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ENVIRONMENTAL EFFECTS
OF THE CONSTRUCTION AND OPERATION
OF A GASEOUS DIFFUSION PLANT

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ENVIRONMENTAL EFFECTS OF THE CONSTRUCTION AND OPERATION OF A GASEOUS DIFFUSION PLANT

SUMMARY

This report was prepared to describe the impacts upon the environment resulting from construction, start-up, and operation of a gaseous diffusion plant. Some of the impacts are typical regardless of location of the plant. Others are atypical and depend upon location; those are presented, by way of example, as they occur at the Portsmouth Gaseous Diffusion Plant. The various environmental contaminants that may be produced in the operating plant are described. The concentrations of those contaminants are stated; and the adverse biological effects of pertinent contaminants are elucidated.

UF₆ may be enriched in the Portsmouth Gaseous Diffusion Plant to almost any U-235 concentration desired. The environmental impact of the plant varies somewhat according to U-235 concentrations. However, commercial plants are not expected to enrich U-235 in concentrations greater than 4%; for this reason, environmental effects due to Portsmouth operations within that range are emphasized.

The study revealed that present discharges from the plants generally have no detrimental effects upon the environment.

PREFACE

Selecting a site for a new gaseous diffusion plant is a complex problem. The diffusion plants are immense and consume large quantities of electrical energy. The principal criteria for site selection are (1) the availability and cost of an abundant supply of electrical energy, (2) an adequate supply of suitable water, (3) an available, local labor supply that may be employed in constructing and operating the plant, (4) suitable, available transportation facilities, (5) temperate climate and weather, and (6) fairly flat natural terrain.

Because the Portsmouth Gaseous Diffusion Plant is the newest of the three diffusion plants owned by the Atomic Energy Commission (AEC), it is used as an example where examples are required in this report. The information is stated in general where there is general applicability; where it is specific for each plant, it is presented, by way of example, for the Portsmouth Gaseous Diffusion Plant. The gaseous diffusion plants monitor their effluent streams, both gaseous and liquid, as well as their ambient environment. The monitoring data are compared routinely with applicable air and water quality standards and effluent standards. Where emission and ambient quality standards are cited and used for comparisons, they are the standards that apply to the Portsmouth Gaseous Diffusion Plant in Ohio; those standards may be different elsewhere.

I. PRECONSTRUCTION ENVIRONMENT

The 4000-acre site on which the Portsmouth Gaseous Diffusion Plant was built had been gently rolling farm land located about one mile east of the Scioto River valley at an average elevation about 120 feet above the Scioto River flood plain. Aerial photographs of the site before and after construction are presented in Figures 1 and 2, respectively. The normal annual rainfall is between 30 and 45 inches, and the normal average minimum and maximum temperatures are 25°F and 87°F, respectively. Wind direction and velocity are shown in the wind rose in Figure 3.

The site area served as the watershed for several wet weather streams. The subsurface soils are primarily clay and silt, providing poor subterranean water supplies. However, the neighboring Scioto Valley offers an abundant supply of water, both from the river and from the massive subterranean gravel deposits underlying the valley floor. The valley was carved deeply by an ancient river, and the gravel and sand deposits that filled the bed are highly porous and serve as the source of one of the most abundant fresh water supplies in the nation.

N
4

Figure 1. PRE-CONSTRUCTION PLANT SITE

Figure 2. POST-CONSTRUCTION PLANT SITE

Figure 3.
24-HOUR WIND ROSE
1953 TO 1955

The waters of the Scioto River are highly polluted with municipal and industrial wastes from sources above plantsite. Water flow in the river ranges from about 500 ft³/second during dry weather to flooding during wet weather; during the wet spring weather the river overflows its banks and occasionally floods a large portion of the 1-1/3-mile-wide valley.¹

The local tributaries flowing into the Scioto River were relatively unpolluted except for agricultural wastes. In the absence of industry, the ambient environment was not contaminated with recognized pollutants.

II. DESCRIPTION OF THE PLANT

The gaseous diffusion plant earns its name from the principal process employed in the plant: separation of uranium isotopes through gaseous diffusion. The gaseous diffusion process is one in which the concentration of a particular isotope of an element, in this case uranium-235, is increased by passing a gaseous compound of the element through successive membranes or diffusion devices specifically designed for that element. Uranium hexafluoride of relatively low U-235 concentration² serves as the feed material. This material moves through the "cascade" (process equipment) under highly regulated conditions until a product material having the desired U-235 concentration is obtained. The ancillary processes, systems, and operations serving the diffusion process include a primary cooling system for removing the heat of compression from the process gas; a recirculating-water cooling system into which the heat is transferred from the primary cooling system and is subsequently rejected from the process; a sanitary water system; a steam plant that furnishes steam for process and building heating; a dry-air plant that furnishes dry air required for operation of plant equipment and instruments; a nitrogen manufacturing facility; a sewage collection, treatment, and disposal system; a furnace for melting scrap aluminum; a decontamination and cleaning facility; a fluorine manufacturing plant; a radio and telephone communication system; laboratories for process control and development; maintenance shops; personnel services, including a hospital and a cafeteria; a central process-control facility; storage and warehouse facilities; a security system, including barriers (fences) and a Fire Department and a Police Department; and various administrative services. At the Portsmouth plant,

¹Flood stage is 16 ft above pool stage; record high and low since construction began were 32.65 ft and -0.42 ft, respectively. Average flow rate is about 5200 ft³/sec; median flow is about 1950 ft³/sec; and low flow--the flow rate exceeded 90% of the time--is about 500 ft³/sec.

²A naturally occurring U-235 isotopic concentration of 0.711% is typical.

most of these processes and systems are sheltered in permanent buildings having approximately 220 acres of floor space and in temporary buildings having approximately 27 acres of floor space. Some of the processes, of course, are not sheltered in buildings; these include the cooling towers, the electrical switchyards, the water towers, part of the water treatment plant, and part of the sewage treatment plant, as well as some open storage facilities.

III. CONSTRUCTION PHASE

Impact on the Land. The generally flat terrain required relatively little alteration. Cutting and filling operations resulted in exposure of nonfertile subsoils and coverage of other fertile soils with subsoil. The principal adverse effect was the temporary but long-term commitment of the portion of the land where buildings were installed, where roads were paved, where railroads were built, and where surfaces were covered, e.g., with gravel or bituminous material to prevent weed growth in open storage areas. A minor adverse effect resulted from earth-moving operations when loosened surface and subsurface soils were washed into natural waterways.

