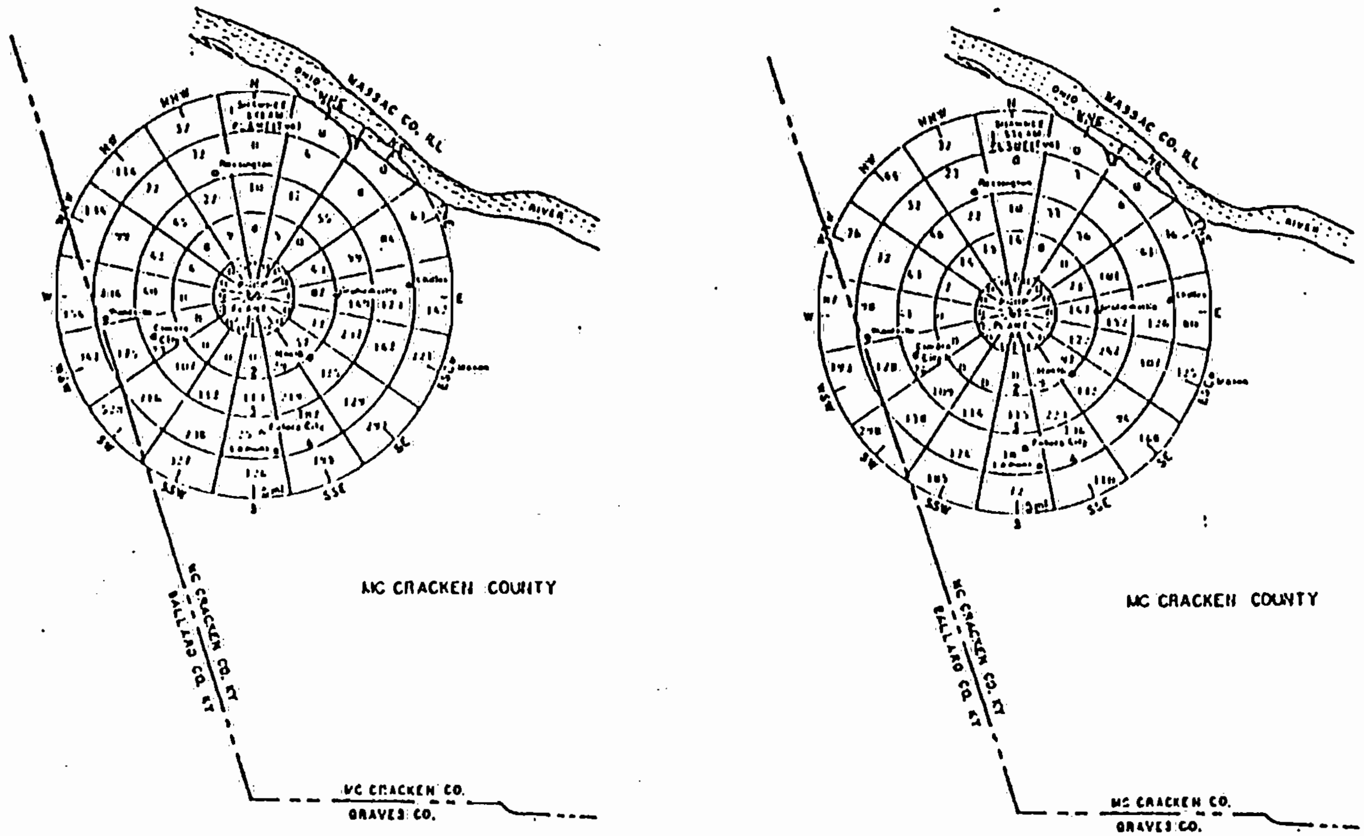


POPULATION (IN NUMBER OF PERSONS)



DENSITY (IN PERSONS PER SQUARE MILE)

Figure C-5. Projected demographics, 2010, for sectors within 5 miles of the PGDP.



POPULATION (IN NUMBER OF PERSONS) DENSITY (IN PERSONS PER SQUARE MILE)

Figure C-6. Projected demographics, 2020, for sectors within 5 miles of the PGDP.

Table C-2. Estimates of sector population densities (persons per square mile), 1980-2020, 0-5 miles from PDGP

Sector	Sector Population Density by Selected Years				
	1980	1990	2000	2010	2020
1	0	0	0	0	0
2	0	0	0	0	0
3	0	0	0	0	0
4	0	0	0	0	0
5	0	0	0	0	0
6	0	0	0	0	0
7	0	0	0	0	0
8	0	0	0	0	0
9	0	0	0	0	0
10	0	0	0	0	0
11	0	0	0	0	0
12	0	0	0	0	0
13	0	0	0	0	0
14	0	0	0	0	0
15	0	0	0	0	0
16	0	0	0	0	0
17	10	12	12	12	14
18	7	7	8	8	8
19	0	0	0	0	0
20	59	63	66	69	73
21	120	127	134	141	147
22	100	105	110	115	122
23	78	83	88	92	97
24	39	42	44	46	49
25	0	0	0	0	0
25	0	0	0	0	0
27	0	0	0	0	0
28	0	0	0	0	0
29	0	0	0	0	0
30	5	5	7	7	7
31	10	12	12	12	14
32	12	14	14	15	15
33	8	9	9	10	10
34	27	29	30	32	33
35	45	48	50	53	56
36	83	88	92	96	101
37	124	131	139	145	152
38	196	209	219	231	242
39	270	286	301	315	332
40	183	193	203	213	223
41	94	100	105	110	115
42	93	99	104	109	114

Table C-2. (Continued)

Sector	Sector Population Density by Selected Years 1980	1990	2000	2010	2020
43	89	94	99	104	109
44	61	64	67	71	74
45	33	35	37	39	41
46	35	37	39	41	43
47	37	40	41	43	46
48	22	24	25	26	27
49	0	0	0	0	0
50	2	2	3	3	3
51	4	5	5	5	6
52	50	52	55	58	61
53	103	109	115	120	126
54	88	93	98	102	107
55	77	81	85	99	94
56	112	118	124	130	136
57	14	15	16	17	18
58	142	150	158	165	174
59	128	136	143	150	158
60	104	110	116	121	128
61	80	85	88	93	98
62	60	63	66	69	72
63	43	45	47	50	52
64	19	20	21	23	23
65	1	1	1	1	1
66	0	0	0	1	1
67	0	0	0	0	0
68	29	31	32	34	36
69	65	69	73	77	80
70	102	108	113	119	125
71	137	145	152	159	168
72	90	95	99	104	110
73	58	62	65	68	72
74	151	160	168	176	185
75	243	258	271	284	298
76	157	166	175	184	193
77	71	75	78	82	87
78	62	66	68	72	76
79	52	56	58	62	64
80	26	28	29	30	32

Table C-3. Sector population estimates, 1980-2020, 0-5 miles from PGDP

Sector	Sector Population by Selected Years				
	1980	1990	2000	2010	2020
1	0	0	0	0	0
2	0	0	0	0	0
3	0	0	0	0	0
4	0	0	0	0	0
5	0	0	0	0	0
6	0	0	0	0	0
7	0	0	0	0	0
8	0	0	0	0	0
9	0	0	0	0	0
10	0	0	0	0	0
11	0	0	0	0	0
12	0	0	0	0	0
13	0	0	0	0	0
14	0	0	0	0	0
15	0	0	0	0	0
16	0	0	0	0	0
17	6	7	7	7	8
18	4	4	5	5	5
19	0	0	0	0	0
20	35	37	39	41	43
21	71	75	79	83	87
22	59	62	65	68	72
23	46	49	52	54	57
24	23	25	26	27	29
25	0	0	0	0	0
26	0	0	0	0	0
27	0	0	0	0	0
28	0	0	0	0	0
29	0	0	0	0	0
30	3	3	4	4	4
31	6	7	7	7	8
32	7	8	8	9	9
33	8	9	9	10	10
34	26	28	29	31	32
35	44	47	49	52	55
36	81	86	90	94	99
37	122	129	136	142	149
38	193	205	215	226	237
39	265	280	295	309	325
40	179	189	199	209	219
41	92	98	103	108	113
42	91	97	102	107	112

Table C-3. (Continued)

