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*Evolution of Environmental Control  
Technologies for Commercial Nuclear  
Fuel Conversion (UFC) Facilities*

LOS ALAMOS NATIONAL LABORATORY  
  
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This work was supported by the US Department of Energy, Office of Environment, Environmental and Safety Engineering Division.

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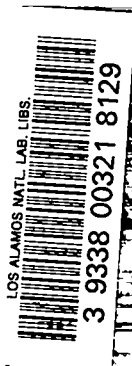
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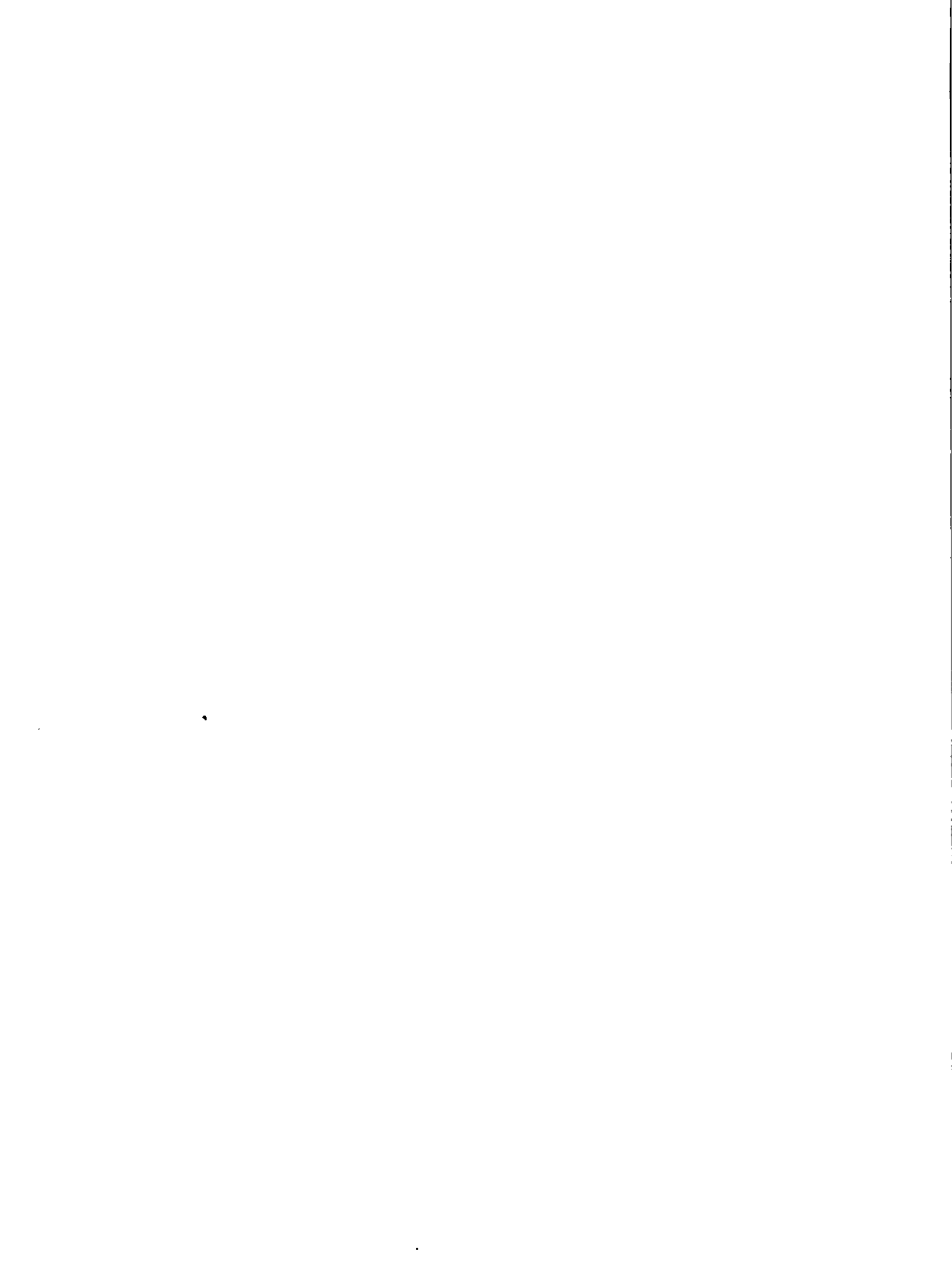
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Issued: October 1982

# Evaluation of Environmental Control Technologies for Commercial Nuclear Fuel Conversion (UF<sub>6</sub>) Facilities

B. L. Perkins





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# EVALUATION OF ENVIRONMENTAL CONTROL TECHNOLOGIES FOR COMMERCIAL NUCLEAR FUEL CONVERSION (UF<sub>6</sub>) FACILITIES

by

B. L. Perkins

## ABSTRACT

At present in the United States, there are two commercial conversion facilities. These facilities process uranium concentrate into UF<sub>6</sub> for shipment to the enrichment facilities. One conversion facility uses a "dry" hydrofluor process, whereas the other facility uses a process known as the "wet solvent extraction-fluorination" process. Because of the different processes used in the two plants, waste characteristics, quantities, and treatment practices differ at each facility. Wastes and effluent streams contain impurities found in the concentrate (such as uranium daughters, vanadium, molybdenum, selenium, arsenic, and ammonia) and process chemicals used in the circuit (including fluorine, nitrogen, and hydrogen), as well as small quantities of uranium.

Studies of suitable disposal options for the solid wastes and sludges generated at the facilities and the long-term effects of emissions to the ambient environment are needed.

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## CHAPTER I

### INTRODUCTION

#### A. Background Information

Uranium conversion facilities are a necessary component in the production of uranium fuel for commercial light water reactors. In the fuel production process, the uranium is originally mined (or recovered by *in situ* processes or as a by-product) from uranium-bearing host material. Except in *in situ* or by-product recovery processes, the uranium in the mined material is usually concentrated in mills located near the mines. This material, known as concentrate or "yellowcake," contains approximately 70-75% uranium and various impurities (depending on mill circuit and original concentrations of impurities in the ore).

The concentrate from the mills and concentrate (or slurry) from *in situ* and by-product recovery processes is sent to conversion facilities, where the uranium in the feed is converted into gaseous (at elevated temperatures) UF<sub>6</sub>. (This conversion to a gaseous compound is done because of the necessity to increase slightly the concentration of the <sup>235</sup>U isotope relative to the <sup>238</sup>U isotope. The only presently proven techniques for performing this "enrichment" use gases for this process.)

The UF<sub>6</sub> product from conversion is sent to the enrichment facilities for the desired increase in the <sup>235</sup>U isotope concentration.

At nuclear fuel fabrication facilities, the enriched UF<sub>6</sub> is converted to uranium dioxide powder. The powder is then densified/pelletized into fuel pellets. The pellets are loaded into long rods; the rods are assembled into fuel "bundles" and shipped to commercial nuclear reactors for use as reactor fuel.

At present in the United States, there are two privately operated uranium conversion facilities: the Metropolis Works operated by Allied Chemical and the Sequoyah facility operated by Kerr-McGee. The Allied facility uses a "dry" conversion process circuit, whereas the Kerr-McGee facility uses a "wet" conversion process. These facilities will be discussed in detail in the next two chapters.

## B. Report Objectives

As part of the evaluation of effluents/wastes relating to the commercial nuclear fuel cycle, the objectives of this report were to determine the process discharge streams produced by the  $UF_6$  conversion facilities, to determine how these streams are presently treated, to collect any publically available emission and monitoring data, to identify the final fate of these wastes, and to assess the adequacy of present waste treatment/disposal techniques and available data.

## C. Framework of Study

To determine the origin, quantity, and types of waste streams generated by the wet and dry processes, a complete block flow diagram for each facility was constructed using material published in environmental reports and similar sources of information. These flow diagrams were then used to try to identify inputs and outputs and thus the origin and composition of each type of waste stream. Next, the treatment techniques for each stream were identified and data on waste types, quantities, and types of disposal collected. Once a draft report of the description and waste data for a facility was complete, the report was sent to the company operating the facility for corrections. Each study was then used as the basis for specific recommendations.

## CHAPTER II

### ALLIED CHEMICAL—METROPOLIS WORKS

#### A. Background Information

From 1958-1964, Allied Chemical operated the Metropolis, Illinois  $UF_6$  production facility to supply feed for the Paducah Gaseous Diffusion plant under an Atomic Energy Commission (AEC) contract. In February 1968, to meet the demands of the commercial power reactor industry, the plant resumed operation, and the

$UF_6$  product has since been shipped to all three Department of Energy (DOE) operated enrichment facilities (Safety Evaluation Report—SER).

At present, Allied Chemical has processed, from concentrate produced internationally, over 200 million pounds of uranium. The current throughput capability is approximately 14 000 tons of uranium annually (Concentrate Sampling—CS).

Purities of 99.99%  $UF_6$  are consistently achieved at the facility; hence, the product exceeds all current enrichment product standards and will most likely be able to meet any upgraded standards set in the future ( $UF_6$  Conversion— $UF_6$ -C). Thus, plant lifetime is expected to be at least another 30 years (Order to Modify License, Amendment No. 4—OML).

If concentrate is to be shipped elsewhere for conversion, Allied offers a uranium concentrate sampling service (CS). Allied Chemical also offers its customers an extensive  $UF_6$  storage service (Custom  $UF_6$  Storage—C  $UF_6$  S).

In addition to  $UF_6$  production and associated activities, Allied has the capacity to manufacture approximately 30 000 lb/wk of liquid fluorine, 1200 ton/yr of sulfur hexafluoride, 2500 lb/wk of antimony pentafluoride, and 10 000 lb/wk of iodine pentafluoride at the Metropolis Works (Environmental Impact Appraisal 1977—EIA 1977). The Metropolis Works is the free world's largest producer of both liquid fluorine and sulfur hexafluoride (Hosey and Hill 1980; Kostick and De-Fillippo 1980). Figure II-1 indicates a plot plan of the facility

The Metropolis Works is located on an 862.3-acre tract bounded on the southwest by the Ohio River. A section of the southeast property boundary is contiguous with the town limits of Metropolis (EIA 1977).

The area is semirural. Close industrial sites include the AEP coal blending plant, the Shawnee Steam Plant, and the Paducah gaseous diffusion plant (EIA 1977). Approximately 450 people are employed at the facility.

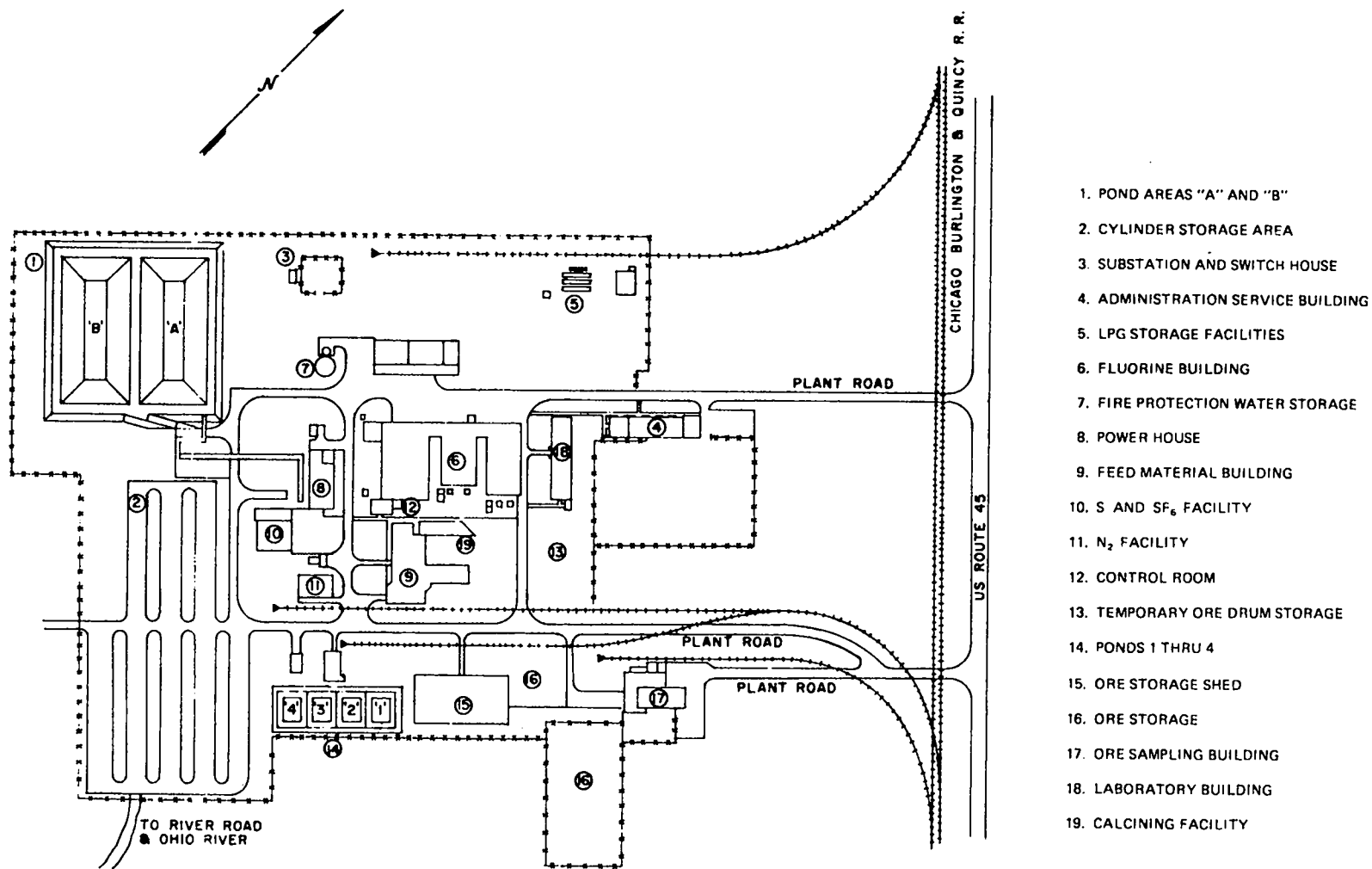
Further data on land use, population, geology, hydrology, and other background characteristics may be obtained from the Environmental Impact Appraisal.

#### B. Normal Processes Having Waste and Effluent Streams

##### 1. Introduction

The Allied facility uses the fluoride volatility process to produce  $UF_6$  from uranium concentrates. The facility does not accept uranium slurries.





1. POND AREAS "A" AND "B"
2. CYLINDER STORAGE AREA
3. SUBSTATION AND SWITCH HOUSE
4. ADMINISTRATION SERVICE BUILDING
5. LPG STORAGE FACILITIES
6. FLUORINE BUILDING
7. FIRE PROTECTION WATER STORAGE
8. POWER HOUSE
9. FEED MATERIAL BUILDING
10. S AND SF<sub>6</sub> FACILITY
11. N<sub>2</sub> FACILITY
12. CONTROL ROOM
13. TEMPORARY ORE DRUM STORAGE
14. PONDS 1 THRU 4
15. ORE STORAGE SHED
16. ORE STORAGE
17. ORE SAMPLING BUILDING
18. LABORATORY BUILDING
19. CALCINING FACILITY

Fig. II-1. Plot plan of the Metropolis site.

When the 55-gallon-drummed concentrate is received, it is weighed, sampled, and analyzed for moisture content. After feed preparation, mechanically sized particles ( $U_3O_8$ ) are reacted with hot cracked ammonia to form uranium dioxide ( $UO_2$ ). This compound is in turn reacted with vaporized anhydrous hydrofluoric acid to form uranium tetrafluoride ( $UF_4$ ) or green salt. Next, the green salt is combined at high temperature in a fluidized bed with gaseous fluorine to form the gas  $UF_6$ . Finally, the  $UF_6$  off-gas stream is further purified by condensation and fractional distillation (EIA 1977).

Each of these steps, with the resulting waste and effluent streams, is discussed in detail in the following sections.

## 2. Receiving and Sampling

The concentrate is received into the plant in 55-gallon drums. The drums are stored outside on specially constructed pads designed to avoid ground water contamination. Rain water from the pad area drains to central collection sumps and is then pumped to uranium spill control ponds\* (OML). Uranium contaminated storm water is also discharged to these ponds. The sludges are allowed to settle, and the decantate is discharged to the main discharge outfall for the plant. There is a sampling station for measuring flow rates (approximately 40 gpm) and obtaining a 24-h composite sample located at a point before the discharge is combined with other discharges at the main discharge outfall. When the minimum freeboard is reached (approximately 2 ft) on a pond, the pond is dredged and the sludge is sent to the pond sludge calciner

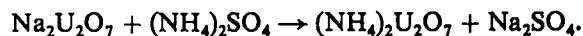
Drums are weighed, and a falling stream method is used to obtain a representative sample (CS). The samples are taken by customer lot to ensure that each customer's concentrate is recorded adequately. The airborne dusts generated in the sampling process are removed through the use of two baghouses in series, which discharge through the 1-3 stack (EIA 1977). Empty drums are aircleaned, with the dust discharge being collected in two baghouses and the cleaned discharge exiting through the 1-11 stack. Details of receiving, sampling, and drum cleaning are given in Figs. II-2 and II-3. All residues from the collection devices are combined with the other concentrates of the customer and drummed until further processing (EIA 1977).

If the samples indicate that the concentrates contain a high percentage of sodium (because of the particular mill circuit used to produce the concentrate), the concentrates are sent to the sodium-removal facility before they are received into the main processing circuit (EIA 1977).

## 3. Sodium Removal (Pretreatment)

Because sodium forms a compound that causes caking and sintering in the fluorination fluid beds, any incoming uranium concentrates containing sodium and all the

uranium concentrates produced by the uranium recovery sections of the  $UF_6$  facility must first have the sodium or potassium removed before they can be processed (Sears et al. 1977). These concentrates are treated by reaction with a solution of  $(NH_4)_2SO_4$  in four counter-current vessels (Fig. II-4). The chemical reaction is



The liquid effluent contains the excess  $(NH_4)_2SO_4$ ,  $Na_2SO_4$ ,  $K_2SO_4$ , and uranium and small quantities of  $^{226}Ra$ ,  $^{230}Th$ , selenium, molybdenum, and other trace impurities. This effluent is sent to the two uranium spill control ponds\* (OML). Uranium contaminated storm water is also discharged to these ponds. The sludges are allowed to settle, and the decantate is discharged to the main discharge outfall for the plant. There is a sampling station for measuring flow rates (approximately 40 gpm) and obtaining a 24-h composite sample located at a point before the discharge is combined with other discharges at the main discharge outfall. When the minimum freeboard is reached (approximately 2 ft) on a pond, the pond is dredged and the sludge is sent to the pond sludge calciner

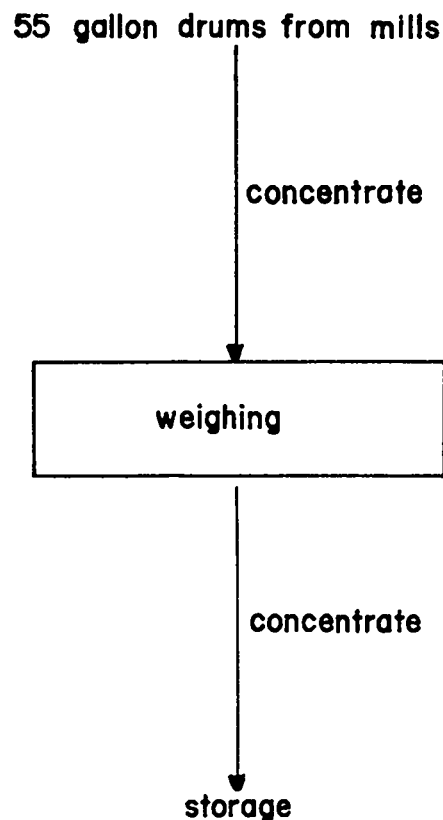


Fig. II-2. Receiving.

\*See Fig. II-14.

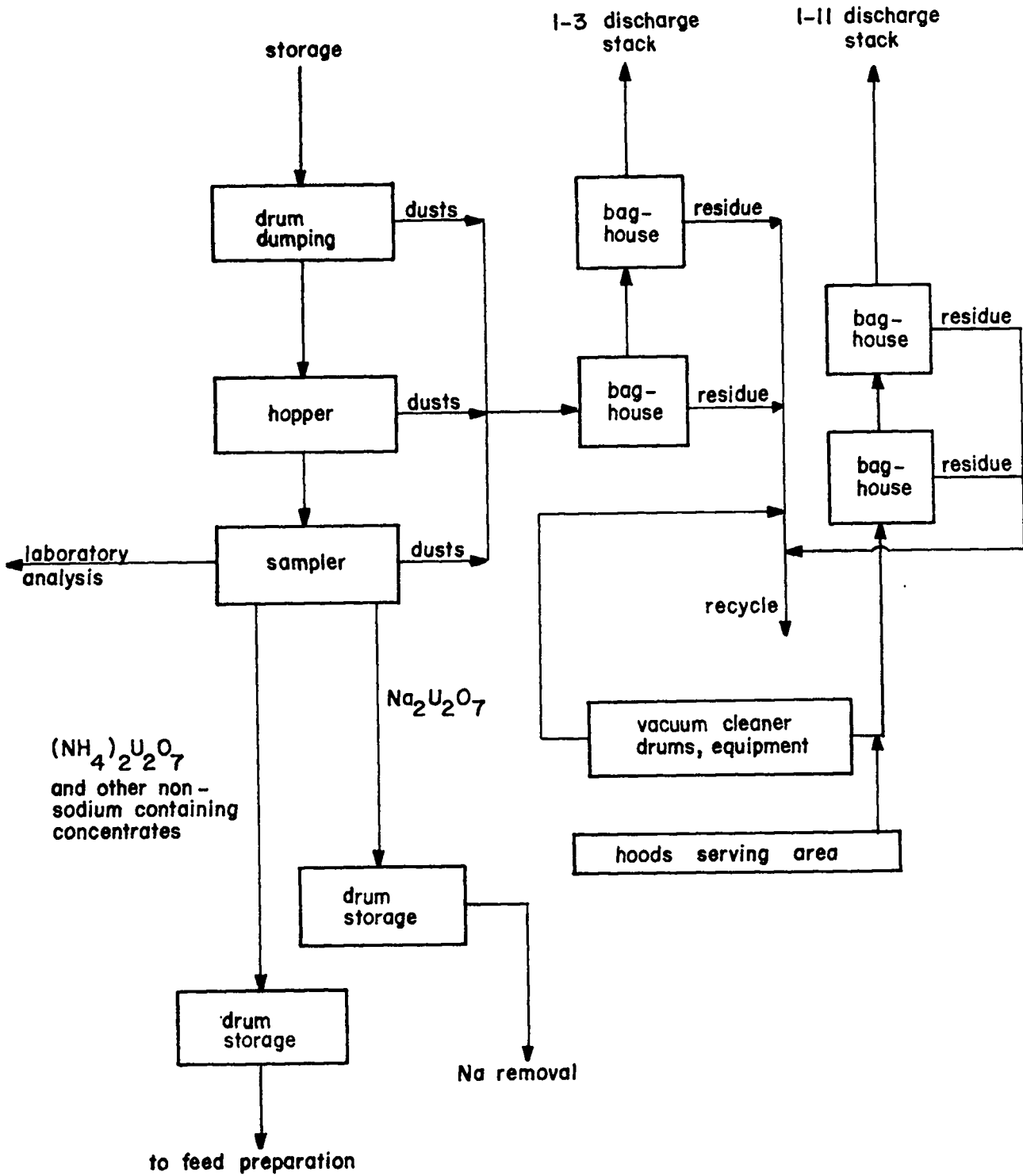


Fig. II-3. Sampling and cleaning.

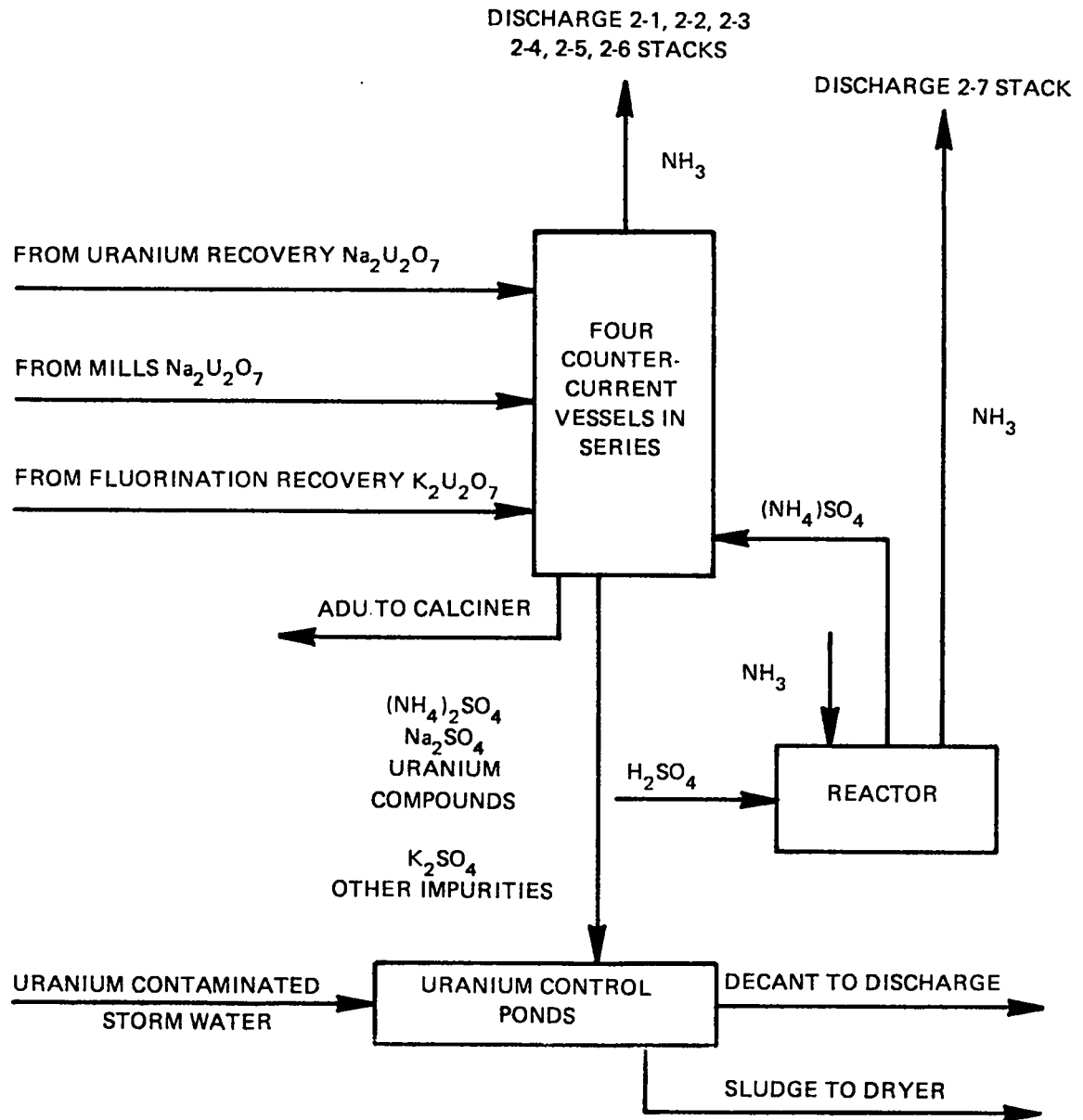


Fig. II-4. Pretreatment (sodium removal).

(which is discussed in Sec. B.11) (OML). Pond liners are inspected and repaired at this time. In addition, all pond liners are underlain by a gravel layer that allows any seepage to drain to a leak detection sump.\*

During pretreatment, ammonium sulfate reacts with hydroxide and possibly carbonate impurities in the concentrate to evolve ammonia (Sears et al. 1977). This ammonia is released through stacks 2-1, 2-2, 2-3, 2-4, 2-5, and 2-6 at the facility (EIA 1977).

\*This information provided by Dale Declue, State of Illinois.

The  $(\text{NH}_4)_2\text{U}_2\text{O}_7$  (ADU) is removed from solution in the last reaction vessel and is sent to the main feed preparation section of the plant.

The  $(\text{NH}_4)_2\text{SO}_4$  is produced on-site (Fig. II-4). Off-gases from the reactor vessel, which include  $\text{NH}_3$ , are vented through the 2-7 stack (EIA 1977).

#### 4. Feed Preparation

In the feed preparation circuit, sodium-free uranium concentrate, either from the pretreatment section or from the sampling section, is first fed into a calciner where

water and ammonia are removed (see Fig. II-5). The off-gases containing ammonia, sulfur dioxide, uranium, and contaminant particulates pass through two baghouses in series. Particulates recovered by blowback of the baghouses are collected and sent back into the blending feed stream (EIA 1977).

Ammonia, sulfur dioxide, and any uranium dusts not collected by the baghouse are emitted from the 1-1 stack.\* The ore calciner heat boiler, having a maximum heat rate of  $8 \times 10^6$  BTU/h, uses natural gas as the fuel, and  $\text{NO}_x$  and  $\text{CO}_2$  are emitted from the 1-9 stack (EIA 1977).

The calcined material is blended and then agglomerated, dried, crushed, and sized before being sent to the reduction circuit (Fig. II-5). Wet off-gas streams join the off-gases from the calciner, whereas dry off-gases pass through two baghouses in series before discharge through the 1-2 stack (EIA 1977). Material collected by the dry stream baghouse is fed into the blending feed stream. The heater for the dryer is fired by natural gas ( $6 \times 10^6$  BTU/h), and off-gases discharge through the 1-8 stack (EIA 1977).