Impact on Water. The land area on which the plant was constructed served only as the watershed for several wet-weather streams and was not traversed by any permanent streams. Precipitation water still flows from the area through the same streams--Little Beaver Creek, Big Run, and a drainage ditch to the Scioto River. However, the distribution of waters to those streams undoubtedly changed somewhat. Additional waters piped into the area from the Scioto River and from well fields in the Scioto valley also began to be discharged to those streams from sewage treatment facilities and some constructional processes.

Impact on Natural Resources. Much of the land on which the plant was constructed was cultivated crop land. The small amount of non-crop land contained natural grasses, shrubs, weeds, vines, and a few trees. The few trees that were destroyed were more than compensated for by the planting of evergreens and locust trees during landscaping of the site. In addition, all exposed soils were planted with grasses.

The adverse effect upon natural resources was the irretrievable expenditure of materials used in construction of the plant.

Impact on Surrounding Communities. The construction and operation of a gaseous diffusion plant definitely affect the surrounding communities.

There is a substantial impact from the large work force required to construct the plant and from the movement of transport vehicles used to carry construction materials to the plantsite. The peak of construction workers employed at the Portsmouth Gaseous Diffusion

Plant was 18,054. This work force, moving into a lightly populated area, required shelter and services that had not been previously available. Temporary housing had to be built and subsequently disassembled or disposed of because the work force was considerably larger than the permanent operating force employed by the operating contractor. New systems had to be built or old ones expanded for supplying water, for waste treatment, for transportation, for business activities, and for general personal services. Providing these services for the construction personnel proved burdensome to the communities, but the ultimate effect was beneficial in that the communities now have modern water treatment and waste disposal systems, modern schools, modern business facilities, and modern services. The permanent houses built during construction days are still occupied, while much of the temporary housing has been moved to rural areas, where it is presently used. Some trailer parks still lie abandoned, but many others are serving the expanding mobile-home market.

Impact of Allied Construction. Gaseous diffusion plants consume huge quantities of electrical energy. In order that such energy would be available for the Portsmouth Gaseous Diffusion Plant, two large fossil-fueled power plants were constructed concomitantly. Both supply electrical energy at 345,000 volts. The Clifty Creek Plant, built about 140 miles away, near Madison, Indiana, has a rated capacity of 1300 Mw; the Kyger Creek Plant, located about 50 miles away, near Gallipolis, Ohio, has a rated capacity of 1000 Mw. When generating at their rated capacities, the two plants together burn approximately 7,000,000 tons of coal per year. Potential air contaminants result from that coal burning. Technology for abatement of pollution from the power plants currently is developing.

The electrical energy is transmitted to the gaseous diffusion plant over high-voltage transmission lines. Voltage is reduced to lower levels by transformers in the diffusion plant switchyards. The power transmission lines are suspended from large metal towers, which occupy land, but farmers continue to use the land under the towers.

Aside from the irretrievable use of coal, the major environmental effect of power generation and transmission is the removal of trees from the power line right-of-way. Those trees, however, have been replaced by lower growing vegetation.

IV. START-UP PHASE

The environmental effects of routine plant operation are described in a subsequent section. However, some effects result simply from start-up of the plant equipment. This preparation consists of conditioning the equipment for use in the plant and charging empty supply systems. At the Portsmouth plant the recirculating cooling

water system was charged with about 30 million gallons of water; the coolant system with 6,000,000 pounds of refrigerant; and the lubricating oil system with 576,000 gallons of lubricating oil.

Uranium hexafluoride, the process gas, is highly corrosive to many metals, and the chemical reactions sometimes form solid reaction products containing uranium. Such reactions should be minimized, both to prevent damage to structural materials and to conserve process material. Accordingly, some of the equipment is treated before being installed in the process system. The small concentrations of gaseous fluorides that escape to the atmosphere are well within those limits considered acceptable in working areas, according to standards of the American Congress of Governmental Industrial Hygienists (ACGIH). The contribution of this operation to the concentrations of fluorides in the ambient environment outside the plant area is immeasurably small.

V. NORMAL OPERATING PHASE

Uranium-containing materials are shipped to and from a gaseous diffusion plant in steel shipping containers that have been approved by the Department of Transportation and the AEC. The largest part of these materials is uranium hexafluoride; the balance is uranium oxide, which is transformed into uranium hexafluoride by chemical processes. The gaseous diffusion process, then, is a two-stage physical process: (1) change of state from solid to gas and (2) diffusion separation based on molecular weight differences. This diffusion process produces practically no waste by-products. What wastes are produced, along with wastes from the ancillary processes, will be described below. The only other significant environmental impacts of the operating gaseous diffusion plant are the irretrievable use of natural resources and the temporary--but long-time--commitment of land used for lagoons and the "hot" burial yard, which also will be considered below.

Environmental standards and regulations are currently being established, and the technological criteria on which those standards are based currently are developing. Few standards or regulations existed when the present gaseous diffusion plants were constructed and began to operate. As new standards and regulations were established by various governmental agencies, the general practice at the diffusion plants has been to install new facilities, systems, or processes to reduce pollutants and contaminants to the lowest practicable concentrations.

Irretrievable Use of Resources. Resources used irretrievably in substantial quantities at the Portsmouth plant are shown in the following tabulation; quantities are current monthly averages (1000 Mw power level).

Gasoline	9,400 gal.	Freon	2,260 lbs.
Diesel Fuel	8,300 gal.	Trichloroethylene	800 gal.
Process Lubricating Oil	570 gal.	Coal	4,400 tons
Electrical Insulating Oil	145 gal.	Nitric Acid	9,000 lbs.
Propane, Liquid	1,000 gal.	Hydrochloric Acid	140 lbs.
Orocol (Betz Labs)	3,400 lbs.	Sulfuric Acid	55,500 lbs.
Caustic Soda	5,500 lbs.	Oxygen, Compressed	16,000 ft ³
Lime	159 tons	Argon, Compressed	3,000 ft ³
Chlorine, Liquid	8,000 lbs.		

At a power level of 2260 Mw, the maximum power level at which the plant is expected to operate in the future, the values for Orocol, lime, and sulfuric acid would be 12,000 lbs., 374 tons, and 179,000 lbs., respectively. The remaining resources would be consumed at approximately the same rate.