Sector	Sector Population by Selected Years				
	1980	1990	2000	2010	2020
43	87	92	97	102	107
44	60	63	66	70	73
45	32	34	36	38	40
46	34	36	38	40	42
47	36	39	40	42	45
48	22	24	25	26	27
49	0	0	0	0	0
50	3	3	4	4	4
51	6	7	7	7	8
52	68	72	76	80	84
53	141	149	157	165	173
54	120	127	134	140	147
55	105	111	117	123	129
56	153	162	170	178	187
57	20	21	22	24	25
58	194	206	216	227	238
59	176	186	196	205	216
60	142	151	159	166	175
61	109	116	121	127	134
62	81	86	90	94	99
63	59	62	65	68	72
64	26	28	29	31	32
65	1	1	1	1	1
66	0	0	0	0	0
67	0	0	0	0	0
68	52	55	57	60	63
69	116	123	129	136	142
70	180	191	200	210	221
71	242	257	269	283	297
72	159	168	176	185	195
73	103	109	115	120	126
74	267	283	297	312	327
75	430	456	479	503	528
76	278	294	309	325	341
77	125	133	139	146	154
78	109	116	121	127	134
79	93	99	103	109	114
80	46	49	52	54	57

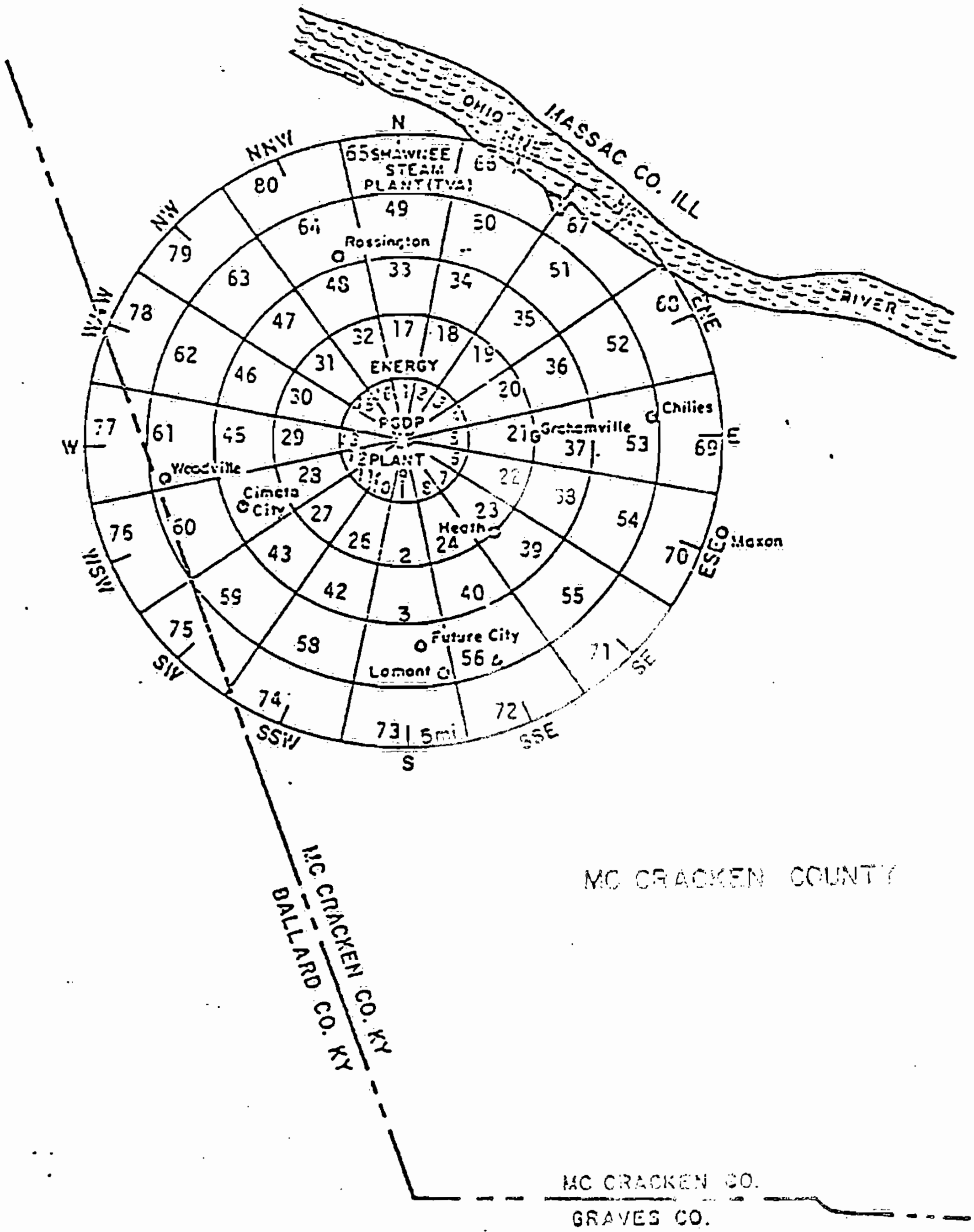


Figure C-7. Sectors within 5-mile radius of the PGDP.

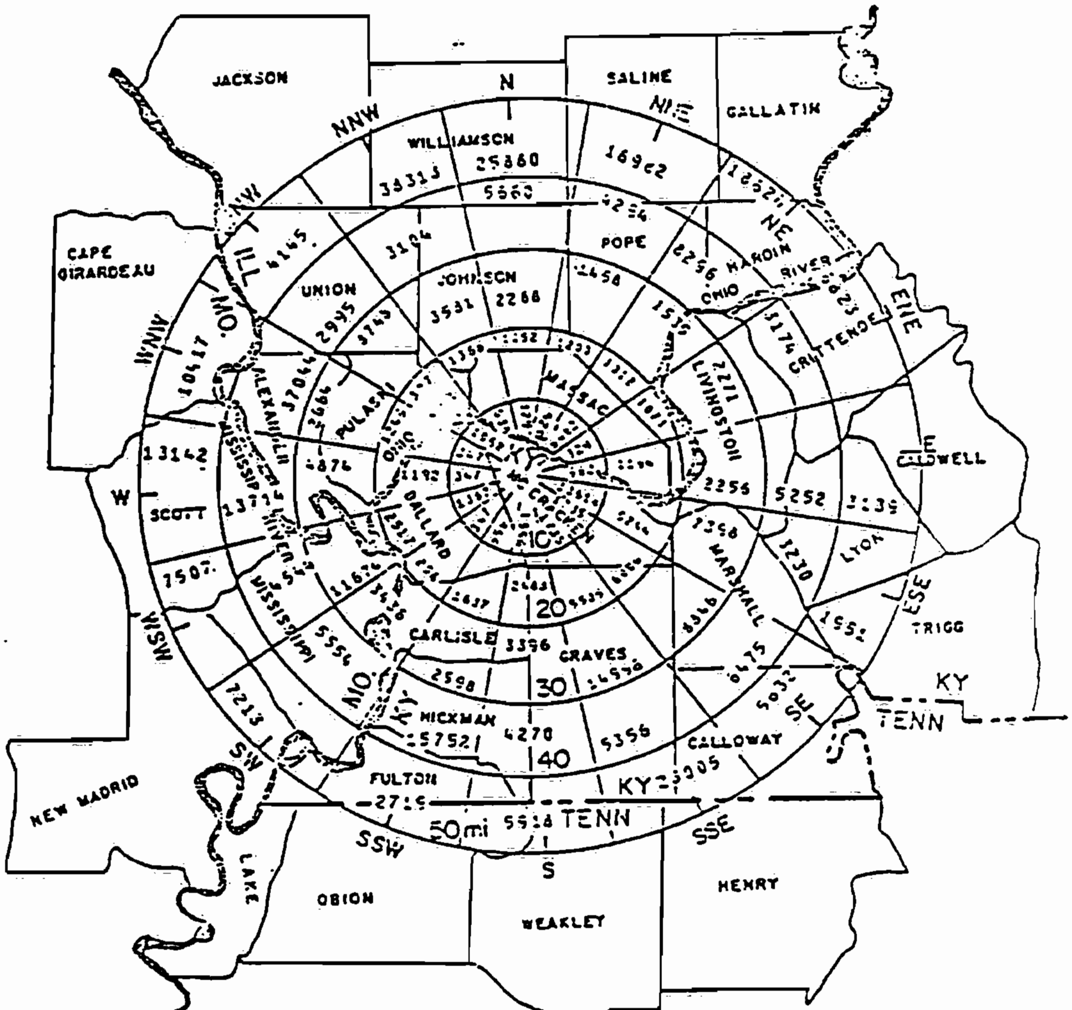


Figure C-8. Projected population for sectors within 5-50 miles of PGDP, 1980.