## 5. Reduction

In the reduction circuit, Allied operates two trains in parallel, both having the same basic design. The  $\text{U}_3\text{O}_8$  from the feed preparation circuit is fed into the reductor vessel where hot cracked ammonia ( $\text{N}_2$  and  $\text{H}_2$ ) and additional nitrogen mix with the feed to form a fluidized bed. The  $\text{U}_3\text{O}_8$  is reduced to  $\text{UO}_2$ , which is withdrawn from the bottom of the bed. Off-gases from the reactor include  $\text{H}_2$ ,  $\text{N}_2$ ,  $\text{H}_2\text{S}$ ,  $\text{AsH}_3$ , vaporized S,  $\text{SeH}_2$ , and particulates composed of  $\text{UO}_2$ , unreacted  $\text{U}_3\text{O}_8$ , and reduced compounds of impurities originally in the concentrate (Fig. II-6) (Sears et al. 1977). (Most of the sulfur originally in the concentrate is volatilized in the reduction off-gases.)

The off-gases pass through two porous metal filters in series, a sulfur condenser, and an incinerator. Residual gases discharge through the 1-48 stack (EIA 1977).

Elemental sulfur from the sulfur condenser is stored on-site.

Particulates collected by cleaning the filters are sent to the uranium recovery section.

Off-gases from the oxide vacuum cleaner are sent through a cyclone and two baghouses in series before discharge through the 1-4 stack (Fig. II-6) (EIA 1977).

\*See Fig. II-5 and Table II-3.

Residues from these collection devices are sent to the uranium recovery section.

The emergency discharge vents on the two trains discharge through the 1-15 and 1-16 stacks, respectively (EIA 1977).

The off-gases from the ammonia dissociator (Fig. II-6) discharge through the 1-45 vent (EIA 1977).

## 6. Hydrofluorination

Again in the hydrofluorination circuit, two trains in parallel are in use. The  $\text{UO}_2$  from reduction is fed into two reactor vessels in series, which use vaporized hydrofluoric acid and  $\text{N}_2$  to fluidize the  $\text{UO}_2$  and permit HF to react with the material to form  $\text{UF}_4$  (Fig. II-7). The off-gases contain the excess HF needed to give good conversion to  $\text{UF}_4$  (10% excess or more), volatile  $\text{SiF}_4$ ,  $\text{BF}_3$ , and some of the molybdenum and vanadium (which were present as impurities in the concentrate) as volatile fluorides and oxyfluorides, and any remaining sulfur as  $\text{H}_2\text{S}$  (Sears et al. 1977). These gases first pass through two sets of two porous carbon filters per set, where the unreacted  $\text{UO}_2$  particles, entrained  $\text{UF}_4$  particles, and any other particulate matter are removed. The gases then pass through two venturi water scrubbers, where the  $\text{H}_2\text{O}$  in the off-gases condenses, and finally through a venturi KOH scrubber and a packed tower using KOH scrubbing liquid (EIA 1977).

The residue from the cleaned carbon filters is sent to uranium recovery. Liquid coming from the venturi water scrubbers contains hydrofluoric acid and is sent to the acid neutralization treatment plant, where lime is added to precipitate the fluorine as  $\text{CaF}_2$  (Fig. II-7. Also see Fig. II-14.) (Hosey and Hill 1980). The uranium content of this stream is reported to average less than 5 ppm (OML). Silicon, boron, and some molybdenum and vanadium, which were originally in the concentrate, are expected to be in the sludge. The liquid from the KOH venturi and packed tower is sent to the liquid treatment systems. Further details on the KOH regeneration system are given in Sec. B.13.

The vacuum cleaning off-gases from the cleaning activities necessary in the hydrofluorination section are routed through a cyclone and two baghouses before discharge through the 1-7 stack. Residues from the dust collectors are sent to the uranium recovery section.

The upper and lower vent spill dampers discharge for each train through the 1-18, 1-20, 1-17, and 1-19 stacks, respectively (Fig. II-7) (EIA 1977).

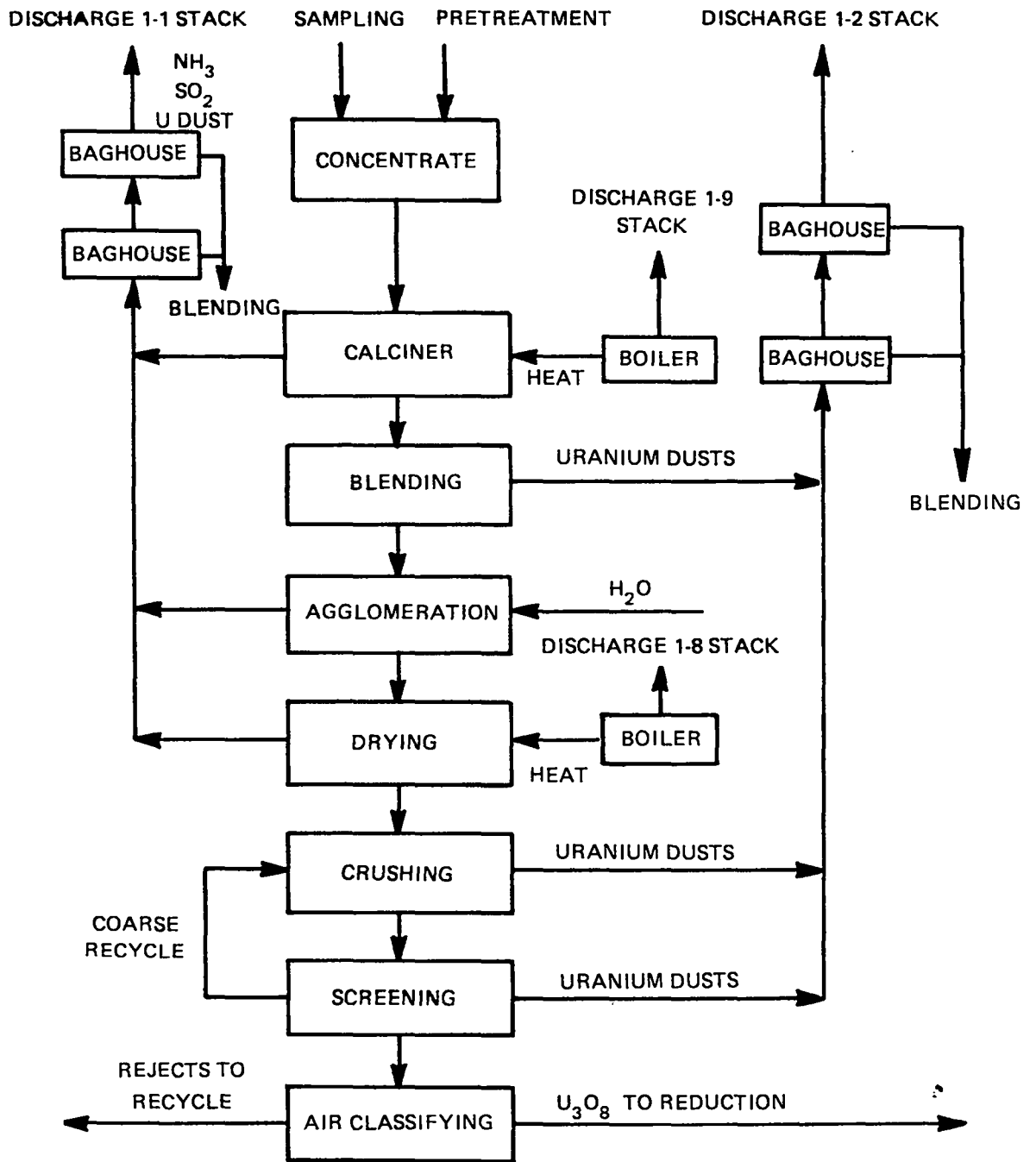


Fig. II-5. Feed preparation.

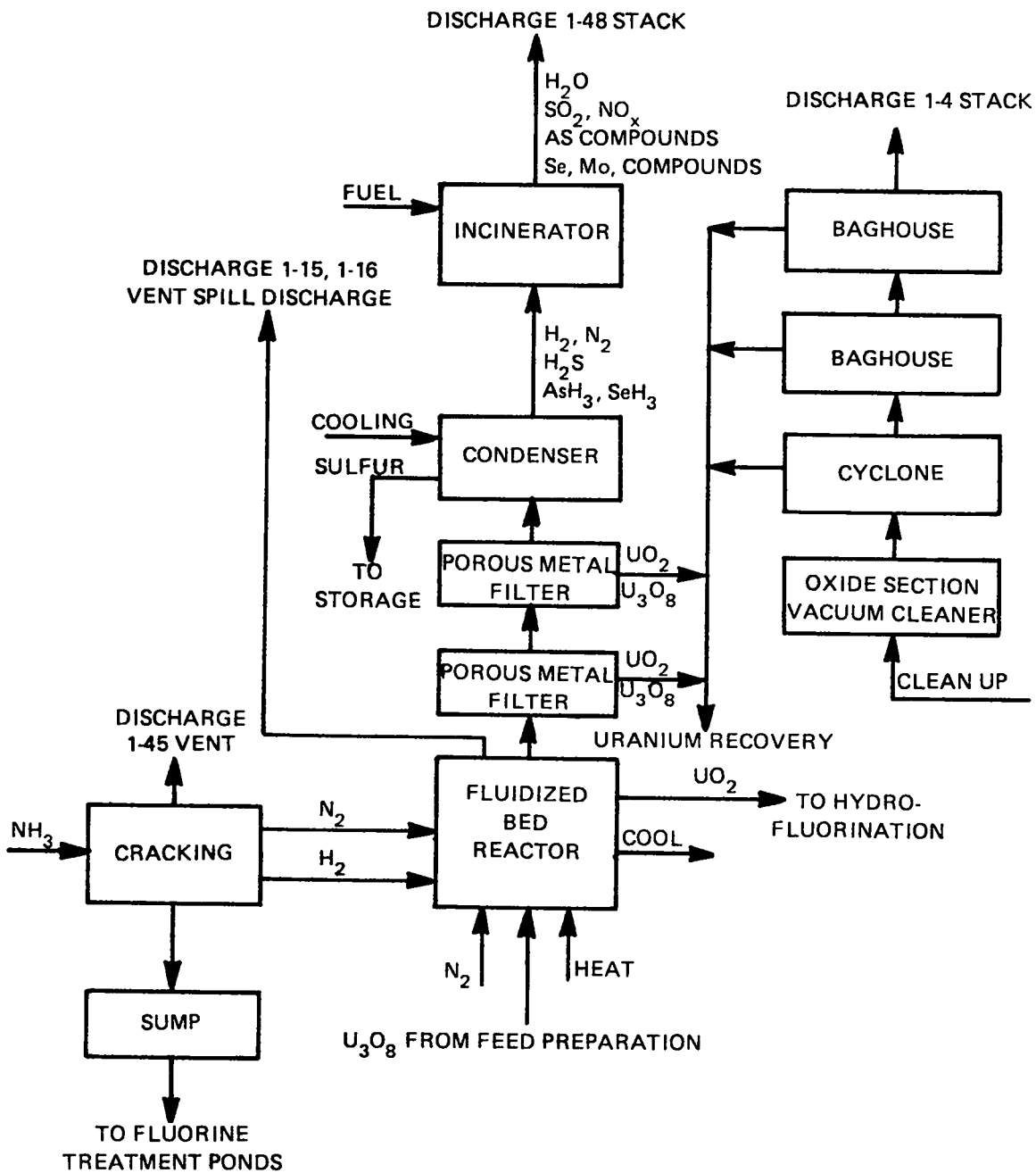


Fig. II-6. Reduction (two trains A and B).

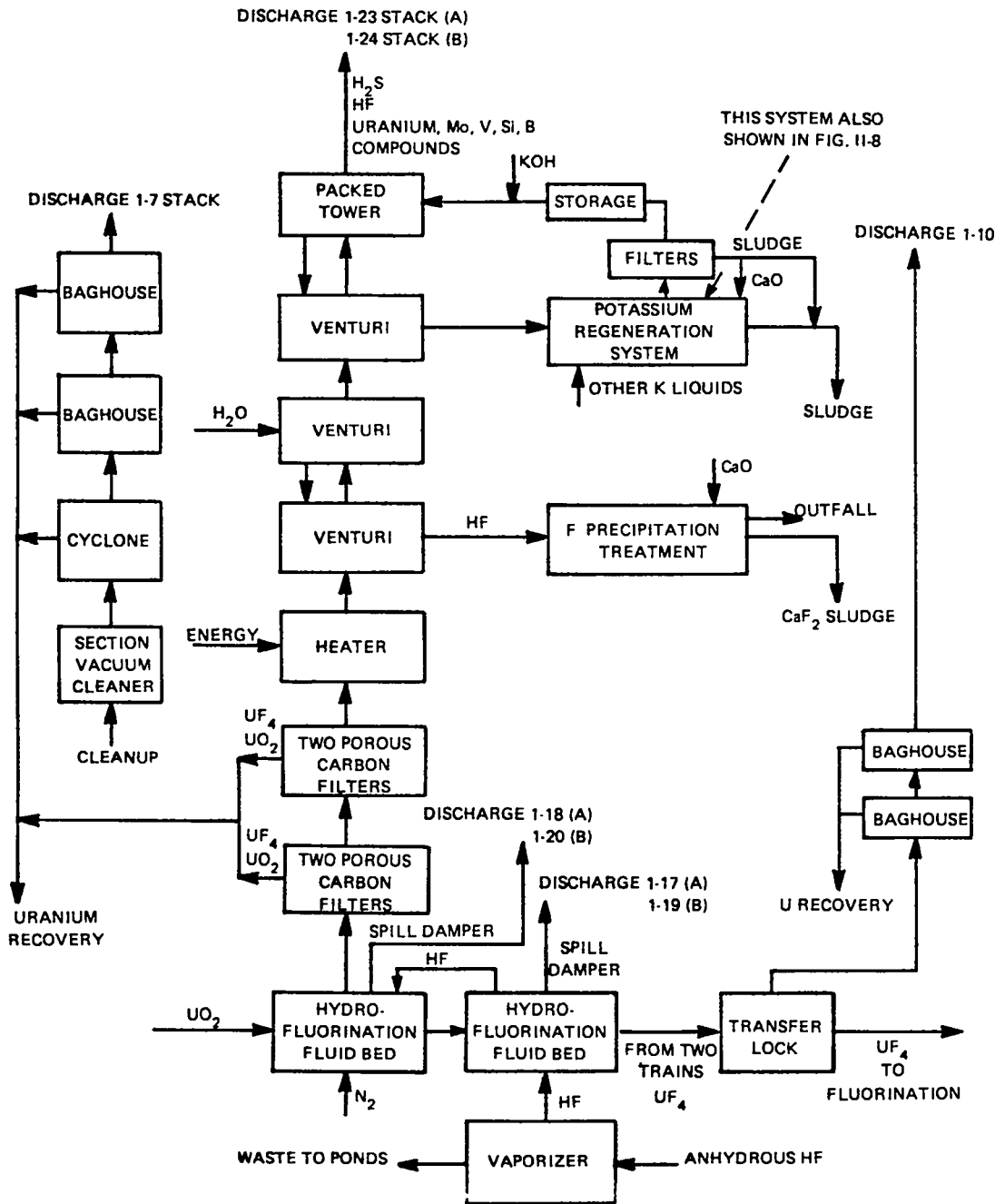


Fig. II-7. Hydrofluorination (two trains A and B).



Sludge from the HF vaporized (Fig. II-7) is sent to the acid treatment plant.

## 7. Fluorination

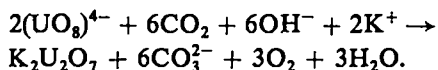
The green salt,  $UF_4$ , produced in the hydrofluorination process is fed into one of two fluid bed reactors used in parallel (Fig. II-8) (EIA 1977). Again, Allied uses two trains at the works.

The bed material is  $CaF_2$  and unreacted  $UF_4$ . The vessels are operated at temperatures of approximately  $1000^\circ F$ , and good temperature control is required. Fluorine,  $F_2$ , from an on-site fluorine production facility (Fig. II-9) is introduced into the reactor vessels to convert the  $UF_4$  into gaseous  $UF_6$  (EIA 1977).

The off-gases, including  $UF_6$ ,  $F_2$ , HF, unreacted  $UF_4$ , and other particulates, and volatilized impurities including  $VF_5$ ,  $VOF_3$ ,  $MoF_6$ , and low concentrations of bismuth, phosphorus, antimony, and chromium fluorides, are first cooled before passing through two sets of sintered nickel filters, each containing two filters (EIA 1977). The material recovered as the filters are cleaned is stored and then sent to the uranium recovery section.

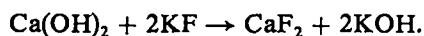
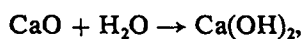
The stream exiting from the filters has the  $UF_6$  removed by condensation in a set of three cold traps used in series (Fig. II-8). Any uncondensed  $UF_6$ ,  $F_2$ , HF, and other volatiles passing from the cold traps are removed from the gas stream by a KOH spray tower, a KOH packed tower, and finally a KOH coke box. The final cleaned gases are emitted from the 1-13 and 1-14 stacks, respectively, for each train (EIA 1977).

Carbon dioxide in the spent scrubber liquid reacts with the uranium and potassium (Sears et al. 1977) as follows.



The  $K_2U_2O_7$  is settled from the KOH solution and sent to the pretreatment facility (Fig. II-4).

Decantate from the uranium settling section is sent to the KOH regeneration system as indicated previously. The reactions are (Sears et al. 1977)



The KOH is then sent back to the scrubbing system (Fig. II-8). In addition to  $CaF_2$ , compounds of uranium,

vanadium, and molybdenum, trace quantities of compounds of silica, carbon, sulfur, and other trace contaminants are expected to be in the sludge (Sears et al. 1977). The KOH treatment system is described more fully in Sec. B.13.

The condensed material in the three cold traps in series is melted and drained to the still feed tanks. Entrained HF is vaporized during melting and passes to the off-gas system (Sears et al. 1977).

From the still feed tanks, the liquid is fed to a low-temperature boiler bubble cap column in which the impurities, such as  $VF_5$ ,  $MoF_6$ ,  $SiF_4$ ,  $CF_4$ ,  $SF_6$ , and  $VOF_3$ , are volatilized and exit from the top of the column. The  $VOF_3$  impurity is condensed in the  $VOF_3$  condenser. The  $VOF_3$  is cleaned from the condenser and stored. Impurities not removed in the condenser are fed back to the system just before the cold traps (Sears et al. 1977).

The liquid  $UF_6$  passes from the low boiler column into the bubble cap, high boiler column (Fig. II-8). In this column, the  $UF_6$  is volatilized and exits from the top of the column. Nonvolatilized impurities are removed from the bottom of the column and stored (EIA 1977).

The gaseous  $UF_6$  from the column is condensed in two cold traps operated in series. The  $UF_6$  is transferred to the  $UF_6$  shipping cylinders by melting the  $UF_6$  and allowing the material to drain into the cylinders.

Because impurities build up on the recycled  $CaF_2$  bed material used in the fluorination reactors, part of the bed material must be withdrawn periodically. This "ash," along with the fluorination-cleaned filter residue, is drummed and stored for a minimum of 6 months to permit the uranium daughters  $^{234}Th$  and  $^{234m}Pa$  to decay. The ash is then sent to the uranium recovery section. A total quantity of ash of about 0.1 ton of ash per ton of uranium processed is produced, and it contains approximately 1.8% of the total uranium processed and most of the uranium daughters originally present in the concentrate (Sears et al. 1977).

The dusts produced by withdrawing bed material from the reactors are passed through a cyclone and two baghouses in series before discharge through the 1-12 stack (EIA 1977). The ash vacuum cleaner systems also discharge from this stack. Residue from cleaning these particulate removal devices is treated similarly to the spent bed material.

Over-pressure releases, etc., discharge through the 1-21 and 1-22 spill damper stacks (EIA 1977).

The feed preparation, reduction, hydrofluorination, and fluorination circuits are all located in the feed



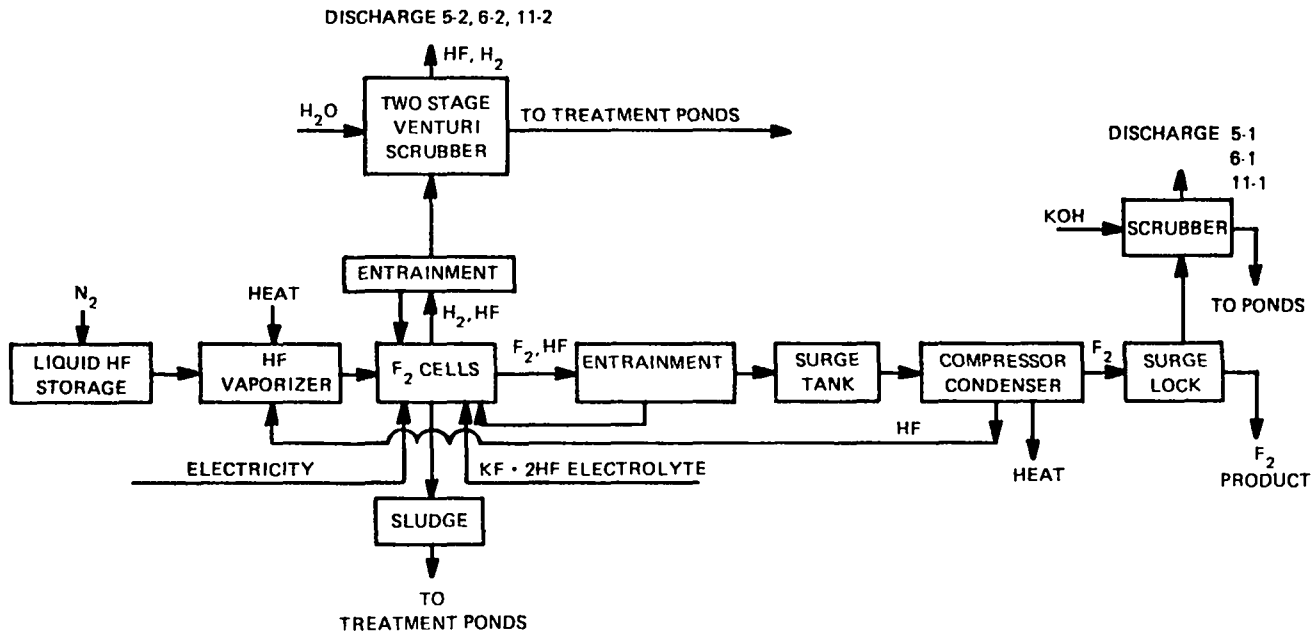


Fig. II-9. Fluorine production.

material building. This building has a complete air changeout approximately once every 5 minutes. The exhausts are through the 1-27, 1-28, 1-29, 1-30, 1-31, 1-32, 1-33, 1-34, 1-35, 1-36, 1-37, 1-38, and 1-39 stacks (EIA 1977).

Washdown of the feed materials building is pumped from collection sumps into the uranium recovery ponds.

The transfer lock to fluorination discharges through two baghouses to the 1-10 stack (Fig. II-7) (EIA 1977). Again, dust collection residue is sent to uranium recovery.

## 8. Fluorine Production

Fluorine is produced on-site by electrolysis (Fig. II-9) using hydrogen fluoride as the raw material. This section is the largest free-world liquid-fluorine-producing operation in existence (Hosey and Hill 1980).

The sludge from clean-up of the cells joins other sludge in the  $\text{CaF}_2$  precipitation ponds. Off-gases and waste gases are scrubbed, and the scrubber liquids containing fluoride compounds are sent to the acid neutralization treatment plant (EIA 1977).

The cleaned gases exit from the stacks noted in Fig. II-9 (EIA 1977).

## 9. Uranium Recovery

There are several sources of uranium-containing wastes produced by the facility, and it is desirable to recover the uranium from these wastes. Thus, uranium-containing dried sludges, spent bed material, filter residue, and various scraps and dusts are sent to the uranium recovery circuit (Fig. II-10).

Off-gases from storage before processing vent through the 3-1 stack (EIA 1977). The main contaminants in the stack off-gases should be radon and radon daughters, if the radium originally in the concentrate feed goes into the ash (as was assumed in the previous section).

The material from storage is first dumped and ground. Dusts from this operation are recovered in a baghouse, and the clean gases exit from the 3-2 stack (EIA 1977).

The finely ground material is leached, using a sodium carbonate solution to solubilize the uranium as the tricarbonat complex. Off-gases from the leaching tanks exit through the 3-3 and 3-4 stacks (EIA 1977).

After leaching, the pregnant solution is filtered. Lime is added to aid in precipitation of any fluoride, and the solution is again filtered. Sludge from the filters is dried. Off-gases from the dryer pass through the dumping and grinding off-gas baghouse.



The dried sludge probably contains all the nondecayed uranium daughters, some residual uranium, and some fluoride compounds. This sludge is drummed and sent to a licensed radioactive waste disposal facility (SER). Approximately 1500 tons of this waste, containing a maximum of 46.9 Ci, is produced yearly (EIA 1977).

The uranium is precipitated from the solution using NaOH. The uranium is filtered and washed and then sent to the sodium removal section. Off-gases from the precipitation vessels are emitted from the 3-5 stack.

Bleed from the leaching circuit (approximately 10%) is sent to the acid neutralization plant.

### 10. Cylinder Wash

Cylinders are returned to Allied from the enrichment facilities. These cylinders contain residual  $UF_6$  and the daughters of uranium that have "grown in" while the cylinders containing  $UF_6$  were in storage. The daughters in general are found plated out on the cylinder walls.

After any residual  $UF_6$  is removed from the cylinder, the cylinder is washed, using a solution of  $Na_2CO_3$  to remove any impurities from the walls and to solubilize the uranium (Fig. II-11). The wash solution is filtered to remove the unleached solids, and the pregnant solution is pumped to join the pregnant solution in the uranium treatment section (Fig. II-10).

The solid residue from the filters contains daughter products of uranium, principally  $^{234}Th$  and  $^{234}Pa$ , and is stored on-site in drums until disposal in a licensed waste disposal facility (EIA 1977).

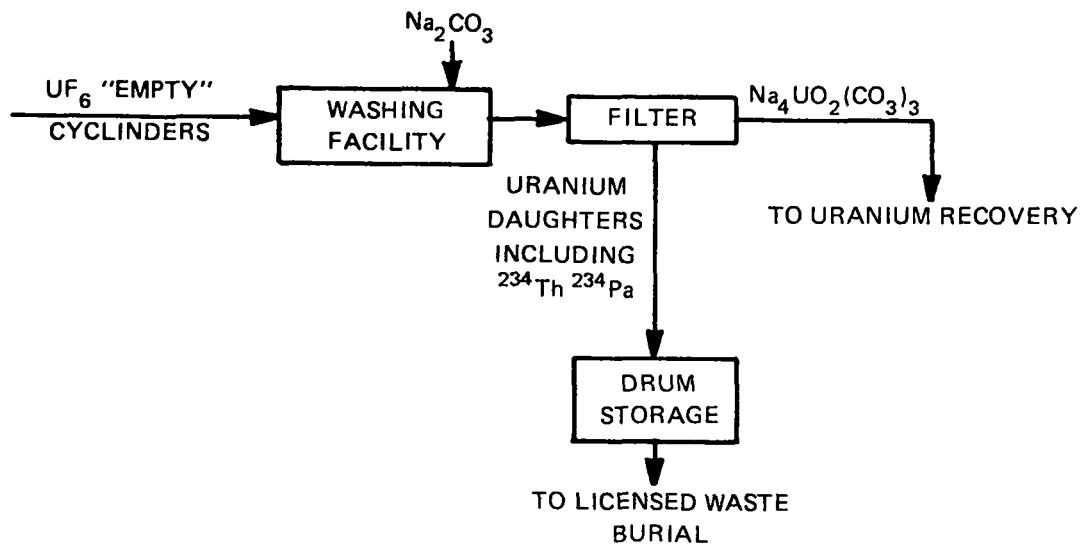


Fig. II-11. Cylinder wash.

### 11. Sludge Dryer

As previously described, the process generates several sludges that contain uranium. Before being sent for uranium recovery, these sludges are dried in a calciner (Fig. II-12). Off-gases containing  $SO_2$ , HF, and particulates from the calcining operation pass through a baghouse and a water spray tower before discharge by means of the 4-2 stack (EIA 1977).

The spent scrubber water, which contains uranium, fluoride compounds, and some sulfur compounds, is sent to the uranium recovery ponds.

The calcined sludges are drummed and stored until they can be processed in the uranium recovery section.

### 12. Storage and Handling

Large quantities (Table II-1) of chemicals are shipped to the Metropolis Works. These chemicals must be unloaded and stored until use. All storage tanks are vented through a scrubbing system.\* Figure II-13 indicates off-gas treatment for the lime-storage facility.

### 13. Liquid Treatment

EPA, in their Field Inspection Notes, describe the liquid treatment as follows (Hosey and Hill 1980).

\*This information provided by A. J. Cipolla, Allied, June 1981.

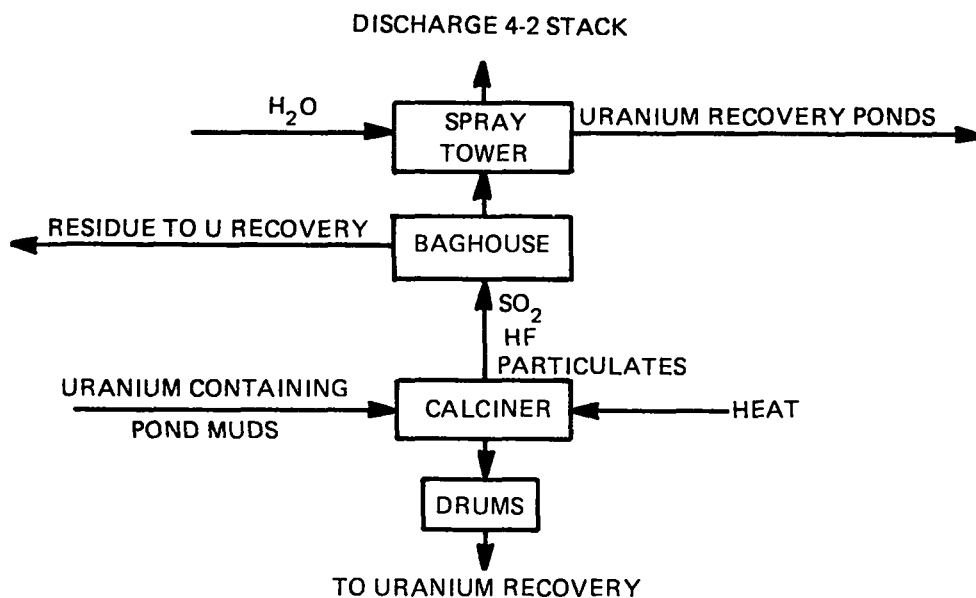


Fig. II-12. Sludge dryer.