The large amount of heat generated in the diffusion plant is removed through a recirculating water cooling system, which at the Portsmouth plant has a capacity of 30.5 million gallons. (Maximum possible flow through the system is 450 mgd. Flow at 1000 Mw power level is 230 mgd.) When the plant is operated at a power level of 1000 Mw, approximately 7.7 million gallons per day (mgd) is lost from the system through evaporation at the cooling towers and approximately 0.4 mgd is discharged from the system as blowdown to control the concentration of dissolved solids. At a power level of 2260 Mw, evaporation at the cooling towers is 17.5 mgd and the blowdown is 1.3 mgd. To make up for the evaporation and blowdown losses, additional water is added continuously to the system. That make-up water and an additional 2.2 mgd needed for sanitary and miscellaneous supplies compose the total water requirements: 10.3 mgd at 1000 Mw, and 21.0 mgd at 2260 Mw power level. The principal adverse environmental impact would be a possible lowering of the water table in the supply aquifer (the wells are located in the Scioto Valley). However, hydrological studies have shown that the supply in the aquifer is ample, aquifer recharge being maintained primarily from the Scioto River.

Other resources are used when plant equipment is replaced as a result of failure or obsolescence. However, recycling makes a large portion of the materials retrievable.

Temporary Commitment of Land. Sludges produced during lime softening of water are stored in lagoons. The sludges consist primarily of calcium carbonate and some magnesium hydroxide. Twenty-three acres of lagoons have been serving the Portsmouth plant. This land could be reclaimed for use by removing the sludges or by digging drainage trenches into the bases or low points in the lagoons to hasten drainage and subsequent compaction.

Small areas of land--about five acres at Portsmouth--are used for burial and storage of materials contaminated with radioactive substances. Although that land will not be usable for dwellings or for agricultural purposes, it could serve some uses in which the soil surface would be covered, e.g., a storage yard.

Environmental Contaminants. Environmental contaminants will be described below according to recognized, specific categories. The variously referenced effluent points and sampling locations at the Portsmouth plant are shown on maps in Figures 4 and 5. The adverse biological effects of pertinent contaminants are described in the Appendix.

1. Noise

A large amount of mechanical equipment is employed in the gaseous diffusion plant, and noise levels in areas immediately adjacent to that equipment often are high. Noise levels in the process buildings may reach 100 dBA. Levels in the maintenance shops may be as great as 125 dBA. Outside the process buildings the noise is merely a low pitched hum; outside the maintenance shops the noise is not discernible. Noise surveys have been conducted in the buildings, and appropriate measures to ensure safety have been taken.

2. Thermal Discharge

Most of the electrical energy used in the gaseous diffusion plant is converted into heat of compression in the process gas. This heat is removed through a primary cooling system and subsequently through the recirculating-water cooling system. The recirculating water is cooled as it flows over induced-draft cooling towers. The temperature of the water going to the towers ranges between 115 and 140°F; that coming off the towers ranges between 70° and 90°F. At a plant power level of 1000 Mw, approximately 7.7 mgd of water is evaporated, the total heat discharged being approximately 3.35 billion Btu/hr. At a plant power level of 2260 Mw, the evaporation rate is 17.5 mgd and the total heat discharged is 7.59 billion Btu per hour. At 1000 Mw, approximately 400,000 gal/day of water is discharged as blowdown to control the concentration of dissolved solids in the system. The blowdown water is discharged from the plant to the Scioto River through a pipeline. The temperature of the water as it enters the pipeline varies from 70° to 90°F, and the temperature at the discharge is approximately 10°F below this temperature. The increase in the river temperature resulting from the inflow of blowdown water is substantially less than 1°F, i.e., less than 0.05°F at 1000 Mw and low river flow. At 2260 Mw the increase would be less than 0.2°F.

3. Radioactivity

Radioactive materials present at a gaseous diffusion plant are primarily uranium and small concentrations of its daughter product, thorium 234. Radioactivity from the former is alpha and from the latter is beta-gamma. The radioactive compounds are carefully contained. Radioactive contamination, therefore, would result only from accidental releases or uranium compounds

Figure 4.
PORTSMOUTH GASEOUS DIFFUSION PLANT
GAS (●) AND LIQUID (▲) RELEASE POINTS

Figure 5. LOCATION OF SAMPLING POINTS

that are cleaned from equipment that is removed from the cascade. Losses from both are extremely small. Radioactive wastes generated in the decontamination and cleaning operation are discharged into a detention pond, where the waste uranium is precipitated chemically before the waste waters are discharged. The waste waters effluent from the detention pond are monitored carefully for radioactivity. At Portsmouth the monitoring location is identified as point 11 on Figure 5. Although this is the only discharge stream normally containing radioactive materials, the effluents from all the gaseous and liquid discharge points shown in Figure 4 are monitored or analyzed routinely for radioactivity. Also, the ambient atmosphere is monitored routinely. Summaries of the radioactivity data, along with applicable standards, are presented in Table I (air samples) and Table II (water samples). Background radioactivity data are presented in Table III.

The highest concentration of alpha activity in water at the Portsmouth plant was found in the discharge from the detention pond at station 11. (Chemical precipitation equipment being installed will effectively prevent discharge of radioactive materials from the detention pond in the future.) The highest concentration there in 1971 corresponded to 1.11% of the concentration guide set by the AEC¹; the average concentration for the year was only 0.45% of the concentration guide. The highest beta-gamma activity for the same place during the same period was 43.9% of the AEC concentration guide; the average was 4.6%. Airborne radioactivity similarly is well controlled. The maximum concentrations of alpha activity and beta-gamma activity detected during 1971 were only 13% and 0.2% of the AEC concentration guide, respectively; average alpha and average beta-gamma concentrations for the year were 1% and 0.04% of the concentration guide, respectively.

Some scrap materials that cannot be decontaminated are buried in a solid-waste burial yard. The yard is fenced to prevent unauthorized entry, and the test wells drilled in the vicinity of the yard are monitored routinely to assure that radioactivity is not leaching through the soil.

4. Solids

Solid wastes are disposed of by incineration, by burial, and by sale for recycle. Those scrap materials that can be economically recovered and disposed of without breach of security are offered for sale to the highest bidder according to normal government regulations. Aluminum scrap, however, is first melted and cast into ingots before sale. Scrap that cannot be adequately decontaminated (removal of radioactivity) is not

¹AEC Manual Chapter 0524 (and its Appendix). These concentration guides are identical to Title 10, Code of Federal Regulations, Part 20.