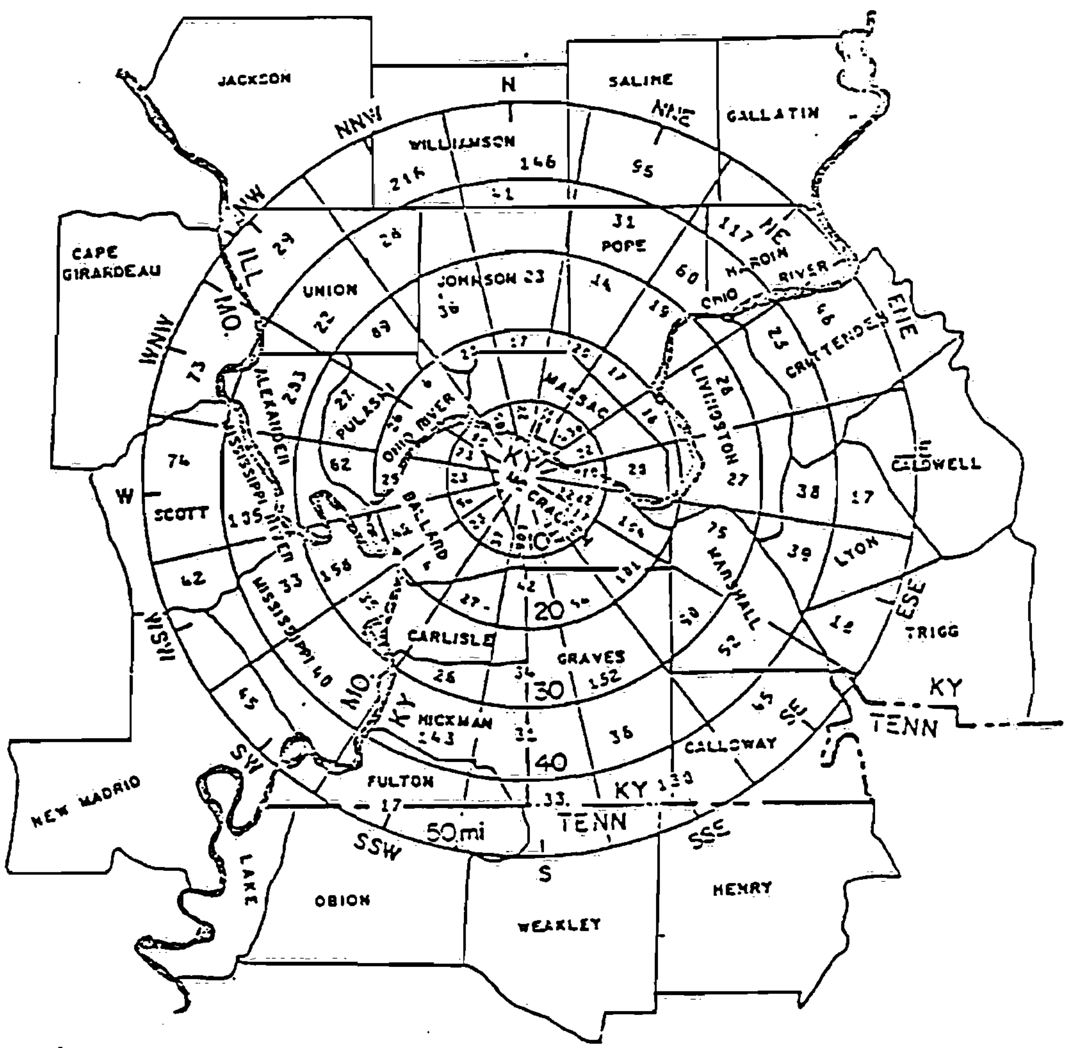


Figure C-9. Projected population density (persons per square mile) for sectors within 5-50 miles of PGDP, 1980.

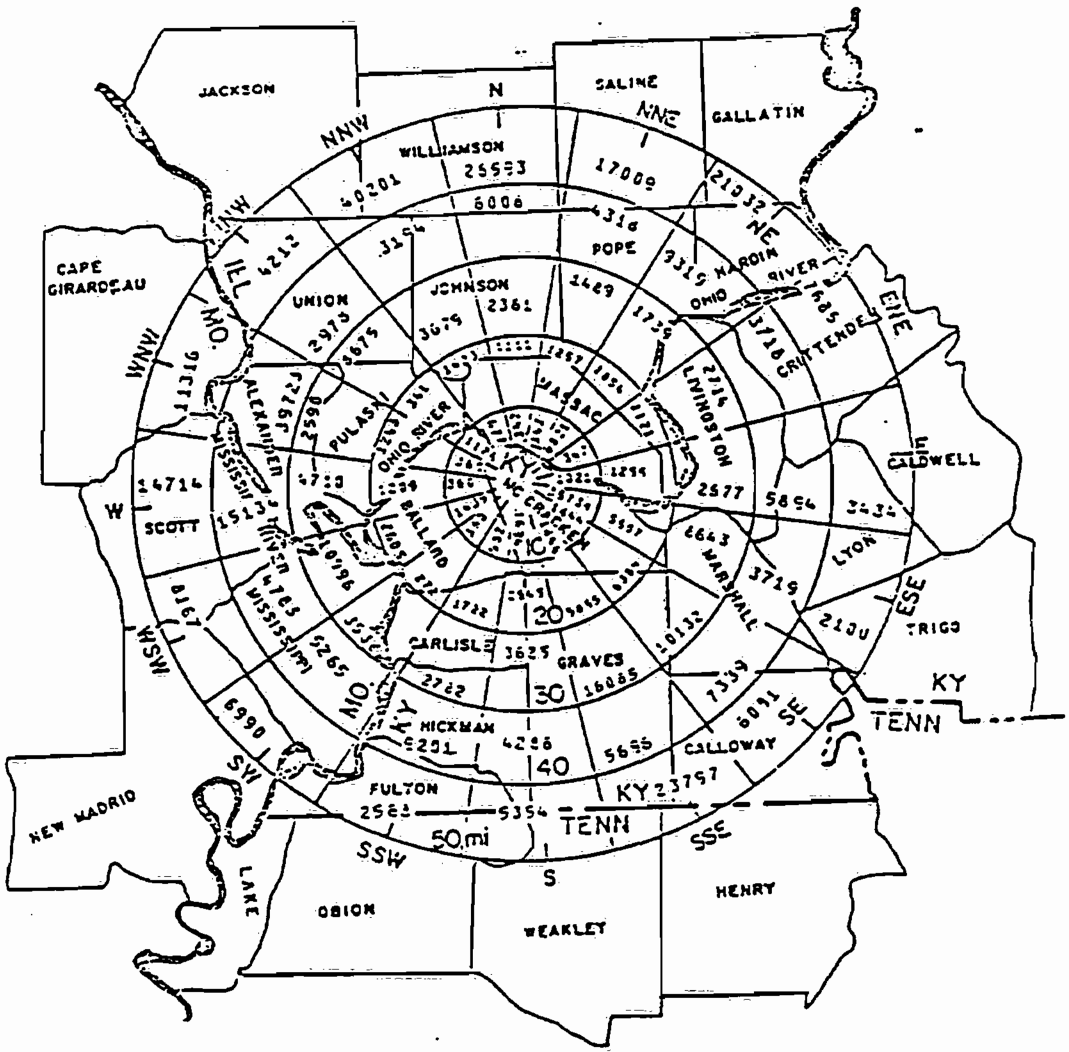


Figure C-10. Projected population for sectors within 5-50 miles of PGDP, 1990.