TABLE II-1

INBOUND SHIPMENTS OF CHEMICALS TO METROPOLIS WORKS

| Commodity            | Physical Description  | Hazardous Nature as Defined by DOT (if applicable) | Packaging Requirements | Transportation Mode  | Average Frequency of Shipments |
|----------------------|-----------------------|--|------------------------|----------------------|--------------------------------|
| Hydrogen fluoride    | Liquid                | Corrosive  | DOT special tank cars  | Rail tank cars       | 11 C/L <sup>a</sup> per month  |
| Potassium bifluoride | Solid, dry            |  | Drums                  | Truck                | 170 drums per quarter          |
| Sulfuric acid        | Liquid                | Corrosive  | DOT special tank cars  | Tank cars and trucks | 1 C/L per month                |
| Lime (hydrated)      | Solid, dry            |  | Bulk                   | Tank trucks          | 276 T/L <sup>b</sup> per year  |
| Potassium hydroxide  | Liquid                | Corrosive  | DOT special tank cars  | Rail tank cars       | 9 C/L per month                |
| Anhydrous ammonia    | Liquid compressed gas | Nonflammable compressed gas                        | DOT special tank cars  | Rail tank cars       | 4 C/L per month                |

<sup>a</sup>Typical carload (C/L) is 80 000 to 120 000 lb net.

<sup>b</sup>Typical truckload (T/L) is 30 000 to 40 000 lb net.

Source: EIA, 1977.

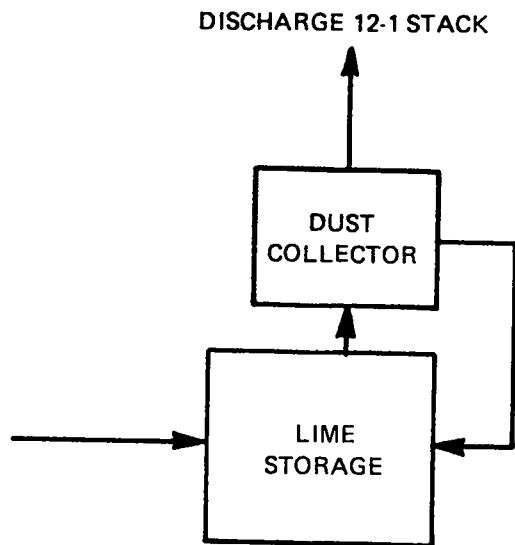


Fig. II-13. Lime plant.

#### “1. Acid Neutralization

Fluoride bearing wastewaters and spent alkaline wastewaters are processed through acid neutralization utilizing three agitator tanks in series. The first agitator tank is used to premix the two wastewater streams. The premixed liquid then flows by gravity to the second neutralizer or agitator tank and then to the third tank for final adjustment. Lime slurry is added as required to each of the tanks from a lime slurry circulating system. The lime slurry is mixed with water to give approximately 10% slurry and is circulated continuously throughout the system to prevent settling. Overflow from the third neutralizer tank flows to one of the two reslurry tanks, which are discharged to the settling ponds.

“Two settling ponds in series are utilized to provide for maximum solid separation and storage for the settled solids. The clarified treated process wastewater from the second settling pond is pumped to an agitator tank for pH adjustment. Sulfuric acid is added to control the pH of the treated process wastewater between 4 and 10 pH. The discharge from the pH adjustment tank is then discharged into the effluent stream. Flow measurement at the pH adjustment tank is provided by a V-notch weir. During the time of inspection the pH control system was under revision in order to provide two stage automatically controlled pH adjustment capability.

#### “2. Potassium Hydroxide Regeneration

Potassium hydroxide regeneration is accomplished by addition of hydrated lime to the spent potassium hydroxide scrubbing solution. The overflow from the regeneration after addition of hydrated lime is pumped to a vacuum filter and then to a 50 foot diameter clarifier for initial solid separation. The overflow from the clarifier is pumped through polishing filters for further solids removal and then to potassium hydroxide storage. From the storage the regenerated potassium hydroxide is pumped to various areas for reuse.

“The clarifier underflow is pumped to one of two rotary vacuum filters for removal of solids. Filter cake from the vacuum filters is discharged to the ore sludge slurry tank and pumped to the settling ponds. Filtrate from the vacuum filter is returned to the clarifier.”

#### 14. Summary

Waste effluents from the Allied facility include air, water, and solid waste. These discharges are summarized in Table II-2. Monitoring data are given later.

#### C. Available Data for Routine Waste/Effluent Releases, Storage, and Disposal

##### 1. Air

Table II-3, taken from the Environmental Impact Appraisal, indicates airborne effluents for the Allied Chemical facility when processing 14 000 tons (12 700 metric tons) uranium per year. Table II-4 summarizes the data and indicates releases in kilograms per metric ton uranium processed.

The Nuclear Regulatory Commission (NRC), in the 1977 Environmental Impact Appraisal, modeled ambient levels of HF using the release data given in Table II-3. It was concluded that some vegetation damage might occur near the plant boundary for vegetation most susceptible to damage caused by HF. Sampling data for fluorides in vegetation during 1971-76 are given in Table II-5. More recent data do not appear to be publically available.

Table II-6 indicates the semiannual radiological air effluent releases for radionuclides as reported to NRC. This table also converts the releases to microcuries per metric ton uranium, assuming the facility was running at 12 700 metric ton/yr of uranium throughput.

**TABLE II-2**  
**SUMMARY OF PRIMARY DISCHARGES**

| Section   | Air  | Liquid   | Solids  |
|---|--|--|---|
| Storage   | Radon  | Rain runoff to U recovery ponds  | None  |
| Sampling  | Concentrate dust, radon  | Washdown containing concentrate to U recovery ponds  | None  |
| Pretreatment                                    | NH <sub>3</sub>  | (NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub> , Na <sub>2</sub> SO <sub>4</sub> , K <sub>2</sub> SO <sub>4</sub> , small per cent of concentrate to uranium recovery ponds | None  |
| (NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub> | NH <sub>3</sub>  | None   | None  |
| Feed preparation                                | All radon in equilibrium, concentrate dust, NH <sub>3</sub> , and SO <sub>2</sub>  | None   | None  |
| Calciner heater                                 | NO <sub>x</sub> , CO <sub>2</sub>  | None   | None  |
| Dryer heater                                    | NO <sub>x</sub> , CO <sub>2</sub>  | None   | None  |
| Reduction                                       | H <sub>2</sub> , NO <sub>x</sub> , H <sub>2</sub> S, AsH <sub>3</sub> , SeH <sub>2</sub> , uranium compounds, N <sub>2</sub> , and SO <sub>2</sub> | None   | Condensed sulfur to storage   |
| Hydrofluorination                               | HF, H <sub>2</sub> S, N <sub>2</sub> uranium compounds, Si, B, Mo, and V compounds   | Water scrubber HF, F, U, Si, and B compounds to acid treatment; KOH liquids to KOH regeneration  | None  |
| Fluorination                                    | F <sub>2</sub> , HF, V, and Mo compounds; uranium compounds  | F, V, Mo, Si, C, and S compounds sent to KOH regeneration; K <sub>2</sub> U <sub>2</sub> O <sub>7</sub> sent to pretreatment   | Distillation residues to storage (Mo, V, Si, B, U, F)<br>Fluorination ash to uranium recovery |
| Fluorine production                             | HF, F <sub>2</sub> , H <sub>2</sub>  | Scrubber liquid containing F compounds to acid treatment   | Cell sludge to acid sludge ponds  |
| Uranium recovery                                | <sup>226</sup> Ra, <sup>230</sup> Th, U, Si, F compounds, and ingrown radon  | <sup>226</sup> Ra, <sup>230</sup> Th, U, Si, Na, and F compounds sent to acid treatment  | Radioactive solid wastes to licensed burial   |
| Cylinder wash                                   | None   | None   | To licensed burial  |
| Sludge calciner                                 | SO <sub>2</sub> , HF, and particulates   | U, F, and S compounds to U recovery ponds (from scrubber)  | None  |
| Chemical storage                                | Chemicals  |  |   |



TABLE II-3

## AIR EFFLUENT SOURCES, TYPES, AND QUANTITIES

| Stack Number | Identification                           | Height (ft) | Actual Air Flow (ACFM) | Emissions (lb/year) <sup>a</sup> and Stack Concentration <sup>b</sup> |       |                      |                       |                 |       |                 |       |                  |       |
|--------------|--|-------------|------------------------|---|-------|----------------------|-----------------------|-----------------|-------|-----------------|-------|------------------|-------|
|              |  |             |                        | HF  |       | Uranium <sup>c</sup> |                       | SO <sub>2</sub> |       | NH <sub>3</sub> |       | H <sub>2</sub> S |       |
|              |  |             |                        | (lb/yr)   | (ppm) | (lb/yr)              | ( $\mu$ Ci/ml)        | (lb/yr)         | (ppm) | (lb/yr)         | (ppm) | (lb/yr)          | (ppm) |
| 1-1          | Wet oxide dust collector                 | 98          | 5040                   |   |       | 115.6                | $4.7 \times 10^{-10}$ | 8800            | 40    | 6570            | 75    |                  |       |
| 1-2          | Dry oxide dust collector                 | 105         | 2650                   |   |       | 30.7                 | $2.5 \times 10^{-10}$ |                 |       |                 |       |                  |       |
| 1-3          | Drum dump dust collector                 | 40          | 4320                   |   |       | 55.4                 | $3.5 \times 10^{-10}$ |                 |       |                 |       |                  |       |
| 1-4          | Oxide vacuum cleaner                     | 98          | 428                    |   |       | 10.0                 | $4.8 \times 10^{-10}$ |                 |       |                 |       |                  |       |
| 1-7          | UF <sub>4</sub> vacuum cleaner           | 12          | 1078                   |   |       | 29.7                 | $6.6 \times 10^{-10}$ |                 |       |                 |       |                  |       |
| 1-8          | Ore dryer combustion gas                 | 100         | 2625                   |   |       | Nil                  |                       |                 |       |                 |       |                  |       |
| 1-9          | Ore calciner combustion gas              | 100         | 2625                   |   |       | Nil                  |                       |                 |       |                 |       |                  |       |
| 1-10         | UF <sub>4</sub> dust collector           | 98          | 2889                   | 876   | 35    | 35.5                 | $7.9 \times 10^{-10}$ |                 |       |                 |       |                  |       |
| 1-11         | Drum cleaner dust collector              | 40          | 5880                   |   |       | 18.0                 | $1.3 \times 10^{-10}$ |                 |       |                 |       |                  |       |
| 1-12         | Ash dust collector and vacuum cleaner    | 86          | 2561                   |   |       | 22.0                 | $1.8 \times 10^{-10}$ |                 |       |                 |       |                  |       |
| 1-13         | "A" coke box                             | 105         | 193                    | 40  | 12    | 80.5                 | $1.3 \times 10^{-8}$  |                 |       |                 |       |                  |       |
| 1-14         | "B" coke box                             | 105         | 193                    | 40  | 12    | 65.0                 | $1.1 \times 10^{-8}$  |                 |       |                 |       |                  |       |
| 1-15         | "A" reductor spill discharge             | 75          | 987                    |   |       | 1.0                  | $2.8 \times 10^{-11}$ |                 |       |                 |       |                  |       |
| 1-16         | "B" reductor spill discharge             | 75          | 987                    |   |       | 13.2                 | $3.7 \times 10^{-10}$ |                 |       |                 |       |                  |       |
| 1-17         | "A" top hydrofluorinator spill damper    | 45          | 6630                   |   |       | 9.8                  | $4.0 \times 10^{-11}$ |                 |       |                 |       |                  |       |
| 1-18         | "A" bottom hydrofluorinator spill damper | 12          | 6630                   |   |       | 0.7                  | $2.8 \times 10^{-12}$ |                 |       |                 |       |                  |       |
| 1-19         | "B" top hydrofluorinator spill damper    | 38          | 987                    |   |       | 57.7                 | $1.6 \times 10^{-9}$  |                 |       |                 |       |                  |       |
| 1-20         | "B" bottom hydrofluorinator spill damper | 15          | 987                    |   |       | 1.8                  | $5.0 \times 10^{-11}$ |                 |       |                 |       |                  |       |
| 1-21         | "A" fluorinator spill damper             | 30          | 987                    |   |       | 6.2                  | $1.7 \times 10^{-10}$ |                 |       |                 |       |                  |       |
| 1-22         | "B" fluorinator spill damper             | 30          | 987                    |   |       | 3.0                  | $8.4 \times 10^{-11}$ |                 |       |                 |       |                  |       |
| 1-23         | "A" HF scrubber                          | 20          | 30                     |   |       | Nil                  |                       |                 |       |                 |       | 6.6              | 5.9   |
| 1-24         | "B" HF scrubber                          | 20          | 30                     |   |       | Nil                  |                       |                 |       |                 |       | 6.6              | 5.9   |
| 1-25         | Dravo heater exhaust                     | 94          | 578                    |   |       | Nil                  |                       |                 |       |                 |       |                  |       |
| 1-26         | Hartzell exhaust                         | 60          | 14 145                 |   |       | 31.8                 | $4.7 \times 10^{-11}$ |                 |       |                 |       |                  |       |

<sup>a</sup>Emissions based on rated capacity of facility (14 000 N.T. U, 1200 N.T. SF<sub>6</sub>, 30 000 lb/week liquid F<sub>2</sub>, 2500 lb/week SbF<sub>5</sub>, and 10 000 lb/week IF<sub>3</sub>).

<sup>b</sup>Stack concentrations reported in ppm by volume.

<sup>c</sup>Actual measured emissions for 1975 operating year.

<sup>d</sup>F<sub>2</sub> dumped during abnormal operation only.

<sup>e</sup>Ca(OH)<sub>2</sub> recorded as 576 lb/year and 3.7 ppm in the effluent treatment plant lime silo dust collector.

Source: EIA, 1977.

TABLE II-3 (cont)

| Stack Number | Identification                                      | Height (ft)           | Actual Air Flow (ACFM) | Emissions (lb/year) <sup>a</sup> and Stack Concentration <sup>b</sup> |       |                      |                       |                   |       |                 |       |                  |       |
|--------------|---|-----------------------|------------------------|---|-------|----------------------|-----------------------|-------------------|-------|-----------------|-------|------------------|-------|
|              |   |                       |                        | HF  |       | Uranium <sup>c</sup> |                       | SO <sub>2</sub>   |       | NH <sub>3</sub> |       | H <sub>2</sub> S |       |
|              |   |                       |                        | (lb/yr)   | (ppm) | (lb/yr)              | (μCi/mf)              | (lb/yr)           | (ppm) | (lb/yr)         | (ppm) | (lb/yr)          | (ppm) |
| 1-27         | Exhaust fan - 1st floor                             | 15                    | 23 000                 |   |       | 0.3                  | $2.7 \times 10^{-13}$ |                   |       |                 |       |                  |       |
| 1-28         | Exhaust fan - 1st floor                             | 15                    | 23 000                 |   |       | 6.7                  | $6.0 \times 10^{-12}$ |                   |       |                 |       |                  |       |
| 1-29         | Exhaust fan - 2nd floor                             | 30                    | 23 000                 |   |       | 25.5                 | $2.3 \times 10^{-11}$ |                   |       |                 |       |                  |       |
| 1-30         | Exhaust fan - 3rd floor                             | 45                    | 23 000                 |   |       | 16.1                 | $1.4 \times 10^{-11}$ |                   |       |                 |       |                  |       |
| 1-31         | Exhaust fan - 3rd floor                             | 45                    | 23 000                 |   |       | 22.1                 | $2.0 \times 10^{-11}$ |                   |       |                 |       |                  |       |
| 1-32         | Exhaust fan - 3rd floor                             | 45                    | 23 000                 |   |       | 22.9                 | $2.0 \times 10^{-11}$ |                   |       |                 |       |                  |       |
| 1-33         | Exhaust fan - 3rd floor                             | 45                    | 23 000                 |   |       | 24.3                 | $2.2 \times 10^{-11}$ |                   |       |                 |       |                  |       |
| 1-34         | Exhaust fan - 4th floor                             | 60                    | 23 000                 |   |       | 35.6                 | $3.1 \times 10^{-11}$ |                   |       |                 |       |                  |       |
| 1-35         | Exhaust fan - 4th floor                             | 60                    | 23 000                 |   |       | 52.0                 | $4.7 \times 10^{-11}$ |                   |       |                 |       |                  |       |
| 1-36         | Exhaust fan - 4th floor                             | 60                    | 23 000                 |   |       | 32.7                 | $2.9 \times 10^{-11}$ |                   |       |                 |       |                  |       |
| 1-37         | Exhaust fan - 5th floor                             | 75                    | 23 000                 |   |       | 28.2                 | $2.6 \times 10^{-11}$ |                   |       |                 |       |                  |       |
| 1-38         | Exhaust fan - 5th floor                             | 75                    | 23 000                 |   |       | 49.6                 | $4.4 \times 10^{-11}$ |                   |       |                 |       |                  |       |
| 1-39         | Exhaust fan - 5th floor                             | 75                    | 23 000                 |   |       | 122.6                | $1.1 \times 10^{-10}$ |                   |       |                 |       |                  |       |
| 1-40         | #1 overhead exhaust fan                             | 90                    | 25 000                 |   |       | 6.2                  | $5.1 \times 10^{-12}$ |                   |       |                 |       |                  |       |
| 1-41         | #2 overhead exhaust fan                             | 90                    | 25 000                 |   |       | 7.1                  | $5.8 \times 10^{-12}$ |                   |       |                 |       |                  |       |
| 1-42         | #3 overhead exhaust fan                             | 90                    | 25 000                 |   |       | 4.8                  | $4.0 \times 10^{-12}$ |                   |       |                 |       |                  |       |
| 1-43         | #4 overhead exhaust fan                             | 90                    | 25 000                 |   |       | Nil                  |                       |                   |       |                 |       |                  |       |
| 1-44         | #5 overhead exhaust fan                             | 90                    | 25 000                 |   |       | Nil                  |                       |                   |       |                 |       |                  |       |
| 1-45         | NH <sub>3</sub> dissociator vent                    | 60                    | 12 580                 |   |       | 17.7                 | $2.9 \times 10^{-11}$ |                   |       |                 |       |                  |       |
| 1-46         | UF <sub>6</sub> back-up dust collector              | not installed to date |                        |   |       |                      |                       |                   |       |                 |       |                  |       |
| 1-47         | "C" fluorinator spill damper                        | 30                    | 987                    |   |       | 0.9                  | $1.9 \times 10^{-11}$ |                   |       |                 |       |                  |       |
| 1-48         | H <sub>2</sub> S incinerator                        | 155                   | 6500                   |   |       | 0.1                  | $3.2 \times 10^{-13}$ | $4.4 \times 10^5$ | 6855  |                 |       |                  |       |
| 2-1          | Na removal, 4th settler and reslurry                | 36                    | 110                    |   |       |                      |                       |                   |       | 1836            | 1438  |                  |       |
| 2-2          | Na removal, 3rd reslurry                            | 36                    | 100                    |   |       |                      |                       |                   |       | 1836            | 1581  |                  |       |
| 2-3          | Na removal, 2nd reslurry                            | 36                    | 100                    |   |       |                      |                       |                   |       | 1836            | 1581  |                  |       |
| 2-4          | Na removal, sewerage tanks                          | 38                    | 115                    |   |       |                      |                       |                   |       | 1836            | 1377  |                  |       |
| 2-5          | Na removal, 2nd & 3rd settlers                      | 38                    | 115                    |   |       |                      |                       |                   |       | 1836            | 1377  |                  |       |
| 2-6          | Na removal, 1st settler & reslurry                  | 36                    | 110                    |   |       |                      |                       |                   |       | 3400            | 2664  |                  |       |
| 2-7          | Na removal, NH <sub>4</sub> SO <sub>4</sub> reactor | 33                    | 5                      |   |       |                      |                       |                   |       | 76              | 1314  |                  |       |
| 3-1          | U-recovery, milled ash storage                      | 28                    | 100                    |   |       |                      |                       |                   |       |                 |       |                  |       |
| 3-2          | U-recovery, dust collector                          | 18                    | 3296                   |   |       |                      |                       |                   |       |                 |       |                  |       |
| 3-3          | U-recovery, 1st leach tank                          | 12                    | 120                    |   |       |                      |                       |                   |       |                 |       |                  |       |
| 3-4          | U-recovery, 2nd leach tank                          | 12                    | 120                    |   |       |                      |                       |                   |       |                 |       |                  |       |
| 3-5          | U-recovery, precipitator                            | 12                    | 120                    |   |       |                      |                       |                   |       |                 |       |                  |       |
| 4-1          | Pond muds calciner, combustion gas                  | 35                    | 856                    |   |       |                      |                       |                   |       |                 |       |                  |       |
| 4-2          | Pond muds calciner, scrubber vent                   | 29                    | 3005                   | 3240  | 193   | 0.9                  | $6.2 \times 10^{-12}$ | 180               | 3.4   |                 |       |                  |       |

TABLE II-3 (cont)

| Stack<br>Number | Identification  | Height<br>(ft) | Actual<br>Air Flow<br>(ACFM) | Emissions (lb/year) <sup>a</sup> and Stack Concentration <sup>b</sup> |                       |                      |                       |                 |       |                 |       |                  |       |
|-----------------|---|----------------|------------------------------|---|-----------------------|----------------------|-----------------------|-----------------|-------|-----------------|-------|------------------|-------|
|                 |   |                |                              | HF  |                       | Uranium <sup>c</sup> |                       | SO <sub>2</sub> |       | NH <sub>3</sub> |       | H <sub>2</sub> S |       |
|                 |   |                |                              | (lb/yr)   | (ppm)                 | (lb/yr)              | (μCi/m <sup>3</sup> ) | (lb/yr)         | (ppm) | (lb/yr)         | (ppm) | (lb/yr)          | (ppm) |
| 5-1             | 5KA fluorine plant, KOH scrubber                                  | 35             | 5                            | 94  | 3.2 × 10 <sup>4</sup> |                      |                       |                 |       |                 |       |                  |       |
| 5-2             | 5KA fluorine plant, H <sub>2</sub> scrubber                       | 30             | 90                           | 2628  | 1839                  |                      |                       |                 |       |                 |       |                  |       |
| 6-1             | 15KA fluorine plant, KOH scrubber                                 | 35             | 5                            | 94  | 3.2 × 10 <sup>4</sup> |                      |                       |                 |       |                 |       |                  |       |
| 6-2             | 15KA fluorine plant, H <sub>2</sub> scrubber                      | 40             | 80                           | 4179  | 2126                  |                      |                       |                 |       |                 |       |                  |       |
| 7-1             | Powerhouse, #1 boiler   | 50             | 7680                         |   |                       |                      |                       | 425             | 0.64  |                 |       |                  |       |
| 7-2             | Powerhouse, #2 boiler   | 50             | 7680                         |   |                       |                      |                       | 425             | 0.64  |                 |       |                  |       |
| 7-3             | Powerhouse, #3 boiler   | 50             | 7680                         |   |                       |                      |                       | 213             | 0.64  |                 |       |                  |       |
| 8-3             | SF <sub>6</sub> plant, IF <sub>3</sub> scrubber                   | 24             | 2.3                          | 2.3   | 426                   |                      |                       |                 |       |                 |       |                  |       |
| 8-4             | SF <sub>6</sub> plant, SbF <sub>3</sub> scrubber                  | 14             | 1                            | 103   | 1.9 × 10 <sup>5</sup> |                      |                       |                 |       |                 |       |                  |       |
| 9-2             | Laboratory hood scrubber  | 18             | 18 900                       |   |                       |                      |                       |                 |       |                 |       |                  |       |
| 11-1            | 15KA fluorine plant additional<br>KOH scrubber                    | 35             | 5                            | 94  | 3.2 × 10 <sup>4</sup> |                      |                       |                 |       |                 |       |                  |       |
| 11-2            | 15KA fluorine plant additional<br>H <sub>2</sub> scrubber         | 40             | 120                          | 394   | 134                   |                      |                       |                 |       |                 |       |                  |       |
| 11-3            | 15KA fluorine plant additional<br>melt tank scrubber              | 40             | 2                            | 71  | 4.3 × 10 <sup>4</sup> |                      |                       |                 |       |                 |       |                  |       |
| 12-1            | Effluent treatment plant lime<br>silo dust collector <sup>d</sup> | 50             | 2100                         |   |                       |                      |                       |                 |       |                 |       |                  |       |

**TABLE II-4**  
**AIR RELEASES ALLIED CHEMICAL**  
**UF<sub>6</sub> FACILITY<sup>a,b,c</sup>**  
(14 000 T/YR)

| Type             | kg/yr     | kg/MTU <sup>d</sup> |
|------------------|-----------|---------------------|
| Uranium          | 482.6     | 0.04                |
| SO <sub>2</sub>  | 204 139.0 | 16.07               |
| HF               | 5377.6    | 0.42                |
| NH <sub>3</sub>  | 8721.0    | 0.69                |
| H <sub>2</sub> S | 5.99      | 0.0005              |

<sup>a</sup>Does not correct for emissions caused by manufacture of liquid F<sub>2</sub>, SbF<sub>3</sub>, SF<sub>6</sub>, IF<sub>6</sub> (SF<sub>6</sub> plant releases about 48 kg/yr of HF).

<sup>b</sup>Does not include boiler combustion products.

<sup>c</sup>Does not include storage losses.

<sup>d</sup>MTU - metric tons uranium.

Table II-7 indicates locations of air sampling stations, and Table II-8 shows average radiological concentrations at these sampling stations (OML).

Using the radiological data given in Table II-8, the solubility classification data obtained by Kalkwarf (see reference noted Kalkwarf 1980) and a suitable model, NRC staff calculated that if an infant lived at the nearest residence, the lung dose caused by the UF<sub>6</sub> facility would be approximately 42.5 mR/yr. (For more information on this calculation, the reader is referred to OML).

Allied personnel recently informed the NRC staff that monitoring data obtained by Allied, which includes <sup>230</sup>Th and U<sub>nat</sub> concentrations, size distributions, and solubility, indicate a dose of approximately 10 mR/yr to an adult living at the nearest residence.\* The critical parameters in determining the dose appear to be concentration, size distribution, and solubilities of airborne U<sub>nat</sub>, <sup>230</sup>Th, and <sup>226</sup>Ra. The <sup>230</sup>Th in particular appears to be very important in the possible exposure.

## 2. Water

There is only one discharge point for the Allied facility. Figure II-14 indicates the various sources of this liquid discharge. Data on water quality as reported in the Environmental Impact Appraisal are given in Table II-9,

\*This information provided by W. T. Crowe, NRC, August 1981.

whereas Table II-10 indicates recent water quality reported by Allied to EPA as required by the NPDES permit. Table II-11 indicates data for a sample taken by the EPA staff during an inspection in November 1980.

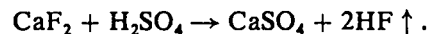
Table II-12 indicates early data for the radiological parameters, whereas Tables II-13 and II-14 give more recent data.

During 1975-1976, the concentration of uranium in the discharge averaged between 0.7 to 0.9 ppm. During the period January 1975 to July 1976, soluble <sup>226</sup>Ra had concentrations ranging from a minimum of less than  $4.2 \times 10^{-10}$   $\mu\text{Ci}/\text{m}^3$  to a maximum of  $9.1 \times 10^{-9}$   $\mu\text{Ci}/\text{m}^3$  (Table II-13). This latter value represents about 30% of the 10 CFR 20 limit, and the NRC staff recommended that improved methods of control be investigated (SER).

Combustion Engineering, under contract to Allied, has collected mud samples of the river bottom and three area lakes for uranium and fluoride content. The author was unable to obtain these data.

## 3. Sludges

At the plant site, there are now approximately 84 000 tons (76 188 metric tons) of spent limestone calcium fluoride sludge produced from treatment of liquids containing minimum amounts of uranium. Approximately 33 000 tons (29 931 metric tons) of the 84 000 tons are reacted calcium fluoride. Allied plans in the next several years to begin a sludge regeneration program. The sludge presently on-site and sludge being generated will be reacted with hydrofluoric acid to convert the remaining limestone into CaF<sub>2</sub> (the reacted sludge will contain approximately 90% by dry weight of CaF<sub>2</sub>). After drying, the material will be sent off-site to another Allied facility where the CaF<sub>2</sub> will be reacted with sulfuric acid to evolve HF for recovery in condensers.



## 4. Solid, Nonsludge Wastes

Approximately four hundred 55-gallon drums of uranium and uranium daughter contaminated trash, consisting of blotting paper, floor sweeping compounds, cleaning rags, etc., are sent annually to a commercial burial site (SER).

The solid residues filtered from the leachate at the uranium recovery facility consist primarily of fluoride compounds that contain U<sub>nat</sub>, <sup>230</sup>Th, <sup>226</sup>Ra, and other minor constituents, such as molybdenum and vanadium. These residues are dried and placed in 55-gallon drums

TABLE II-5

RESULTS OF ALLIED SAMPLING OF VEGETATION FOR FLUORIDE CONTENT FROM 1971-1976<sup>a</sup>

| Fluoride Content of Vegetation (ppm dry weight) |        |        |        |      |        |      |        |      |        |                    |                     |
|---|--------|--------|--------|------|--------|------|--------|------|--------|--------------------|---------------------|
| Station   | 1971   |        | 1972   |      | 1973   |      | 1974   |      | 1975   |                    | 1976                |
|   | Spring | Fall   | Spring | Fall | Spring | Fall | Spring | Fall | Spring | Fall               | Spring <sup>b</sup> |
| 1   | 0.9    | 120.0  | <0.25  | 2.5  | 18.5   | 18.0 | 4.6    | <5   | 6.8    | 14.4               | 2.8                 |
| 2   | 0.6    | 528.0  | <0.25  | 3.2  | 7.0    | 8.0  | 4.5    | 6    | <5     | 12.8               | 2.5                 |
| 3   | 0.5    | 41.0   | 26.5   | 2.8  | 5.8    | 32.0 | 4.6    | 7    | 7.5    | 424.8 <sup>c</sup> | <2                  |
| 4   | 0.6    | 6.0    | <0.25  | 2.0  | 0.3    | <2.5 | 4.6    | <5   | 6.0    | 7.6                | <2                  |
| 5   | 0.9    | 1080.0 | <0.25  | 5.0  | 4.0    | <2.5 | 4.1    | 6    | 32.0   | 7.6                | <2                  |
| 6   | 0.9    | 53.0   | <0.25  | 3.2  | 0.9    | <2.5 | 3.2    | 6    | 7.0    | 20.0               | 1.9                 |
| 7   | 0.6    | 75.0   | <0.25  | 6.5  | 3.2    | <2.5 | 2.0    | 7    | <5     | 16.0               | 2.8                 |
| 13  | 0.9    | 420.0  | <0.25  | 5.5  | 15.0   | <2.5 | 4.5    | 10   | 20.4   | 19.5               | 2.8                 |

<sup>a</sup>Station 13 was located onsite at an agricultural field.