Table I
RADIOACTIVITY IN AIR SAMPLES*
CY 1971

Location	Number of Samples	Alpha			Beta-Gamma		
		Highest Values x 10 ⁻¹³ μ Ci/ml	Averages		Highest Values x 10 ⁻¹³ μ Ci/ml	Averages	
			x 10 ⁻¹³ μ Ci/ml	Percentage of RCG**		x 10 ⁻¹³ μ Ci/ml	Percentage of RCG***
3	143	5.3 + 2.7	0.4 + 0.1	0.88	16.6 + 4.2	4.0 + 0.7	0.04
12	144	5.0 + 2.5	0.4 + 0.1	0.88	21.1 + 5.3	4.4 + 0.8	0.04
24	143	5.3 + 2.7	0.5 + 0.1	1.20	20.3 + 5.2	4.3 + 0.8	0.04
29	138	4.8 + 2.4	0.5 + 0.1	1.15	19.3 + 4.8	4.3 + 0.8	0.04

*Limit of sensitivity: 1.61×10^{-14} μ Ci/ml

**Radioactivity Concentration Guides (AEC Manual Chapter 0524): 40×10^{-13} μ Ci/ml

***R.C.G.: $10,000 \times 10^{-13}$ μ Ci/ml

Table II

RADIOACTIVITY IN WATER SAMPLES

CY 1971

Alpha Activity*					
Location	Number of Samples	Water Flow Rate ft ³ /sec	Highest Values x 10 ⁻⁸ µCi/ml	Averages	
				x 10 ⁻⁸ µCi/ml	Percentage of RCG***
1	12	7129	0.41 + 0.27	0.25 + 0.24	0.008
2	12	Not Meas.	6.30 + 1.07	1.01 + 1.19	0.03
3	31	0.4	0.45 + 0.27	0.11 + 0.05	0.004
4	11	Not Meas.	1.35 + 0.45	0.23 + 0.31	0.008
5	12	Not Meas.	0.45 + 0.27	0.27 + 0.22	0.009
6	41	7129	4.05 + 0.85	0.36 + 0.27	0.01
7	15	4.3	20.70 + 1.86	8.48 + 2.70	0.28
8	15	4.3	12.15 + 1.46	6.98 + 1.47	0.23
10	30	0.4	0.90 + 0.41	0.25 + 0.09	0.008
11	30	1.8	33.30 + 2.33	13.62 + 3.48	0.45
12	11	Not Meas.	0.32 + 0.23	0.11 + 0.10	0.004
13	12	Not Meas.	8.10 + 1.22	2.28 + 1.38	0.08
14	12	7129	0.90 + 0.41	0.35 + 0.18	0.01
Beta-Gamma Activity**					
1	12	7129	3.0 + 2.7	1.2 + 0.8	0.06
2	12	Not Meas.	7.6 + 4.1	1.0 + 1.4	0.05
3	32	0.4	4.0 + 3.0	0.9 + 0.4	0.04
4	11	Not Meas.	5.8 + 3.6	1.4 + 1.1	0.07
5	12	Not Meas.	3.2 + 2.7	0.9 + 0.7	0.04
6	41	7129	20.7 + 6.8	1.0 + 1.0	0.05
7	15	4.3	175.5 + 19.0	80.6 + 36.7	4.03
8	15	4.3	163.4 + 20.0	56.3 + 25.2	2.82
10	31	0.4	9.0 + 4.5	1.2 + 0.7	0.06
11	31	1.8	878.0 + 43.9	92.2 + 71.1	4.61
12	11	Not Meas.	2.7 + 2.5	0.8 + 0.5	0.04
13	12	Not Meas.	34.6 + 8.7	14.0 + 7.3	0.70
14	12	7129	7.6 + 4.1	1.7 + 1.4	0.08
*Limit of sensitivity: 0.05 x 10 ⁻⁸ µCi/ml			***R.C.G. (α) : 3,000 x 10 ⁻⁸ µCi/ml		
**Limit of sensitivity: 0.5 x 10 ⁻⁸ µCi/ml			(β-γ) : 2,000 x 10 ⁻⁸ µCi/ml		

Table III
BACKGROUND* RADIOACTIVITY**
CY 1971

Location	Number of Samples	Highest Rates mR/hr	Average Rates mR/hr	Total*** Activity mR
3	131	0.0221 + 0.0033	0.0112 + 0.0004	98.1 + 3.5
12	135	0.0186 + 0.0028	0.0104 + 0.0004	89.4 + 3.4
24	136	0.0788 + 0.0118	0.0135 + 0.0016	119.1 + 14.1
29	130	0.0257 + 0.0039	0.0121 + 0.0005	106.0 + 4.3

*Open-shield geiger tube at three feet above ground level.

**Limit of sensitivity: 1.0×10^{-4} mR/hour

***Total for year

Note: Average background rate for the Portsmouth Gaseous Diffusion Plant in 1954 was 0.0119 mR/hr, not significantly different from present rates.

offered for sale, but, rather, is buried in a fenced-in burial yard. Contaminated burnable scrap is incinerated to permit recovery of uranium (the incinerator effluent is filtered). Classified documents also are incinerated. Other solid wastes are disposed of in a sanitary landfill.

5. Liquids

Most of the wastes leaving a gaseous diffusion plant are materials dissolved in water. The liquid effluents from the Portsmouth plant are discharged through Little Beaver Creek, through Big Run, through a drainage ditch discharging into the Scioto River, and through two pipelines that discharge into the Scioto River.

Waste waters containing sludges from the water treatment plant are discharged into lagoons, where the sludges settle and the supernatant soft water flows into Little Beaver Creek. The discharge is continuous; the average discharge rate at a plant power level of 1000 Mw is approximately 130,000 gpd, and at the 2265 Mw power level is about 260,000 gpd. The average pH of the water influent to the lagoons ranges between 8.5 and 9.5; effluent water, as a result of dilution from precipitation and surface runoff, has a pH of approximately 8.

Most of the waters flowing through the west drainage ditch (point 8 in Figure 4) to the Scioto River result from surface drainage. Average flow through the drainage ditch is about 96 million gal/yr.