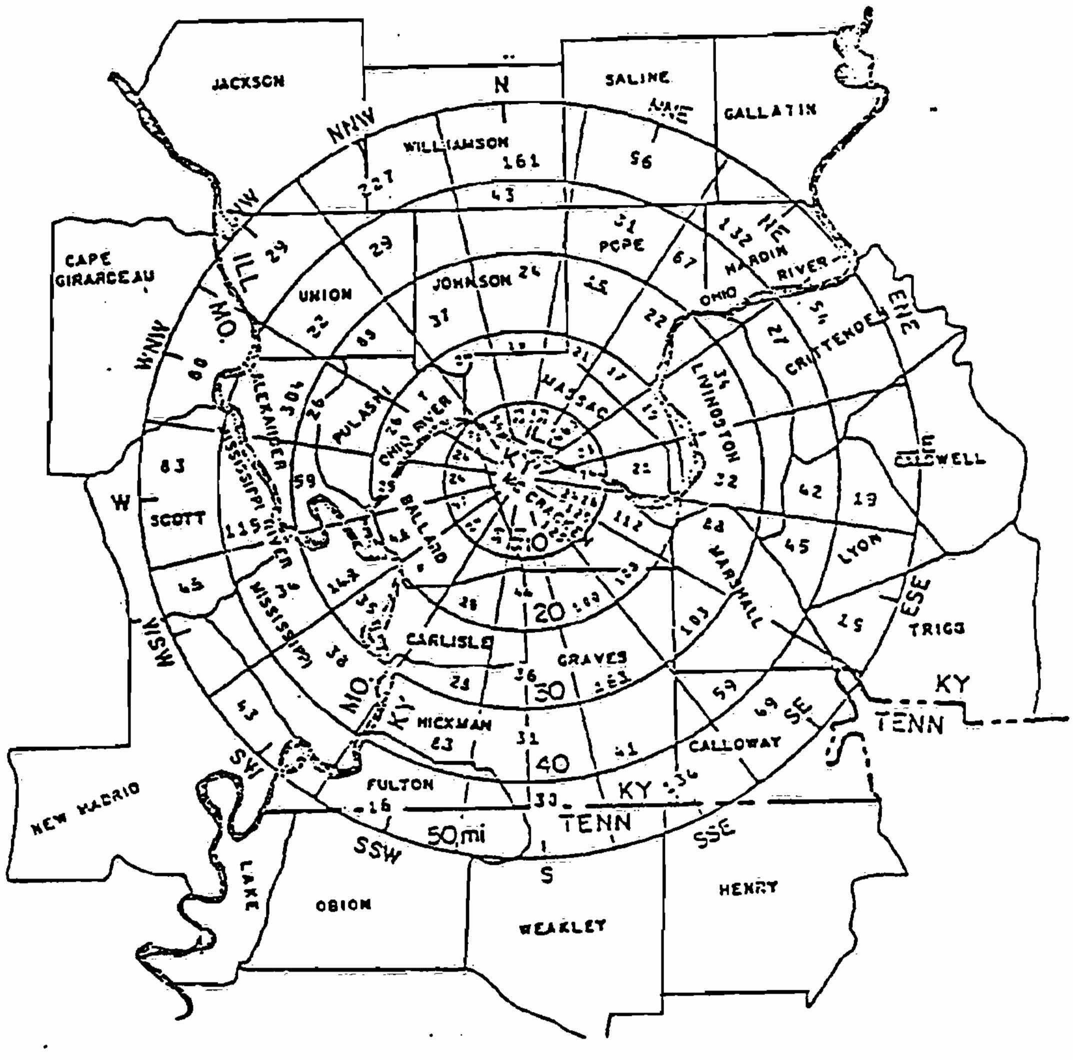


Figure C-11. Projected population density (persons per square mile) for sectors within 5-50 miles of PGDP, 1990.

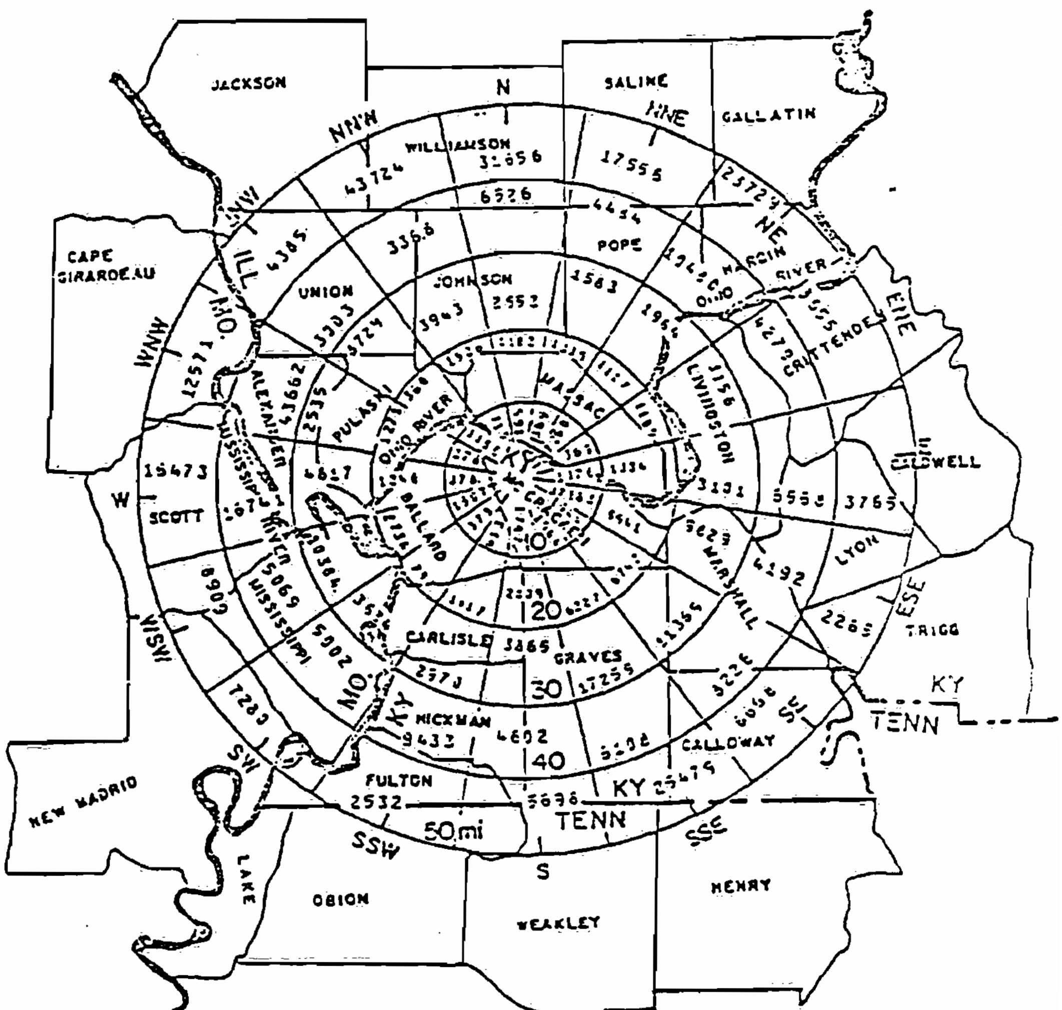


Figure C-12. Projected population for sectors within 5-50 miles of PGDP, 2000.

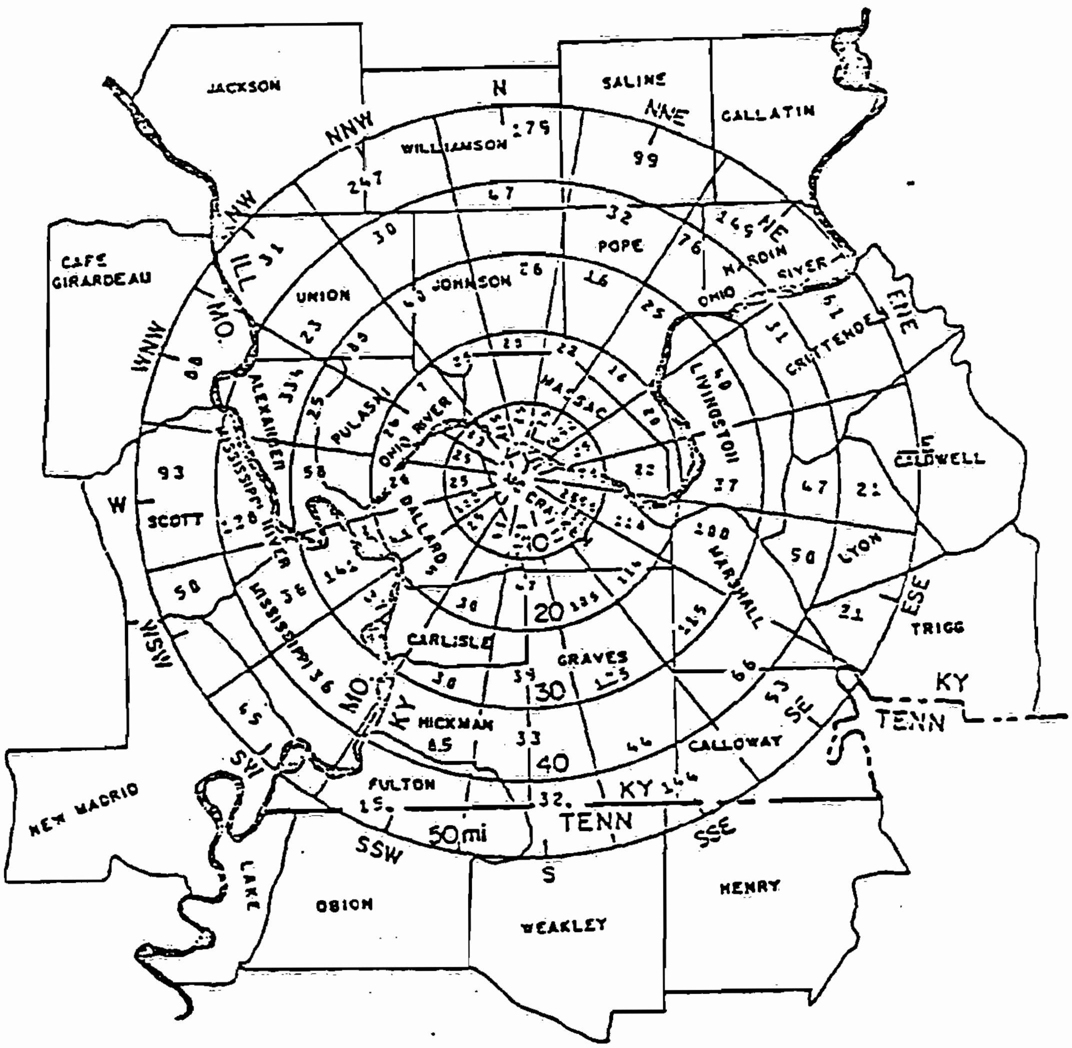


Figure C-13. Projected population density (persons per square mile) for sectors within 5-50 miles of PGDP, 2000.