<sup>b</sup>The fall values were not available.

<sup>c</sup>Believed to be an error.

Source: SER and responses to Nuclear Regulatory Commission questions.

TABLE II-6

## RADIOLOGICAL EFFLUENT RELEASES TO THE AIR

| Period        | Discharge                 |   |                            |   |                            |   |
|---------------|---------------------------|---|----------------------------|---|----------------------------|---|
|               | U <sub>nat</sub><br>(μCi) | U <sub>nat</sub> μCi <sup>a</sup><br>(MTU) <sup>b</sup> | <sup>230</sup> Th<br>(μCi) | <sup>230</sup> Th μCi <sup>a</sup><br>(MTU) | <sup>226</sup> Ra<br>(μCi) | <sup>226</sup> Ra μCi <sup>a</sup><br>(MTU) |
| July-Dec 1976 | 180 000                   | 28.3  | 760                        | 0.12  | 46                         | 0.01  |
| Jan-June 1977 | 130 000                   | 20.5  | 980                        | 0.15  | 44                         | 0.01  |
| July-Dec 1977 | 160 000                   | 25.2  | 1600                       | 0.25  | 29                         | 0.004                                       |
| Jan-June 1978 | 170 000                   | 26.8  | 1000                       | 0.16  | 45                         | 0.01  |
| July-Dec 1978 | 120 000                   | 18.9  | NA                         | —   | NA                         | —   |

<sup>a</sup>Assuming 6350 metric tons uranium per six month period.

<sup>b</sup>MTU - metric tons uranium throughput.

Source: Reports to NRC.

TABLE II-7

LOCATIONS OF ENVIRONMENTAL AIR SAMPLING STATIONS

| Air Sampler Number | Location                               |
|--------------------|--|
| 6                  | 5300 ft NNE (Metropolis Airport)       |
| 8                  | 1035 ft NE of UF <sub>6</sub> Building |
| 9                  | 775 ft NNW of UF <sub>6</sub> Building |
| 10                 | 720 ft SW of UF <sub>6</sub> Building  |
| 11                 | 1240 ft N of UF <sub>6</sub> Building  |
| 12                 | 590 ft SSE of UF <sub>6</sub> Building |
| 13                 | 755 ft NE of UF <sub>6</sub> Building  |

Source: Order to Modify License, Amendment No. 4.

TABLE II-8

SUMMARY OF ENVIRONMENTAL AIR MONITORING RESULTS IN 1979

| Sample Point | 1979 Data   |                        |                        |                        |                        |
|--------------|---|------------------------|------------------------|------------------------|------------------------|
|              | Average Concentration ( $\mu\text{Ci}/\text{m}^3$ ) |                        |                        |                        |                        |
|              | <sup>234</sup> U                                    | <sup>235</sup> U       | <sup>238</sup> U       | <sup>226</sup> Ra      | <sup>230</sup> Th      |
| 6            | $2.64 \times 10^{-15}$                              | $1.22 \times 10^{-16}$ | $2.64 \times 10^{-15}$ | $4.57 \times 10^{-17}$ | $2.79 \times 10^{-16}$ |
| 8            | $8.99 \times 10^{-15}$                              | $4.13 \times 10^{-16}$ | $8.99 \times 10^{-15}$ | $6.08 \times 10^{-17}$ | $3.08 \times 10^{-15}$ |
| 9            | $1.42 \times 10^{-14}$                              | $6.51 \times 10^{-16}$ | $1.42 \times 10^{-14}$ | a                      | a                      |
| 10           | $1.72 \times 10^{-14}$                              | $7.91 \times 10^{-16}$ | $1.72 \times 10^{-14}$ | a                      | a                      |
| 11           | $1.42 \times 10^{-14}$                              | $6.51 \times 10^{-16}$ | $1.42 \times 10^{-14}$ | $4.20 \times 10^{-17}$ | $1.70 \times 10^{-15}$ |
| 12           | $1.36 \times 10^{-14}$                              | $6.27 \times 10^{-16}$ | $1.36 \times 10^{-14}$ | a                      | a                      |
| 13           | $1.53 \times 10^{-14}$                              | $7.05 \times 10^{-16}$ | $1.53 \times 10^{-14}$ | a                      | a                      |

\*The licensee analyzed only the air samples at stations No. 6, 8, and 11 for <sup>226</sup>Ra and <sup>230</sup>Th. Analysis of air samples showed the ratio of <sup>230</sup>Th to natural uranium to be much higher than the yellow-cake feed average over 33 mills (<sup>230</sup>Th/U-natural = 0.0052).

Source: Order to Modify License, Amendment No. 4.

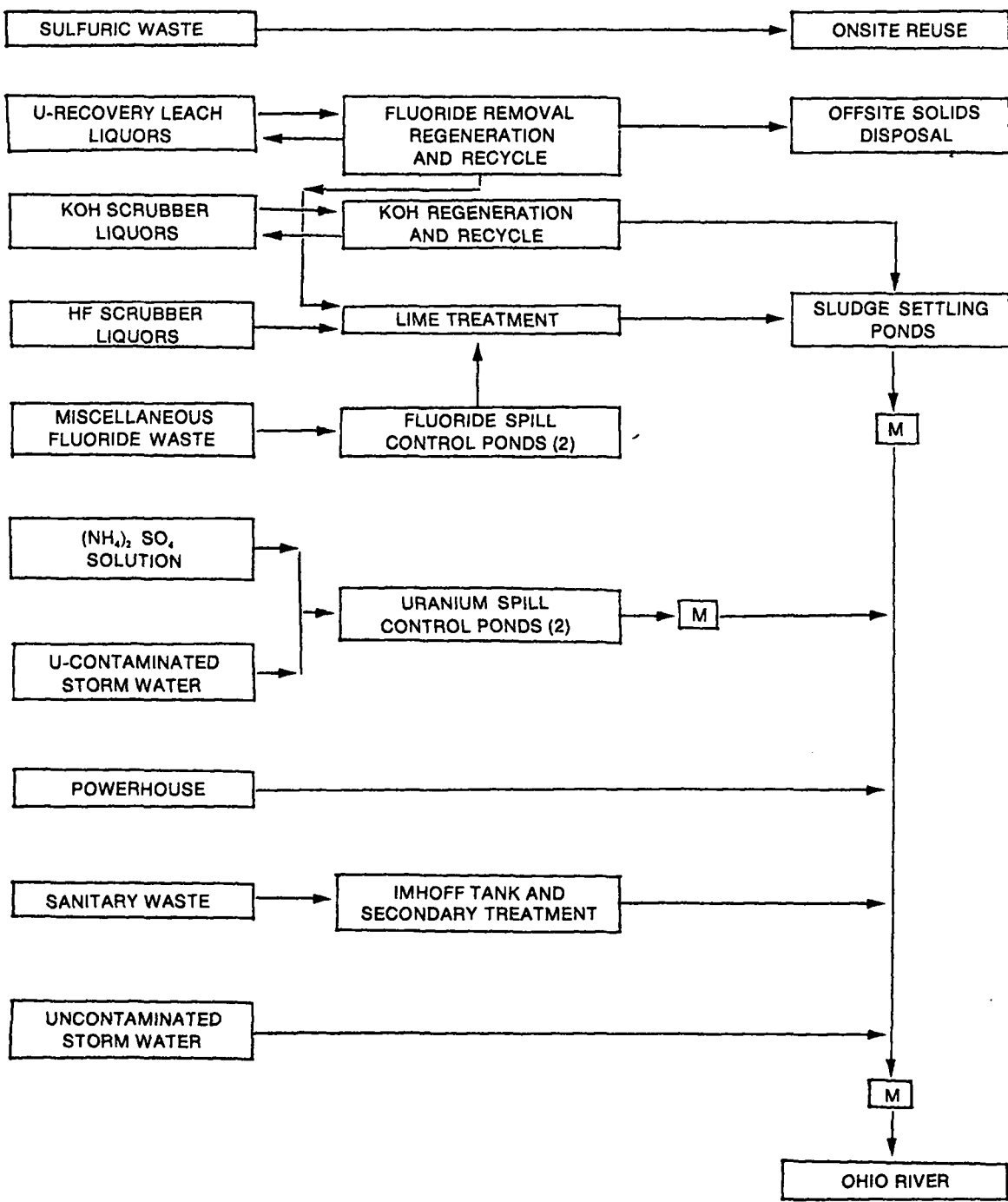


Fig. II-14. Current wastewater disposition. M = monitoring station.

Source: EIA 1977.

TABLE II-9

LIQUID EFFLUENT CONTAMINANT LEVELS AT  
COMBINED (SANITARY AND PROCESS) OUTFALL

Sampling Frequency Weekly or Greater

| Parameter                             | Average ppm<br>12 Months Ending<br>April 1, 1976 | Average ppm<br>April 1, 1976 to<br>April 1, 1977 |
|---------------------------------------|--|--|
| Arsenic                               | 0.15   | 0.03   |
| Chloride                              | 26.3   | 28.9   |
| Chromium (Cr <sup>3+</sup> )          | 0.05   | 0.03   |
| Chromium (Cr <sup>6+</sup> )          | 0.003  | 0.003  |
| Fluoride                              | 149  | 8.3  |
| Iron                                  | 0.51   | 0.21   |
| Molybdenum                            | 0.12   | 0.08   |
| Nickel                                | 0.07   | 0.02   |
| pH (average)                          | 7.1  | 7.6  |
| Phosphate                             | 1.4  | 1.3  |
| Silver                                | 0.07   | 0.04   |
| Solids (total dissolved) <sup>a</sup> | 904  | 636  |
| Solids suspended                      | 74   | 3.4  |
| Sulfate <sup>a</sup>                  | 84   | 234  |
| Vanadium                              | 0.15   | 0.08   |
| Average flow (Mgd)                    | 3.46 × 10 <sup>6</sup>                           | 3.21 × 10 <sup>6</sup>                           |

<sup>a</sup>This varies directly with the sulfate content of incoming ore.

Source: EIA 1977.

for shipment to a commercial burial site. It is reported that 1500 tons (1361 metric tons) of this material, containing a calculated maximum of 46.9 Ci of total activity, is produced annually (EIA 1977). Table II-15 indicates data on the individual radionuclides. (Recent data from Allied indicate 188 pCi <sup>226</sup>Ra and 3600 pCi <sup>230</sup>Th per gram of uranium in the current feed concentrate, or slightly more than <sup>230</sup>Th than the 1976 concentrate.)<sup>\*</sup> It appears that because most of the activity caused by these radionuclides is alpha decay, the gross alpha activity of this drummed material is approximately 34.5 nCi/g.

Contaminated pieces of no longer usable process equipment are decontaminated so far as is feasible and then delivered by rail car to a dealer of radioactive contaminated metal scrap. Noncontaminated scrap is sold to various scrap dealers (EIA 1977).

As far as could be determined, condensed sulfur is stored at the site, as well as residues from the UOF<sub>3</sub> condenser and high boiler column.

<sup>\*</sup>Letter from A. J. Cipolla to Betty Perkins, June 29, 1981.

## D. Inadvertent Releases Involving Wastes and Effluents

### 1. Operational

From time to time, there will be small vent releases of toxic materials caused by over-pressurizing, seal failure, loss of power, plant cleanup and repair operations, process problems, etc. Discharges into the plant buildings may be released to the ambient environment because there are no off-gas cleanup systems operating on the building exhaust vents.

These types of releases would be expected to occur fairly frequently; however, there are no data publically available as to frequency, rate of release, and types of release.

### 2. Releases from Pond Operations

The plant is located less than 1 mile from the Ohio River. A breach in the dikes of the fluorine treatment ponds could result in some movement of CaF<sub>2</sub> sludge and some loss of fluorine-containing liquids. A breach in the uranium settling ponds could discharge uranium-containing sludge, whereas a breach in the fluoride spill control ponds could discharge fluoride compounds and small amounts of uranium. A breach could be caused by a break in the fill line causing erosion of the embankment, etc. The ponds are lined and underlain by gravel drain-leak-detection systems, so it would not appear that breach by tunneling caused by liquid-soil interactions would occur.

### 3. Releases Caused by Rupture of Ducts and Piping Carrying Waste Streams

Other types of accidents involving wastes would be for a liquid transfer line to break or for a line carrying gaseous waste discharge to rupture before entering the cleanup system. The consequences of such breaks would depend on the type of line, size of rupture, etc.

### 4. Failure of Effluent and Waste Treatment Equipment

Inadvertent releases could also occur if any dust collection equipment developed failures that resulted in channeling the gas flow around the collector. Inadvertent releases of fluoride compounds might occur if any of the various scrubbing systems became clogged, the liquid flow was reduced, contact time was reduced, there was mist eliminator failure, etc.



TABLE II-10

ALLIED MONITORING (NPDES) OUTFALL WATER QUALITY

| Date       | Flow (MGD) | Flow (m <sup>3</sup> /day) | TDS (mg/l) | Maximum TSS (mg/l) | Maximum F (mg/l) | pH <sup>min</sup> | pH <sup>max</sup> |
|------------|------------|----------------------------|------------|--------------------|------------------|-------------------|-------------------|
| Dec 1980   | 4.717      | 17 854                     | 1071       | 1.3                | 7.6              | 6                 | 7.5               |
| Nov 1980   | 4.564      | 17 275                     | 669        | 4.6                | 12.8             | 6.1               | 8.3               |
| Oct 1980   | 4.741      | 17 944                     | 1190       | 2.1                | 8.2              | 6.0               | 9.0               |
| Sept 1980  | 4.481      | 16 983                     | 785        | 1.9                | 7.4              | 3.9               | 8.3               |
| Aug 1980   | 4.599      | 17 407                     | 752        | 7.0                | 5.6              | 6.9               | 8.5               |
| July 1980  | 4.468      | 16 911                     | 824        | 1.8                | 9.2              | 6.5               | 8.4               |
| June 1980  | 4.844      | 18 334                     | 859        | 1.6                | 14.0             | 7.1               | 8.6               |
| May 1980   | 4.203      | 15 908                     | 966        | 2.2                | 6.2              | 6.4               | 9.3               |
| April 1980 | 4.188      | 15 852                     | 946        | 2.8                | 5.8              | 6.1               | 9.2               |
| March 1980 | 4.325      | 16 370                     | 904        | 2.0                | 6.0              | 5.9               | 8.8               |
| Feb 1980   | 4.043      | 15 303                     | 948        | 2.0                | 7.0              | 6.1               | 8.8               |
| Jan 1980   | 4.155      | 15 727                     | 836        | 6.0                | 7.0              | 6.0               | 8.7               |
| Dec 1979   | 4.210      | 15 935                     | 968        | 1.0                | 6.0              | 6.2               | 8.9               |
| Nov 1979   | 4.106      | 15 541                     | 1078       | 5.0                | 16.0             | 6.5               | 9.0               |
| Oct 1979   | 3.826      | 14 481                     | 849        | 3.0                | 8.0              | 6.6               | 8.7               |
| Sept 1979  | 4.055      | 15 348                     | 1244       | 3.0                | 10.0             | 6.0               | 8.7               |
| Aug 1979   | 4.015      | 15 197                     | 973        | 3.0                | 19.0             | 6.3               | 9.2               |
| July 1979  | 3.740      | 14 155                     | 1176       | 2.0                | 11.0             | 6.3               | 8.8               |
| June 1979  | 3.986      | 15 087                     | 754        | 64.0               | 11.0             | 6.1               | 8.0               |
| May 1979   | 4.025      | 15 234                     | 922        | 9.0                | 8.0              | 6.4               | 8.7               |
| April 1979 | 4.239      | 16 044                     | 838        | 60.0               | 8.0              | 3.6               | 8.7               |
| March 1979 | 4.380      | 16 578                     | 931        | 12.0               | 9.0              | 6.2               | 8.8               |
| Feb 1979   | 4.796      | 18 152                     | 1382       | 4.0                | 14.0             | 6.5               | 8.2               |
| Jan 1979   | 3.857      | 14 598                     | 1007       | 4.0                | 5.0              | 6.7               | 8.4               |

Source: NPDES reports by Allied Chemical to EPA.

TABLE II-11

WATER QUALITY OF EPA SAMPLE AT OUTFALL

| Item            | Concentration mg/l |
|-----------------|--------------------|
| Arsenic         | 0.002              |
| Barium          | 0.04               |
| Boron           | 0.04               |
| Chromium (tot.) | 0.02               |
| Copper          | 0.02               |
| Iron (tot.)     | 0.06               |
| Manganese       | 0.01               |
| Selenium        | 0.003              |
| Zinc            | 0.02               |
| Fluoride        | 6.5                |
| Phenols         | 0.0                |
| TSS             | 2.0                |
| pH              | 6.8                |

Source: EPA compliance inspection.

TABLE II-12

RADIOACTIVITY IN FACILITY LIQUID EFFLUENT

|                                 | 1962 | 1969  | 1971  | 1973  |
|---------------------------------|------|-------|-------|-------|
| Average alpha activity (pCi/ml) | 0.51 | 0.031 | 0.188 | 0.217 |
| Maximum alpha activity pCi/ml   | 0.58 | 0.065 | 0.560 | 0.500 |
| Average beta activity (pCi/ml)  | NA   | 0.247 | 0.377 | 0.516 |
| Maximum beta activity pCi/ml    | NA   | 0.402 | 0.770 | 1.11  |
| Average uranium (ppm)           | 3.1  | 1.0   | 0.7   | 0.7   |

Source: EIA 1977.

TABLE II-13

**ISOTOPIC ANALYSIS OF METROPOLIS WORKS  
EFFLUENT WATER (002 OUTFALL) IN  
MICROCURIES PER MILLILITER**

|             | <sup>235</sup> U      |                       | U Natural               |                  | <sup>226</sup> Ra                         |                      | <sup>232</sup> Th    |                      | <sup>232</sup> Th     |                      |
|-------------|-----------------------|-----------------------|-------------------------|------------------|---|----------------------|----------------------|----------------------|-----------------------|----------------------|
|             | Soluble               | Insoluble             | Calculated <sup>a</sup> | Wet <sup>b</sup> | Soluble                                   | Insoluble            | Soluble              | Insoluble            | Soluble               | Insoluble            |
| <b>1975</b> |                       |                       |                         |                  |   |                      |                      |                      |                       |                      |
| January     | $6.0 \times 10^{-9}$  | $1.0 \times 10^{-8}$  | 1.1                     | 1.0              | $2.1 \times 10^{-8}$                      | $5.2 \times 10^{-9}$ | $1.0 \times 10^{-9}$ | $1.0 \times 10^{-9}$ | $1.7 \times 10^{-8}$  | $1.0 \times 10^{-9}$ |
| February    | $3.0 \times 10^{-10}$ | $7.4 \times 10^{-10}$ | 0.1                     | 0.8              | $2.6 \times 10^{-9}$                      | $6.7 \times 10^{-8}$ | $1.0 \times 10^{-9}$ | $5.2 \times 10^{-7}$ | $1.8 \times 10^{-10}$ | $8.4 \times 10^{-8}$ |
| March       |                       |                       |                         | 1.8              | Sample discarded before isotopic analysis |                      |                      |                      |                       |                      |
| April       | $2.9 \times 10^{-8}$  | $9.5 \times 10^{-9}$  | 2.5                     | 1.1              | $4.0 \times 10^{-9}$                      | $7.2 \times 10^{-8}$ | $1.6 \times 10^{-7}$ | $5.8 \times 10^{-7}$ | $1.4 \times 10^{-8}$  | $6.6 \times 10^{-8}$ |
| May         | $1.0 \times 10^{-8}$  | $3.0 \times 10^{-10}$ | 0.7                     | 1.0              | $7.4 \times 10^{-9}$                      | $6.8 \times 10^{-8}$ | $1.0 \times 10^{-9}$ | $8.1 \times 10^{-7}$ | $3.4 \times 10^{-10}$ | $7.4 \times 10^{-8}$ |
| June        | $4.5 \times 10^{-9}$  | $3.3 \times 10^{-9}$  | 0.5                     | 0.5              | $1.8 \times 10^{-9}$                      | $5.3 \times 10^{-8}$ | $6.4 \times 10^{-9}$ | $4.2 \times 10^{-7}$ | $1.8 \times 10^{-10}$ | $4.4 \times 10^{-9}$ |
| July        | $5.8 \times 10^{-9}$  | $1.0 \times 10^{-8}$  | 1.1                     | 0.5              | $9.1 \times 10^{-9}$                      | $1.0 \times 10^{-8}$ | $5.4 \times 10^{-8}$ | $2.2 \times 10^{-7}$ | $1.8 \times 10^{-10}$ | $1.0 \times 10^{-9}$ |
| August      | $4.7 \times 10^{-9}$  | $8.8 \times 10^{-9}$  | 0.9                     | 0.8              | $4.2 \times 10^{-10}$                     | $1.0 \times 10^{-9}$ | $6.2 \times 10^{-8}$ | $2.1 \times 10^{-7}$ | $1.8 \times 10^{-10}$ | $1.0 \times 10^{-9}$ |
| September   |                       |                       |                         | 0.5              | Sample discarded before isotopic analysis |                      |                      |                      |                       |                      |
| October     | $8.5 \times 10^{-9}$  | c                     | 0.3                     | 1.0              | $4.4 \times 10^{-9}$                      |                      | $1.2 \times 10^{-7}$ |                      | $1.8 \times 10^{-10}$ |                      |
| November    | $6.6 \times 10^{-9}$  | $8.4 \times 10^{-9}$  | 1.0                     | 0.5              | $8.0 \times 10^{-9}$                      | $6.0 \times 10^{-9}$ | $8.3 \times 10^{-8}$ | $1.4 \times 10^{-7}$ | $3.6 \times 10^{-9}$  | $4.8 \times 10^{-9}$ |
| December    | $4.4 \times 10^{-9}$  | $6.3 \times 10^{-9}$  | 0.7                     | 0.2              | $6.0 \times 10^{-9}$                      | $6.7 \times 10^{-9}$ | $6.1 \times 10^{-8}$ | $1.2 \times 10^{-7}$ | $4.3 \times 10^{-9}$  | $3.0 \times 10^{-9}$ |
| Average     | $8.0 \times 10^{-9}$  | $6.4 \times 10^{-9}$  | 0.9                     | 0.8              | $6.5 \times 10^{-9}$                      | $3.2 \times 10^{-8}$ | $5.5 \times 10^{-8}$ | $3.4 \times 10^{-7}$ | $3.2 \times 10^{-9}$  | $2.7 \times 10^{-8}$ |
| <b>1976</b> |                       |                       |                         |                  |   |                      |                      |                      |                       |                      |
| January     |                       |                       |                         | 0.7              | Sample discarded before isotopic analysis |                      |                      |                      |                       |                      |
| February    | $2.1 \times 10^{-9}$  | $6.9 \times 10^{-9}$  | 0.6                     | 0.5              | $3.7 \times 10^{-9}$                      | $1.0 \times 10^{-9}$ | $2.9 \times 10^{-8}$ | $1.2 \times 10^{-9}$ | $1.8 \times 10^{-9}$  | $1.0 \times 10^{-9}$ |
| March       | $3.5 \times 10^{-9}$  | $9.3 \times 10^{-9}$  | 0.8                     | 0.6              | $4.6 \times 10^{-9}$                      | $5.8 \times 10^{-9}$ | $2.9 \times 10^{-8}$ | $1.5 \times 10^{-7}$ | $2.5 \times 10^{-9}$  | $1.0 \times 10^{-9}$ |
| April       | $1.1 \times 10^{-8}$  | $3.6 \times 10^{-9}$  | 1.0                     | 0.6              | $4.2 \times 10^{-10}$                     | $5.8 \times 10^{-9}$ | $8.0 \times 10^{-8}$ | $1.0 \times 10^{-7}$ | $2.0 \times 10^{-9}$  | $2.2 \times 10^{-9}$ |
| May         | $1.1 \times 10^{-8}$  | $3.2 \times 10^{-9}$  | 0.9                     | 0.8              | $2.5 \times 10^{-9}$                      | $2.5 \times 10^{-9}$ | $8.6 \times 10^{-8}$ | $1.0 \times 10^{-7}$ | $2.4 \times 10^{-9}$  | $1.7 \times 10^{-9}$ |
| June        | $2.5 \times 10^{-8}$  | $2.2 \times 10^{-9}$  | 1.8                     | 1.7              | $4.8 \times 10^{-9}$                      | $2.9 \times 10^{-9}$ | $1.7 \times 10^{-7}$ | $2.3 \times 10^{-7}$ | $1.8 \times 10^{-10}$ | $1.6 \times 10^{-9}$ |
| July        | $6.8 \times 10^{-9}$  | $2.7 \times 10^{-9}$  | 0.6                     | 0.7              | $4.8 \times 10^{-10}$                     | $3.8 \times 10^{-9}$ | $7.7 \times 10^{-8}$ | $7.0 \times 10^{-8}$ | $1.8 \times 10^{-10}$ | $2.7 \times 10^{-9}$ |
| August      | $1.2 \times 10^{-8}$  | $2.7 \times 10^{-9}$  | 0.9                     | 1.5              | $5.0 \times 10^{-9}$                      | $5.0 \times 10^{-9}$ | $9.9 \times 10^{-8}$ | $1.1 \times 10^{-7}$ | $1.1 \times 10^{-9}$  | $1.7 \times 10^{-9}$ |
| Average     | $1.0 \times 10^{-8}$  | $4.4 \times 10^{-9}$  | 0.9                     | 0.9              | $3.1 \times 10^{-9}$                      | $3.8 \times 10^{-9}$ | $8.3 \times 10^{-8}$ | $1.1 \times 10^{-7}$ | $1.5 \times 10^{-9}$  | $1.7 \times 10^{-9}$ |

<sup>a</sup>Total natural uranium calculated from <sup>235</sup>U concentration.

<sup>b</sup>Fluorimetric uranium analysis of monthly composite samples.

<sup>c</sup>Insoluble portion of sample lost in sample preparation.

Source: EIA 1977.

TABLE II-14

RADIOLOGICAL EFFLUENT RELEASES TO THE WATER

| Period           | Discharge             |                                |                        |                                 |                        |                                 |
|------------------|-----------------------|--------------------------------|------------------------|---------------------------------|------------------------|---------------------------------|
|                  | $U_{nat}$<br>$\mu Ci$ | $\frac{U_{nat} \mu Ci^a}{MTU}$ | $^{230}Th$<br>$\mu Ci$ | $\frac{^{230}Th \mu Ci^a}{MTU}$ | $^{226}Ra$<br>$\mu Ci$ | $\frac{^{226}Ra \mu Ci^a}{MTU}$ |
| July-Dec<br>1976 | 1 240 000             | 195.3                          | 5200                   | 0.82                            | 22 000                 | 3.46                            |
| Jan-June<br>1977 | 950 000               | 149.6                          | 3200                   | 0.50                            | 11 000                 | 1.73                            |
| July-Dec<br>1977 | 190 000               | 187.4                          | 3000                   | 0.47                            | 11 000                 | 1.73                            |
| Jan-June<br>1978 | 950 000               | 149.6                          | 2300                   | 0.36                            | 26 000                 | 4.09                            |
| July-Dec<br>1978 | 960 000               | 151.2                          | NA                     | -                               | NA                     | -                               |

<sup>a</sup>Assuming 6350 metric tons uranium per 6-month period.

Source: Submittals to NRC.

TABLE II-15

ISOTOPIC CONTENT OF URANIUM RECOVERY FACILITY SOLID WASTES

| Isotope       | Source  | Radioactivity (curies) |
|---------------|---|------------------------|
| Uranium (nat) | Unrecoverable   | 1.9 <sup>a</sup>       |
| $^{226}Ra$    | Long-lived daughters not removed in the milling process | 2.1                    |
| $^{230}Th$    | Long-lived daughters not removed in the milling process | 36.1                   |
| Thorium (nat) | Natural thorium not removed in the milling process      | 6.8                    |
| Total         |   | 46.9 <sup>a,b</sup>    |

Apparently no data are available for the extent and frequency of treatment equipment failure. Because in many cases Allied has multiple scrubber systems, malfunction of one scrubber should be compensated for to some extent in the other scrubber systems. Allied personnel monitor scrubber pressure drop and temperature at 2-hour intervals, and off-gas scrubber samples are analyzed at 4-hour intervals.

5. Transportation

An accident involving transport of wastes to the contaminated-scrap dealer or the commercial waste burial site could result in release of waste material.

E. Long-Term Releases

One of the major concerns for long-term release will be with the material in the drums sent to the commercial low-level waste burial sites. Most wastes accepted for burial at these sites have fairly short half-lives, and it is usually felt that concern for containment only extends to

<sup>a</sup>Based on the 1976 operating year and scaled to 14 000 tons of uranium annual throughput. The licensed material is reasonably uniformly distributed in these dry solids, with an average specific activity of 0.0014  $\mu Ci/g$ .

<sup>b</sup>Short-lived daughters are not included because of the 1-yr decay time allowed before the material is disposed of. Total activity is calculated by measurement of isotopic content of incoming ore concentrates and subtracting the measured and calculated effluent losses.