The effluent flowing into Big Run (point 7 in Figure 4) discharges from a detention pond. The pond collects surface drainage, wastewaters from the administration building air-conditioning system, leaching liquors from the coal storage yard, and waste waters from the steam plant. Sulfuric acid is used in the steam plant to regenerate hydrogen zeolite water softeners. The effluent from these softeners is neutralized in a neutralization pit before discharge into the detention pond. Sodium chloride is used to regenerate the sodium zeolite ion exchange water softeners; and the effluent from these softeners is discharged directly to the detention pond. Sodium sulfite is used to consume the free oxygen in the boiler water. It is converted to sodium sulfate in the process and is drained to the detention pond. Sodium hydroxide is used to adjust the pH of the boiler feed water; and the alkaline effluent from the plant serves to adjust the pH of the otherwise slightly acidic water in the detention pond. The annual volume of water discharged from the detention pond is approximately 100 million gallons.

The waters flowing into Little Beaver Creek from the east drainage ditch (point 9 in Figure 4 and station 11 in Figure 5)

have several sources: surface drainage, the dry air plant, the nitrogen plant, and the X-701B detention pond. The detention pond receives part of the water from the laundry and the liquid wastes from the decontamination and cleaning facilities; the water in the pond is treated chemically to precipitate uranium. Sodium hydroxide is used in the nitrogen plant to scrub carbon dioxide from the incoming air. After approximately 150 hours of use, the sodium hydroxide in this solution has converted almost entirely to sodium carbonate; this solution becomes a part of the effluent from the nitrogen plant. Surface drainage contributes about 31 million gallons per year, the X-701B pond contributes 27 million gallons per year, and the nitrogen and dry air plants contribute 365 million gallons per year, resulting in a total flow into Little Beaver Creek of 423 million gallons per year.

A system of ditches drains surface water from the north end of the plant; a single collection ditch discharges the water to Little Beaver Creek north of the plant. Condensate (hot water) from the feed-vaporization facility also discharges into one of the ditches. Also, the water in the ditches may be contaminated with traces of oil from an electrical switchyard, with small quantities of fluoride that have escaped reaction in a neutralization pit, and with chromate-containing water that sprays from a cooling tower.

All the sanitary sewage and a portion of the laundry (point 11 in Figure 4) discharge flow through a sewage treatment plant where they receive both primary and secondary treatment as well as postchlorination before being piped (point 12 in Figure 4) to the Scioto River. The effluent from the plant is analyzed regularly to assure that its quality meets the standards established by the Ohio Water Pollution Control Board. The principal analyses are biochemical oxygen demand (B.O.D.), dissolved oxygen, suspended solids, and pH. Chlorine additions are regulated to assure that excessive free chlorine is not present in the ultimate discharge to the river.

Water used in the recirculating-water cooling system is softened and then treated with a proprietary corrosion-inhibitor formulation (Orocol) containing dichromate, polyphosphate, zinc sulfate, and sodium acid sulfate. This treatment provides a relatively non-corrosive, film-forming water containing approximately 20 ppm chromate (approximately 9 ppm Cr^{+6}). During continuous recycling of the water and evaporation from the cooling towers, the concentration of dissolved solids increases. This increase is limited to a specified value through continuous discharge (blowdown) of a regulated volume of water piped (point 10 in Figure 4) to the Scioto River. The blowdown rates at the 1000 Mw and

2260 Mw levels are approximately 400,000 gpd and 1,300,000 gpd, respectively.¹ The concentrations of contaminants in the blowdown water are shown in Table I; in addition, ranges of total phosphate and total sulfate concentration in the blowdown are 1.5 - 2.2 ppm and 1500 - 1800 ppm, respectively. These data were collected during calendar year 1971, a period during which the corrosion-inhibitor formulation contained sodium fluoride. Current concentrations of fluoride in the RCW discharge are less than the values shown because sodium fluoride no longer is used.

Other waste liquids are treated variously. Waste chemicals from the laboratory are treated in a detention-neutralization pit before discharge into the sanitary sewer system. Non-contaminated waste oils that do not contain environmentally persistent toxic chemicals are used for dust control purposes, e.g., road surfaces. Spent electrolyte from the fluorine generation plant, which is mostly potassium fluoride, is washed from the generators (approximately 150 gallons per year) into a limestone neutralization pit.

Standards for concentrations of pollutants in effluents have not been established. For comparison purposes, however, stream quality standards for potable water supplies are shown in Table IV along with the pollutant concentrations for the four major discharge streams. Table V shows pH, Cr⁺⁶, and fluoride data (1971) for all the water sampling stations.

6. Gases and Airborne Materials

Hydrogen fluoride is dissociated by electrolysis in the manufacture of the fluorine that is used to convert oxides of uranium to uranium hexafluoride that may be fed into the diffusion cascade. Small quantities of hydrogen fluoride are present in both the hydrogen and the fluorine streams. The hydrogen stream is vented to atmosphere after passing through a scrubber that removes approximately 95% of the HF. The scrubber effluent liquor is discharged through a neutralization pit. HF in the fluorine stream is trapped by adsorption; it subsequently is desorbed thermally, scrubbed from the system, and neutralized in a limestone neutralization pit. A measurable excess of fluorine is required for the feed-preparation reaction, and this excess currently is disposed of through venting to the atmosphere (Portsmouth plant: point 6 in Figure 4). Average concentrations of fluorine found in the ambient environment at the Portsmouth plant are less than 1 ppb, a concentration recognized as a safe limit in the two states that have established standards; fluoride data for 1971 are presented in Table VI.

¹Included in the FY 1974 budget, now subject to Congressional approval, is a central liquid waste disposal facility that will reduce the hexavalent chromium concentration in the blowdown from 9 ppm to about 0.05 ppm.

Table IV

CONCENTRATIONS OF POLLUTANTS CONTAINED IN LIQUID WASTE STREAMS DURING 1971

	Fluorides (mg/l)		Chromium (Cr ⁺⁶) (mg/l)		Zinc (mg/l)		Mercury (mg/l)		Nitrates (mg/l)		Uranium (mg/l)		pH	
Standards*	1.0		0.05		5.0		0.005		45		60		8.5 - 6	
	<u>Max.</u>	<u>Avg.</u>	<u>Max.</u>	<u>Avg.</u>	<u>Max.</u>	<u>Avg.</u>	<u>Max.</u>	<u>Avg.</u>	<u>Max.</u>	<u>Avg.</u>	<u>Max.</u>	<u>Avg.</u>	<u>High</u>	<u>Low</u>
Discharge Stream														
1. West Drainage Ditch (Station 10)	0.4	0.2	0.01	<0.01	0.4	0.1	U.D.**	U.D.	n.d.***	n.d.	0.019	0.005	8.5	7.7
2. Big Run Station 3)	0.3	0.2	0.01	<0.01	0.8	0.3	U.D.	U.D.	n.d.	n.d.	0.009	0.002	8.6	6.9
3. Ditch to Little Beaver Creek (Station 11)	3.9	0.6	0.13	0.03	0.4	0.1	U.D.	U.D.	11.0	2.3	0.400	0.052	8.7	7.2
4. Pipeline for Recirculating Cooling Water Blowdown	4.3	4.0	10.8	9.4	2.7	2.2	U.D.	U.D.	n.d.	n.d.	n.d.	n.d.	6.4	6.1

*These are applicable stream quality standards for potable water supplies, not for effluents (see Appendix A); standards for effluents have not been established.