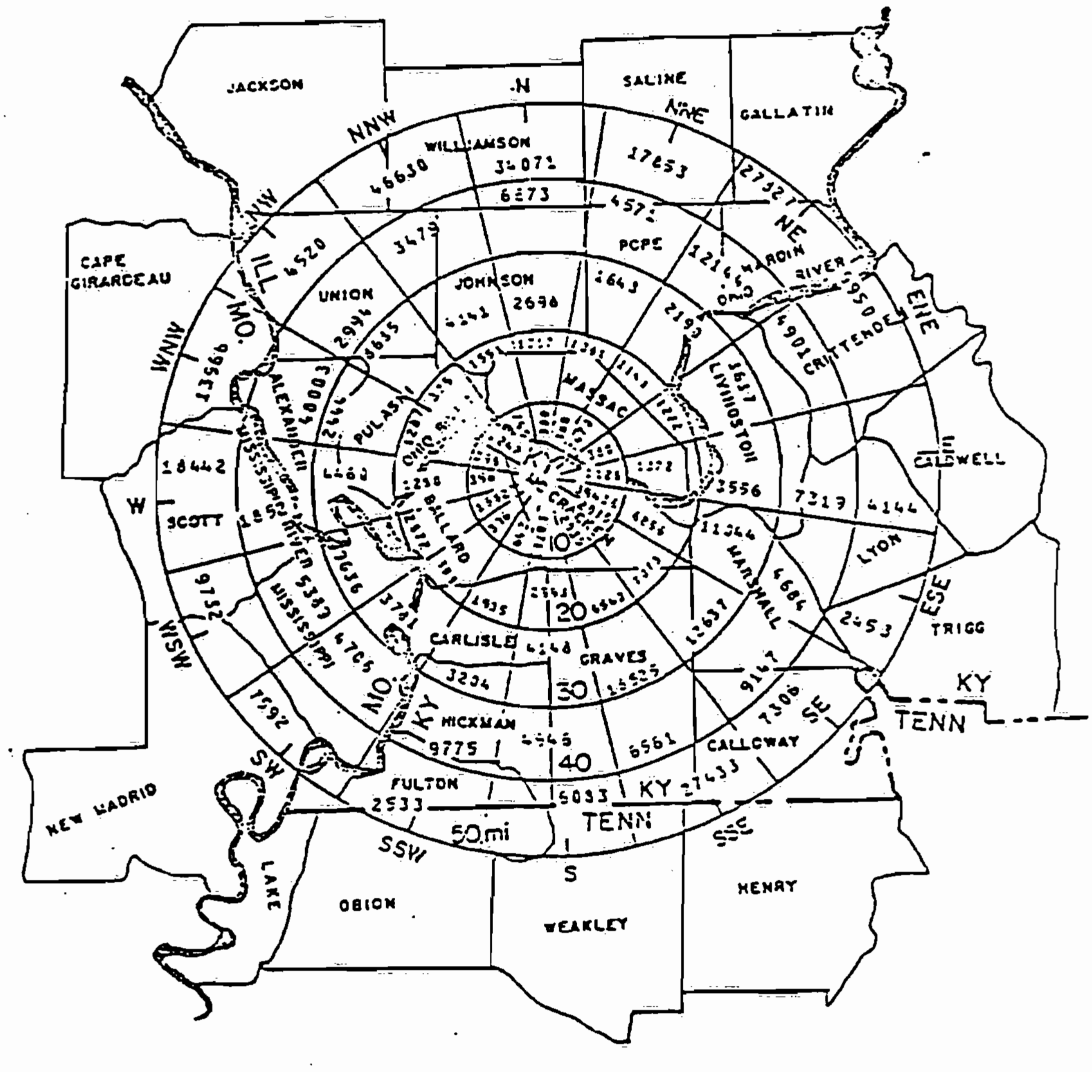


Figure C-14. Projected population for sectors within 5-50 miles of PGDP, 2010.

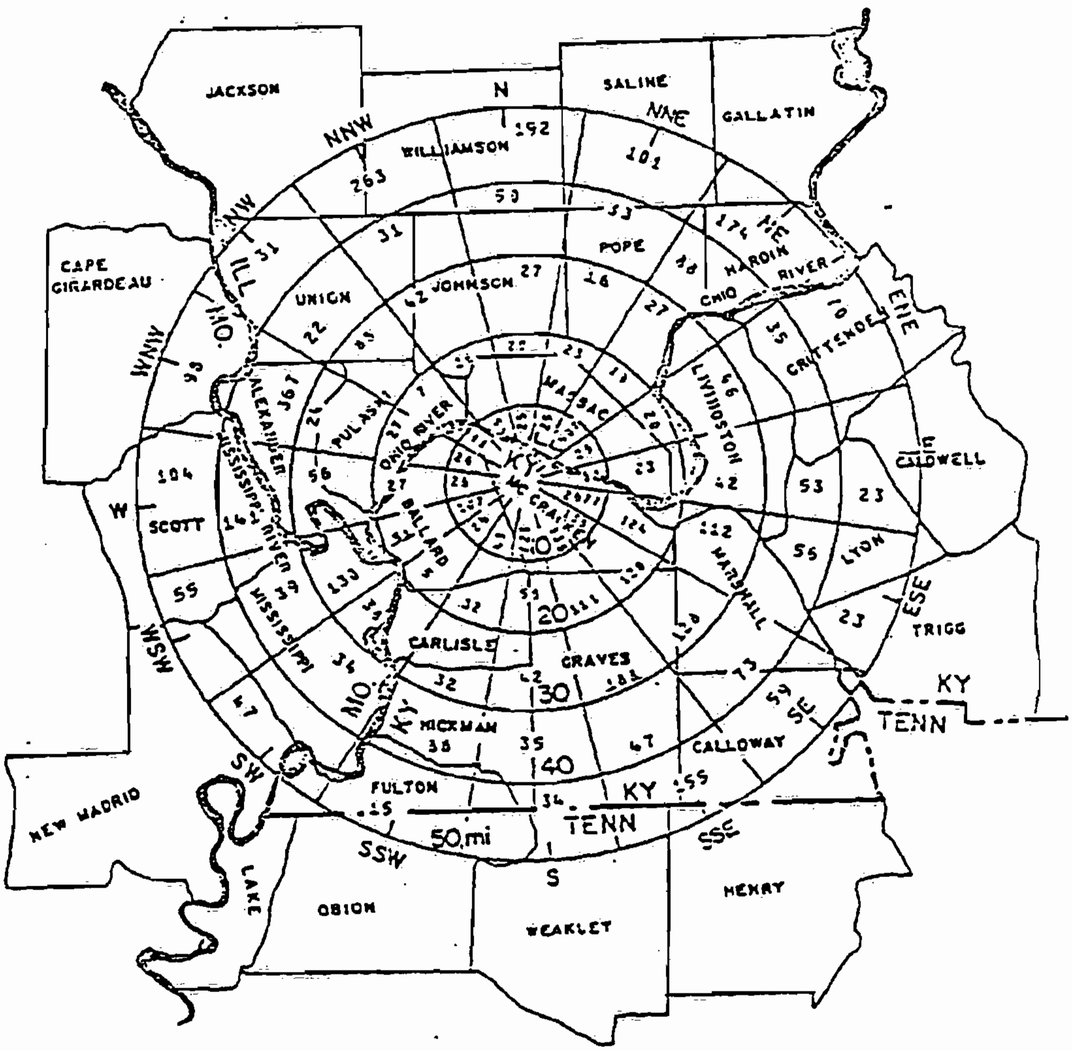


Figure C-15. Projected population density (persons per square mile) for sectors within 5-50 miles of PGDP, 2010.