Source: EIA 1977.

a few hundreds of years. However, the radioactive wastes from Allied have long half-lives; in addition, long-lived daughters will grow in from the uranium and thorium parents. Thus, adequate containment of these types of wastes at a low-level waste disposal site are of concern.

#### F. Recommendations

To obtain a better data base for assessment of the Allied UF<sub>6</sub> plant wastes, the following projects should be undertaken.

- (1) Determine the types and quantities of emissions occurring from the reduction stacks and the quantity of uranium in the condensed sulfur from the reduction stack sulfur condenser.
- (2) Study the long-term effects of the liquid discharge on the Ohio River.
- (3) Perform an independent study of the size distribution, solubility, and ambient air concentrations of <sup>230</sup>Th, <sup>226</sup>Ra, and U<sub>nat</sub> in regions surrounding the plant at locations that may have maximum concentrations as determined by modeling of dispersion of stack emissions.
- (4) Perform an independent study of fluorine concentrations at various times of the year in soils and plants surrounding the facility, particularly at locations that stack emission data and modeling indicate will be areas of maximum fluorine deposition.
- (5) Trace the fates of arsenic, selenium, molybdenum, and vanadium from stack off-gases.
- (6) Determine the <sup>230</sup>Th emissions from the grinding and sizing operations of the uranium recovery circuit to define the need for further off-gas cleanup (that is, 3-2 stack emissions).
- (7) Determine the frequency and types of inadvertent emissions.
- (8) Study sources and extent of fugitive emissions (including emissions from the building vents).
- (9) Provide information on contaminants in decantate from the uranium spill control ponds.
- (10) Perform an independent study of external radiation levels outside the site near the fence and concentrations of uranium and <sup>230</sup>Th in surrounding surface soils.

- (11) Monitor HF emissions from all stacks. (Note: This is also a recommendation of the NRC staff.)
- (12) Monitor independently soluble and insoluble <sup>226</sup>Ra releases in the 002 outfall.
- (13) Determine what trace contaminants are in the CaF<sub>2</sub> sludge that is proposed to be used for manufacture of HF.

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## CHAPTER III

### KERR-McGEE NUCLEAR CORPORATION— SEQUOYAH

#### A. Background

In 1970, Kerr-McGee Nuclear began operation of a uranium hexafluoride production facility having a design throughput of 5000 tons (4535 metric tons) of uranium a year. Since then, an expansion program has been completed, doubling throughput to 10 000 tons (9070 metric tons) of uranium a year (Order to Modify License, Amendment 9—OML).

The facility (Fig. III-1) is located in a rural region near Gore, Oklahoma on a 2100-acre site, of which 75 acres is a restricted, fenced area for the conversion facility. The site is bounded on the west by the Illinois and Arkansas Rivers. Detailed data on the geology, hydrology, climate, land use, etc., may be obtained from the Final Environmental Statement (Final Environmental Statement 1975—FES 1975).

Approximately 150 people are employed at the plant.

#### B. Process Description

##### 1. Introduction

The facility uses the wet solvent extraction-fluorination process to convert uranium concentrates into UF<sub>6</sub>. The facility can receive the concentrates either dry in 55-gallon drums or as a wet slurry (FES 1975).

Upon receipt, the concentrate is weighed and sampled. The concentrate is processed by dissolving in nitric acid and removing uranyl nitrate by solvent extraction and stripping. The pure uranyl nitrate is further concentrated and denitrified to produce uranium trioxide (UO<sub>3</sub>), after which UO<sub>3</sub> is reduced to UO<sub>2</sub> with cracked ammonia. Next, UO<sub>2</sub> is reacted with anhydrous hydrogen fluoride to produce UF<sub>4</sub>. Finally, the UF<sub>4</sub> is converted to UF<sub>6</sub> by reaction with F<sub>2</sub> (FES 1975)

A detailed description of each process step, including the treatment of waste and effluent streams, follows.

##### 2. Receiving and Sampling

Uranium concentrate, received in 55-gallon drums, is weighed and approximately 0.1% of the concentrate removed for sampling by emptying each drum into an elevated hopper and removing representative samples of the concentrate as it moves downward to a collection vessel. The sampled concentrate is either redrummed and stored for future processing or delivered to storage hoppers in the digestion area (FES 1975).

Any dusts produced during sampling and collection are passed through a cyclone and baghouse whose off-gases in turn are routed to the main plant dust collection system. A vacuum cleaner is used to collect any spilled concentrate and clean the drums and sampling system. The vacuum off-gases containing uranium concentrate dusts are sent through a cyclone and baghouse and then are combined with the off-gases from sampling before these gases enter the sampling clean-up system (Fig. III-2). Residues from the two clean-up systems are discharged back to the system (FES 1975; OML).

Rain run-off from the drum storage area drains to a sump where solids are separated and liquids overflow to the outfall.

##### 3. Digestion

Uranium concentrates (including slurries) are fed in batches into three 5000-gallon (18.9 m<sup>3</sup>) stirred, hot, 40%-nitric-acid digester tanks. The digestors are operated at subatmospheric pressure, with off-gases passed through a small eductor scrubber before being routed to the nitric acid recovery tower (Fig. III-3) (OML; Application for Permit, 1978—AP 1978).

Each batch dissolution takes 2 hours, during which time 552 pounds (250 kg) of NO<sub>2</sub> and 72 pounds (33 kg)

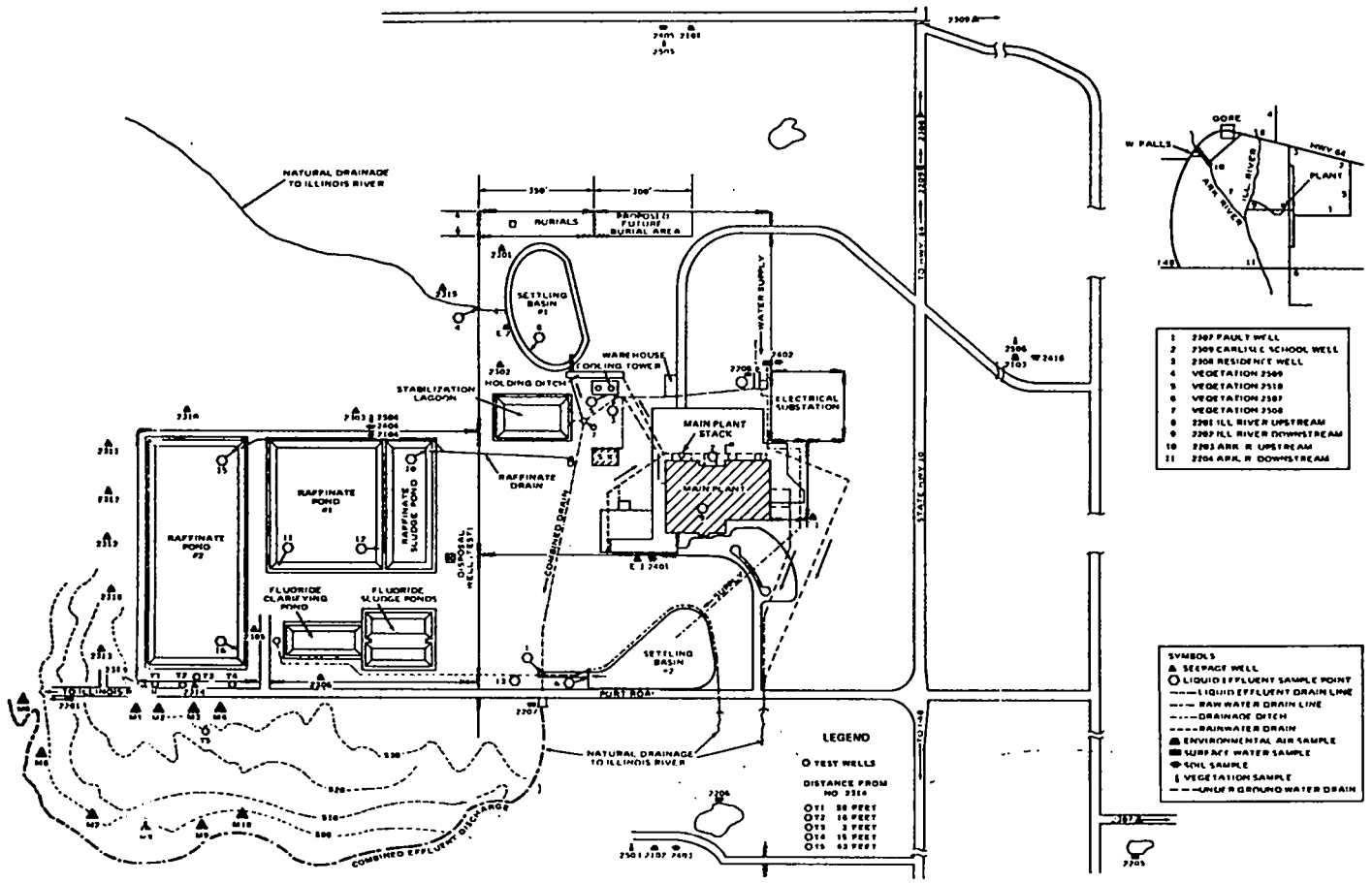


Fig. III-1. Sequoyah facility showing new and proposed additions.

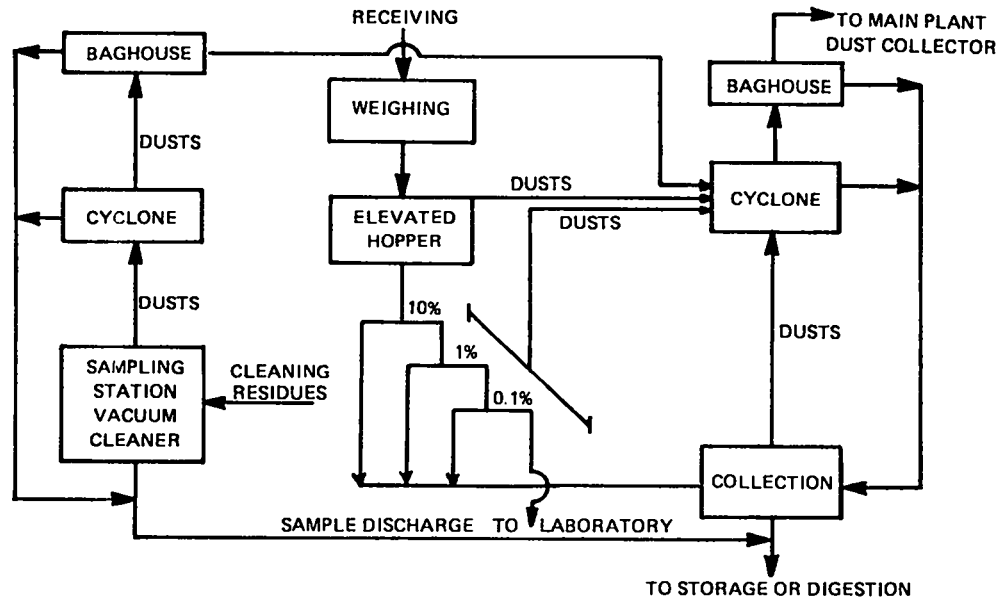


Fig. III-2. Receiving and sampling.

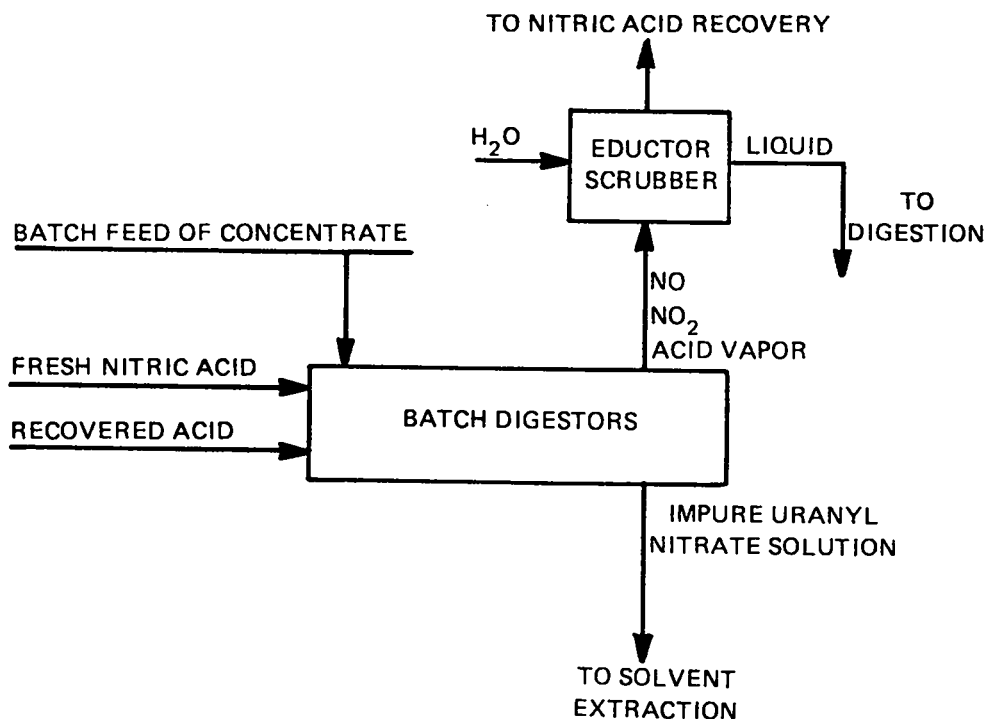


Fig. III-3. Digestion.

of NO are evolved. At the full facility production rate, 20 batches are run per week (AP 1978).

Washdown waters during cleaning of the digestion section are discharged to the digestors.

#### 4. Solvent Extraction and Acid Scrubbing

The impure uranyl nitrate digestion solution is processed by counter-current solvent extraction in pump-decanters using a tributylphosphate-hexane solvent that sorbs the uranyl nitrate (Fig. III-4). The uranium-loaded solvent is scrubbed with slightly acidified water (FES 1975).

Organic vapors emitted through pump seals, etc., are removed from the building by means of the main exhaust system. Hexane off-gases are passed through a condenser (AP 1978).

Discharge from washdown of the facility is routed to the solvent extraction feed tank.

The raffinate (see Fig. III-4) from solvent extraction contains most of the impurities originally present in the uranium concentrate. Typical impurities are  $^{226}\text{Ra}$ ,  $^{230}\text{Th}$ , arsenic, selenium, vanadium, molybdenum, silicon, and sulfur. A small amount of organic solvent and nitrogen compounds is also present. This stream is sent to the raffinate disposal ponds (FES 1975).

#### 5. Stripping and Solvent Purification

The uranyl nitrate is re-extracted into the aqueous phase using extraction pulse columns (Fig. III-5). Any process off-gases are removed in the building process air (FES 1975).

Seal leaks and washdown water are routed to the solvent extraction feed tank.

The barren solvent is purified for recycle by washing with ammonium sulfate and sodium hydroxide. The spent clean-up bleed joins the raffinate stream and is discharged to the raffinate ponds. The off-gases from solvent purification pass through a condenser before discharge through the hexane vent (AP 1978; FES 1975).

#### 6. Scrubbing, Decanting, and Concentration

Any residual organics in the aqueous strip solution are removed in a hexane scrub-decanter. The uranyl nitrate strip solution is initially concentrated in single-effect evaporators and then further concentrated in boil-down tanks to which sulfuric acid or ammonium sulfate [approximately 2.3 lb/hr (1.04 kg/hr) of sulfur] is added to improve product reactivity in subsequent conversion steps (Fig. III-6) (FES 1975; AP 1978).

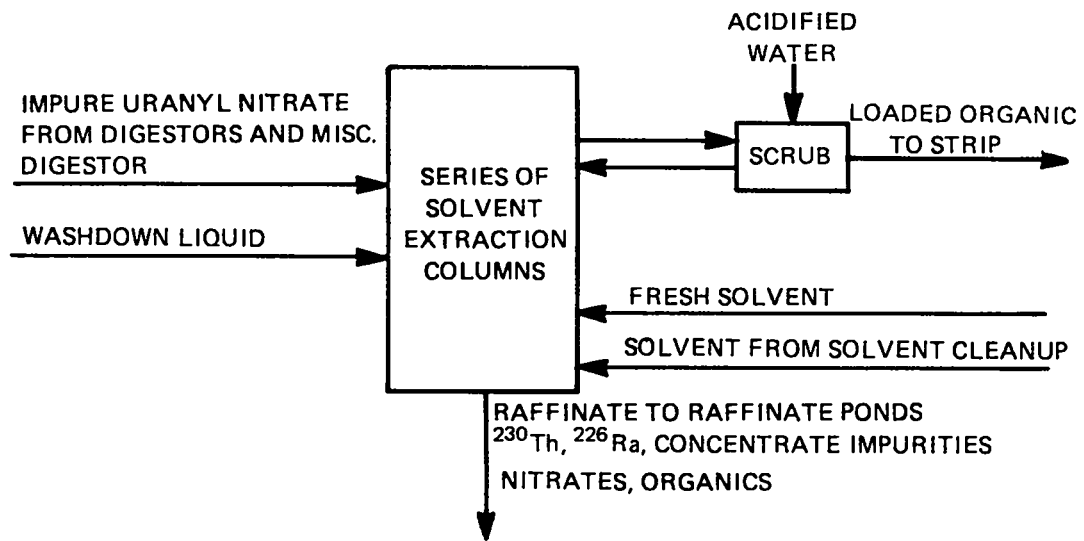


Fig. III-4. Solvent extraction and acid scrubbing.

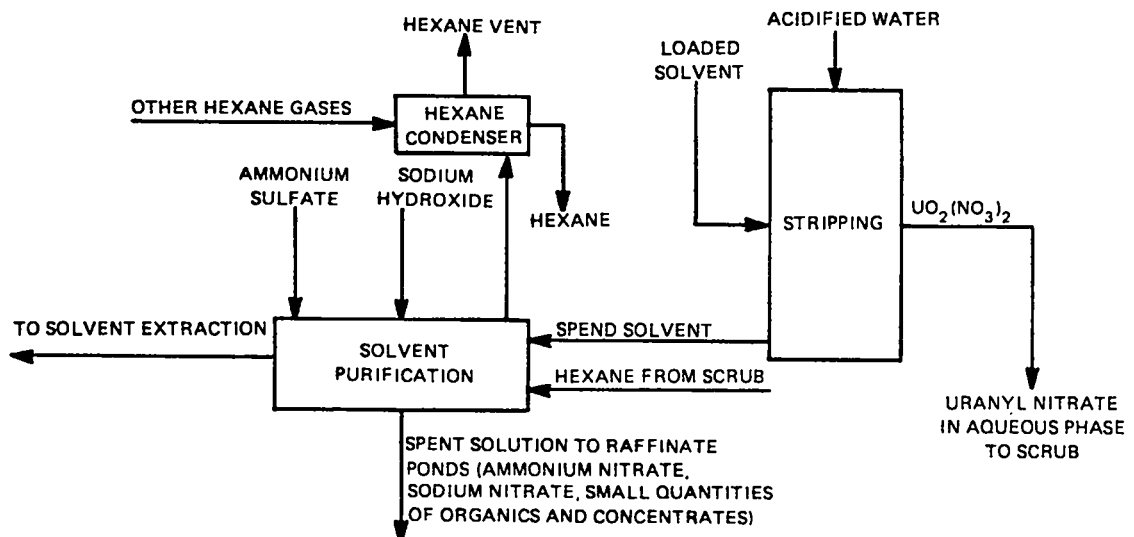


Fig. III-5. Stripping and solvent purification.



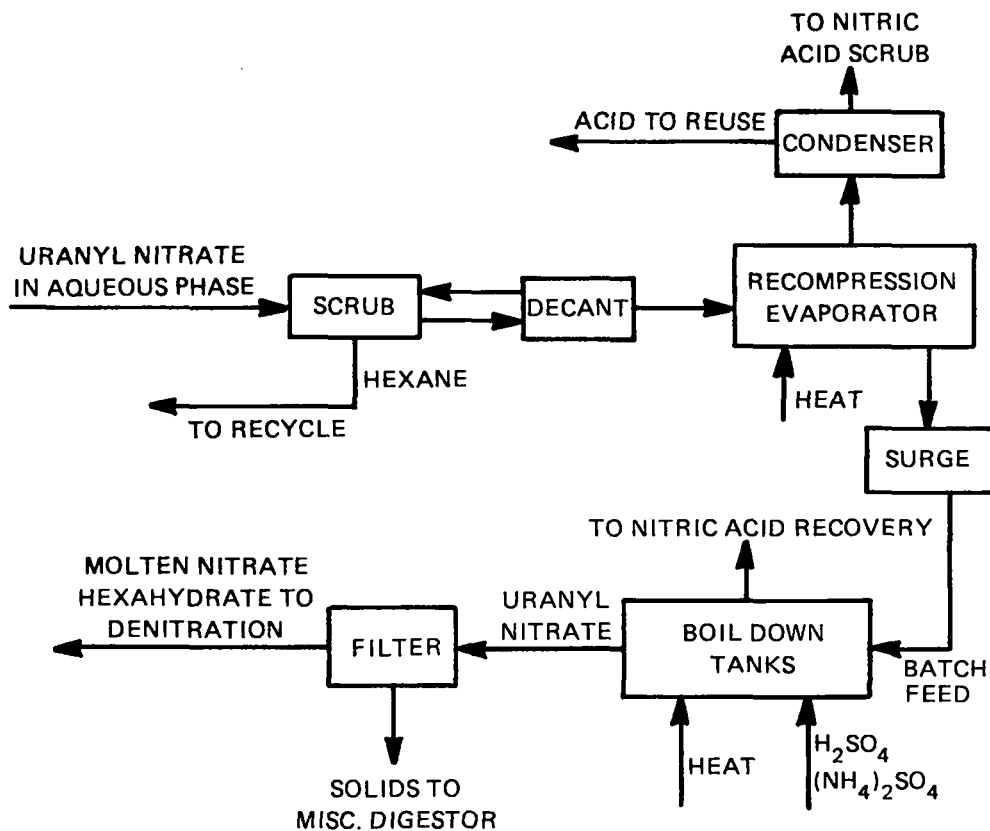


Fig. III-6. Scrubbing, decanting, and concentration.

Off-gases from the evaporator pass through a condenser and then to the central nitric acid scrubber. Acid recovered in the condenser is reused. Off-gases from the concentrator boil-down tanks are routed to the nitric acid recovery scrubber (Safety Evaluation Report-SER 1977; AP 1978).

### 7. Denitration and Feed Preparation

The concentrated uranyl nitrate solution, containing about 10 lb of uranium per gallon, is decomposed to uranium trioxide, oxides of nitrogen, and nitric acid vapor in four electrically heated trough-type denitrators (Fig. III-7). At the design rate, approximately 1040 lb (472 kg) per hour of  $\text{NO}_2$  is evolved (FES 1975; AP 1978).

Denitrator off-gases pass through a water scrubber, after which the gases are combined, cooled further to condense additional nitric acid, and routed to the central nitric absorber system. There are two bubble cap column absorbers in this system, operating in parallel. In addition to gases from digestion, concentration, and denitration, the absorbers also receive vapors vented from the

nitric acid storage tanks and other vessels with  $\text{NO}_x$  off-gases. Off-gases vent through the main plant stack. Acidic liquid from the absorbers is recycled to the digestion system (AP 1978).

The uranium trioxide, now in the form of solid granules, goes to a surge bin and then to a hammer mill, where it is pulverized (Fig. III-7). After screening and air classifying, the purified material is ready for reduction (FES 1975).

Surge bin, hammer mill, and sizing section  $\text{UO}_3$  dusts pass through the central baghouse dust collector. Fines are sent to the miscellaneous digester (discussed in Sec. B.13) (FES 1975).

### 8. Reduction

The purified uranium trioxide, introduced into the reactor beds through a screw feeder, is contacted and reduced with cracked ammonia in two fluid bed reactors operated in series (Fig. III-8). The reduced material ( $\text{UO}_2$ ) is drawn to a surge bin where separation of the gases from the reacted pellets occurs. The off-gases contain unreacted ammonia, hydrogen, nitrogen, oxides

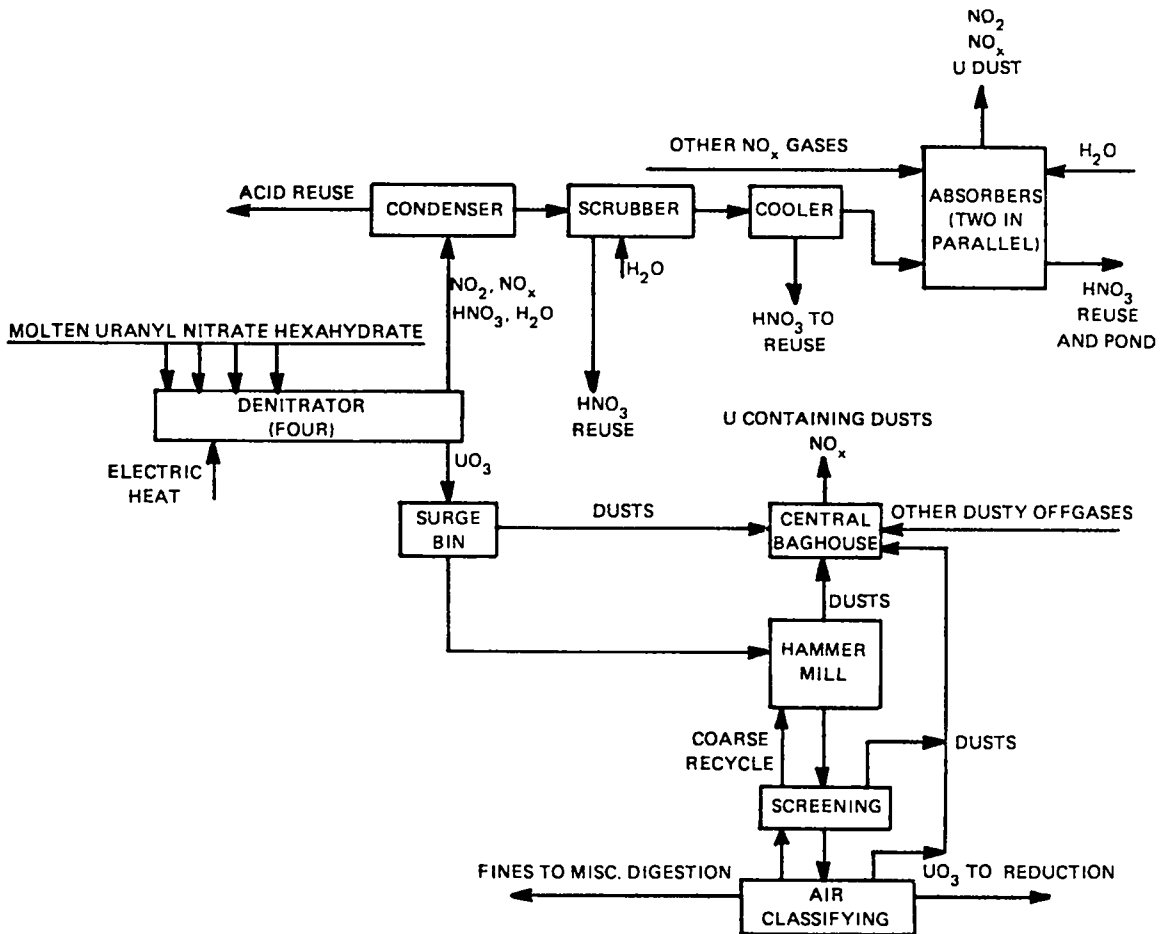


Fig. III-7. Denitration.

of nitrogen,  $H_2S$ , sulfur,  $UO_2$ - and  $UO_3$ -containing dusts, and water vapor. These off-gases are vented through a sintered metal filter and a backup filter. After condensation of elemental sulfur, the excess hydrogen and  $H_2S$  are oxidized, and the gas stream is vented through the steam boiler stack. The gases from this stack can contain small quantities of uranium oxides, oxides of nitrogen,  $SO_2$ , etc. (FES 1975; AP 1978).

The ammonia dissociator used to produce the  $N_2$  and  $H_2$  also has a small gaseous discharge.

A central vacuum cleaner system services all process areas from concentrate sampling through reduction (Fig. III-8). The off-gases from this system discharge through a cyclone and baghouse before delivery to the main plant dust collector, which in turn consists of a cyclone and baghouse. Residues from these collection devices are sent to the miscellaneous digester (OML).

## 9. Hydrofluorination

The  $UO_2$  from reduction is screw fed into the first of two stirred-bed hydrofluorinators (Fig. III-9). Here the material is fluidized with HF and reaction product gases, and converted to  $UF_4$ . The reactants are drawn off into an interstage hopper where the solids are fed to a second-stage stirred hydrofluorinator. In this vessel, HF obtained by vaporizing anhydrous (Fig. III-9) HF is introduced to fluidize and complete the reaction to  $UF_4$ . Solid  $UF_4$  product is delivered to the hydrofluorination storage bin, whereas the gases are cycled to the first-stage hydrofluorinator (FES 1975).