**U.D., not detected

***n.d., not discharged to this stream

Table V
WATER SAMPLES, pH AND SELECTED CONSTITUENTS
CY 1971

Location	Number of Samples	Water Flow Rates ft ³ /sec	pH*	
			Highest Values pH	Lowest Values pH
1	12	7129	8.6	7.5
2	12	Not Meas.	8.1	7.4
3	33	0.4	8.6	6.9
4	11	Not Meas.	7.9	7.4
5	12	Not Meas.	8.0	7.4
6	41	7129	8.7	7.6
7	15	4.3	8.4	7.8
8	15	4.3	8.6	7.9
10	31	0.4	8.5	7.7
11	31	1.8	8.7	7.2
12	11	Not Meas.	7.9	7.6
13	12	Not Meas.	8.5	7.6
14	12	7129	8.5	7.8

*Limits of sensitivity: pH, 0.1
Fluorides, 0.1 mg/l
Chromium (hexavalent), 0.01 mg/l

Standards for potable
water supplies: Fluorides, 1.0 mg/l, Ohio Water Pollution
Control Board, 4/14/70
Chromium (hexavalent), 0.05 mg/l, Ohio
Water Pollution Control Board, 4/14/70
pH, 6-8.5, Ohio Water Pollution Control
Board, 4/14/70

Table V (Continued)

WATER SAMPLES, pH AND SELECTED CONSTITUENTS

CY 1971

Fluorides*			Chromium (Cr ⁺⁶)*		
Highest Values mg/l	Averages		Highest Values mg/l	Averages	
	mg/l	% of Applicable Standards		mg/l	% of Applicable Standards
0.70 + 0.10	0.40 + 0.08	40	0.01 + 0.01	<0.01	<20
0.30 + 0.10	0.18 + 0.04	18	UD	UD	-
0.30 + 0.10	0.22 + 0.02	22	0.01 + 0.01	0.01	20
0.10 + 0.10	0.08 + 0.03	8	UD	UD	-
0.10 + 0.10	0.09 + 0.02	9	0.01 + 0.01	<0.01	<20
1.10 + 0.11	0.43 + 0.05	43	0.04 + 0.01	<0.01	<20
1.00 + 0.10	0.55 + 0.13	55	0.04 + 0.01	0.02 + 0.01	40
0.80 + 0.10	0.47 + 0.10	47	0.08 + 0.01	0.04 + 0.02	80
0.40 + 0.10	0.22 + 0.02	22	0.01 + 0.01	<0.01	<20
3.90 + 0.39	0.58 + 0.28	58	0.13 + 0.02	0.03 + 0.01	60
0.10 + 0.10	0.08 + 0.03	8	UD	UD	-
0.40 + 0.10	0.22 + 0.07	22	0.03 + 0.01	0.01 + 0.01	20
1.00 + 0.10	0.65 + 0.11	65	-	0.004**	8

**Calculated value, assuming instantaneous complete mixing of the RCW effluent and one-half of the river (Scioto) flow at low river stage.

Table VI
FLUORIDES* IN AIR SAMPLES
CY 1971

<u>Location</u>	<u>Number of Samples</u>	<u>Highest Concentrations, ppb</u>	<u>Averages, ppb</u>
3	144	5 + 0.4	1.0 + 0.2
12	144	5 + 0.4	0.8 + 0.1
24	146	4 + 0.3	0.8 + 0.1
29	138	5 + 0.4	0.8 + 0.1

*Limit of detection: 0.6 ppb through November; 0.3 ppb since December 1.
No present standards in Ohio; expected standard: 1 ppb.

Table VII
SO₂ IN AIR SAMPLES*
CY 1971

<u>Location</u>	<u>Number of Samples</u>	<u>Highest Concentrations μg/M³</u>	<u>Averages</u>	
			<u>μg/M³</u>	<u>% of Applicable Standards**</u>
3	143	466 + 70	29 + 9	48
12	144	354 + 53	42 + 10	70
24	148	210 + 32	28 + 6	47
29	140	142 + 21	28 + 6	47

*Limit of detection: 1 μg/M³

**National Secondary Standard (40 CFR Part 50) and State of Ohio Standard.

Although the process gas is pure uranium hexafluoride, other gases intrude into the system, e.g., refrigerant (Freon) in-leakage when a cooler fails. These contaminants accumulate in the cascade and are routinely removed and disposed of through chemical degradation, trapping, chemical reaction, or, in some cases, by venting (Portsmouth plant: points 1 and 2 in Figure 4). Where massive inleakage of air occurs during equipment failure, the air is removed from the cascade through cold recovery systems, the air being vented (Portsmouth plant: points 3 and 4 in Figure 4) to atmosphere and the uranium being trapped in chemical traps and cold traps. These various vents are monitored continuously to assure that contaminants are not emitted to the atmosphere. Routine monitoring has shown that such careful control has been successful.

Anytime uranium hexafluoride is moved from one containment device to another there is a possibility of accidental release. However, the environmental impact of such releases is very small because uranium hexafluoride reacts quickly with the moisture in the atmosphere and forms an easily recoverable solid. Where UF_6 is handled routinely, such as in the Portsmouth sampling facility (point 5 in Figure 4), ventilation systems are equipped with mechanical traps and with monitoring systems to detect radioactive contamination. When equipment containing refrigerant fails or is removed from service for maintenance or replacement, the refrigerant normally is evacuated from the system. However, some small quantities of residual refrigerant do escape through vaporization into the atmosphere. These contaminants have not been detected in the plant environment.

Before replacement equipment for the cascade is installed and exposed to the process gas, it, like the initial equipment, is given a conditioning treatment to minimize corrosion. The quantities of fluorides lost from the conditioning system are small and are not detectable outside of this facility during operation.