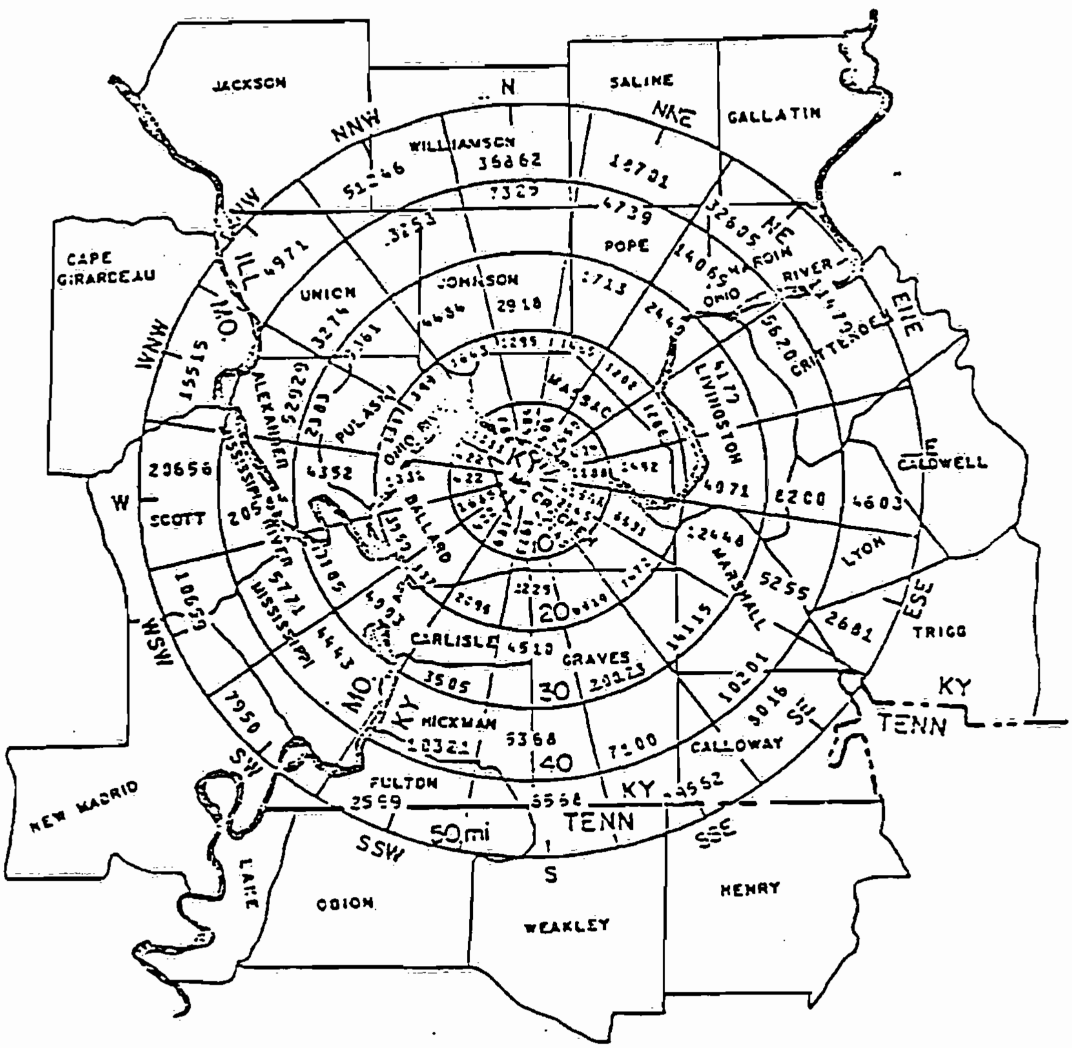


Figure C-16. Projected population for sectors within 5-50 miles of PGDP, 2020.

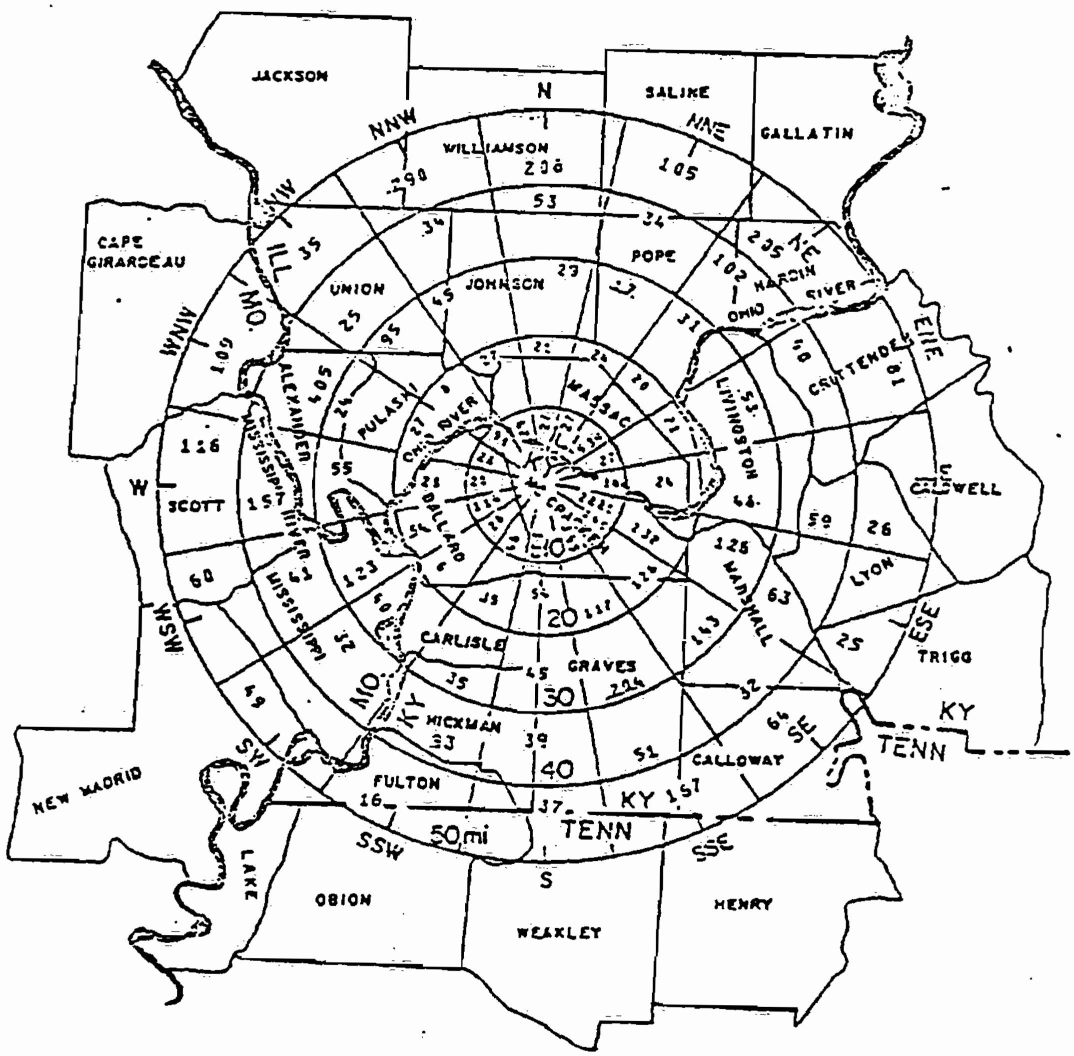


Figure C-17. Projected population density (persons per square mile) for sectors within 5-50 miles of PGDP, 2020.