Off-gases from the interstage hopper discharge through two carbon filters to remove  $UF_4$  and  $UO_2$  dusts. The residues from these filters are sent to the miscellaneous digester. The cleaned gases pass through a

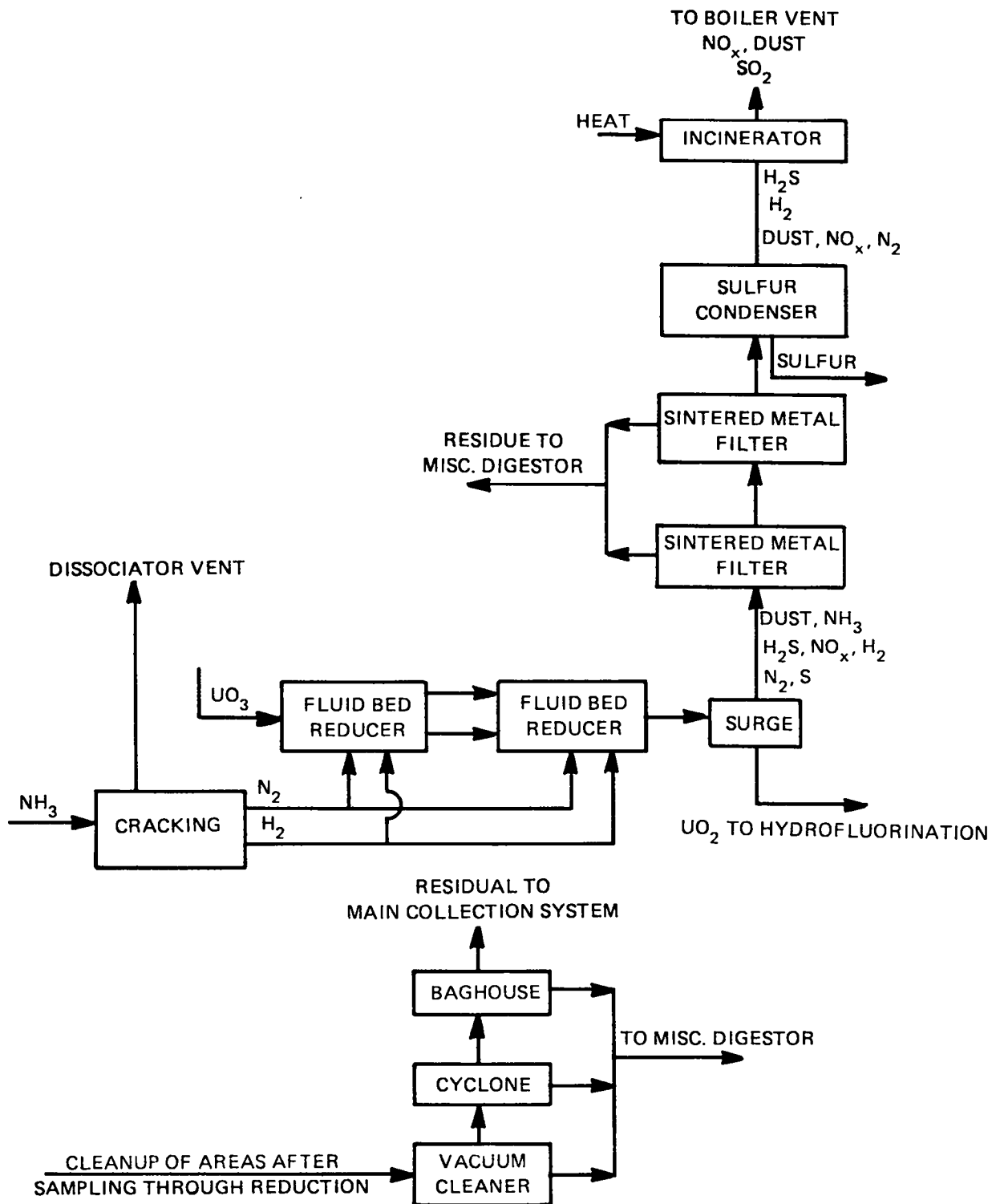


Fig. III-8. Reduction.

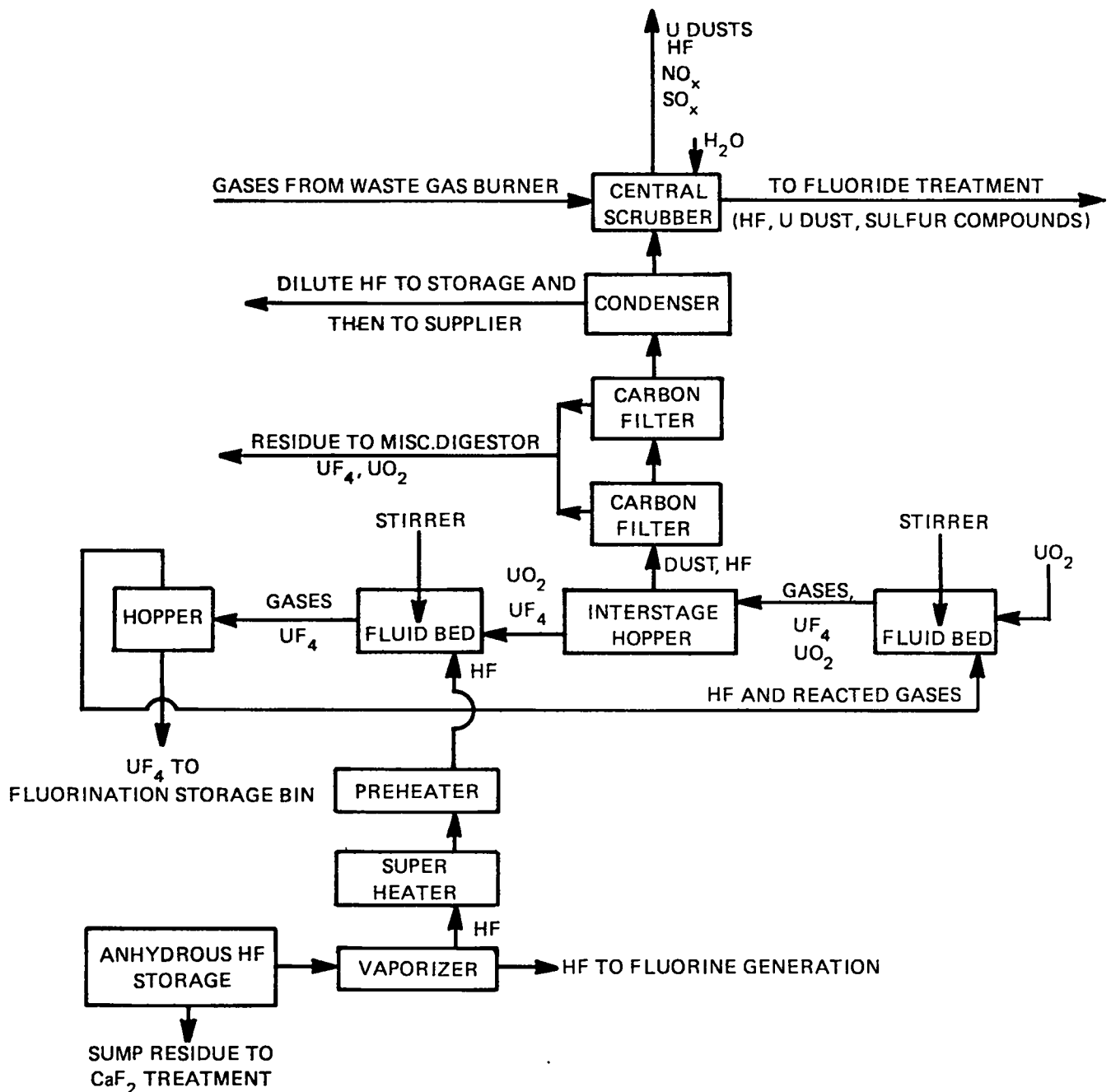


Fig. III-9. Hydrofluorination.

condenser to remove as dilute hydrofluoric acid unreacted HF and the water produced in the chemical reaction. This dilute acid is returned to the anhydrous-HF supplier (FES 1975).

The condenser off-gases are routed to the main fluorine off-gas counter-current water scrubber. In this scrubber, further particulate removal and some removal of fluorine compounds and any sulfur-containing compounds takes place. This liquid waste is sent to the fluoride treatment ponds. The scrubber off-gases contain

$\text{NO}_x$ , HF and other fluorides, sulfur compounds, and a small quantity of uranium-containing particulates (FES 1975).

#### 10. Fluorination

The fluorination system is a once-through fluorination process (Fig. III-10). There are two primary reactors through which the  $\text{UF}_4$ ,  $\text{F}_2$ , and reaction products are routed. The gaseous reaction products and entrained

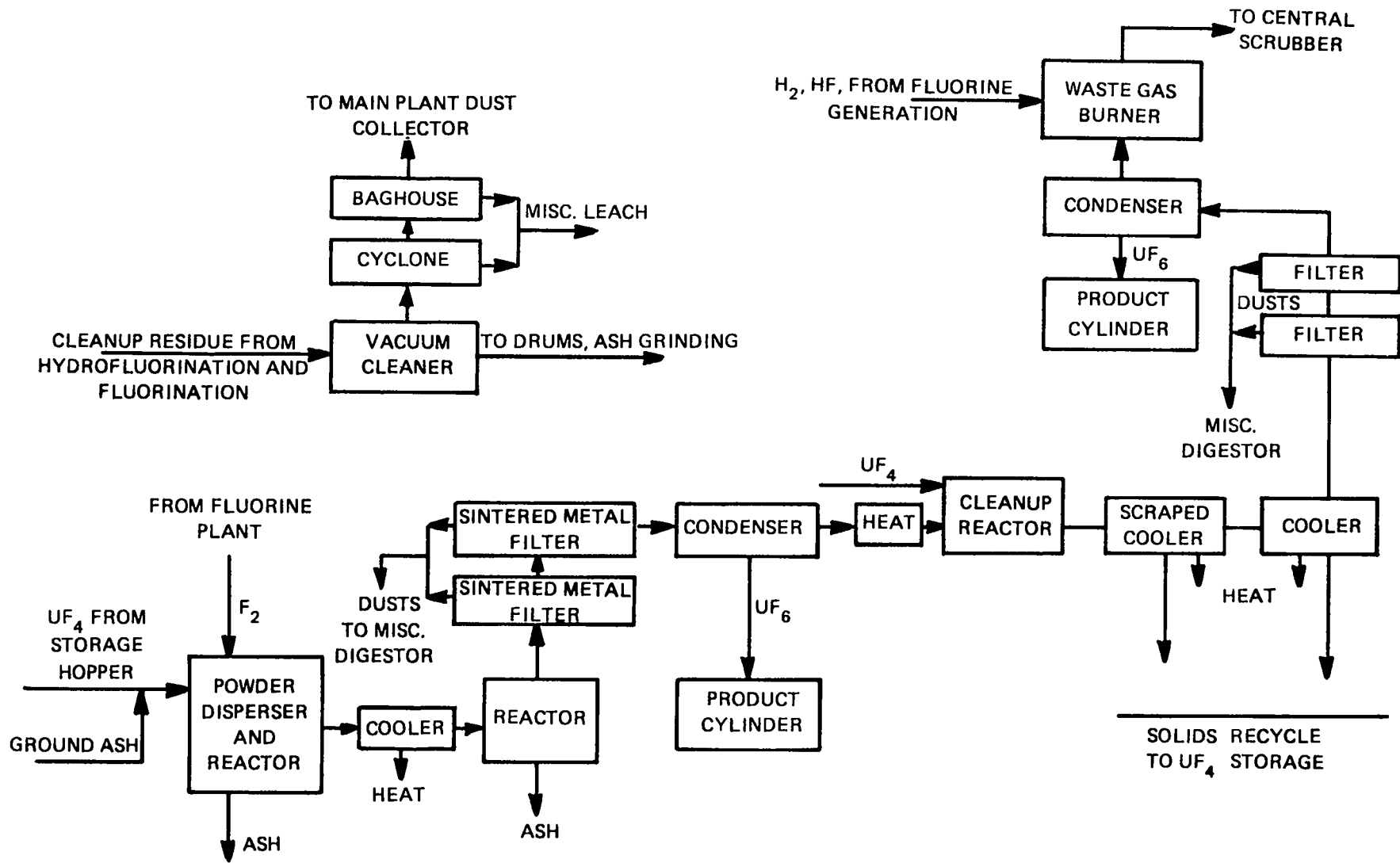


Fig. III-10. Fluorination.

solids pass through two filters to remove particulates. The filter residue is sent to the miscellaneous digester. As indicated in Fig. III-10,  $UF_6$  is condensed from the reactor off-gas stream. This condensed product is periodically melted and drawn off into the final product cylinders (FES 1975).

Excess  $F_2$  is used in the primary reactors to maximize the reaction to  $UF_6$ . Any unreacted  $F_2$  is heated and introduced to a clean-up reactor where  $UF_4$  is also added. The  $F_2$  reacts with the  $UF_4$ , and  $UF_6$  product gases again pass through two filters and a  $UF_6$  condenser. The final off-gases are passed through a waste gas burner and finally into the main fluorine off-gas water scrubber, which has been discussed previously. Any unreacted  $UF_4$  solids from the clean-up reactor are returned to the  $UF_4$  storage bin (FES 1975).

The clean-up reactor is not operated all the time, in which case the off-gases from the primary reactor circuit pass directly to the waste gas burner (FES 1975).

A vacuum cleaner is used in cleaning the area and vessels located in the hydrofluorination and fluorination section. The discharge from this system passes through a cyclone and baghouse (Fig. III-10) before joining the plant gases being routed to the main plant dust collection system. The material collected in the vacuum system is drummed until it can be handled in the ash grinding system (OML).

The fluorinator ash and vacuum cleaner residue from clean-up of the hydrofluorination and fluorination sections is ground, sized, and cycled back to the fluorination towers (Fig. III-11). Any remaining uranium daughters in this "ash" are collected as dust in the fluorination

filters and ultimately rejected in the raffinate from the miscellaneous digester.

## 11. Fluorine Production

Fluorine is produced on-site by electrolysis of hydrogen fluoride dissolved in a fused-salt bath of potassium bifluoride (Fig. III-12). Both hydrogen and fluorine product streams are filtered (to remove any entrained electrolyte) and then compressed and cooled to remove HF [condensed HF is reused in the system (FES 1975)].

The hydrogen stream is sent to the waste gas burner (which also incinerates the final off-gases from fluorination). The waste gas burner off-gases then pass through the main plant fluorine-gas water scrubber (discussed previously).

The  $F_2$  stream is sent to the fluorination towers (FES 1975).

The cells have to be periodically renewed. Sludges from cell cleanup and the filter residue are sent to the fluoride treatment ponds (FES 1975).

## 12. Miscellaneous Wastes and Effluents

The process areas in the manufacturing building are ventilated at a rate of 3000 ft<sup>3</sup>/min (1.4 m<sup>3</sup>/s). A central dust collection system is in operation, which includes collection hoods around packing glands, routinely opened equipment, and solids transfer areas. This collection system's off-gases are cleaned in a baghouse before discharge to the ambient atmosphere (OML).

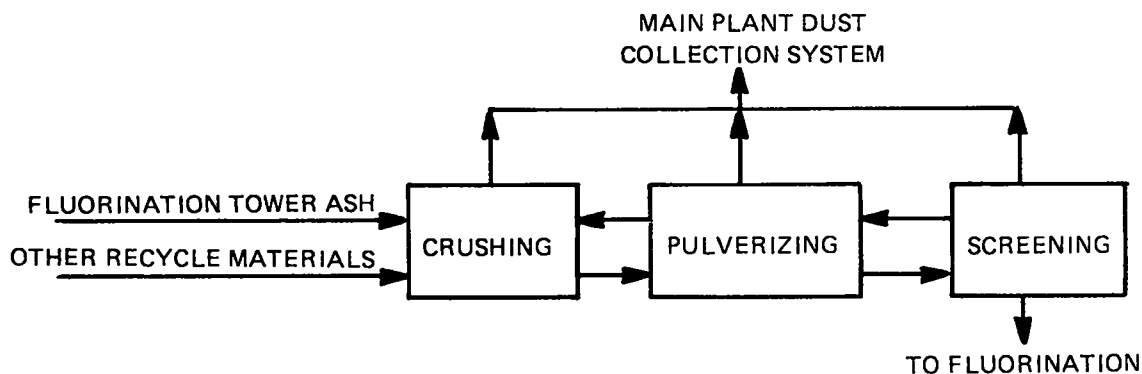


Fig. III-11. Ash grinding.

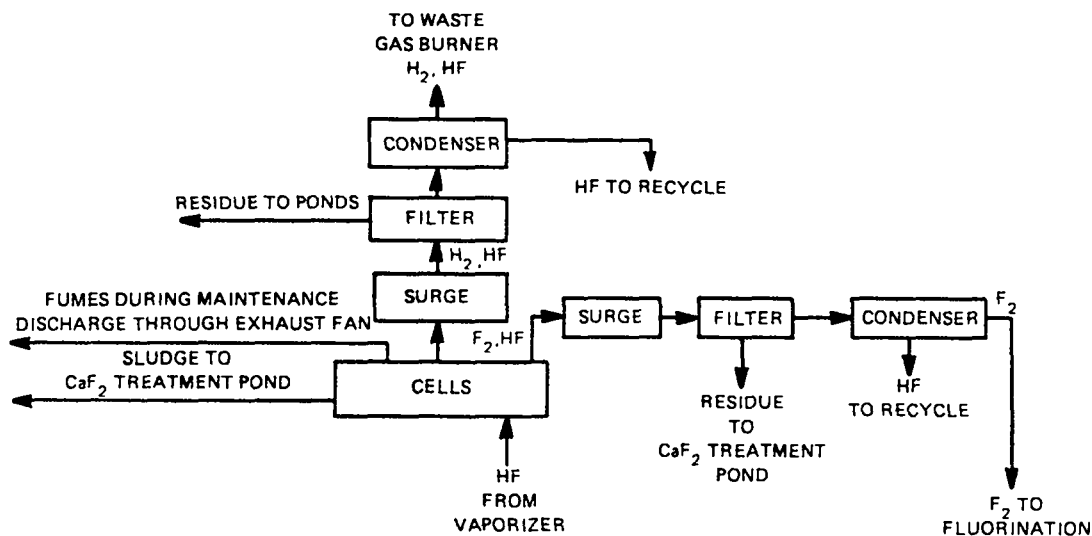


Fig. III-12. Fluorine production.

### 13. Miscellaneous Digester

Residues from the main plant vacuum cleaners, central baghouse dust collector, air classifier, reduction, hydrofluorination, and fluorination filters, and other miscellaneous residues containing uranium are dissolved with nitric acid in the miscellaneous digester (Fig. III-13) (FES 1975).

Off-gas from the miscellaneous digester is processed through a water scrubbing system and a caustic scrubber before being sent to the nitric acid recovery system. The scrubber liquids are sent to the raffinate ponds (SER). The impure uranyl nitrate solution then joins the uranyl nitrate solution from the main digesters before solvent extraction (SER).

### 14. UF<sub>6</sub> Cylinder Wash

Cylinders are returned to Kerr-McGee from the enrichment facilities. These cylinders contain residual UF<sub>6</sub> and the daughters of uranium that have "grown in" while the loaded cylinders were in storage. The daughters are generally found plated out on the cylinder walls.

After residual UF<sub>6</sub> is removed, the cylinder is washed with dilute nitric acid. The wash solution is filtered to remove any unleached solids and sent to the main solvent extraction circuit. Thus, the uranium daughter products, principally <sup>234</sup>Th and <sup>234</sup>Pa, ultimately report to the raffinate ponds.

### 15. Chemical Inventories

The facility maintains an inventory of uranium concentrate feed, UF<sub>6</sub> product, nitric acid, anhydrous ammonia, lime, anhydrous hydrogen fluoride, liquid nitrogen, hexane, and small quantities of tributyl phosphate, sulfuric acid, soda ash, aluminum hydroxide, sodium hydroxide, potassium bifluoride, lithium fluoride, ammonium sulfate, and carbon anodes (FES 1975).

There are loading and storage emissions associated with these inventories. As noted earlier, vapors from the nitric acid storage tanks are vented to the nitric acid absorbers. Gases from the HF storage tanks are vented to the central water scrubbing tower (FES 1975).

### 16. Summary of Discharges

Table III-1 summarizes the process discharges from each operation.

#### C. Available Data for Routine Releases, Disposal, and Treatment of Wastes

##### 1. Airborne Effluents

Table III-2, taken from the Environmental Statement, indicates airborne effluents for the Kerr-McGee facility when it was designed to process 5000 tons (4535 metric tons) of uranium per year. Table III-3 indicates dis-

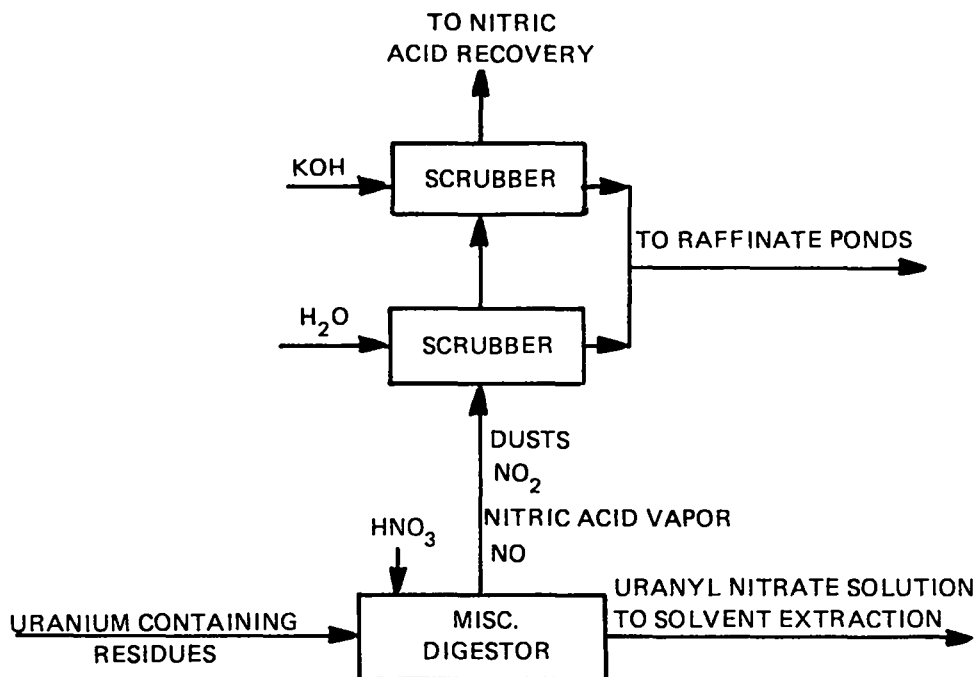


Fig. III-13. Miscellaneous digester.

charges in terms of kilograms/metric ton processed uranium. Table III-4, taken from data submitted to the Oklahoma State Department of Health, indicates the emissions expected at 10 000 tons (9070 metric tons) of uranium per year. Table III-5 indicates these discharges in terms of kilograms/metric ton processed uranium. Comparison of Tables III-3 and III-5 indicates that emissions per metric ton processed may change depending on equipment changes.

Table III-6 indicates recent data obtained from Kerr-McGee for concentrations of fluorine in soils and plants surrounding the facility.

Table III-7 indicates recent radionuclide releases to the ambient air taken from reports submitted to the NRC by Kerr-McGee (Kerr-McGee Nuclear Corporation, Environmental Report for Sequoyah Facility—ERSF), whereas Table III-8 indicates these releases as kilograms/metric ton processed.

There appear to be no currently available data on actual ambient air radionuclide concentrations at nearby residences and their solubility and particle sizes. The NRC has directed Kerr-McGee to start such a monitoring program (OML).

Calculations performed by the NRC indicate, from the limited stack emission and very limited meteorological data available, that the EPA 25-mR/yr (not including radon and radon daughters) requirement is being met by Kerr-McGee (OML).

## 2. Water

There are currently two discharge points at the Sequoyah facility. A continuous discharge combines decantate from the fluoride treatment ponds, sanitary waste, cooling tower water, and plant by-pass water (Fig. III-14). The other discharge is intermittent consisting of rain water run-off from fields being treated with decantate from the raffinate treatment ponds.

Table III-9 lists discharge data submitted by Kerr-McGee to the EPA as required by the NPDES permit for the continuous discharge (outfall 001). This table also converts this discharge to kilogram of contaminant per metric ton of uranium processed. (Although the exact throughput of Kerr-McGee is not publically available, an estimated production rate of 19.88 metric tons/day uranium in 1980 seems reasonable.)

Table III-10 shows similar NPDES discharge data for the field treatment run-off (outfall 002). This discharge is discussed more fully in the section on pond wastes.

Table III-11 indicates radiological liquid effluent release rates. Table III-12 converts this to release per metric ton of uranium processed. Table III-13 lists water sampling data for intake and discharge; Table III-14 lists water data up- and down-stream for 1972, and Table III-15 indicates the same location data for 1974. Table III-16 indicates the plant water balance.



**TABLE III-1**  
**SUMMARY OF DISCHARGES**

| Process                                       | Discharge  |  |
|---|--|--|
|   | Air  | Ponds  |
| Sampling                                      | Dust and radon   | Wash water (concentrate)   |
| Digestion                                     | NO <sub>x</sub>  | Wash water<br>(concentrate, nitric acid)   |
| Solvent extraction<br>treatment and stripping | Hexane, TBP,<br>NO <sub>x</sub>  | Plant washdown water and<br>raffinate (U, U daughters,<br>Mn, As, Se, V, Mo, Si, and S<br>compounds, ammonium nitrate,<br>sodium nitrate, organics, and<br>dilute nitric acid) |
| Concentration                                 | NO <sub>x</sub>  | Plant wash water and weak acids  |
| Denitration and<br>feed preparation           | NO <sub>x</sub> ,<br>Dust  | Plant wash water and weak acids  |
| Reduction                                     | NO <sub>x</sub> , N <sub>2</sub> ,<br>H <sub>2</sub> O, U oxides,<br>SO <sub>2</sub> | Plant wash water   |
| Hydrofluorination                             | HF, NO <sub>x</sub> ,<br>SO <sub>x</sub> , Dust                                      | Scrubber water and plant wash<br>water (F, U, S compounds)   |
| Fluorination and<br>ash grinding              | F <sub>2</sub> , HF, dust  | Scrubber water and plant wash<br>water (F, U, S compounds)   |
| Fluorine production                           | H <sub>2</sub> O, HF, H <sub>2</sub>   | Sludges and filter residue   |
| Miscellaneous digester                        | Dusts, NO <sub>x</sub> ,<br>fluoride compounds                                       | Potassium compounds,<br>nitrates, uranium,<br>fluoride compounds   |
| Cylinder wash                                 |  | (Liquid-to-solvent extraction;<br><sup>234</sup> Th and <sup>234</sup> Pa decay in<br>discharge to raffinate pond)   |
| Chemical inventories                          | Hexane, HF, NH <sub>3</sub> ,<br>lime dust, radon, nitric acid                       |  |

TABLE III-2

**SUMMARY OF AIRBORNE EFFLUENTS AT DESIGN THROUGHPUT 5000 T/YR  
(Quantities in Metric Tons per Month)**

| <u>Effluent Source</u>              | <u>Uranium</u>        | <u>Nitrogen Dioxide</u> | <u>Sulfur Dioxide</u> | <u>Fluorides</u>   | <u>Water</u> | <u>Nitrogen</u> | <u>Oxygen</u> | <u>Hexane</u> |
|-------------------------------------|-----------------------|-------------------------|-----------------------|--------------------|--------------|-----------------|---------------|---------------|
| Sample preparation room             | $1 \times 10^{-5}$    |                         |                       |                    |              |                 |               |               |
| Absorber tail gas                   |                       | 4.6                     |                       |                    | 280          | 540             | 160           |               |
| Reduction off-gas                   |                       |                         | 1.5                   |                    | 91           | 1700            | 470           |               |
| HF scrubber                         | $2 \times 10^{-4}$    |                         |                       | 0.006              | 62           | 3700            | 1100          |               |
| Fluorine vent                       |                       |                         |                       | 0.095 <sup>b</sup> |              |                 |               |               |
| Dust collectors                     | $1.6 \times 10^{-3}$  |                         |                       |                    |              |                 |               |               |
| Fluorine cell rework                |                       |                         |                       | 0.30               |              |                 |               |               |
| Natural gas combustion <sup>a</sup> |                       | 5.8                     |                       |                    | 2800         | 18 000          | 480           |               |
| Process building roof vents         | $3.8 \times 10^{-3}$  |                         |                       |                    |              |                 |               |               |
| Hexane vent                         |                       |                         |                       |                    |              |                 |               | 8.8           |
| <u>Total Air Stream</u>             | $5.61 \times 10^{-3}$ | 10.4                    | 1.5                   | 0.131              | 3233         | 23 940          | 2210          | 8.8           |

<sup>a</sup>Based on combustion of  $63.6 \times 10^6$  ft<sup>3</sup> of natural gas per month with 10% excess air.

<sup>b</sup>Includes elemental fluorine.

Source: FES 1975.

TABLE III-3

AIRBORNE EFFLUENTS (NONRADIOLOGICAL)  
AT 4535 METRIC TON/YR (OMITS COMBUSTION)\*

| Discharge       | Metric<br>T/Yr | Kg/Metric<br>T Uranium |
|-----------------|----------------|------------------------|
| NO <sub>2</sub> | 55.2           | 12.17                  |
| SO <sub>2</sub> | 18.0           | 3.97                   |
| Fluorides       | 1.57           | 0.35                   |
| N <sub>2</sub>  | 71 280.0       | 15 720.00              |
| Hexane          | 105.6          | 23.29                  |

**COMBUSTION EMISSIONS  
FOR GAS-FIRED BOILERS**

|                 |      |       |
|-----------------|------|-------|
| NO <sub>2</sub> | 69.6 | 15.35 |
|-----------------|------|-------|

\*Combustion emissions will depend on fuel used.

TABLE III-5

AIRBORNE EFFLUENTS (NONRADIOLOGICAL)  
AT 9070 METRIC TON/YR

| Discharge         | Metric<br>T/Yr | Kg/Metric<br>T Uranium |
|-------------------|----------------|------------------------|
| NO <sub>x</sub>   | 223.2          | 24.6                   |
| SO <sub>2</sub>   | 49.56          | 5.46                   |
| Fluoride          | 2.09           | 0.23                   |
| Fluoride (ground) | 0.384          | 0.04                   |
| Hexane            | 168.0          | 18.52                  |

TABLE III-4

**AIRBORNE EFFLUENT SUMMARY**  
Level of Production

Present Level = 5000 Short Tons U/Yr, Expanded Level = 10 000 Short Tons U/Yr

| Item              | Metric Tons per Month<br>Level of Production |                       | Grams per Second<br>Level of Production |          | Highest<br>Concentration, µg/m <sup>3</sup><br>Distance: 1/2 mile<br>Level of Production |          | Ambient<br>Air Quality<br>Standards<br>(µg/m <sup>3</sup> ) |
|-------------------|--|-----------------------|---|----------|--|----------|---|
|                   | Present                                      | Expanded <sup>a</sup> | Present                                 | Expanded | Present  | Expanded |   |
|                   | NO <sub>x</sub>                              | 10.4 <sup>b</sup>     | 18.6                                    | 3.96     | 7.07   | 1.98     |   |
| SO <sub>2</sub>   | 1.51 <sup>c</sup>                            | 4.13                  | 0.574                                   | 1.56     | 0.287  | 0.78 WSW | 60 <sup>e</sup>   |
| Fluoride          | 0.101 <sup>c</sup>                           | 0.174                 | 0.12                                    | 0.066    | 0.115  | 0.252 SW | 0.5 <sup>f</sup>  |
| Fluoride (ground) | 0.030 <sup>c</sup>                           | 0.032                 | 0.004                                   | 0.012    |  |          |   |
| Hexane            | 8.8 <sup>c</sup>                             | 14.0                  | 3.69                                    | 5.33     |  |          | 15.88 g/sec <sup>g</sup>                                    |

<sup>a</sup>Information Source: Table II - page 24, June 1975, Environmental Information on Expansion.