The only large quantity of organic solvent, trichloroethylene, is kept in one large cleaning tank. The tank normally is covered, and provisions are made for recovering the largest portion of the solvent vapor. A small portion of the vapor, however, does escape, but does not violate existing state standards.

The steam plant is the major source of environmental contaminants at the Portsmouth Gaseous Diffusion Plant. Approximately 46,000 tons of 3% sulfur coal are burned per year to satisfy a steam demand averaging 104,000 pounds per hour, resulting in emissions of sulfur dioxide, particulate matter, and nitrogen oxides. The average emission rate of nitrogen oxide is 105 pounds per hour. Sulfur dioxide and particulate matter emissions are governed by the State according to the quantity produced per million Btu input. Current emissions of particulate matter at the Portsmouth plant are in the neighborhood of 0.17 pound

per million Btu input, a value within that permitted through July 1, 1975; at that date, emissions standards for the gaseous diffusion plant at Portsmouth will become 0.13 pound per million Btu, making modification of the steam plant or of operating procedures necessary in order to comply with that stricter standard. SO₂ emission rates average slightly under 6 pounds per million Btu input and are in excess of the standards promulgated by the Ohio Air Pollution Control Board. The use of fuel containing concentrations of sulfur lower than 3% is expected to correct the condition. SO₂ concentrations detected in the ambient air from the burning of 3% sulfur coal during 1971 are shown in Table VII.

As the recirculating cooling water passes over the cooling towers, a portion is carried into the air as fine droplets of mist. Upon evaporation of the water, solids that had been dissolved are lost in the drift and become airborne particulate matter. Chromium, at a concentration of 9 mg/l, is contained in the water. However, there is no dependable means of measuring the concentration and the total quantity of the chromium being discharged into the atmosphere. Also, there has been no resolution of the effect of concentrations and quantities of chromium upon the environment.

VI. ADVERSE ENVIRONMENTAL IMPACT OF CREDIBLE ACCIDENTS

The gaseous diffusion plants are designed with extensive safeguard systems to minimize the probability of accidents and to minimize the effects and extent of an accident. In the evaluation of credible accidents at the Portsmouth Gaseous Diffusion Plant, only a major HF release could cause a significant impact on the environment.

Uranium-235 can self-sustain a nuclear reaction under certain conditions. However, at the gaseous diffusion plants equipment is designed and constructed and controls are employed to assure that those conditions are never reached. Equipment size and spacing is controlled to keep all mass quantities of U-235 below those needed for a critical reaction. Moderating impurities in the process are controlled carefully. The density of UF₆, e.g., when accidentally depositing as a solid, is carefully monitored and controlled in the cascade to prevent massive accumulation, and administrative procedures are followed carefully. Evidence of this care is demonstrated in the fact that there has never been a critical reaction occur at a gaseous diffusion plant. It is important to note, nevertheless, that where critical reactions have occurred elsewhere through accident, all the adverse effects were highly localized and there was no explosion to spread radioactive contamination. Where a critical reaction does occur, radiation exposures within a few feet of the reaction can be lethal, but assured safety accompanies distance. At the Portsmouth Gaseous

Diffusion Plant there is no possibility that a critical reaction could cause damaging radiation off plantsite.

Accident analyses made at the Portsmouth Gaseous Diffusion Plant have indicated clearly that the potential hazards of an inadvertent release of anhydrous hydrofluoric acid are greater than the hazards from any other type of accident. Although it is highly unlikely, it is possible that large quantities of anhydrous HF could be lost from containment, perhaps resulting from a misvalving accident or an accident in pumping operations. As in the case of a critical reaction, distance lends safety.

The borders of the plant property are about a mile away, in every direction, from the location of the large quantities of anhydrous hydrofluoric acid. For a lethal plume of 1000 mg/M^3 of HF to extend that far, directly downwind, under average weather conditions (wind velocity about 3.6 M/sec) would require a release, and vaporization over a period of 15 minutes, of 35,000 pounds of anhydrous HF. Under the same weather conditions and vaporization rate, a release of about 88 pounds of anhydrous HF would yield a concentration of 2.5 mg/M^3 --the 8-hour day tolerance limit--at a distance of one mile. The occurrence of such an accident is highly remote. An empty storage tank is constantly available for containing anhydrous HF; if an in-service tank becomes damaged (except for severe rupture), the HF can be pumped quickly from the damaged tank into the spare one. Also, the entire stage area around the tanks is diked to prevent spread of any release HF; thus the surface area would be restricted and the rate of evaporation would be kept very low. In addition, the containment by the dikes provides for relatively easy neutralization of the HF. So, in almost any event the adverse effects of an HF release also would be highly localized. The tanks and transfer system are inspected regularly to assure safe operation.

APPENDIX

Biological Impact, Adverse Effects of Pertinent Environmental Contaminants

Fluoride in Air. Biological injury from gaseous fluorides can result from accumulation in plants and subsequent ingestion by animals. Since plants exhibit species sensitivity to fluoride, injury to vegetation depends upon the species of plant, plant maturity, adsorption capacity, fluoride concentration, and duration of exposure, as well as weather and soil conditions and availability of nutrients. The extent of injury also depends upon the rate of fluoride adsorption, i.e., the plants can tolerate larger accumulations of fluoride if adsorbed more slowly over extended periods. The minimum ambient concentration having significant effects upon fluoride accumulation in forage crops appears to be slightly greater than 1 ppb.

Nitrogen Oxides in Air. Excessive concentration of nitrogen oxides in the air can be damaging to plants, but the concentrations of nitrogen oxides capable of causing such damage have not been determined precisely. Products of reactions involving nitrogen oxides are known to have caused corrosion and failure of metal parts. The principal adverse effect upon human health is an increased incidence of acute respiratory disease. Again, the minimum concentrations capable of causing damage have not been identified precisely. The national ambient air quality standard for public health and welfare is 0.05 ppm, annual arithmetic mean.

Sulfur Dioxide and Particulate Matter in Air. Sulfur dioxide adsorbed by plants can produce both visible leaf injury and chlorosis. The extent of the injury, of course, depends on the concentration of sulfur dioxide in the ambient air. Since plants exhibit species sensitivity to sulfur dioxide, some varieties of plants are injured more quickly and more extensively than others. Acute injury can occur to some trees and shrubs at concentrations as low as 0.3 ppm.