Table C-4. Sector population estimates, 1980-2020, 5-50 miles from PGDP

Sector	Sector Population by Selected Years				
	1980	1990	2000	2010	2020
81	329	347	369	380	404
82	329	347	369	380	404
83	6,462	6,821	7,260	7,470	7,950
84	329	347	369	380	404
85	962	1,021	1,078	1,126	1,188
86	33,618	35,738	37,663	39,436	41,566
87	1,735	1,844	1,944	2,035	2,145
88	1,735	1,844	1,944	2,035	2,145
89	1,596	1,696	1,787	1,871	1,973
90	556	582	613	642	681
91	347	360	378	396	422
92	1,387	1,435	1,507	1,582	1,685
93	347	360	378	396	422
94	347	360	378	396	422
95	1,062	1,126	1,186	1,242	1,311
96	638	677	715	745	788
97	1,052	1,111	1,182	1,217	1,295
98	1,200	1,257	1,339	1,381	1,465
99	1,012	1,054	1,117	1,148	1,202
100	1,073	1,121	1,189	1,222	1,286
101	1,194	1,255	1,334	1,372	1,452
102	5,244	5,607	5,941	6,256	6,631
103	6,006	6,389	6,742	7,073	7,472
104	5,539	5,895	6,227	6,540	6,919
105	2,483	2,645	2,809	2,993	3,225
106	1,637	1,722	1,817	1,935	2,096
107	256	272	287	308	337
108	2,517	2,605	2,736	2,872	3,059
109	1,192	1,209	1,246	1,280	1,331
110	1,245	1,248	1,271	1,287	1,317
111	327	341	360	375	399
112	1,368	1,423	1,508	1,551	1,643
113	2,288	2,361	2,552	2,698	2,918
114	1,458	1,489	1,583	1,643	1,713
115	1,535	1,739	1,964	2,190	2,440
116	2,271	2,714	3,158	3,637	4,179
117	2,256	2,677	3,101	3,556	4,071
118	7,398	8,643	9,829	11,044	12,448
119	8,846	10,132	11,369	12,637	14,115
120	14,996	16,085	17,259	18,525	20,073
121	3,396	3,625	3,865	4,148	4,510
122	2,598	2,782	2,970	3,204	3,505

Table C-4. (Continued)

Sector	Sector Population by Selected Years				
	1980	1990	2000	2010	2020
123	3,435	3,532	3,634	3,781	4,003
124	11,674	10,996	10,384	9,636	9,105
125	4,874	4,710	4,617	4,460	4,352
126	2,684	2,590	2,535	2,444	2,383
127	8,748	8,675	8,729	8,685	9,361
128	3,581	3,679	3,943	4,141	4,484
129	5,660	6,008	6,526	6,873	7,325
130	4,294	4,318	4,484	4,571	4,739
131	8,296	9,319	10,480	12,144	14,069
132	3,174	3,718	4,279	4,901	5,620
133	5,252	5,894	6,568	7,319	8,200
134	3,230	3,719	4,192	4,684	5,255
135	6,475	7,339	8,226	9,147	10,201
136	5,356	5,696	6,103	6,561	7,100
137	4,270	4,288	4,602	4,946	5,368
138	15,752	9,201	9,433	9,775	10,321
139	5,554	5,265	5,002	4,706	4,443
140	4,544	4,783	5,069	5,389	5,771
141	13,714	15,134	16,741	18,527	20,584
142	37,044	39,723	43,662	48,003	52,929
143	2,995	2,978	3,003	2,994	3,274
144	3,104	3,194	3,368	3,479	3,753
145	25,880	28,593	31,656	34,071	36,862
146	16,982	17,009	17,556	17,853	18,701
147	18,626	21,032	23,729	27,827	32,605
148	6,823	7,686	8,655	9,950	11,479
149	3,139	3,434	3,765	4,144	4,603
150	1,951	2,100	2,265	2,453	2,681
151	5,632	6,081	6,668	7,306	8,016
152	23,005	23,797	25,479	27,433	29,562
153	5,918	5,354	5,698	6,083	6,568
154	5,798	2,568	2,532	2,533	2,599
155	7,213	6,990	7,280	7,592	7,950
156	7,507	8,167	8,909	9,732	10,659
157	13,142	14,714	16,473	18,442	20,655
158	10,417	11,316	12,571	13,966	15,515
159	4,145	4,212	4,385	4,520	4,971
160	38,313	40,201	43,724	46,630	51,246

Table C-5. Estimates of sector population densities (persons per square mile), 1980-2020, 5-50 miles from PGDP

	Sector Population Density by Selected Years				
Sector	1980	1990	2000	2010	2020
81	22	23	25	25	27
82	22	23	25	25	27
83	438	463	492	507	539
84	22	23	25	25	27
85	70	74	78	82	86
86	2282	2426	2556	2677	2821
87	117	125	131	138	145
88	117	125	131	138	145
89	108	115	121	127	133
90	37	39	41	43	46
91	23	24	25	26	28
92	94	97	102	107	114
93	23	24	25	26	28
94	23	24	25	26	28
95	80	84	89	93	98
96	50	54	57	59	62
97	17	18	20	20	21
98	20	21	22	23	24
99	17	17	18	19	20
100	18	19	20	20	21
101	20	21	22	23	24
102	104	112	118	124	132
103	101	108	114	120	126
104	94	100	105	111	117
105	42	44	47	50	54
106	27	29	30	32	35
107	4	4	5	5	6
108	45	46	48	51	54
109	25	25	26	27	28
110	26	26	26	27	27
111	6	7	7	7	8
112	23	24	25	26	27
113	23	24	26	27	29
114	14	15	16	16	17
115	19	22	25	27	31
116	28	34	40	46	53
117	27	32	37	42	48
118	75	88	100	112	126
119	90	103	115	128	143
120	152	163	175	188	204
121	34	36	39	42	45
122	26	28	30	32	35

Table C-5. (Continued)

Sector	Sector Population Density by Selected Years				
	1980	1990	2000	2010	2020
123	35	35	37	38	40
124	158	149	141	130	123
125	62	59	58	56	55
126	27	26	25	24	24
127	89	88	88	88	95
128	36	37	40	42	45
129	41	43	47	50	53
130	31	31	32	33	34
131	60	67	76	88	102
132	23	27	31	35	40
133	38	42	47	53	59
134	39	45	50	56	63
135	52	59	66	73	82
136	38	41	44	47	51
137	31	31	33	35	39
138	143	83	85	88	93
139	40	38	36	34	32
140	33	34	36	39	41
141	105	115	128	141	157
142	283	394	334	367	405
143	22	22	23	22	25
144	28	29	30	31	34
145	146	161	179	192	208
146	96	96	99	101	105
147	117	132	149	174	205
148	48	54	61	70	81
149	17	19	21	23	26
150	18	19	21	23	25
151	45	49	53	59	64
152	130	134	144	155	167
153	33	30	32	34	37
154	36	16	15	15	16
155	45	43	45	47	49
156	42	46	50	55	60
157	74	83	93	104	116
158	73	80	88	98	109
159	29	29	31	31	35
160	216	227	247	263	290

Table D-1. Tentative regulatory levels for use with State of Kentucky Noise Control Act

Land Use Class	Maximum Exceedance Levels, dBA[a]		
	L_{50}	L_{10}	L_1
I (Daytime)	60	65	75
I (Nighttime)	50	55	65
II (24 hours)	60	65	75

(a) A-weighted sound level, expressed as dBA, takes into account the human response to the frequency characteristic of sound in the normal hearing range.

Table D-2. Summary of guidelines for limits on environmental noise
(Adapted from the U.S. Environmental Protection Agency Document, "Information on Levels of Environmental Noise Requisite To Protect Public Health and Welfare with an Adequate Margin of Safety", 1974.)

YEARLY AVERAGE* EQUIVALENT SOUND LEVELS IDENTIFIED AS REQUISITE TO PROTECT THE PUBLIC HEALTH AND WELFARE WITH AN ADEQUATE MARGIN OF SAFETY

	Measure	Indoor		To Protect Against Both Effects (b)	Outdoor		To Protect Against Both Effects (b)
		Activity Interference	Hearing Loss Consideration		Activity Interference	Hearing Loss Consideration	
Residential with Outside Space and Farm Residences	L_{dn}	45		45	55		55
	$L_{eq(24)}$		70			70	
Residential with No Outside Space	L_{dn}	45		45			
	$L_{eq(24)}$		70				
Commercial	$L_{eq(24)}$	(a)	70	70(c)	(a)	70	70(c)
Inside Transportation	$L_{eq(24)}$	(a)	70	(a)			
Industrial	$L_{eq(24)(d)}$	(a)	70	70(c)	(a)	70	70(c)
Hospitals	L_{dn}	45		45	55		55
	$L_{eq(24)}$		70			70	
Educational	$L_{eq(24)}$	45		45	55		55
	$L_{eq(24)(d)}$		70			70	
Recreational Areas	$L_{eq(24)}$	(a)	70	70(c)	(a)	70	70(c)
Farm Land and General Unpopulated Land	$L_{eq(24)}$				(a)	70	70(c)

Code:

a. Since different types of activities appear to be associated with different levels, identification of a maximum level for activity interference may be difficult except in those circumstances where speech communication is a critical activity. (See Figure D-2 for noise levels as a function of distance which allow satisfactory communication.)
b. Based on lowest level.
c. Based only on hearing loss.
d. An $L_{eq(8)}$ of 75 dB may be identified in these situations so long as the exposure over the remaining 16 hours per day is low enough to result in a negligible contribution to the 24-hour average, i.e., no greater than an L_{eq} of 60 dB.