<sup>b</sup>Information Source: Historic Records - 1974 - No Allow. for Boiler Gen.

<sup>c</sup>Information Source: Table XI (Revised) - page 12, Jan 1973, App. Environmental Report Supplemental No. 2.

<sup>d</sup>EPA National Primary and Secondary Ambient Air Quality Standard.

<sup>e</sup>EPA National Secondary Ambient Air Quality Standard.

<sup>f</sup>State of Washington Ambient Air Fluoride Standard.

<sup>g</sup>Oklahoma State Health Department, Air Quality Services, Environmental Service - Guidelines for Interpretation and Enforcement of Regulation No. 15 (15.33).

TABLE III-6  
FLUORIDE CONCENTRATIONS  
IN SOIL AND VEGETATION

| Soil Location <sup>a</sup>       | Fluoride ( $\mu\text{g/g}$ ) |         |
|----------------------------------|------------------------------|---------|
|                                  | April                        | October |
| 1000 ft South                    | 284                          | 130     |
| 1000 ft West                     | 110                          | 170     |
| 1000 ft North                    | 213                          | 85      |
| 1000 ft East                     | 156                          | 140     |
| 6000 ft South                    | 111                          | 180     |
| 6000 ft West                     | 280                          | 150     |
| 6000 ft North                    | 207                          | 410     |
| 6000 ft East                     | 249                          | 120     |
| Vegetation Location <sup>a</sup> |                              |         |
| 1000 ft South                    | 44                           | 31      |
| 1000 ft West                     | 10                           | 122     |
| 1000 ft North                    | 9                            | 34      |
| 1000 ft East                     | 29                           | 48      |
| 6000 ft South                    | 17                           | 29      |
| 6000 ft West                     | 7                            | 26      |
| 6000 ft North                    | 10                           | 28      |
| 6000 ft East                     | 12                           | 33      |

<sup>a</sup>Distance from the plant.

Source: Kerr-McGee Corp.

To improve the data base on the effects of the water outfall discharge into the Illinois River, the NRC asked Kerr-McGee for an environmental monitoring program that would include the analyses of bottom sediments and benthic populations. The results of the population study for 1980 (as supplied by Kerr-McGee) are given in the Appendix.

### 3. Heat Load Estimate

Heat is discharged both as a discharge-water temperature rise (see Table III-9) and as evaporation. While running at a throughput of 10 000 tons uranium/year (9070 metric tons), the plant dissipates approximately 68 million Btu/h (19.72 million watts) through evaporation and drift loss from the cooling tower and 5 million Btu/h (1.45 million watts) through

the cooling water discharge. Other dissipation processes include pond evaporation and convection. The total heat load is approximately 134 million Btu/h (39 million watts). This indicates a heat dissipation load of approximately  $0.136 \times 10^{12}$  joules per metric ton of uranium processed (FES 1975).

### 4. Ponds and Sludges

*a. Raffinate Ponds.* Figure III-15 illustrates the typical waste inputs and their expected compositions discharged to the two raffinate ponds. Presently, anhydrous ammonia is added to the incoming liquors to maintain a pH of 5 to 8 to precipitate metals and other contaminants. The neutralized raffinate pond decantate is then pumped to a mixing basin where barium is added to remove radium (ERSF). The barium-radium precipitate is stored as sludge.\*

An evaporator is used to increase evaporation in the holding pond. In addition, after radium removal, liquid is discharged as a fertilizer onto about 400 acres of nearby fields (OML). Data on water quality from run-off of these fields is given in Table III-10. The raffinate decantate placed on the fields has been reported by Kerr-McGee to the NRC to have a pH of approximately 8.5 and contain 1 pCi/l of  $^{226}\text{Ra}$ ,  $1.34 \times 10^{-7}$   $\mu\text{Ci/ml}$   $U_{\text{nat}}$ , and  $50 \times 10^{-9}$   $\mu\text{Ci/ml}$   $^{230}\text{Th}$  (FES 1975). These data can be compared with  $2.0 \times 10^{-5}$   $\mu\text{Ci/ml}$   $U_{\text{nat}}$ ,  $1.4 \times 10^{-6}$   $\mu\text{Ci/ml}$   $^{226}\text{Ra}$ , and  $0.75 \times 10^{-6}$   $\mu\text{Ci/ml}$   $^{230}\text{Th}$  for neutralized raffinate also submitted as data by Kerr-McGee. Kerr-McGee reported treated raffinate as containing 0.3 mg/l arsenic (FES 1975).

For raffinate sludges, Kerr-McGee has reported to NRC that the radionuclide content of the raffinate ponds as of December 1973 was 8625 kg of uranium, 0.091 Ci of radium, and 0.157 Ci of thorium. Assuming 10 884 metric tons processed up to that time, indications are that 0.79 kg of uranium is discharged to the ponds per metric ton of uranium processed (FES 1975). Table III-17 provides data supplied by Kerr-McGee for the 1980 average of impurities in incoming concentrate. These contaminants, in general, ultimately report to the raffinate pond sludge.

Table III-18 reports recent data submitted to NRC concerning raffinate sludge composition (ERSF).

During the period when the raffinate ponds were unlined, seepage was detected. More details on the

\*This information provided by W. J. Shelley, Kerr-McGee, June 1981.

TABLE III-7

**RADIOLOGICAL AIR EFFLUENTS RELEASE RATES**  
( $\mu\text{Ci}$ )

| Period        | Gross Alpha | $^{238}\text{U}^a$    | $^{235}\text{U}$ | $^{234}\text{U}$ | $^{230}\text{Th}$ | $^{226}\text{Ra}$ |
|---------------|-------------|-----------------------|------------------|------------------|-------------------|-------------------|
| Jan-June 1976 | 24 000      | 12 067                | 550              | 11 374           | 7                 | 2                 |
| July-Dec 1976 | 21 200      | 10 659                | 486              | 10 047           | 6                 | 2                 |
| Jan-June 1977 | 25 340      | 12 741                | 580              | 12 009           | 8                 | 2                 |
| July-Dec 1977 | 45 800      | 23 028                | 1049             | 21 705           | 14                | 4                 |
| Jan-June 1978 | 20 490      | 10 302                | 469              | 9711             | 6                 | 2                 |
| July-Dec 1978 | 51 300      | 25 794                | 1175             | 24 311           | 15                | 5                 |
| Jan-June 1979 | 50 000      | 25 140                | 1145             | 23 695           | 15                | 5                 |
| July-Dec 1979 | 108 600     | 93 100 <sup>b,c</sup> |                  |                  | 1744              | 840               |
| Jan-June 1980 | 86 300      | 83 800 <sup>b</sup>   |                  |                  | 1503              | 900               |

<sup>a</sup>The licensee analyzed the plant dust for isotopic uranium and  $^{230}\text{Th}$  and  $^{226}\text{Ra}$ ; the ratio of individual nuclides for the contribution of gross alpha is as follows:

$$^{238}\text{U}; ^{235}\text{U}; ^{234}\text{U}; ^{230}\text{Th}; ^{226}\text{Ra} = 50.28:2.29:47.39:0.03:0.01.$$

<sup>b</sup>Reported as  $\text{U}_{\text{nat}}$ .

<sup>c</sup>One batch release  $4.47 \times 10^{-3}$  Ci.

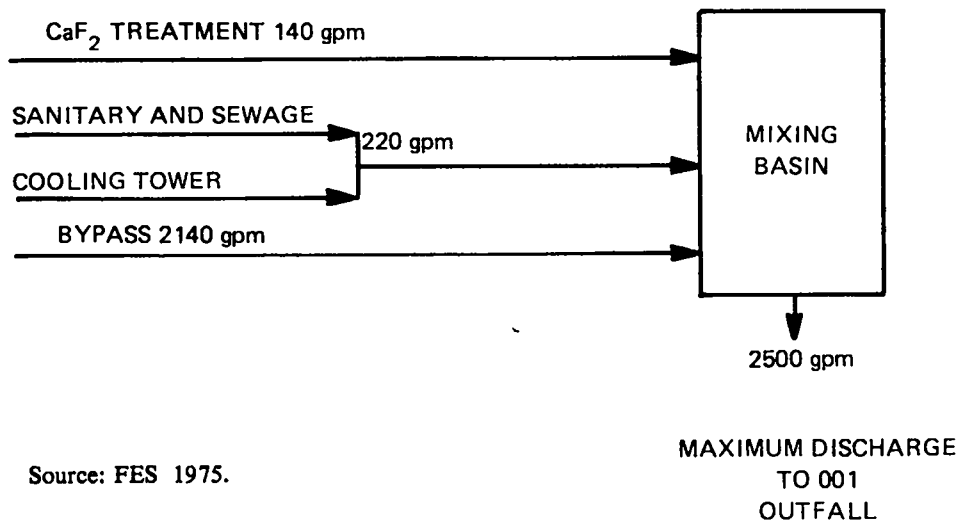
Source: Reports from Kerr-McGee to NRC.

TABLE III-8

**RADIOLOGICAL AIR EFFLUENT RELEASE RATES AS A  
FUNCTION OF THROUGHPUT<sup>a</sup> (ALL UNITS  $\mu\text{Ci}$ )**

|                                | 1976   | 1977   | 1978   |
|--------------------------------|--------|--------|--------|
| MTU Throughput                 | 3537   | 4173   | 5533   |
| Gross Alpha                    | 45 200 | 71 140 | 71 790 |
| Gross Alpha/(MTU)              | 12.78  | 17.05  | 12.97  |
| $^{238}\text{U}$               | 22 726 | 35 769 | 36 096 |
| $^{238}\text{U}/(\text{MTU})$  | 6.43   | 8.57   | 6.52   |
| $^{235}\text{U}$               | 1036   | 1629   | 1644   |
| $^{235}\text{U}/(\text{MTU})$  | 0.29   | 0.39   | 0.30   |
| $^{234}\text{U}$               | 21 421 | 33 714 | 34 022 |
| $^{234}\text{U}/(\text{MTU})$  | 6.06   | 8.08   | 6.15   |
| $^{230}\text{Th}$              | 13     | 22     | 21     |
| $^{230}\text{Th}/(\text{MTU})$ | 0.004  | 0.01   | 0.003  |
| $^{226}\text{Ra}$              | 4      | 6      | 7      |
| $^{226}\text{Ra}/(\text{MTU})$ | 0.001  | 0.001  | 0.001  |

<sup>a</sup>MTU is metric tons uranium throughput.



Source: FES 1975.

Fig. III-14. Sources of the 001 outfall.

monitoring wells and water quality of the seepage are given in the Final Environmental Statement.

At present, one unlined raffinate pond is full. However, all active discharge is to lined ponds.\*

Kerr-McGee recently submitted to NRC a plan to dispose of the raffinate sludges. A portion of this submittal is given below.

“At the current plant production capacity of 9,090 MTU per year, sludge is generated at a rate of 2.3 million gallons per year. It is estimated that there was a total of 10 million gallons of sludge in inventory in pond 2 at the end of 1979. At the projected end of plant life, in the year 2000, an estimated 56 million gallons will have been generated for burial.

“The program for removal and disposition of the radioactive sludges consists of the following:

- “1. The sludge in pond 1 is to be transferred by a barge-mounted pump to pond 2 to permit modification of pond 1 to become Clarifier A as approved in a previous license amendment.
- “2. The inventory of sludge in pond 2 and sludge subsequently deposited in Clarifier A will be transferred at the rate of 20,000 gallons per day to large cone-bottom dewatering tanks adjacent to Clarifier A where excess water will be removed and returned to Clarifier A.

\*This information provided by William Nixon, NRC, April 1981.

“3. The dewatered sludge (approximately 60% H<sub>2</sub>O) will then be pumped from the dewatering tanks via a pipeline through a booster station to the disposal site approximately one mile away.

“4. At the disposal site the sludge will enter a ribbon blender and be mixed with an equal volume of Portland cement and/or another material with equal or better radon stabilization characteristics. (Experiments with clay additions as a diluent have shown some promise for additional radium stability.)

“5. The sludge-cement mixture will flow by gravity to 4' x 4' x 8' forms erected in the disposal pit.

“6. After solidification, the blocks will be covered with polyethylene film to minimize leaching of nitrate and radium by rainwater.

“7. The disposal pit will be constructed in phases to permit layering of the solidified sludge in a running brick pattern. This method of placement will permit isolation of run-off water from clean rain water and at the same time permit surface reclamation of each completed block pattern as the solidification progresses.

#### “The Disposal Pit

The initial excavation for sludge disposal will be approximately 400' x 500' x 60' deep with side slopes of 3H to 1V. The sides and bottom of the

TABLE III-9

KERR-McGEE 001 OUTFALL WATER QUALITY

| 1980<br>Sampling<br>Period | Av<br>Flow<br>MGD | Av Flow<br>m <sup>3</sup> /s × 10 <sup>-2</sup> | kg/day     |           |                   |         |                |               | mg/l                   | mg/l                  | °F          | °F          | Min<br>pH        | Max<br>pH        |
|----------------------------|-------------------|---|------------|-----------|-------------------|---------|----------------|---------------|------------------------|-----------------------|-------------|-------------|------------------|------------------|
|                            |                   |   | Max<br>TSS | Av<br>TSS | Max<br>F          | Av<br>F | Max<br>Nitrate | Av<br>Nitrate | Max<br>Oil &<br>Grease | Av<br>Oil &<br>Grease | Min<br>Temp | Max<br>Temp |                  |                  |
| Sept                       | 3.19              | 13.98   | 40.0       | 13.0      | 7.6               | 5.1     | 57.0           | 24.0          | 4.0                    | 1.0                   | 62          | 72          | 2.0 <sup>a</sup> | 8.3              |
| Aug                        | 3.21              | 14.06   | 52.0       | 13.0      | 15.0              | 7.0     | 31.0           | 16.0          | 3.0                    | 0.7                   | 64          | 70          | 6.7              | 8.6              |
| July                       | 3.26              | 14.28   | 61.0       | 20.0      | 10.0              | 5.6     | 36.0           | 25.0          | 2.0                    | 0.4                   | 62          | 70          | 6.8              | 8.2              |
| June                       | 3.38              | 14.81   | 50.0       | 20.0      | 11.0              | 5.5     | 36.0           | 23.0          | 1.0                    | 0.5                   | 62          | 70          | 7.1              | 8.6              |
| May                        | 3.60              | 15.77   | 25.0       | 13.0      | 15.0              | 9.0     | 31.0           | 25.0          | 4.0                    | 2.0                   | 57          | 66          | 7.1              | 8.6              |
| April                      | 3.49              | 15.29   | 35.0       | 15.0      | 35.0 <sup>a</sup> | 7.0     | 22.0           | 17.0          | 5.0                    | 2.0                   | 50          | 59          | 6.9              | 9.2 <sup>a</sup> |
| March                      | 3.40              | 14.90   | 220.0      | 32.0      | 17.0              | 6.0     | 23.0           | 16.5          | 2.0                    | 1.0                   | 50          | 58          | 7.3              | 8.9              |
| Feb                        | 3.41              | 14.94   | 47.0       | 13.0      | 17.0              | 6.0     | 17.0           | 13.0          | 4.0                    | 1.0                   | 50          | 55          | 7.4              | 9.2 <sup>a</sup> |
| Jan                        | 3.32              | 14.54   | 39.0       | 20.0      | 15.0              | 5.0     | 29.0           | 19.0          | 5.0                    | 2.5                   | 47          | 57          | 7.1              | 8.8              |
| Average                    | 3.36 <sup>c</sup> | 14.72   |            | 17.67     |                   | 6.24    |                | 19.83         |                        |                       |             |             |                  |                  |
| Average/MTU <sup>b</sup>   |                   |   |            | 0.89 kg   |                   | 0.31 kg |                | 1.00 kg       |                        |                       |             |             |                  |                  |

<sup>a</sup>Noncompliance.

<sup>b</sup>Assuming 8000 T/year = 7256 MT/yr = 19.88 MT/day.

<sup>c</sup>Average flow 2333 gpm.

Source: NPDES data.

TABLE III-10

KERR-McGEE 002 OUTFALL WATER QUALITY

| 1980<br>Sampling<br>Period | Max Flow<br>MGD   | Max Flow<br>m <sup>3</sup> /s × 10 <sup>-2</sup> | Av TSS<br>mg/l    | Av<br>Dissolved<br><sup>226</sup> Ra<br>pCi/l | Av<br>Total<br><sup>226</sup> Ra<br>pCi/l | Av<br>Ammonia<br>mg/l | Av<br>Nitrate<br>mg/l | Max<br>pH | Min<br>pH |
|----------------------------|-------------------|--|-------------------|---|---|-----------------------|-----------------------|-----------|-----------|
| Sept                       | No flow           |  |                   |   |   |                       |                       |           |           |
| Aug                        | No flow           |  |                   |   |   |                       |                       |           |           |
| July                       | 0.43 <sup>a</sup> | 1.88   | 28.0              | 0.14  | 0.15                                      | <0.2                  | 0.6                   | 6.8       | 6.7       |
| June                       | 0.03 <sup>b</sup> | 0.13   | 79.0 <sup>c</sup> | NA  | NA  | <0.2                  | 1.3                   | 6.6       | 7.2       |
| May                        | No flow           |  |                   |   |   |                       |                       |           |           |
| April                      | No flow           |  |                   |   |   |                       |                       |           |           |
| March                      | No flow           |  |                   |   |   |                       |                       |           |           |
| Feb                        | No flow           |  |                   |   |   |                       |                       |           |           |
| Jan                        | No flow           |  |                   |   |   |                       |                       |           |           |

<sup>a</sup>24 h only.

<sup>b</sup>4 days only.

<sup>c</sup>Noncompliance.

Source: NPDES

TABLE III-11

RADIOLOGICAL LIQUID EFFLUENTS  
RELEASE RATES

| Period        | Gross<br>Alpha<br>(Ci) | Natural<br>Uranium<br>(Ci) | <sup>230</sup> Th<br>(μCi) | <sup>226</sup> Ra<br>(μCi) |
|---------------|------------------------|----------------------------|----------------------------|----------------------------|
| Jan-June 1976 | 0.548                  | 0.492                      |                            |                            |
| July-Dec 1976 | 0.480                  | 0.490                      |                            |                            |
| Jan-June 1977 | 0.712                  | 0.610                      |                            |                            |
| July-Dec 1977 | 1.195                  | 0.968                      |                            |                            |
| Jan-June 1978 | 1.105                  | 0.885                      |                            |                            |
| July-Dec 1978 | 0.894                  | 0.825                      |                            |                            |
| Jan-June 1979 | 1.519                  | 1.351                      |                            |                            |
| July-Dec 1979 | 1.449                  | 1.290                      | 103.3                      | 113.1                      |
| Jan-June 1980 | 1.751                  | 1.496                      | 189.0                      | 214.0                      |

Source: Kerr-McGee reports to NRC.

TABLE III-12

RADIOLOGICAL LIQUID EFFLUENT RELEASE  
RATES AS A FUNCTION OF THROUGHPUT

|   | 1976   | 1977   | 1978   |
|---|--------|--------|--------|
| Ton<br>Uranium<br>Throughput              | 3900   | 4600   | 6100   |
| Metric Ton<br>Uranium<br>Throughput       | 3537   | 4173   | 5533   |
| Gross Alpha<br>μCi × 10 <sup>6</sup>      | 1.028  | 1.907  | 1.999  |
| Gross Alpha (μCi)<br>per<br>Metric Ton    | 290.64 | 456.99 | 361.29 |
| U <sub>nat</sub> μCi × 10 <sup>6</sup>    | 0.982  | 1.578  | 1.710  |
| U <sub>nat</sub> μCi<br>per<br>Metric Ton | 277.64 | 378.15 | 309.05 |



TABLE III-13

**CHEMICAL PARAMETERS OF INTAKE WATER AND DISCHARGE  
DAILY/AVERAGE CONCENTRATIONS, mg/l**

| Parameter                          | Untreated <sup>a</sup><br>Intake | Combined <sup>a</sup><br>Discharge | Suggested <sup>b</sup><br>Criteria | U.S.P.H.S. <sup>c</sup><br>MPC |
|------------------------------------|----------------------------------|------------------------------------|------------------------------------|--------------------------------|
| Alkalinity (as CaCO <sub>3</sub> ) | 73-94                            | 99                                 | 120                                | —                              |
| B.O.D. 5-day                       | 2                                | 2                                  | 1.0 - 3.0(max)                     | —                              |
| Chemical oxygen demand             | 10                               | 10                                 | —                                  | —                              |
| Total solids                       | 138                              | 235                                | —                                  | —                              |
| Total dissolved solids             | 137                              | 232                                | 1000                               | 500                            |
| Total suspended solids             | 6                                | 20                                 | —                                  | —                              |
| Total volatile solids              | 50                               | 50                                 | —                                  | —                              |
| Ammonia (as N)                     | 1.4                              | <1                                 | 0.1                                | —                              |
| Kjeldahl nitrogen                  | 1.3                              | <1                                 | 10                                 | —                              |
| Nitrate (as N)                     | 0.57                             | 3.5                                | 10                                 | 10 <sup>d</sup>                |
| Phosphorus total                   | 0.04                             | 0.3                                | —                                  | —                              |
| Color (Pt-Co units)                | 25                               | 15                                 | 20 - 70                            | 15                             |
| Turbidity (Jackson units)          | 7                                | 8                                  | 0 - 40                             | 5                              |
| Total organic carbon               | 1.7                              | 1.0                                | —                                  | —                              |
| Total hardness                     | 89                               | 110                                | —                                  | —                              |
| Phosphorus (ortho)                 | <0.1                             | <0.1                               | —                                  | —                              |
| Sulfate                            | 6.6                              | 16                                 | 250                                | 250                            |
| Sulfide                            | <0.1                             | <0.1                               | —                                  | —                              |
| Chloride                           | 5                                | 50                                 | 50                                 | 250                            |
| Fluoride                           | 0.1                              | 1.54                               | 1.5                                | 0.7 - 1.2<br>1.4 - 2.4*        |
| Aluminum                           | 0.18                             | 0.40                               | —                                  | —                              |
| Barium                             | 0.1                              | 0.125                              | —                                  | 1.0*                           |
| Cadmium                            | <0.01                            | <0.01                              | 0                                  | 0.01*                          |
| Cyanide                            | 0                                | 0                                  | 0                                  | 0.01                           |
| Calcium                            | 32                               | 46                                 | —                                  | —                              |
| Chromium                           | 0.075                            | 0.060                              | 0                                  | 0.05*                          |
| Copper                             | 0.033                            | 0.090                              | 3.0                                | 1.0                            |
| Iron                               | 0.85                             | 1.0                                | 0.3                                | 0.3                            |
| Lead                               | <0.01                            | <0.01                              | —                                  | 0.05*                          |
| Magnesium                          | 2                                | 2                                  | —                                  | —                              |

<sup>a</sup>Reported by Licensee to EPA Region VI in Permit Application No. OK-076-0Y12-000111, Revised February 1, 1973.

<sup>b</sup>Suggested Criteria of Raw Water Quality for the State of Oklahoma (for Municipal use). Ref. No. 1845, "Water Quality Criteria," California State Water Resources Control Board Publication 3A (Reprint, December 1971).

<sup>c</sup>US Public Health Service Drinking Water Standards 1962. Values reported are "suggested limit that should not be exceeded" except starred values, which are listed under "Cause for Rejection."

<sup>d</sup>Actually listed as 45 mg/l nitrate.

Source: FES 1975.

TABLE III-13 (cont)

| Parameter | Untreated <sup>a</sup><br>Intake | Combined <sup>a</sup><br>Discharge | Suggested <sup>b</sup><br>Criteria | U.S.P.H.S. <sup>c</sup><br>MPC |
|-----------|----------------------------------|------------------------------------|------------------------------------|--------------------------------|
| Manganese | 0.02 – 3.3                       | 1.3                                | —                                  | 0.05                           |
| Mercury   | <0.001                           | <0.001                             | —                                  | —                              |
| Potassium | 1                                | 1                                  | —                                  | —                              |
| Sodium    | 3                                | 35                                 | 0 – 10                             | —                              |
| Tin       | <0.01 – 0.7                      | 0.04                               | —                                  | —                              |
| Titanium  | <0.01                            | <0.01                              | —                                  | —                              |
| Zinc      | 0                                | 0.04                               | —                                  | 5.0                            |

TABLE III-14

EFFECT OF LIQUID EFFLUENT ON NITRATE  
AND FLUORIDE CONTENT OF SURFACE WATERS

| Water Sample Source            | Period Jan-Oct 1971 <sup>a</sup>  |                                     |                                   |                                     |
|--------------------------------|-----------------------------------|-------------------------------------|-----------------------------------|-------------------------------------|
|                                | Nitrate                           |                                     | Fluoride                          |                                     |
|                                | Average<br>Concentration<br>(ppm) | % of<br>USPHS<br>(MPC) <sup>b</sup> | Average<br>Concentration<br>(ppm) | % of<br>USPHS<br>(MPC) <sup>b</sup> |
| Raw water <sup>c</sup>         | 0.40                              | 0.89                                | 0.53                              | 27.9                                |
| Combined effluent <sup>c</sup> | 1.36                              | 3.02                                | 0.76                              | 40.0                                |
| Illinois River                 |                                   |                                     |                                   |                                     |
| Upstream                       | 0.24                              | 0.53                                | 0.59                              | 31.1                                |
| Downstream                     | 0.24                              | 0.53                                | 0.64                              | 33.7                                |
| Arkansas River                 |                                   |                                     |                                   |                                     |
| Upstream                       | 0.28                              | 0.62                                | 0.81                              | 42.6                                |
| Downstream                     | 0.18                              | 0.40                                | 0.80                              | 42.1                                |

<sup>a</sup>Data are average analyses of monthly composites.

<sup>b</sup>US Public Health Service Drinking Water Standards 1962:

Nitrate 45 ppm (limit that should not be exceeded);

Fluoride 0.7 - 1.2 ppm (limit that should not be exceeded)

Fluoride 1.4 - 2.4 ppm (cause for rejection)

Fluoride 1.9 ppm used for calculation.

<sup>c</sup>Monthly composite of daily samples. Others sampled weekly.

Source: FES 1975.

TABLE III-15

**1974 ENVIRONMENTAL WATER SAMPLES SURFACE  
UNITED STATES TESTING RESULTS  
RADIOACTIVE UNITS,  $\alpha$ ,  $\beta$ , Ra, U -  $\mu\text{Ci}/\text{m}^3 \times 10^{-8}$   
CHEMICAL UNITS  $\text{NO}_3$ ,<sup>a</sup> F - ppm**

| Location                             | Analysis                     | January | February | March  | April | May    | June  | July | August | September | October |
|--------------------------------------|------------------------------|---------|----------|--------|-------|--------|-------|------|--------|-----------|---------|
| 2201<br>Illinois River<br>Upstream   | Nitrate                      | 0.2     | 0.2      | 0.5    | 0.8   | 0.6    | 0.2   | 0.5  | 0.3    | 0.2       | 0.2     |
|                                      | Fluoride                     | <0.5    | <0.5     | <0.5   | <0.5  | 0.4    | 0.8   | 0.5  | 0.9    | 0.7       | 0.2     |
|                                      | Gross $\alpha$               | <0.8    | <0.8     | <0.8   | <0.8  | <0.8   | <0.8  | <0.7 | <0.8   | —         | —       |
|                                      | Gross $\beta$                | <2.2    | <2.5     | <2.0   | <2.5  | <2.6   | <1.9  | <1.5 | <1.6   | —         | —       |
|                                      | Uranium<br><sup>226</sup> Ra | 3.2     | 2.7      | 0.7    | <0.7  | 0.7    | <0.5  | <0.5 | <0.5   | 1.1       | <0.5    |
|                                      |                              |         |          | 0.007  |       |        | 0.03  |      |        |           |         |
| 2202<br>Illinois River<br>Downstream | Nitrate                      | 0.6     | <0.2     | 0.4    | 0.7   | 0.4    | 0.2   | 0.5  | 0.3    | 0.1       | 0.2     |
|                                      | Fluoride                     | <0.5    | <0.5     | <0.5   | 0.7   | 0.8    | 0.2   | 0.3  | 0.3    | 0.6       | 0.2     |
|                                      | Gross $\alpha$               | <0.8    | <0.8     | <0.8   | <0.8  | 1.5    | <0.8  | 0.9  | 2.0    | —         | —       |
|                                      | Gross $\beta$                | <2.2    | <2.5     | <2.0   | <2.5  | <2.6   | <1.9  | <1.5 | <1.6   | —         | —       |
|                                      | Uranium<br><sup>226</sup> Ra | 5.2     | 5.4      | 0.9    | 0.8   | 0.6    | <0.5  | 0.7  | 0.7    | 0.5       | <0.5    |
|                                      |                              |         |          | <0.007 |       |        | 0.014 |      |        |           |         |
| 2203<br>Arkansas River<br>Upstream   | Nitrate                      | 0.7     | 0.2      | 0.8    | 0.8   | <0.1   | 0.5   | 0.6  | 0.3    | 0.4       | 0.4     |
|                                      | Fluoride                     | <0.5    | <0.5     | <0.5   | <0.5  | 0.4    | 0.7   | 0.3  | 0.4    | 1.8       | 0.3     |
|                                      | Gross $\alpha$               | <0.8    | <0.8     | <0.8   | 2.1   | <0.8   | <0.8  | <0.7 | <0.8   | —         | —       |
|                                      | Gross $\beta$                | <2.2    | <2.5     | <2.0   | <2.5  | <2.6   | <1.9  | <1.5 | <1.6   | —         | —       |
|                                      | Uranium<br><sup>226</sup> Ra | 3.0     | 3.0      | 0.7    | <0.7  | <0.5   | <0.5  | <0.5 | <0.5   | 0.5       | <0.5    |
|                                      |                              |         |          | 0.024  |       | <0.007 |       |      |        |           |         |
| 2204<br>Arkansas River<br>Downstream | Nitrate                      | 0.8     | 0.1      | 0.8    | 0.9   | 1.9    | 0.5   | 0.6  | 0.4    | 0.5       | 0.4     |
|                                      | Fluoride                     | <0.5    | <0.5     | <0.5   | <0.5  | 0.5    | 0.3   | 0.3  | 0.3    | 0.4       | 0.3     |
|                                      | Gross $\alpha$               | <0.8    | <0.8     | <0.8   | <0.8  | <0.8   | <0.8  | <0.7 | 1.4    | —         | —       |
|                                      | Gross $\beta$                | <2.2    | <2.5     | <2.0   | <2.5  | 7.1    | <1.9  | <1.5 | <1.6   | —         | —       |
|                                      | Uranium<br><sup>226</sup> Ra | 3.7     | 4.0      | 0.7    | 1.3   | <0.5   | 0.7   | 0.5  | 2.9    | 1.0       | <0.5    |
|                                      |                              |         |          | 0.021  |       |        | 0.010 |      |        |           |         |

<sup>a</sup>Nitrate reported as nitrogen.