Man and various animals respond to excessive concentrations of sulfur dioxide in the air by developing bronchial constriction. Most persons exhibit respiratory irritations when the sulfur dioxide concentration is 5 ppm or above. Concentrations as low as 1 ppm are injurious to certain sensitive individuals.

The national primary ambient air quality standards--those necessary to protect the public health--and the national secondary ambient air quality standards--those necessary to protect the public welfare--for SO₂ are stated as follows:

	<u>Primary</u>	<u>Secondary</u>
Annual arithmetic mean	80 µg/M ³	60 µg/M ³
Maximum 24-hour concentration	365 µg/M ³	260 µg/M ³
Maximum 3-hour concentration	---	1,300 µg/M ³

Primary and secondary ambient air quality standards for particulate matter are as follows:

	<u>Primary</u>	<u>Secondary</u>
Annual geometric mean	75 $\mu\text{g}/\text{M}^3$	60 $\mu\text{g}/\text{M}^3$
Maximum 24-hour concentration	260 $\mu\text{g}/\text{M}^3$	150 $\mu\text{g}/\text{M}^3$

Sulfuric acid is more irritating to man than is sulfur dioxide, and the effects of sulfuric acid depend greatly on particle size. Therein lies an adverse effect of particulate matter in the air. Particulate matter can participate in the oxidation of sulfur dioxide to sulfuric acid, thereby contributing to the adverse impact of sulfur dioxide through the greater irritation caused by sulfuric acid.

Trichloroethylene in Air. Trichloroethylene is not highly toxic. The ACGIH threshold limit value for an 8-hour working day is 100 ppm. Permissible environmental levels have not been set. The primary environmental effect is the interaction with oxides of nitrogen to form smog in highly polluted locales.

Radioactivity in Air or Water. Radiation causes damage to living cells through ionization, which can alter the cell structure and can also adversely affect a cell's ability to function normally. When radiation is extensive, tissues and entire body organs can be affected adversely. The extent of damage resulting from a "dose" of radiation depends on the length of time over which that dose was received.

The biological effects of radiation from uranium depend almost exclusively on whether the dose is internal or external to the body. External alpha radiation is absorbed almost completely by the dead layers of skin tissue. Internal radiation may result from inhalation or ingestion of either soluble or insoluble compounds of uranium. The body is capable of disposing of the soluble forms through normal elimination processes. Following ingestion or inhalation of soluble uranium compounds, approximately 90% of the soluble uranium is eliminated in the first 24 hours, the remainder having an effective half-life in the body of about 30 hours; significant concentrations of uranium cannot be detected after about 1 week. Insoluble uranium compounds are not eliminated so successfully, especially in the case of excessive inhalation. The uranium compounds normally reside in the lungs, and the effective half-life may be as great as 1000 days. Obviously, substantial damage can result because of the long retention in the body.

The AEC has established guides that state the concentrations of radioactivity that may be considered safe both in water and in air. Those levels for mixed-uranium-isotopes (alpha) radiation in water

and in air are 3.0×10^{-5} $\mu\text{Ci/ml}$ and 4×10^{-12} $\mu\text{Ci/ml}$, respectively. Concentration guides also have been set for beta and gamma radiation (radiation emanating from the daughter products of uranium radioactive decay); those limits for radioactivity in water and in air are 2.0×10^{-5} $\mu\text{Ci/ml}$ and 1×10^{-9} $\mu\text{Ci/ml}$, respectively.

Chlorine in Water. Concentrations of chlorine in water as great as 50 mg/l do not cause adverse effects in humans or land plants. The tolerable limit for aquatic plants is in the neighborhood of 3.0 mg/l. Some fresh water fish are affected adversely when exposed continuously to free chlorine concentrations greater than 0.03 mg/l.

Chromium in Water. Soluble chromium, either in the trivalent or hexavalent state, may be toxic to aquatic life. The toxicity varies widely with the valence state of chromium, the species of aquatic life, the temperature, and the chemistry of the water. The major problem encountered with chromium is that common to heavy metals: accumulation because of the body's inability to eliminate it. The concentration of chromium that is safe in natural streams appears to be 0.05 mg/l.

Dissolved Solids in Water. Waters containing as much as 4000 mg/l of dissolved solids may be used for drinking water; fresh-water fish and aquatic life are reported to tolerate 2000 mg/l. However, the U. S. Public Health Service (USPHS) specified a desirable limit of 500 mg/l on the basis of taste threshold.

Fluorides in Water. Fluorides in drinking water ranging in concentration from 0.8 to 1.5 mg/l are beneficial in reducing dental decay, especially in children. No harmful effects have been observed, other than mottling of teeth, at concentrations as great as 5 mg/l. Continuous, uniform concentrations as great as 1.5 mg/l do not interfere with aquatic life.

Mercury in Water. Mercury and its salts are toxic to humans and to aquatic life. Lethal concentrations for some fish are as low as 0.01 mg/l. Potable water supply standards for Ohio state a limit of 0.005 mg/l.

Nitrates in Water. Excess nitrates in water cause irritation of the mucous lining of the gastrointestinal tract and have been found guilty of causing methemoglobinemia in infant humans and in livestock. Reported difficulties have been associated with water containing 50 mg/l or more of nitrate nitrogen (approximately 225 mg/l of NO_3). USPHS drinking water standard is 45 mg/l. The primary effect on aquatic life is the excessive growth of vegetation.

pH of Water. The Ohio water quality standards for fish and aquatic life limit pH to the range of 6 to 8.5. Deviations from these limits have varying effects on aquatic life depending on factors

such as the rate of pH change, the species of aquatic life involved, and the quality of the water body involved. The Ohio limit is conservative, representing an ideal which is often violated by natural phenomena such as runoff from decaying vegetation.

Uranium in Water. Most of the literature citing the effects of uranium in water deals with radiological problems. The chemical effects, other than those of certain specific salts of uranium, are not well known. Therefore, the principal hazard of uranium ingestion seems to be that common to heavy metals. The AEC concentration guides make allowance for chemical toxicity; these are stated under Radioactivity. For natural uranium the concentration corresponds to 60 mg/l.

Zinc in Water. Except at high concentrations, zinc does not cause adverse physiological effects in man or livestock, but concentrations as low as 0.1 mg/l can be lethal to fish in the absence of calcium, i.e., in soft water. The USPHS has set a limit of 5 mg/l as an acceptable concentration of zinc in potable water supplies.

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