Note: Explanation of identified level for hearing loss: The exposure period which results in hearing loss at the identified level is a period of 40 years.

*Refers to energy rather than arithmetic averages.

Table D-3. Paducah Gaseous Diffusion Plant NPDES permit discharge limits as of July 1, 1977

	001 Big Bayou Creek		002 Little Bayou Creek		003 C-616		004 C-615		005 C-611 Lagoon 1		006 C-611 Lagoon 2		
	Avg.	Max.	Avg.	Max.	Avg.	Max.	Avg.	Max.	Avg.	Max.	Avg.	Max.	Units
Chromium (total)	0.3	0.5		0.3	0.5	1.0							mg/l
Chromium (+6)	0.05	0.08	0.05	0.08	0.05	0.10							mg/l
Dissolved oxygen	See Note 1		See Note 1										mg/l
Dissolved solids	1000	1500	1000	1500									mg/l
Fluoride	3.5	4.0											mg/l
Oil and grease	10	15	10	15	10	15							mg/l
Temperature	See Note 2		See Note 2										°F
pH	See Note 3		See Note 3		See Note 3		See Note 3		See Note 4		See Note 4		Std Units
Copper					0.5	1.0							mg/l
Zinc					0.5	1.0							mg/l
BOD_5							10	15					mg/l
Fecal coliform							200	400					No./100 ml
Suspended solids					30	45			30	50	30	50	mg/l

Note 1: Dissolved oxygen not be less than 5.0 mg/l as 24-hr average, nor less than 4.0 mg/l at any time.

Note 2: Temperature not to exceed the following:

Jan 50	May 80	Sep 87
Feb 50	Jun 87	Oct 78
Mar 60	Jul 89	Nov 70
Apr 70	Aug 89	Dec 57

Note 3: pH not to be less than 6.0, nor greater than 9.0.

Note 4: pH not to be less than 6.0, nor greater than 10.0.

Table D-4. Kentucky aquatic life standards, water quality criteria, and National Pollutant Discharge Elimination System (NPDES) permit conditions applicable to Big and Little Bayou creeks

(Concentrations in mg/l except pH)

Parameter	Aquatic Life Standards	1976 Water Quality Criteria	NPDES Limits
Dissolved oxygen	5.0	5.0	2/15/75-6/30/77
pH	6-9	6.5-9	6-9
Temperature rise	5°C	—	—
Temperature maxima	89°F (31.7°C) (April 70°F-21.1°C; June 87°F-30.6°C)	90°F (32°C)	—
Toxic Materials			
Cr^{6+}/Cr^{3+}	2.7/3.3	0.10[f]	5.0 (9.0)[e]
Fluoride	—	—	30.0
Chlorine	0.03	0.01	—
Ammonia[a]	0.02	0.02	—
Copper	0.04-0.4	0.04-0.4	—
Nickel	0.07	0.007	—
Zinc	0.76-1.0	0.076	—
Cyanide	0.01	0.005	—
Lead[b]	1.0(b)	0.1[b]	—
Mercury	0.0008	0.0005	—
Nitrate[c]		—	—
Oil and grease	Variable[d]	Variable[d]	10 (15)[e]
Phenols	0.50	0.20	--
PCB's	0.0008	1×10^{-6}	—

(a) As un-ionized NH_3.

(b) Soluble lead determined by 0.45 μ membrane filtration.

(c) As nitrate.

(d) Depends on specific composition

(e) Daily average (daily maximum in parenthesis).

(f) Total chromium.

Table D-5. Kentucky and federal drinking water standards applicable to Ohio River water at the point of withdrawal[a]

Parameter	Kentucky	Federal Primary	Federal Secondary[b]
Chromium	0.05[c]	0.05[d]	
Cyanide	0.025		
Fluoride	1.0	1.4-2.4[e]	
Lead	0.05	0.05	
Mercury		0.002	
Chloride			250
Copper			1.0
Sulfide			0.05
Iron			0.3
Manganese			0.05
pH			6.5-8.5
Sulfate			250
Total diss. solids	750		500
Zinc			5.0
Radioactivity (α)	3[f]		
(β)	1000		

(a) Concentrations in mg/l except pH (units) and radioactivity (picocuries/l).

(b) Proposed.

(c) Hexavalent.

(d) Total.

(e) Depending on temperature.

(f) Dissolved.

CHEMICAL DISPERSION MODEL

Assumptions

- Steady-state conditions exist over the time-frame of the analysis.
- Radionuclides behaved conservatively, i.e., did not undergo decay or sorb onto sediment particles and settle out of the water column.
- Steady-state effluent concentrations were set at the highest value historically measured by PGDP.
- The plume mixing width was no greater than one quarter the river width for the first mile downstream. This assumption was based on thermal plume measurements done at Joppa which showed the plume staying relatively close to shore.
- Average river flow velocity was assumed based on the calculated cross-section; average creek inflow rates were assumed.

For continuous release of a pollutant into a river moving at right angles to the effluent, the concentration, C, in three dimensions is given by:[1]

$$C = \frac{\dot{m}}{2\pi (DyDz)^{0.5}} \exp \left\{ \frac{-U}{4x} \left[\frac{Y^2}{Dy} + \frac{Z^2}{Dz} \right] \right\}$$

where,

$\dot{m}$ = mass release rate (kg/sec)

Dy, Dz = dispersion coefficients in lateral and vertical directions, respectively (m^2/sec)

U = average river flow velocity (m/sec)

x,y,z = rectangular coordinate distances (m).

Integration and rearrangement yields an expression for that receiving water volume, V* which gives a dilution factor to some critical concentration, C*(kg/m^3). C* may be a standard or criterion or may be a value to approaching the background concentration in the limit,

$$V^* = K \quad \{1-2 \ln [(\frac{2\pi C^*}{\dot{m}t})K]\}$$

where,

$K = (DyDz)^{0.5} Ut^2 = 0.387\ nU^2t^2R^{5/6}$

and R = hydraulic radius (m).

Making the assumption of steady-state, that is, if $K >> \dot{m}t/2\pi C^*$, then

$$V^* = \frac{0.065}{n}\left(\frac{\dot{m}}{C^* U}\right)^2 R^{-5/6} \quad \text{or}$$

$$V^* = 0.065\, nS\left(\frac{\dot{m}}{C^*}\right)^2 R^{1/2}$$

and where,

S = slope of the hydraulic grade line, (m/m)

n = Manning's n

Values for the Ohio River near PGDP are:

U = 0.33 m/sec

R = 3.70 m

n = 0.025.

These values will be used to calculate the potential impact on downstream water users in the Ohio River due to PGDP discharges.

Table D-6. Thermal water quality standards for the State of Kentucky

(1) Industrial water supply — temperature shall not exceed 95° Fahrenheit at any time (35°C)

(2) Aquatic Life — the following criteria are for evaluation of conditions for the maintenance of well balanced, indigenous fish population. The aquatic use standards shall not apply to areas immediately adjacent to outfalls. Areas immediately adjacent to outfalls shall be as small as possible, be provided for mixing only, and shall not prevent the free passage of fish and drift organisms.

(a) Temperature shall not exceed 89°F (31.7°C)

(b) There shall be no abnormal temperature changes that may affect aquatic life unless caused by natural conditions

(c) The normal daily and seasonal temperature fluctuations that existed before the addition of heat due to other than natural causes shall be maintained

(d) The maximum temperature rise at any time or place above natural temperatures shall not exceed 5°F (28°C) in streams. In addition, the water temperature for all streams shall not exceed the maximum limits indicated in the following:

Table D-6. (Continued)

Stream maximum temperature for each month in degrees Fahrenheit (F) and Centigrade (C)

Month	F	C
January	50	10
February	50	10
March	60	15.6
April	70	21.1
May	80	26.7
June	87	30.6
July	89	31.7
August	89	31.7
September	87	31.7
October	78	30.6
November	70	21.1
December	57	13.9

THERMAL DISPERSION MODEL

This model is adequate to approximately predict the thermal dispersion and convection along a river which is assumed to be homogeneously mixed in the vertical direction and in differential form is

$$V\ \partial T/\partial X = A\ \partial^2 T/\partial y^2 \quad , \qquad (1)$$

where

- T is the temperature in the river at any point (°F)
- X is the longshore distance from the plant discharge (ft)
- y is the offshore distance (ft)
- V is the longshore current (ft/sec)
- A is a dispersion coefficient, (ft^2/sec).

A solution to Equation (1) for constant discharge rate and temperature is

$$T = T_G + B\ (T_D - T_G)\ [\pi D^2\ AVX]^{-1/2}\ \exp\ [-Vy^2/(4AX)] \qquad (2)$$

where