Source: FES 1975.

TABLE III-16

**WATER BALANCE FOR SEQUOYAH  
AT 10 000 TON U/YR (9070 MTU)**

| Source                       | Gal/Min |
|------------------------------|---------|
| Received                     | 2800    |
| To plant process             | 660     |
| Bypass                       | 2140    |
| Loss by evaporation          | 300     |
| Plant discharge <sup>a</sup> | 360     |
| Outfall                      | 2500    |

<sup>a</sup>Plant discharge includes sewage lagoon overflow, sanitary wastes, decantate from the fluorine precipitation treatment system, and cooling tower water discharge.

Source: FES 1975.

opening will be provided with a 5-foot compacted clay liner (permeability of  $10^{-9}$  cm/sec) covered by a 30-mil reinforced Hypalon membrane liner. The Hypalon liner is recommended by the manufacturer for prevention of diffusion of nitrate ion through the clay. The disposal pit will be constructed in phases with a barrier wall provided to separate possibly contaminated water from relatively clean rainwater. The phased approach to pit construction will provide minimal surface disturbance and permit early land reclamation of phases as they are completed. The land reclamation will consist of backfilling and topsoil replacement and reseeding to restore native vegetation."

(Kerr-McGee Nuclear Corporation Environmental Report for Sequoyah Facility Raffinate Sludge Disposal).

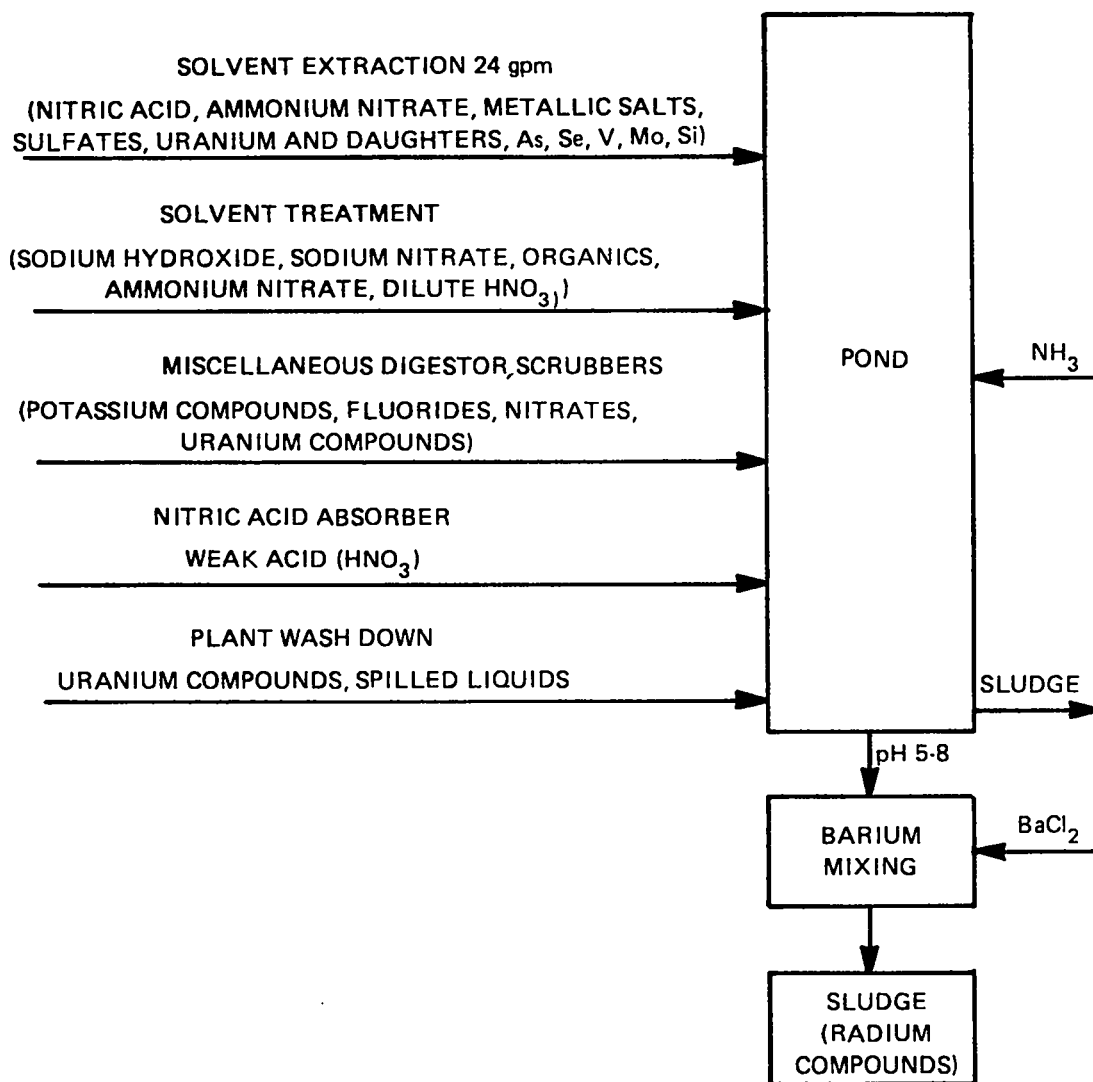


Fig. III-15. Discharge to raffinate ponds.

In addition to the proposal made to the NRC for on-site disposal of raffinate sludges, Kerr-McGee is also seeking approval from the licensing staff of the State of New Mexico to dispose of the sludge on the Kerr-McGee Ambrosia Lake uranium mill tailings pile located near Grants, New Mexico. The material would be transported to New Mexico primarily as a back-haul on trucks delivering concentrate slurry to the UF<sub>6</sub> plant.\*

*b. Fluoride Treatment Ponds.* Figure III-16 illustrates the various waste inputs and their expected composition going to the fluoride treatment ponds.

\*Letter from W. J. Shelley, Kerr-McGee to Al Topp, State of N.M., Aug. 7, 1981.

As shown in Fig. III-16, slaked lime is added to the inflow and reacts with the dilute HF and other chemical compounds to produce calcium fluoride/calcium hydroxide/calcium sulfate sludge, which settles out in the sludge pit (OML). About 600 tons (544 metric tons) of sludge are generated each year (FES 1975). Over the life of the plant, it is estimated that 18 200 metric tons of calcium fluoride sludge containing 2.5 metric tons of uranium will require disposal (FES 1975).

Recent Kerr-McGee data indicate that 3762 metric tons of CaF<sub>2</sub> sludge containing an activity of 33 μCi/ft<sup>3</sup> have been buried on-site in four locations. At present, however, all generated sludge is being held in retention

TABLE III-17

CONCENTRATE IMPURITIES  
1980 Average of all Lots Sampled

| Impurity                                | Values in<br>Per Cent on a<br>Uranium Basis <sup>a</sup> |
|---|--|
| Nitric Acid<br>insoluble U <sup>6</sup> | 0.02   |
| Molybdenum (Mo)                         | 0.08   |
| Vanadium (V)                            | 0.05   |
| Calcium (Ca)                            | 0.25   |
| Thorium (Th)                            | 0.06   |
| Zirconium (Zr)                          | <0.03  |
| Boron (B)                               | <0.01  |
| Phosphorus (P)                          | 0.06   |
| Halogens (Cl, Br, I as Cl)              | 0.13   |
| Fluoride (F)                            | 0.01   |
| Carbonate (CO <sub>3</sub> )            | 0.07   |
| Sulfur (S)                              | 1.00   |
| Arsenic (As)                            | <0.05  |
| Sodium (Na)                             | 0.72   |
| Magnesium (Mg)                          | 0.09   |
| Iron (Fe)                               | 0.53   |
| Silicon (Si)                            | 0.53   |

<sup>a</sup>Sequoyah Facility Lab results. <sup>226</sup>Ra is not routinely run.

Source: Kerr-McGee.

ponds until NRC approves a license amendment for burial.\*

Sulfuric acid is added to achieve a pH between 6-8, and the liquid is fed to a clarifying lagoon (FES 1975). The discharge from the clarifying lagoon, approximately 140 gpm (0.00883 m<sup>3</sup>/s), joins the sanitary discharge, cooling tower discharge, and bypass water for discharge at the 001 outfall.

### 5. Solid Nonsludge Wastes

Nonradioactive combustible materials, such as boxes, crates, paper, and rags, were burned in an open pit incinerator whose off-gases discharged directly to the ambient air. Ashes and unburned residue were buried in the pit. Other types of combustible nonradioactive

\*This information provided by W. J. Shelley, Kerr-McGee, June 1981.

TABLE III-18

CHEMICAL CONSTITUENTS OF WET SLUDGE

| Element                   | Percent |
|---------------------------|---------|
| Al                        | 0.15    |
| As                        | 0.012   |
| B                         | <0.013  |
| Ca                        | 0.10    |
| Cl (incl Br & I)          | 0.005   |
| C (from CO <sub>2</sub> ) | 0.02    |
| Fe                        | 0.25    |
| F                         | 0.001   |
| K                         | 0.005   |
| Mg (incl Mn, Ni, Pb)      | 0.06    |
| Mo                        | 0.03    |
| Na                        | 0.12    |
| N                         | 0.73    |
| P                         | 0.04    |
| Si                        | 0.24    |
| S                         | 0.33    |
| V                         | 0.02    |
| Zr                        | <0.10   |
| H <sub>2</sub> O          | 60.0    |

### RADIONUCLIDES IN WET SLUDGE

| Radionuclide  | (pCi/g) |
|---|---------|
| Ra  | 22      |
| <sup>230</sup> Th   | 5060    |
| <sup>234</sup> Th   | <640    |
| <sup>228</sup> Th + <sup>232</sup> Th   | <450    |
| <sup>210</sup> Pb, <sup>210</sup> Po, <sup>227</sup> Ac }<br><sup>228</sup> Ra, <sup>231</sup> Pa, <sup>235</sup> U } | <750    |
| <sup>238</sup> U + <sup>234</sup> U   | <270    |

Source: Kerr-McGee Nuclear Corporation Environmental Report for Sequoyah Facility Raffinate Sludge Disposal.

wastes are burned in an enclosed incinerator whose off-gases discharge to the boiler stack (FES 1975).

Uncontaminated noncombustible wastes are buried in accordance with the solid waste disposal requirements of Oklahoma (FES 1975).

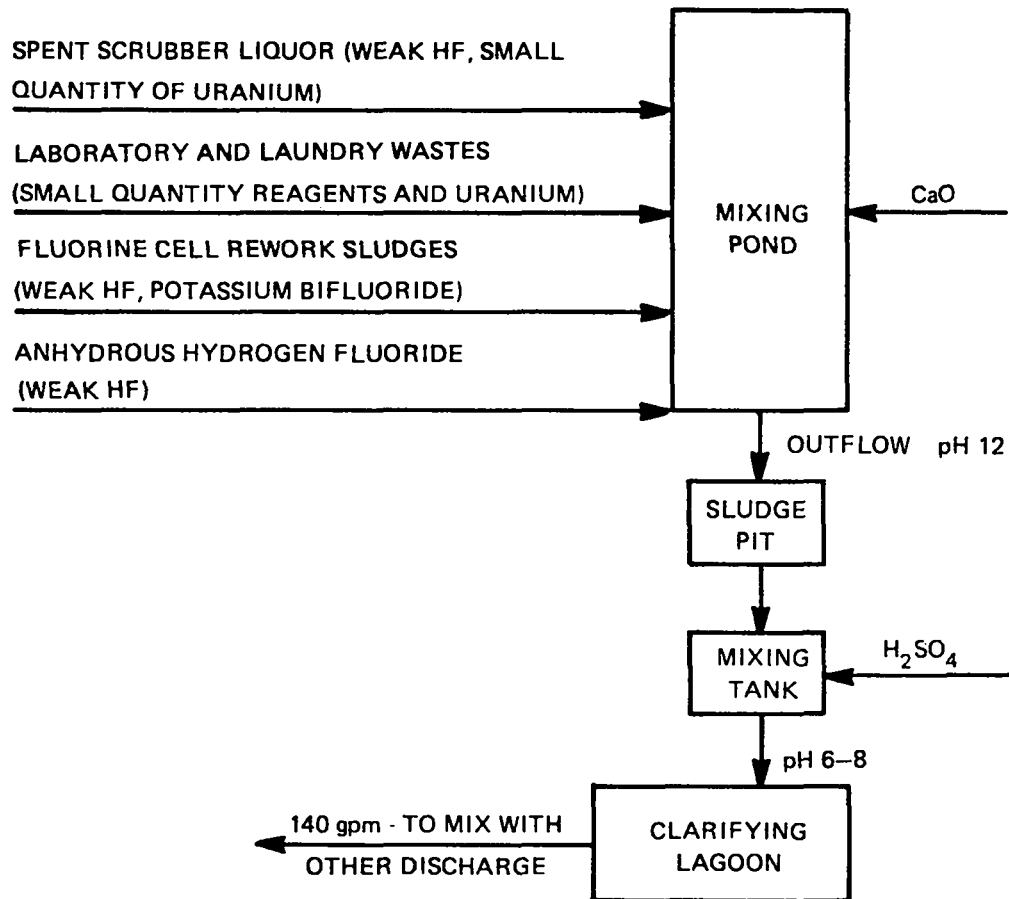


Fig. III-16. Liquid discharge treatment system for fluorine-containing wastes.

Radioactive wastes, such as scrapped equipment, gloves, respirators, and other contaminated solids, were buried on-site at a depth of at least 4 ft. Through June 1974, these wastes contained a total of 370 kg of natural uranium. These wastes are currently being stored.\* Contaminated drums are being accumulated for disposal through a licensed scrap dealer (FES 1975).

#### D. Inadvertent Releases Involving Wastes and Effluents

##### 1. Operational

From time to time, there will be small vent releases of process chemicals because of over-pressurizing, seal failure, loss of power, plant cleanup and repair operations, process problems, etc. There are no data available

\*This information provided by William Nixon, NRC, April 1981.

as to frequency, rate of release, and types of release (FES 1975).

##### 2. Releases from Pond Operations

In 1971, some lime and calcium fluoride were transferred from the fluoride sludge pit to the raffinate pond. Subsequent air drying and wind dispersion of a portion of this material resulted in above-average fluoride concentrations in some areas at the site. No cattle are allowed to graze in this region of dispersion (FES 1975).

The raffinate ponds are located near the river. It has been estimated that 14 million gallons (52 990 m<sup>3</sup>) of raffinate could be discharged to the river in the worst possible accident. Ammonia, nitrates, and organics in the raffinate could conceivably cause localized fish kills. Approximately 0.2 Ci of <sup>226</sup>Ra, 0.09 Ci of <sup>230</sup>Th, and 7700 kg of uranium might be discharged to the river (FES 1975).

### 3. Releases Caused by Rupture of Ducts and Piping Carrying Process Streams

Other types of accidents involving a discharge would be for a liquid-transfer line to break, discharging untreated waste. A gas transfer line, such as the duct for HF, hydrogen, or off-gases from the reduction unit to the combustion system, could also break, discharging untreated gases to the ambient air.

### 4. Failure of Effluent and Waste Treatment Equipment

Inadvertent releases could also occur if any dust collection equipment developed failures that resulted in channeling the gases around the collection device. Inadvertent releases of HF would result if (1) parts of the water scrubber became plugged, (2) there was a decrease in the liquid flow through the scrubber, or (3) the mist eliminator was damaged.

There appear to be no incidents or data available on releases caused by these types of treatment equipment failures.

Another inadvertent release could occur if the slaked lime feeder failed on the  $\text{CaF}_2$  precipitation ponds. Depending on how long the condition existed, excess HF could be discharged to the river. Table III-9 indicates maximum levels of contaminants sampled in this discharge; this table indicates that over the reported sampling period, no major treatment failures occurred.

### 5. Transportation

No radioactive wastes have ever been transported off-site. Thus, possible public transportation accidents would only involve incoming concentrate and non-radioactive materials such as HF and ammonia, unless the State of New Mexico accepts the proposal for raffinate sludge disposal on a tailings pile, or unless in later years, other radionuclide-bearing waste is shipped off-site.

### E. Long-Term Releases

Long-term releases of waste could occur from

- (1) subsurface movement of buried wastes (saturated or unsaturated flow),
- (2) man-caused disturbance of burial areas,

- (3) natural erosion (such as gully erosion or movement of the river to the burial area) exposing wastes,
- (4) animal-caused disturbance of burial areas,
- (5) plant root penetration of burial sites, and
- (6) radon diffusion through soils.

The burial areas must retain their integrity essentially "forever" if long-term releases are to be minimized.

The probability of long-term containment will depend on the final treatment/disposal of the presently generated uranium containing wastes and the raffinate and  $\text{CaF}_2$  treatment sludges and future land use at the on-site burial ground.

### F. Recommendations

To obtain a better data base for assessment of the Kerr-McGee  $\text{UF}_6$  plant, the following projects should be undertaken.

- (1) Mass balance determinations for all materials entering the plant,
- (2) monitoring of nonroutine releases and fugitive emissions,
- (3) independent routine stack sampling of HF releases and oxides of nitrogen releases and seasonal fluoride and nitrate compound concentrations in surrounding soils and plants,
- (4) further environmental studies of the effects of the liquid discharge on the adjacent waterways,
- (5) routine sampling for  $\text{U}_{\text{nat}}$ ,  $^{226}\text{Ra}$ , and  $^{230}\text{Th}$  in ambient air, water, and soils, including the respirable and soluble fractions in air, at locations determined from modeling of dispersion of stack and fugitive emissions to be locations of possible maximum concentration,
- (6) in-depth studies of long-term effects, which may result from routine emissions,
- (7) determination of possible long-term buildup of  $^{230}\text{Th}$  and other contaminants on fields receiving raffinate decantate,
- (8) determination of the influence of change in operating conditions on plant discharges. (for example,  $\text{NO}_x$  emission appears to depend on such factors as feed, temperature, and strength of acid in digestion circuit, operation of nitric acid absorbers, etc.),

- (9) determination of the content of raffinate sludges and the safety aspects of transport of these,
- (10) determination of the proper disposal of solid radioactive wastes now stored on-site,
- (11) determination of the content of  $\text{CaF}_2$ -containing sludges,
- (12) determination of the adequacy of proposed sludge (both  $\text{CaF}_2$ -containing and raffinate) disposal as to long-term effects,
- (13) determination of the contaminants in the condensed sulfur and suitable disposal techniques, and
- (14) determination of the possible long-term fate of wastes presently buried on-site, and
- (15) hydrotesting of any underground waste lines to ensure that pipes are not leaking.

## REFERENCES

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## CHAPTER IV

### CONCLUSIONS AND RECOMMENDATIONS

#### A. Effluent/Waste Characterization

Although the  $\text{UF}_6$  facilities have extensive waste treatment systems in operation, airborne radioactive releases from the facilities are larger than at fuel fabrication facilities (Table IV-1). Of particular concern are the radionuclides  $^{230}\text{Th}$  and  $^{226}\text{Ra}$ , which occur as impurities in the concentrate feed to the  $\text{UF}_6$  conversion facilities. (The impurities, of course, are not present in fuel fabrication feed.)

In addition to radionuclides, waste streams (air, water, and solid) contain fluoride compounds, nitrogen compounds (composition and quantity somewhat dependent on whether the wet or dry process is used), organic compounds (again dependent upon process used), and trace elements found in the concentrate, such as molybdenum, vanadium, and arsenic, all of which may adversely affect the environment (depending on concentration, compound, etc.).

#### B. Plant Circuit Design and Waste Treatment

Because each  $\text{UF}_6$  facility is very different, specific recommendations have been included in Chapters II and III. When a new  $\text{UF}_6$  facility is built in the US, a detailed comparison of resource requirements, effluent/waste generation, safety, etc., should be made for the wet vs dry process.



TABLE IV-1

## A SUMMARY OF THE RELEASE OF RADIOACTIVITY IN THE ENVIRONMENT

|  | Air Effluents ( $\mu\text{Ci}/\text{yr}$ ) |                         | Liquid Effluent ( $\text{Ci}/\text{yr}$ ) |          |
|--|--|-------------------------|---|----------|
|  | EIA  | Reported<br>(7/76-6/77) | EIA                                       | Reported |
| <b>Fuel Fabrication Plants</b>                 |  |                         |   |          |
| 1. Westinghouse<br>(Columbia, S.C.)            | 3700                                       | 3010                    | 0.319                                     | 0.116    |
| 2. General Electric<br>(Wilmington, N.C.)      | 2079                                       | 2520                    | 0.300                                     | 0.760    |
| 3. Combustion Engineering<br>(Hematite, Mo.)   | 409  | 467                     | 0.026                                     | 0.026    |
| 4. Babcock & Wilcox (CNFP)<br>(Lynchburg, Va.) | 6  | 6                       | a   | a        |
| 5. Exxon Nuclear Co.<br>(Richland, Wash.)      | 100  | 12                      | a   | a        |
| 6. B&W Apollo<br>(Apollo, Pa.)                 | 695  | 695 (1/78-6/78)         | 3.5                                       | 3.5      |
| 7. Combustion Engineering<br>(Windsor, Conn.)  | 20   | 11                      | a   | a        |
| <b>UF<sub>6</sub> Conversion Plants</b>        |  |                         |   |          |
| 1. Allied Chemical Corp.<br>(Metropolis, Ill.) | 320 000                                    | 310 000                 | 1.68                                      | 2.19     |
| 2. Kerr-McGee<br>(Sequoyah, Okla.)             | 45 717                                     | 46 400                  | 1.8                                       | 1.2      |

\*Insignificant.

Source: Internal Summary, Nuclear Regulatory Commission, Washington, D.C., 1979.

### C. Recommendations for Monitoring

Although the publically available data on routine operation identifies no major areas of serious concern, further publically available data, obtained by an independent monitoring group, on the size, distribution, and solubility of the various radionuclides in the ambient air at locations determined by modeling of dispersion of stack and fugitive emissions would aid in assessment. In addition, published concentrations of fluoride and nitro-

gen compounds and trace elements in ambient air, soils, plants, surface and ground water, and foraging animals would aid in evaluation of these facilities for the effects of nonradioactive emissions and waste disposal practices.

Nonroutine releases, which occur during process upsets, equipment malfunction, maintenance, etc., and releases that occur because of fugitive emissions, need additional monitoring and evaluation. No attempt was made to define releases and wastes generated during decontamination and decommissioning. These also need further study.

**D. Recommendations for Studies of Long-Term Aspects**

The long-term aspects of the following need further study.

(1) Buildup of radionuclides and other contaminants in surrounding soils and waters,

(2) disposal of solid wastes and sludges, including nonradioactive sludge and solid wastes, and

(3) effects caused by wastes presently disposed of at the site.



APPENDIX\*

AQUATIC BIOTA IN THE ILLINOIS RIVER NEAR THE  
EFFLUENT DISCHARGE POINT

\*This information provided by Kerr-McGee Nuclear.

Benthic Macroinvertebrate Monitoring Program for 1980  
in the Illinois River Adjacent to the Effluent Outfall  
of the Sequoyah Facility

The 1980 monitoring program ended with the fall sampling period (October 25—December 6). This period corresponds with two previous sampling periods: fall of 1978 and fall of 1979. The fall is a well established sampling period in this program and should be continued in future monitoring. It is also an ideal period because it does not coincide with high probabilities of vandalism (fishing pressure).

The results from the upstream station, which corresponds with Transect 6B of the initial monitoring program, are as follows: number of species, 18; number of individuals, 559; and diversity index, 2.58. The results from the downstream station, which is near Transect 1B of the initial monitoring program, are: number of species, 18; number of individuals, 962; and diversity index, 1.14. The results from the effluent mouth are: number of species, 32; number of individuals, 343; and diversity index, 2.16.

This data, compared with the 1978 and 1979 fall sampling periods, show a striking difference for all parameters (Table I). The upstream station showed the greatest degree of difference with the previous two years, and the effluent station showed the minimum degree of difference. The low values for all three parameters for the upper Illinois River suggest that the water below Tenkiller Lake is of lower quality than the two previous falls.

TABLE I  
COMPARISON OF THREE CONSECUTIVE FALL  
SAMPLING PERIODS  
1978-1980

| Station        | Number of Species | Number of Individuals | $\bar{d}$ |
|----------------|-------------------|-----------------------|-----------|
| U (6B) Fall 78 | 35                | 2294                  | 3.09      |
| U (6B) Fall 79 | 40                | 2484                  | 3.11      |
| U (6B) Fall 80 | 18                | 599                   | 2.58      |
| D (1B) Fall 78 | 24                | 962                   | 3.05      |
| D (1B) Fall 79 | 40                | 1687                  | 2.85      |
| D (1B) Fall 80 | 18                | 962                   | 1.14      |
| EM Fall 78     | 29                | 783                   | 4.08      |
| EM Fall 79     | 35                | 403                   | 2.52      |
| EM Fall 80     | 32                | 343                   | 2.16      |

U - upstream station.  
D - downstream station.  
EM - effluent mouth.

**LIST OF SPECIES AND NUMBER OF INDIVIDUAL ORGANISMS AT  
STATIONS IN THE ILLINOIS RIVER, OCTOBER 26—DECEMBER 6  
(Pooled Samples)**

| Species List                     | Upstream | Downstream | Effluent<br>Mouth |
|----------------------------------|----------|------------|-------------------|
| Coelenterata                     |          |            |                   |
| <i>Hydra</i> sp.                 | 17       | 4          | 6                 |
| Annelida                         |          |            |                   |
| <i>Nais</i> sp.                  | 30       | 25         | 22                |
| <i>Dero</i> sp.                  | 7        | 9          | —                 |
| <i>Stylaria lacustris</i>        | 5        | —          | 3                 |
| Arthropoda                       |          |            |                   |
| Amphipoda                        |          |            |                   |
| <i>Gammarus</i> sp.              | —        | —          | 1                 |
| Insecta                          |          |            |                   |
| Coleoptera                       |          |            |                   |
| <i>Oreodytes</i> sp.             | —        | —          | 2                 |
| <i>Deronectes</i> sp.            | —        | —          | 1                 |
| Odonata                          |          |            |                   |
| Unidentified Coenagrionidae      | —        | —          | 3                 |
| Ephemeroptera                    |          |            |                   |
| <i>Caenis</i> sp.                | —        | —          | 2                 |
| <i>Stenacron</i> sp.             | 1        | 1          | —                 |
| Trichoptera                      |          |            |                   |
| <i>Hydroptilla</i> sp.           | 1        | —          | 4                 |
| Diptera                          |          |            |                   |
| <i>Glyptotendipes</i> sp.        | 255      | 808        | 235               |
| <i>Glyptotendipes senells</i>    | 48       | 4          | 2                 |
| <i>Cladotanytarsus</i> sp.       | 154      | 2          | 24                |
| <i>Trissocladius</i> sp.         | 29       | 1          | 2                 |
| <i>Parachironomus</i> sp.        | 3        | 3          | 2                 |
| <i>Chrionomus</i> sp.            | 1        | 33         | 1                 |
| <i>Potthastla</i> sp.            | 4        | —          | —                 |
| <i>Cricotopus</i> sp. C          | 17       | —          | 2                 |
| <i>Cricotopus</i> sp. C          | 8        | —          | 3                 |
| <i>Rheotanytarsus</i> sp.        | 7        | —          | 5                 |
| <i>Einfeldia</i> sp.             | —        | 29         | —                 |
| <i>Psectrocladius</i> sp. B      | —        | 13         | 1                 |
| <i>Dicrotendipes nervosus</i>    | —        | 5          | 1                 |
| <i>Micropsectra</i> sp.          | —        | 1          | 3                 |
| <i>Conchapelopia</i> sp.         | —        | 1          | 2                 |
| <i>Ablabesmyia mallochi</i>      | —        | 1          | 6                 |
| <i>Polypedillum</i> sp.          | —        | —          | 1                 |
| <i>Tribelos</i> sp.              | —        | —          | 2                 |
| <i>Ablabesmyia ornata</i>        | —        | —          | 1                 |
| <i>Tanytarsus</i> sp.            | —        | —          | 2                 |
| <i>Labrundinia</i> sp.           | —        | —          | 1                 |
| <i>Dicrotendipes modestus</i>    | —        | —          | 1                 |
| Number of species                | 18       | 18         | 32                |
| Number of individuals            | 599      | 962        | 343               |
| Mean species diversity $\bar{d}$ | 2.58     | 1.14       | 2.16              |

Source: Kerr-McGee.

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